Environmental Management Accounting for Cleaner Production

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Environmental Management Accounting for Cleaner Production

Springer

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Foreword from the Editors

This fifth volume of the Environmental and Sustainability Accounting Network (EMAN) would not have been possible without the continuous support of the many active network members submitting papers and engaging in EMAN conferences. The role of environmental management accounting (EMA) support for Cleaner Production in companies and Cleaner Production initiatives by governments has been discussed intensively since the EMAN-EU conference in Graz in 2006.

At the Helsinki conference in 2007 EMAN celebrated its tenth birthday. The network has grown since its foundation in 1997 to more than 2,000 members from academia, companies, NPOs and the public sector and is continuously accepting new members. From the initial core group of EMAN-EU the global network has developed five regional networks EMAN-Europe (www.eman-eu.net), EMAN-Asia Pacific (www.eman-ap.net), EMAN Africa (www.eman-af.net) and EMAN-Americas (www.eman-am.net). All regional networks are members of EMAN-Global (www.eman-global.net) which serves to secure communication and interaction between the regional EMAN sections. This development shows the growing interest in a topic which was previously considered to be a rather specialist area. It is of great solace that in the last decade various accounting organisations have started to deal with environmental and sustainability accounting and that IFAC has issued a guideline on EMA.

Whereas the development and implementation of some tools of environmental management cost accounting, especially material flow cost accounting, is encouraging and spreading, other areas of sustainability accounting are still in an early stage of development or research. EMAN is therefore challenged to further support the research, knowledge transfer, and implementation of new tools supporting corporate sustainability.

Furthermore, various application areas have substantial development potential, such as accounting for biodiversity and its related economic effects, and accounting for social and stakeholder related issues to name two growing areas of interest.

Hence, in spite of the successes of the last decade EMAN is still confronted with various sustainability accounting and information management challenges.

The editors would like to thank all authors for their contributions. Special thanks also to more than 20 reviewers who are not mentioned by name here to secure the

anonymity of the review process and its scientific improvement effect. Many thanks to the Centre for Accounting, Governance and Sustainability, University of South Australia, for assistance provided by Paul Shum and Paul Burger with the proofing process and to Maik Philipp for his patience and diligence bringing all papers to the required layout format. The support of Dorli Harms and Cornelia Fermum from the Centre for Sustainability Management (CSM), Leuphana University of Lueneburg, is appreciated very much. Last but not least the editors would like to thank Takeesha Moerland-Torpey from Springer for her support.

The editors
Stefan Schaltegger, Martin Bennett,
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Preface

Several current global trends are causing cleaner production to grow in relevance and importance. Of especial significance are the inexorable rises in the price of energy and raw materials in the global marketplaces as well as the ever-increasing pressures being brought to bear by international buyers and investors alike looking for greater and greater efficiency along supply chains. All this is making more and more companies aware of the low efficiency with which they use their material and energy resources and the negative effects this is having on their profitability and competitiveness.

An independent global evaluation of UNIDO's and UNEP's joint cleaner production programme has underscored these facts, and has concluded that a cleaner production strategy is still very appropriate for companies, in the developing as well as the developed countries. Often, companies are using inefficient processes and technologies that are often obsolete, which, as a consequence, consume more energy and resources than would be the case if companies were using "state of the art" processes. As a result, production costs are higher, affecting competitiveness and profitability. These inefficiencies are also leading to rapid environmental degradation, as excessive amounts of pollution and wastes are generated, and a reduction in population's quality of life. Company audits undertaken by our 38 cleaner production centres and programmes have highlighted time and again the large savings waiting to be enjoyed in all industry sectors. However, most factories do not know it, because they have no monitoring and data collection system in place, so bearing out once again the old saying: "What you do not measure you cannot manage!"

The environmental and sustainability accounting tool gives companies the opportunity to collect, evaluate, and interpret the information they need to estimate their cleaner production saving potential and to make the right decision for the right CP option. In the following chapters, readers will find different applications of the tool and interesting case studies. I hope this will inspire many companies to adopt this tool and to tap into the savings waiting to be harvested through cleaner production.

Heinz Leuenberger
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Part I
Introduction and Structure

Chapter 1
Environmental Management Accounting (EMA) as a Support for Cleaner Production

Stefan Schaltegger, Martin Bennett, Roger L. Burritt, and Christine Jasch

Abstract The potential for Cleaner Production (CP) to benefit businesses is well-demonstrated, but it is not yet as widely adopted as might be expected. This is unlikely to be entirely because of the lack of adequate information—other possible reasons could be that (i) CP is commonly seen as being only relevant to manufacturing, (ii) the institutional framework does not encourage the adoption of CP as well as it might do, and (iii) there is no single one-to-one relationship between organisational change (such as a move to CP) and accounting change.

This contribution addresses the last-mentioned reason for hindrances to the wider adoption of CP and investigates the relationship between CP developments and innovations in relation to information requirements and accounting.

Three distinct strategies can be identified through which CP might benefit business: efficiency, consistency, and sufficiency. So far CP policies and promotion have focused only on efficiency strategies. However, each of these strategies has differing information needs which might be at least partially met by EMA. Two factors that will affect the type of information that is most appropriate in any situation are (i) how radical and innovatory (rather than merely incremental) any particular change is, and (ii) whether a particular innovation is new and as yet only experimented with by a few early adopters, or applied in a mass market.

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1.1 Cleaner Production: Improving Economic Performance Through Environmental Improvements

Historically the usual (and apparently reasonable) assumption amongst most managers has been that improving environmental performance represents only extra costs for a firm, with no corresponding benefit other than to ensure compliance with laws and regulations and thus avoid possible prosecutions and fines. Corporate environmental managers have struggled against this preconception in their organisations and have sought ways of 'making a business case' for their activities—this has been the motivation which has stimulated innovations such as Baxter International's Environmental Financial Statement, which was effectively a regular periodic cost-benefit analysis of the company's environmental programme over time (Bennett and James 1998a; concerning the business case for sustainability see, e.g., Schaltegger and Wagner 2006a). The Cleaner Production Programme of UNIDO (www.unido.org), UNCTAD (2000), the PREPARE network (www.prepare-net.org), and the WBCSD (2002, www.wbcsd.org)—to mention a few—all promote the approach that Pollution Prevention Pays.

However, an alternative and increasingly credible hypothesis is that by contrast, dirty production is inefficient production, and waste and pollution are signs of low efficiency. In a completely efficient production system, wastes would either not be created in the first place or would be converted into products with a market value. Clean production (CP) on the other hand is a sign of more efficient production; and efficient production in turn is more innovative and competitive, and in principle also economically superior. The most common definition of CP is that of the United Nations Environment Programme (UNEP Industry and Environment) which calls for "the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risks to humans and the environment" (http://www.unepie.org/cp/home.html).

Behind this general view of cleaner production focusing on greater efficiency, is a vast number of theoretical and practical arguments and examples which have created the foundation for the popularity of Cleaner Production measures and this new line of thought.

Firstly, many company examples have shown that adopting environmental protection measures can often substantially reduce costs. Secondly, a growing number of companies in both the manufacturing and services sectors have demonstrated the potential to reduce both their costs and their environmental impacts at the same time (e.g. see the cases reviewed in Burritt 2004). This represents an improvement in eco-efficiency, which can be defined as an improvement in the relationship between economic performance and environmental impacts (Schaltegger and Sturm 1990, 1992, 1998). Eco-efficiency is not just about bridging a perceived gap between competitive industrial production and environmental concerns, but rather about increasing competitiveness through improved environmental perfor-mance (e.g. Schaltegger and Sturm 1998; Schaltegger and Wagner 2006b). CP can play a crucial role in achieving eco-efficiency (Fresner et al. 2006; Jasch and Schnitzer 2002; Schnitzer et al. 1999; Schnitzer 1995; Yacooub and Fresner (2006)).

Thirdly, what may be really crucial is that the application of eco-efficient processes is often recognised as a key indicator of good management generally; or conversely, managers who neglect to implement measures which could increase eco-efficiency probably also show that they are not only under-performing in environmental protection but in terms of economic results too. In short, there is higher potential than might once have been expected for companies to increase eco-efficiency, and managements which fair to realise this potential are perceived to be under-performing.

However, it also seems that this potential is being realised only very slowly and even when it does occur, is not always identified and applied systematically throughout a company. Technical developments of CP which have been proposed, discussed, and applied in pilot studies by CP experts too often remain as merely niche examples, even though they could be applied on a large scale in many companies and industries (e.g. Schnitzer and Ulgiati 2007) which are presently missing these opportunities. CP represents not merely a technical solution for the production department, but also an internal corporate strategy which requires all decision-makers in a company to assess the potential to adopt cleaner technologies and techniques in all parts of the organisation.

This is why lack of information about the economic and environmental potential of CP is a substantial obstacle to dissemination. Furthermore, and related to this, business information management systems and particularly accounting have not yet been institutionally developed and implemented in a sufficiently broad manner to cope with the insight that so many opportunities exist to achieve such substantial potential for eco-efficiency. This may be a fundamental answer to the question of why the implementation of CP has been so slow and lagging.

However, it is unlikely that the sole reason is a lack of information: firstly because the role of management information and its effect on businesses' performance is already well documented, and secondly because various accounting approaches to the collection and measurement of eco-efficiency potential in production have been proposed and discussed in academia for the last 15 years (e.g. Schaltegger and Sturm 1992; Schaltegger 1998). Clearly, difficulties in obtaining information about inefficiencies cannot be the only factor affecting the take-up of CP techniques.

There are also other possible reasons for slow adoption. First is the possibility which was identified in early research (e.g. Fichter et al. 1997; Umweltbundesamt and Bundesumweltministerium 1995; IFAC 2005) that the notion of CP is often perceived too narrowly as being relevant only to organisations with large manufacturing functions. This is understandable, since the focus of much environmental management accounting (EMA) information which has been generated to improve eco-efficiency has also been very much on the narrow notion of detecting the materials flows and associated environmental costs occurring in manufacturing, to show how significant these might be in economic terms. However since environmental costs occur throughout the value chain, the effect is to encourage an unhelpful type of tunnel vision which ignores non-manufacturing environmental costs.

In practice, all types of organisations have a potential to make economic gains by introducing CP—not only the primary and manufacturing sectors but also services and knowledge-based organisations. Whilst the emphasis to date has largely been on the manufacturing sector, there are also millions of organisations worldwide providing services and management activities which are also important in examining moves towards securing sustainable outcomes for businesses and society.

A second reason could be a set of institutional circumstances which may promote or interfere with the take-up of EMA. For example, if environmental and economic gains can be demonstrated for one particular organisation in its own setting, this is likely to encourage other organisations to copy this technique and strive for similar gains, to be competitive and to establish a reputation for being clean and green. This can be either encouraged or constrained by industrial or professional associations which act in the interests of their members to promote acceptable behaviour (e.g. Bennett et al. 2004; Bouma and van der Veen 2002; Bouma and Correlje 2003). Similarly CP and EMA can be promoted by government regulations which enforce the need for organisations to gather and submit data which is considered necessary to monitor and maintain oversight of their operations. Theoretical foundations for the establishment of an optimal set of institutional arrangements have not so far been discussed extensively in the literature (e.g. Schaltegger et al. 2002).

Thirdly, as Broadbent and Laughlin have argued (2005, p. 19), there is no one-to-one relationship between organisational change (as for example required by CP) and accounting change. Accounting change can be used as part of a strategy to introduce (or resist) change in organisations when the parties who are affected see this as a useful or unnecessary disturbance, but there are also many other mechanisms which can be used to amplify or to blunt the disturbances which accompany change. Change is not simply brought about by untrammeled market forces which push organisations to take action to secure the maximum efficiency gain once these are known to exist, and EMA research needs to take up the challenge of gaining a fuller understanding of the reasons of why change occurs and why in other situations it may be blocked. For example, executives may see the issue as a minor distraction to the organisation's core activities and therefore fail to provide the top-level support that would be needed for it to occur.

An analysis of the role and potential for improvements in environmental accounting practice to provide a catalyst for CP, and thus to increase competitiveness by improving environmental performance, requires as a minimum an overview of recent knowledge transfer initiatives such as that by IFAC (2005), new case studies and new methodological developments.

To provide a basis for further analysis and discussion, the next sub-section provides an overview of some alternative management strategies for CP that might be possible.

1.1.1 What Is Cleaner Production?

The United Nations Industrial Development Organisation (UNIDO) and the United Nations Environmental Programme (UNEP) have provided some of the most important initiatives to promote CP in the last decade (see e.g., http://www.unido.org, http://www.uneptie.org/PC/cp).

CP can be described as a preventive, integrated strategy in which costly end-of-pipe pollution control systems are replaced by measures which reduce and avoid pollution and waste throughout the entire production cycle, through the efficient use of raw materials, energy and water (e.g. http://www.uneptie.org/pc/cp/understanding_cp/home.htm, see also http://www.unido.org/cp). CP aims to increase production and corporate productivity through the more efficient use of raw materials, water and energy in order to reduce wastes and emissions of any kind at source rather than simply to deal with them afterwards, and to contribute to improved product designs for products which will be more environment-friendly and cost-effective over the whole of their life-cycles. CP's main objectives are to:

- Minimise the use, as well as optimise the reuse and recycling, of hazardous and non-hazardous materials
- Use materials in the manufacturing process in a more efficient way, reducing the amount of inputs needed and the amount of non-desired outputs
- Minimise risks and improve human capital through worker hygiene and safety programs
- Improve monetary returns by minimizing energy consumption and reducing material and handling costs. This may often require capital investment

Moving towards cleaner and more efficient production requires several things: a readiness to change established attitudes, the implementation of corporate environmental management, the promotion and implementation of technology change, the collection and use of necessary information, and a supportive institutional context. Environmentally sound technologies are less polluting, resource-efficient, recycle more of their wastes and products, and handle residuals in a more environmentally friendly manner, than do the technologies which they substitute. Cleaner technologies generate low or no waste which would give rise to a need for pollution prevention. As noted above, the basic principles of CP can be applied to any and all industrial processes, products, and services:

- *Production processes*: CP is a result of reducing the use of any kind of inputs such as raw materials, water and energy, as well as the substitution of toxic and dangerous raw materials by less dangerous materials.
- *Products*: From a product perspective, CP means that environmental, health and safety impacts of products are eliminated or reduced throughout their entire life cycle.
- *Services*: CP means that direct and indirect environmental effects are reduced in the creation and performance of services.

Given the objectives, scope and application areas of CP, the question arises as to what general sustainability strategies are available which could help to achieve a stronger take-up of CP, and what kind of information is needed by management in order to make good decisions. Good decisions are defined as those which support efficient and effective production, where effectiveness is seen in terms of the implementation of organisational and management structures and processes which are designed to bring about reductions in resource use, changes in patterns of the use of resources which are detrimental to the environment, and hence greater efficiency and effectiveness. The following section will consider the alternative strategies that are available.

1.1.2 Sustainability Strategies of Cleaner Production

Three alternative (or complementary) corporate sustainability strategies are available to help corporate management design and realise CP (see e.g. Huber 1995; Schaltegger et al. 2003): respectively, strategies of eco-efficiency, consistency and sufficiency.

Efficiency strategies include both *eco-efficiency strategies* and *ecological efficiency strategies*, which should be distinguished. *Ecological efficiency strategies* aim to reduce the environmental damage associated with the production and use of each product, over its entire life-cycle (Schaltegger and Sturm 1990). By contrast, *eco-efficiency strategies* (also known as economic-ecological efficiency strategies, see e.g. Schaltegger 1998) focus on the relationship between economic performance and environmental impacts (e.g. the value added by a product or process, divided by the environmental impact added). The objective of eco-efficiency strategies is to achieve a certain level of economic result with the least possible undesired environmental side-effects, or conversely to achieve the best possible economic results from a given level of environmental impacts. Eco-efficiency strategies always focus on optimization and are thus often technically based, although the behavioural issues associated with design and implementation are also important. Eco-efficiency strategies closely match the goals and the main current approach of CP.

Consistency strategies, like eco-efficiency strategies, are often technical in nature. They differ from eco-efficiency strategies in that they focus not on optimizing the relationship between inputs and outputs, but rather on replacing environmentally harmful substances with more environmentally friendly materials and energy flows (e.g. Braungart and McDonough 2002; Huber 1995). Consistency strategies are in line with the approach of industrial ecology since they search for materials and energy flow designs which can be sustained indefinitely because of their compatibility with natural material and energy flows. This can be termed ‘cradle to cradle’ (rather than ‘cradle to grave’) production which integrates waste back into the manufacturing processes.

Sufficiency strategies are a behavioural rather than a technical approach to environmentally responsible behavior (e.g. Huber 1995). Sufficiency has usually been associated with the personal philosophies of individuals rather than being seen as a possible corporate strategy, but it can be adapted to meet this purpose too. At an individual level and simply expressed, sufficiency means being content with a given situation rather than continually seeking more products, and adopting values other than those which depend on material possessions. The resulting lower demand for products and services then reduces the related environmental impacts. At a corporate level a sufficiency strategy cannot result in lower demand in general but in lower demand for materials and products (e.g. Schaltegger et al. 2002). A sufficiency-oriented business strategy might, for example, imply the substitution of products by services, or a business considering how many functions in a product or service are really adding significant value for its customers and then eliminating whatever features are not justified by this criterion.

Efficiency strategies are most obviously in line with the CP approach but consistency and sufficiency strategies can also support CP, even though this might not have been recognised to the same extent so far. All strategies require a supply of relevant information if they are to be successfully implemented in either a company or in the wider industrial and societal systems. The following sections discuss the information requirements and the role of EMA that is most appropriate for each of these three sustainability strategies.

1.2 Efficiency Strategies for Cleaner Production and EMA

1.2.1 Ecological and Eco-Efficiency Strategies

Of the three broad sustainability strategies described above, efficiency strategies are those which are most obviously in line with CP. However, even within this group, the information requirements and the scope of implementation which is most appropriate will vary substantially, depending on the kind of efficiency which is being considered. Firstly, *single-efficiency* measures must be distinguished from *cross-efficiency* figures. In the context of CP, the main single measures of efficiency are those which reflect profitability, such as return on investment and ecological efficiency. Ecological efficiency is defined as the relationship between a desired output and the extra environmental impact which has to be incurred in order to receive this output and can be measured as (Schaltegger and Sturm 1990):

Ecological efficiency = desired output/environmental impact added

Ecological efficiency is therefore a technical measure of environmental performance which requires information about physical material flows, which can be provided by EMA.

The most important *cross-efficiency* figure for CP is eco-efficiency as this measures the relationship between an economic performance indicator and an environmental performance indicator. In contrast to ecological efficiency strategies, eco-efficiency strategies focus on the relationship between economic performance and environmental impacts (e.g. value added divided by environmental impact added, Schaltegger and Sturm 1990, p. 240ff.):

Eco-efficiency = economic value creation/environmental impact added

To measure ecological efficiency it is enough to know the quantities of materials and energy used, the emissions caused, and the number of desired outputs created. Measures of physical environmental management accounting (PEMA—see Burritt et al. 2002), and the respective EMA tools to track, trace, measure and report physical information, are therefore required.

To measure and improve eco-efficiency, however, requires both environmental and economic information, i.e. not only physical but also monetary environmental management accounting (MEMA) information (Schaltegger and Sturm 1992; Schaltegger 1998; Schaltegger and Burritt 2000; Burritt et al. 2002). Furthermore, for this information to be practically useful, management must ensure that the scope of environmental and economic measures respectively are consistent so that both the physical performance indicator and the monetary performance indicator cover the same range of issues, geographic area, and aggregation level (see Schaltegger and Burritt 2000).

1.2.2 Products, Functions and Needs Perspectives of Efficiency

A further distinction can be made to sub-divide efficiency strategies in terms of their main object of focus (e.g. Schaltegger et al. 2002):

- *Product* or *process efficiency* looks at a given product or process and aims to reduce the inputs that are used by using less materials and creating less waste at each stage of production or stage of the product life-cycle. An example would be the improvement of the ecological or eco-efficiency of a car.
- *Function efficiency* increases the breadth of this focus by considering not only a single product or service but also the range of different products or services which could serve to fulfil the same function. An example would be the function of moving a certain individual from place A to place B. This person could take a car, a street tram, a bicycle, a helicopter, etc. Different environmental impacts and economic effects will be caused depending on which means is chosen to fulfil this function. Strategies to improve function efficiency search for the best product or product-service combination to fulfil the function in the most efficient manner.
- *Needs-related efficiency* extends the focus even further, by asking what kind of human need underlies the desire to fulfil a function. For example, the underlying need for an individual's transport could be either to exchange information with another person, or actually to meet them face-to-face. In the first case the same purpose as personal mobility might alternatively be provided by telephone, video conference, etc., without any physical movement, whereas in the second case only physical movement will suffice and functional efficiency considerations will be necessary.

CP has a very different meaning for each of these three dimensions of efficiency:

- From the *product efficiency perspective*, CP means cleaner products or processes in the sense of optimizing a given product or process. In the transportation example above this could mean improving the efficiency of a given model of car (as measured, for example, by the quantity of fuel consumed per kilometre), or design and production of a printing machine to optimise efficiency in consuming ink and energy.
- Modern EMA approaches should be able to provide the information necessary for this with little problem since the basic data will usually be part of the production information system.
- From the *function efficiency perspective*, however, the focus of the efficiency strategy will be to optimise a system (e.g. the optimization of the transport system, or of the printing system e.g. by using computer-to-plate technologies for printing which do not require films and spray-based printing). The function perspective will usually exceed the focus of even modern EMA, since, it requires going beyond established schemes of information and thinking, and so requires an enlargement of the scope of the accounting.
- Even more challenging is the *needs perspective*, as this requires a comparison of different systems (e.g. of a physical transportation system compared to electronic information systems such as video conferences; or for the printing example, a comparison of printing versus electronic communication of pictures and texts). The optimization which is sought goes beyond the limits of a given production or product system and like the sufficiency strategy, requires consideration of what needs are driving the demand for products and services. Current conventional and even most EMA approaches are likely to be inadequate to provide information which motivates management to devise new solutions to fulfill the underlying needs.
- The aim of an EMA system here should be to serve as an ‘ideas machine’ (Earl and Hopwood 1979) to support the initial brainstorming phases rather than as a more traditional and mechanistic ‘answer machine’, and to follow the concept of a garbage-can into which various problems and solutions are dumped by organisation participants, which March and Olsen (1976) argue is a more appropriate context for decision-making in situations when there is a high degree of uncertainty over both means and objectives. Following these first brainstorming phases, innovative indicator-based EMA approaches might then become appropriate to provide a basis for assessments.

Consideration of the information which is needed to implement the three efficiency strategies, considering products, functions and needs respectively, shows (see Table 1.1) that EMA is likely to be effective in providing information for the optimization of given products and production systems (product and process efficiency), but it is challenged if this focus is enlarged. Function-oriented and needs-oriented approaches to CP require new, innovative methods of information management. EMA has to move from a given, standardised set of procedures and tools to more flexible, indicator-based approaches which provide a framework to

Table 1.1 Comparison of different levels of innovation with their respective information needs and relevant EMA approaches

Perspective	Character of CP innovation	Character of information	Characteristics of supportive EMA approaches
Product/process	Incremental CP innovation (alterations of product/process)	Past information about current product/process and comparison of direct alternatives	Environmental cost accounting, investment appraisal, physical and monetary budgeting, financial and physical planning
Function	Substantial CP innovation	Comparison of alternatives with different scope. Past information about current product/process and comparison of very different product alternatives	Investment appraisal, physical and monetary budgeting, financial and physical planning
Needs	Radical CP innovation	Long term physical and financial information. Firstly, general information about different possible ways of fulfilling needs. Secondly, indicator-based information about the environmental and economic effects of a wide range of alternative possible ways of fulfilling needs.	Indicators and indicator systems, investment appraisal, physical and financial planning

specify the type of indicator, the measurement procedures, and the scope, on the basis of a prior analysis of the needs and of the intended recipients.

In any case, some basic information about materials and energy flows, as well as, about monetary effects will be necessary at some stage as the planning for alternative CP strategies progresses, even for the needs efficiency perspective. This leads into a discussion of a number of different efficiency perspectives, defined on the basis of their respective materials and energy effects.

1.2.3 Resource and Materials Efficiency

As discussed above, eco-efficiency is a general term which has to be defined more specifically if it is to be made operational. Focusing on materials and energy flows, eco-efficiency can be defined as either (a) emissions in relation to an economic performance indicator or (b) resource consumption and use in relation to an economic performance indicator. The first perspective is traditionally related to end-of-pipe technologies, although this is neither usually the most cost-efficient way to reduce emissions over the long-term nor the only possible view.

The CP philosophy is based on the fact that any reduction of materials and energy used will result in fewer emissions—in other words, its focus is on resources and resource flows. It therefore logically flows that the most important kinds of efficiency in the context of CP are different kinds of resource efficiency, the most important types of which are materials and energy efficiency respectively. These are related to each other, firstly, because materials contain energy and vice versa much energy is transported using energy carriers (i.e. the physical form in which energy is contained, such as oil or coal), and secondly because the use of materials is related to the use of energy and vice versa. Nevertheless, the question of whether the focus is on energy or materials as the unit of measurement affects how the information is managed.

Resource efficiency is eco-efficiency which concentrates on the relationship between the economic performance and resource use performance respectively of a product or process which fulfills a function or serves a given need. The resource efficiency of a product or function is thus defined as:

1.2.3.1 Resource Efficiency: Economic Performance per Unit of Resource Use/ a Product, Process, or Function

An example, of the resource efficiency of a function, would be the contribution margin divided by the resource use per car, of a paint coating system used in manufacturing cars.

Resource efficiency covers all kinds of resources including materials taken from and impacts upon elements of the natural environment such as forests, coasts, and coral reefs. For industrial purposes to which CP is related, materials efficiency which focuses on the materials flows is usually an adequate focus.

To improve materials efficiency requires accurate and relevant information about all material flows related to a product, process, function, or need. CP approaches do not usually conduct an environmental assessment of the materials involved in the product or production system, as their focus is on the quantitative reduction of materials inputs. The MIPS approach (Material Intensity of the Product System, von Weizsäcker 1998; Schmidt-Bleek and Bierter 1998) is compatible with a purely quantitative view on materials flows. This measures environmental impact added as the sum of all materials flows connected to a product system, in kilograms and tons. Energy is also considered in kilograms, as the induced material flows related to the use of energy. However, in most applications in companies, material efficiency is defined as the material flows induced by the company or by one of its production systems or plants.

The usual break-down of the eco-efficiency concept into a combined product efficiency and materials efficiency perspective makes the operationalisation of incremental improvements easier, and more compatible with conventional technical and economic thinking. Accounting and EMA have developed to provide the necessary past-oriented information, based on a continuous recording system which provides a secure basis for information, and figures which can be compared against those which are compiled for investment appraisals and financial planning. The challenge for EMA, however, increases substantially when we broaden the efficiency perspective, or even more when the focus of CP is expanded into consistency or sufficiency perspectives.

1.3 Consistency Strategies and EMA

The basic idea of a consistency strategy for improving products and production systems is to substitute the usual materials and energy carriers so that the materials which are used are instead those which are consistent with material flows in nature. As with efficiency, consistency strategies are related to technical innovations, but their focus is not on reducing the use of materials and energy but on harmonizing usage with the material contents of flows which are observed in the natural environment. Consistency strategies aim for "a composition of matter streams and energy forms which is able to exist permanently in an industrial ecology" (Huber 1998, p. 27).

For most industrial products and processes this means that materials such as heavy metals, non-biodegradable plastics, etc., are substituted by biodegradable, more renewable, and mostly carbon-based materials.

Whereas an efficiency strategy may be confronted with physical and economic limitations when a high efficiency level is reached, in theory at least, a consistency strategy has no such limitations because it does not aim at—in the extreme—using no materials at all. Some proponents of the consistency strategy (e.g. Braungart and McDonough 2002) in fact argue that once a perfect match of materials used in an industrial system is achieved, it could even be ecologically desirable to have large throughputs (for example, in order to create compostable materials).

This may be basically true, and there is no doubt that the consistency approach bears enormous innovation potentials for CP. However, even materials which are quite common in the natural environment cannot be created in unlimited quantities without potentially causing environmental problems. One limitation of the consistency strategy may be that the sheer amount of natural materials may also create problems of crowding or overload, as is the case with carbon dioxide (CO_2). CO_2 is one of the most common natural gases and carbon generally is actually one of the most important components of animals and plants, but the levels of pollution which are currently being caused globally by consumption of carbon resources such as coal and oil which have been built up in nature over many millennia are overtaxing nature's capacities of CO_2 regeneration. Even if non-regenerative resources such as coal and oil are excluded, an ecosystem can still be overtaxed with a large amount of natural material, such as organic compounds, in a lake and river. A combination of efficiency strategies and consistency strategies may therefore provide more successful approaches to CP than a one-sided view.

The *information requirements* needed to support consistency strategies for CP are both similar to efficiency strategies and at the same time more challenging, especially if the interrelation between efficiency and consistency strategies is considered. Firstly, consistency measures also require a good overview of the mass of materials flows and balances, a requirement which can be fulfilled by an ambitious physical EMA system (i.e. PEMA tools). Secondly, however, the material flows must be assessed according to their compatibility with those materials which are common in the natural environment. Such an assessment is part of a sophisticated physical management accounting system and has similarities with the assessment approaches which are applied in life cycle assessment (LCA). However, life cycle assessment and evaluation approaches do not usually check compatibi-lities with natural material flows in the way that would be needed for a consistency strategy, but rather assess the environmental impact or damage potential.

In conclusion, the measurement requirements are firstly, measurement of the quantity of materials used, and secondly, assessment of the consistency quality of the materials used. Information on both of these aspects is needed to provide a basis for decisions on the potential to substitute less natural materials with more natural materials.

EMA is thus challenged to investigate what information will add value in this, and to develop approaches which are adequate to support effective consistency-oriented CP measures.

1.4 Sufficiency Strategies and EMA

Sufficiency strategies are less technical than efficiency and consistency strategies, and take start from a view that environmental problems are influenced to a substantial degree by psychological phenomena. Sufficiency is, therefore, a socially oriented approach to environmental problems. Sufficiency means having enough and reducing demand or consumption, so that with decreased demand the use of resources and the pollution of the environment are reduced. A strategy of sufficiency can follow “reflection about the environmental consequences of personal consumption and way of leading one’s own life” (Reisch 1998, p. 44).

In their extreme, sufficiency strategies are not compatible with the current incentives for individuals and the market behavior of companies and consumers. However, the basic idea can be transferred to the design of production systems and products (e.g. Schaltegger et al. 2002). This then prompts thoughts and questions about cleaner products and production systems such as:

- *Omission of products, and substitution of products by services*: can the needs be satisfied with other, more easily produced and less environmentally harmful, products or services?
- *Omission of parts of the product or production system*: what parts of the product can be omitted without loss of functionality and appeal?
- *Partial omission of products or omission of product replacements through a product-service combination*: how can attractive product-service combinations be created which replace (complementary) products or product parts, or prolong the use and fashion of products?

Currently most managers would struggle to imagine creating a business on the basis of a sufficiency strategy. However, so long as sufficiency strategies are not taken to extremes they often merge with efficiency strategies. This can be the case for instance if less functional product parts, packaging, production procedures, etc. are reviewed and it is asked whether their contribution to the fulfillment of a function or human need is sufficiently valuable to justify their costs and environmental impacts. The omission of such parts and the reduction of products to their basic functionalities can even build a basis for successful marketing (for example, by launching a product range with a design and communication of "back to basics" or "the pure function"). However, it is not only efficiency strategies that can be compatible with sufficiency, as consistency strategies can also be combined with sufficiency: for example, designing a product without the feature of a glossy appearance in its painting by refraining from some toxic ingredients in the paint or by using another coating can be considered to be a sufficiency aspect which would both reduce materials inputs and costs, thus achieving increased eco-efficiency.

The *information management requirements* to support sufficiency strategies are very different from pure efficiency and consistency strategies to CP. The kind of information required is created in cognitive reflection processes and can neither be standardised nor directly quantified. EMA is challenged at a high strategic level and needs to include very fundamental and general groups of information which are related to consumption patterns and the use of products as well as perceptions in society.

The fundamental *measurement requirements and challenges for EMA* are firstly, about the composition of production processes and products in terms of functionality and the environmental impacts for each functional component; and secondly, the measurement of the environmental impacts of different technologies, products, and production systems which aim to fulfill certain functions and needs. Thirdly, this information has to be compared against information about alternative product parts, functional units, services and substituting products.

In summary, CP approaches, whether efficiency-oriented as they usually are, or based on consistency or sufficiency considerations, require innovation processes. This raises the question of how EMA can best support sustainability innovation processes.

1.5 Cleaner Production, Innovation Process and Measurement

CP requires innovations. Sustainability innovations such as ecological or eco-efficiency innovations are created in complex, usually non-linear innovation processes with various steps loops and actors involved (Schnitzer 1995; Schaltegger and Wagner 2008).

Even if the innovation processes are non-linear, some basic phases can be distinguished ranging from the creation of ideas, inventions and prototypes to their introduction into the niche market and establishment in the mass market. Table 1.2 illustrates these basic phases of the innovation processes which spread from the first idea to the creation of the invention and through to establishment in the mass market.

As shown in Table 1.2, measurement of the contribution to CP and sustainability which can be made by an idea, prototype, or innovation will inevitably differ depending on the stage in the innovation cycle. For the idea and invention phase *ad hoc* information will be sufficient, whereas when these move on to testing the

Table 1.2 EMA challenges and measurement of environmental and sustainability progress in the innovation phases of CP processes

Potential improvement			Realised improvement	
Idea	Invention	Prototype	Niche market	Mass market
Potential sustainability effect	First estimates and measures, based on a single prototype	Measures on an ad hoc basis	Improved measures, and introduction of continuous measurement approaches	Sustainability effects actually realised; comparison with alternative products/ processes, comparison with goals and prototype results
Ad hoc information	Ad hoc information, with perhaps the first approximate indicators	Ad hoc information, with more sophisticated indicators	Continuous measurement, with simple EMA methods slowly becoming more sophisticated	Concrete operational measures on a continuous basis, established EMA methods

invention with prototypes, indicators will be needed to measure the ecological and sustainability effects. With introduction into niche markets and then establishment in the mass market, it will become necessary to create continuous information through an increasingly sophisticated information management system. The focus of information requirements can also vary greatly in all of phases of the innovation process, depending on whether what is under consideration is a production process, a company, an industry or a product life-cycle.

In summary, CP is strongly related to innovation and the requirements for EMA differ substantially depending on the sustainability strategy taken, the innovation phase, and the breadth of scope under consideration. The main challenge which CP sets for research in EMA is therefore to provide frameworks and procedures which go far beyond the current conventional and EMA approaches. From a research perspective, such frameworks need to be couched in terms of their theoretical foundations: the drivers of change, the processes associated with change, and the rate of change, as well as the discourses about incentives and barriers to change in the interrelated contexts of technological, organisational and accounting innovations and their development.

1.6 Outlook and Structure of the Book

This volume of the Environmental and Sustainability Accounting Network (EMAN) on CP and EMA addresses specific issues of the relationship between CP and EMA, and furthermore, in keeping with the practice of past EMAN books, also includes contributions covering new issues in EMA in general.

Part II on *EMA in Cleaner Production—Theories and Models* presents a collection of papers with a specific focus on the role of EMA for CP.

In Chapter 2 *Applying Best Available Techniques in Environmental Management Accounting: From the definition to an assessment method* Valérie Laforest, expresses concerns about the ambiguity associated with the 12 characteristics for selecting

Best Available Techniques in accordance with the European directive on integrated pollution prevention and control. A set of objectives is proposed, for which indicators and parameters are established (e.g. objective: prevention; indicator: compliance with regulation; parameters: regulation (yes or no)), and it is suggested that these should become part of an EMA system if decision-making about Best Available Techniques in Europe is to be simplified and improved.

Chapter 3, by Claus Lang-Koetz, Severin Beucker and Daniel Heubach, looks at *Estimating Environmental Impact in the Early Stages of the Product Innovation Process*. Addressing environmental impacts at the front end of the product development process provides the focus of this chapter, in contrast with much literature which considers the back end. Environmental impacts tend to be designed into products in the same way that costs are locked in at early stages of design. Information on the internet about substances, materials and processes is available to help with implementation of action strategies to reduce environmental impacts in these early stages.

In Chapter 4, *Unravelling the Impacts of Supply Chains. A New Triple-Bottom-Line Accounting Approach and Software Tool*, Thomas Wiedmann and Manfred Lenzen draw attention to the importance of identifying indirect as well as direct environmental impacts. They also stress the need to pinpoint shared responsibility for indirect impacts so they can be reduced with no double-counting. The quantified method suggested is to allocate responsibility using a ratio of value-added to net output. A supporting software tool which quantifies these impacts and their allocation is also discussed.

In Chapter 5, *Life-Cycle Based Sustainability Assessment of Products and the Relation with EMA*, Walter Klöpffer and Isa Renner discuss *Life Cycle Costing* (LCC) as the logical counterpart of LCA for the economic assessment. LCC surpasses the purely economic accounting and cost calculation by taking into account the use and end-of-life phases, and hidden costs. For this component, a guideline is being developed by SETAC. As a next step the paper proposes the incorporation of social indicators into Social Life Cycle Assessment, or “SLCA”.

In Chapter 6, Ralf Isenmann deals with *Environmental Statements on the Internet—From a mere EMAS requirement to an online environmental communication tool*, and promotes the media-specific capabilities that the Internet offers in disseminating information in an updated and target group-tailored fashion that enables interactive communication and promotes stakeholder dialogue.

Zygfryd Nowak and Michal Cichy explain a *Phenomenological Model of Cleaner Production* in Chapter 7, based on Polish examples of cleaner production. The study examines the effects of a CP strategy and reveals that 79 Polish CP companies succeeded over 10 years in reducing their environmental impacts at a faster rate than Polish industry generally. A benchmarking model is introduced to facilitate comparison by any company in Poland.

Part III, EMA Support for Cleaner Production—Case Studies, brings together papers which illustrate the role and possible roles of EMA in companies to support CP.

In Chapter 8, Maria Csutora and Roberta De Palma provide an overview of UNIDO experiences in *Using EMA to Benchmark Environmental Costs: Theory and Experience from Four Countries through the UNIDO TEST Project*. This project simultaneously introduced environmental management accounting (EMA), cleaner production assessment (CPA) and environmental management systems (EMS) into the companies, with the implementation of CPA being instrumental in identifying non-product output costs. The analysis of material and energy flows provided the basis for assessing and comparing the performance of the production processes against the standards defined by the technical specifications of the existing technology and against the standards of best available technology (BAT) or theoretical standards. On the basis of this analysis, companies were enabled to make strategic decisions such as to phase out products and to plan investments in environmental technologies through a step-by-step approach.

In Chapter 9, Maryna Möhr-Swart, Faan Coetzee and James Blignaut discuss *Sustainable Development in the South African Mining Industry: The Role of Cleaner Production and EMA*. The main focus is on water and electricity management by mining companies with the introduction of CP and EMA being seen as possible solutions. While the chapter considers the motivations for, and the economic, technological, legislative and managerial barriers against, the adoption of CP, it also mentions the potential of mining and the Cleaner Development mechanism of Kyoto, a tool of growing importance.

In Chapter 10, Michael Koefoed provides insights into the application of *Environmental Management Accounting in the Metal Finishing Industry*. In 2000, Danida funded a 4-year Cleaner Production (CP) Demonstration Project to create CP awareness, to build full-scale CP demonstration projects, and to build capacity in the sector for the sustainable uptake of Cleaner Technology (CT). Drivers and barriers for CT uptake in South Africa and the applied strategies (choice of CP assessment methods, training strategy and role of environmental regulator) and results, savings of water, metals and chemicals are discussed.

Martin Kurdve delivers in Chapter 11 a paper on *Chemical Management Services (CMS): Safeguarding Environmental Outcomes*. It draws on experiences from implementing CMS in one of Sweden's automotive companies, and meetings with European CMS providers. CMS is seen as a business strategy that may allow reduction in the volume of chemicals sold, while maintaining profits from use of chemicals for suppliers. In traditional business, the user would try to achieve the same reduction with less support from the supplier.

Part IV deals with conceptual developments and new areas of EMA.

In Chapter 12 Wei Qian and Roger Burritt look at *The Development of EMA: An Institutional View*. Through the examination of cognitive, regulatory, and normative institutions they consider the development of EMA in four institutional contexts, involving (i) direct regulatory pressures, (ii) social environmental movements, (iii) professional structure and inter-professional communication, and (iv) environmental mimicry in specific organisational fields. It is argued that inter-professional communication is the first and the most important step for the development of EMA with the current division between professional groups providing a significant obstacle. Suggestions are made as to how this division might be overcome.

In Chapter 13, Seakle Godschalk asks whether *Corporate Environmental Accounting Makes Business Sense*. The different elements of environmental accounting—EMA, Environmental Financial Accounting, Environmental Reporting and Environmental Audit (or assurance)—are outlined and their relative benefits explained. Emphasis is placed on the need for integration of the different environmental accounting elements if the full benefits of environmental accounting are to be achieved.

In Chapter 14, *An Environmental Accounting Model for a Natural Reserve*, Francesco Marangon, Maurizio Spoto and Francesca Visintin explain how they developed a model to assess, in economic terms, the costs and benefits of a natural marine reserve in Italy. This was initially based on the United Nations' System for Integrated Environmental and Economic Accounting (SEEA) but had to be adapted to overcome the limitations when applied to an individual environmental asset rather than at a national level. They concluded that the benefits created by the natural reserve compared well against the cost to the community of preser-ving it, and that this model can be of practical value to policy-makers by providing indicators and statistics which they can use to monitor the interaction between the economy and the environment and provide a tool for strategic planning and policy analysis.

In Chapter 15, Wynand Wentzel, Brian Reilly and Yvonne Reilly examine the question of how to account for a very specific type of environmental asset in *Measurement and Recognition of Wildlife in the Financial Statements of Public Sector Entities: A South African Perspective*. Wildlife in South Africa's conservation areas underpins its tourist industry and the authors argue that it meets the usual accounting criteria of an asset, and that accounting for it monetarily is important to manage it properly and evaluate the impact of environmental changes such as droughts, diseases and poaching. However, there are particular issues involved in achieving this, both practical and of principle, and a review of six different entities' approaches in their financial annual reports revealed wide differences. The main practical issue is simply how best to physically count an asset which is mobile and uncontrollable, and the paper reviews several alternative methods. The issues of principle include meeting the requirements of International Accounting Standards for fair value accounting and the basis on which monetary values should be determined, on which the authors make recommendations.

In Chapter 16, *Environmental Management Accounting and Environmental Accountability Within Universities: Current Practice and Future Potential* is a report by Huei-Chun Chang and Craig Deegan of a case study they carried out to assess the use of environmental accounting in an Australian university. The university had a long history of commitments to environmental sustainability and had already incorporated the environment into its curricula, implemented energy efficiency programmes, and published environmental information in its annual report. However, despite this, there was little evidence as yet of the use of EMA, although there was an obvious potential to implement it by adapting the university's current conventional accounting practices. The authors identified the barriers to EMA adoption as institutional pressures, a low profile of accounting for the environment, and existing managerial attitudes.

Chapter 17 by Christine Jasch and Deborah Savage, gives an overview of the core elements of *The IFAC International Guidance Document on EMA* which was published by the International Federation of Accountants (IFAC) in 2005. EMA is defined to be the identification, collection, analysis and use of two types of information for internal decision-making: (a) physical information on the use, flows and destinies of energy, water and materials (including wastes) and (b) monetary information on environment-related costs, earnings and savings. EMA places a particular emphasis on physical information because (1) the use of energy, water, and materials, as well as the generation of waste and emissions, are directly related to many of the environmental impacts of organisational operations, and (2) material purchase costs are major cost drivers in many organisations. Monetary information under EMA can include various types of environment-related costs; including materials purchase costs, environmental protection expenditures, and others. Prominent uses of EMA-type data for business management and pollution prevention are discussed.

Part V presents three papers on International EMA Developments and Surveys.

In Chapter 18, Robert Langford *Environmental Performance Indicators—Key Features of Some Recent Proposals* analyses and compares the recommendations on the design and use of environmental performance indicators made respectively by the Global Reporting Initiative, the United Nations Conference of Trade and Development, and ISO 14031. He concludes there is substantial divergence between their respective prescriptions and that standardisation or convergence will be difficult to achieve in view of differing approaches and would require increased co-ordination and co-operation. On balance, the GRI approach offers some attractive features in comparison to the other approaches.

In Chapter 19, Climate change is an issue which is of increasing concern, including to investors. However *The Need for Standardised Disclosure on Climate Risk in Financial Reports: Implications from the JICPA Reports*, Takeshi Mizuguchi argues that current disclosures are inadequate to provide investors with the information they need. He reviews two research reports published by the Japanese Institute of Certified Public Accountants which survey current practice in Japan and conclude that although there is a high rate of disclosure of greenhouse gas emissions amongst large Japanese companies, wide variations in the scope of what each company reports make it impossible for users to compare performance between companies or make appropriate calculations of eco-efficiency. This leads to a recommendation that mandatory standardised disclosure would be appropriate for quantitative information on issues that are common for most companies, though not necessarily on all aspects of environmental and sustainability performance.

In Japan, the Ministry of Environment's guidelines on environmental accounting are widely followed by companies, which means most manufacturing sites are obliged to collect environmental accounting data and send this to their headquarters so that the company can comply. However, these guidelines focus on external disclosure and do not necessarily mean that the data is also used at an operational level to influence actions and behaviours. Katsuhiko Kokubu and Eriko Nashioka carried out a survey on *Environmental Management Accounting Practices in Japanese Manufacturing Sites* which is reported in Chapter 20 to assess how far this was happening, and found that in nearly 50% of cases this was not happening and recommended that company headquarters should provide more guidance on how they might use environmental accounting information to help improve performance.

Part VI provides four Case Studies on EMA.

Chapter 21 by Lars Munkøe and Christine Jasch, Waste Reduction Program Based on IFAC's EMA Guideline in Danisco A/S, is on a corporate pilot program in 2005/06, "Global Waste Initiative", which Danisco carried out to test the adequacy of IFAC's guidance document on EMA as a tool for production sites in the global biotech and food ingredients industrial sector. Their main conclusions were that the overall environment-related costs are considerably higher than the perception of the individual sites and their management. Additionally, the assessments demonstrated a need for strengthening the relation between the environmental and accounting functions of a manufacturing facility to make use of EMA for improvement of environmental efficiency.

In Chapter 22, Yasushi Onishi, Katsuhiko Kokubu, and Michiyasu Nakajima present a case study on *Implementing Material Flow Cost Accounting in a Pharmaceutical Company* in Japan. They found that this had been successful in helping to achieve continuous improvement in both environmental performance and achieving cost savings by helping to reduce wastes. The main reasons for this success were firstly that the company combined MFCA with its ERP system and thus integrated MFCA data into the corporate financial information system. The second reason was the introduction of a regular annual performance evaluation meeting involving a high number of managers at different levels and from different functions across the company to review the results. This meant that MFCA data were now taken into account in evaluating the performance of individual managers.

Chapter 23 by John Hermansen, Anne Kristine Nertun, and Grunde Pollestad is *Operational Use of the Environmental Accounting and Information Software TEAMS at Hydro Aluminium Sunndal, Norway*. This is a case study of a Norwegian aluminium company which implemented an EMA software tool, Total Environmental Accounting and Managements System (TEAMS), focussing on how this could be implemented as an effective information and reporting tool for the business. TEAMS replaced the company's existing network of spreadsheets for environmental management activities such as accounting and reporting which had created an unnecessarily complex, brittle and vulnerable system. The paper describes TEAMS and how it was implemented, and identifies further adaptations that could be made to further enhance its usefulness. It concludes that the standard functions satisfied most needs identified by users within the company and could also support its external reporting.

In Chapter 24, Despite having good management systems and an environmental strategy in place, Petrochina the company has recently had several serious environmental and safety accidents. In *Failure of an Environmental Strategy: Lessons from an Explosion at Petrochina and Subsequent Water Pollution*, Xiaomeo Guo compares the operating strategy and financial performance against the environmental strategy and performance, and shows that having an environmental strategy does not necessarily ensure good environmental performance. Only the integration of the environmental strategy into the operating strategy will help with jointly implementing environmental and financial goals.

The book concludes with Part VII on Success Factors in Implementation.

Martin Bennett researched how EMA information generated by one organisation's environmental accounting system was then used in practice by those within the organisation to whom it was directed. *Evaluating Management Accounting from a User Perspective: A Study of the Environmental Accounting System of the Environment Agency in England and Wales* (Chapter 25) reports that although there were as yet few tangible examples of specific decisions or actions which were influenced, there were several easily identifiable barriers which temporarily blocked this and offered valuable learning points for others. In particular, deficiencies in the organisation's main accounting systems which were currently being addressed. Despite this the prospective users were still enthusiastic about the potential that a functioning environmental accounting system might offer and suggested several different types of use.

In Chapter 26, *An Empirical Examination of the Role of Environmental Accounting Information in Environmental Investment Decision-Making*, Tapan Sarker and Roger Burritt ask how the availability of environmental accounting information is likely to affect managers' willingness to take environmental considerations into account when making decisions on investments, and to make environmental investments to avoid future environmental risks. To establish this, they carried out an experimental study on a number of decision-making managers from diverse functions in the Australian offshore petroleum industry. They concluded a positive relationship between the information which is disclosed and the impact on environmental investment decision-making by managers, who become more willing to take investment decisions that consider the environment and future environmental risk reduction. They also considered the possible affect of a regulatory regime (command-and-control or voluntary self-regulatory) but found that this had less affect.

The book's final chapter presents the results of Anna Kumpulainen and Tuula Pohjola's study of the success of the implementation of an EMA system through longitudinal case studies at four large Finnish companies in *Success Factors in Developing EMA—Experiences from Four Follow-Up Case Studies in Finland*. These EMA systems were established as part of a co-ordinated research project, but when the researchers returned to the companies a few years later they found that in only one case had the company continued with the EMA system. They identified the main explanatory factor as the attitude of senior management, which in the company which had continued its system had considered not only the compliance gains but also possible eco-efficiency and strategic positioning benefits. They identified eight distinct critical success factors in implementing EMA, and conversely a number of factors which might instead lead to failure, the main one being a perception in many companies that environmental issues are not yet considered an integral part of core business processes but merely a way to placate environmentally-conscious stakeholders.

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Part II
EMA in Cleaner Production—Theories and Models

Chapter 2
Applying Best Available Techniques in Environmental Management Accounting: From the Definition to an Assessment Method

Valérie Laforest

Abstract This paper presents a method to evaluate the efficiency of industrial processes in comparison with, or to validate, best available techniques (BAT). The approach can be used as decision support in applying environmental regulations as well as to put in place an environmental management accounting system.

The European Directive 96/61/EC 24 September 1996 on integrated pollution prevention and control (IPPC) integrates environmental protection by a process of licensing all industrial activities at the European level. The objective of this directive is to reach a coherent level of environmental performance through the use of BAT.

Twelve considerations are given in Appendix IV of the IPPC directive for BAT selection which was adopted as French environmental regulations. Since these complicated concepts were put into practice some type of decision aid or support is necessary for the industries concerned. To clarify the meaning of each aspect and to better evaluate techniques, a study was carried out based on a questionnaire. This endeavour gave rise to a selection method. The results show a possible lack of homogeneity and inaccuracy in the considerations of the IPPC directive. The study also established seven objectives to be taken into account when selecting the BAT. For each objective, criteria, indicators and measurement parameters were determined. Finally, the suggested method could be used to assess relevant options for the continuous improvement of BAT or cleaner production implementation.

2.1 Introduction

The principle of best available techniques (BAT), as defined by the European integrated pollution prevention and control (IPPC) directive no. 96/61/EC, has become a significant issue for industry to deal with, and the implementation of this Directive

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actually compels companies to apply BAT. Appendix IV of the IPPC defines the 12 considerations to be taken into account for the selection of BAT. Unfortunately, this information does not seem to be sufficiently clear to enable an efficient selection of these techniques or their adoption by all parties. To clarify each consideration and to better assess these techniques, a survey was carried out with the French parties concerned. This survey's objective is to develop an assessment method to help compare different techniques in their industrial settings.

This paper is organised as follows. Firstly, the European regulation will be considered. The concept of BAT will be presented, as well as the French framework. Secondly, the European procedure on exchange of information about BAT, called the BAT Reference document (BREF), will be described. There will then be a presentation of the role of BAT in environmental management accounting (EMA). Finally, the study will examine the results obtained. In conclusion, some reflections will be provided on the use of this method developed for EMA systems.

2.2 Integrated Environmental Regulation and the BAT Principle

2.2.1 Legislative Framework and Definition

2.2.1.1 The European Context

The BAT principle is defined by the European directive 96/61EC 24 September 1996 on Integrated Pollution Prevention and Control (IPPC) as being "the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole" (Directive 1996).

The terms "best", "available" and "techniques" are defined as follows:

- 'Techniques' shall include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.
- 'Available' techniques shall mean those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator.
- 'Best' shall mean most effective in achieving a general high level of protection for the environment as a whole.

This text, largely inspired by the French regulation, integrates environmental protection at the European level through a process of industrial licensing of each of the industrial activities listed in Appendix 1 to obtain a high level of environmental protection throughout the European Union. These licences must be based on the best available techniques as defined in Article 2.11. The objective of the directive is to attain a unified and coherent level of environmental protection based on the use of BAT. The IPPC directive was required to be implemented by 30 October 1999 in all new activities or in all those modifications having an impact on the environment. All existing European industrial activities were required to comply with it by October 2007 (de Chefdebien 2001).

A regulation regarding officially identified sites for the protection of the environment (ICPE) provides the judicial basis for French industrial environmental policy. It is founded upon an integrated approach to the environment and considers the impact on natural landscapes, public health and industrial risk. Businesses are obliged to explain and justify environmental impacts. This regulation enables industrialists to have an overall view of their impact and encourages them to set up preventive management at the conception phase of an industrial site. The regulation also plays a part in applying the principle of prevention (Aida 2006; Lucas 2000; Ordonnance 2000).

2.2.1.2 The Framework

The operational control procedures are based on the principle of BAT to define emission limit values or the lowest economically viable levels for these identified enterprises. These considerations are included in the required environmental impact study that any company wishing to set up in business must supply before obtaining official authorisation. In addition, every decade some industrial concerns must assess the way in which their business previously functioned to update their procedures with the IPPC Directive. This is to be carried out in accordance with the 29 June 2004 decree and 6 December 2004 circular (Arrêté 2004; Circulaire 2004). This assessment, or 'auto evaluation', must be based on a comparison between the plant's current performance and that which could be obtained with BAT, which is in response to article 13 of the IPPC Directive. Unfortunately, no existing method is available to help firms and enterprises comply. A standard would provide an efficient way to improve the environment across complete industrial sectors (Lucas 2000).

2.2.1.3 Exchange of Information

Article16.2 of the directive requires the European Commission to organise an exchange of information concerning BAT between member states and the industries concerned. The objectives are: to encourage European countries to achieve technological homogenisation; to diffuse emission levels and techniques used in the European Community throughout the world; to help member states effectively to implement the regulation; and to accomplish a comprehensive database, notably with the publication of reference documents.

To carry out this exchange, the Commission created the Information Exchange Forum (IEF) which is composed of member state industries (technical centres, unions) and non-governmental organisations (NGO). The role of the IEF is to coordinate and plan the information exchange and assess and validate the results of the exchange which are summarised in the BREF (Bailly 2001).

The European IPPC Bureau (EIPPCB), in close collaboration with the IEF organised the exchange of information and produced the BREF which member states have decided upon. In fact, EIPPCB writes the BREF based on the recommendations of technical working groups which are composed of member states, industrial and NGO experts, and which supply the data and information and check the draft documents produced by the EIPPCB.

2.3 The BREF Process

There are two BREF objectives. Firstly, catalogue existing European processes which have been industrially tried and tested for the activities which are defined in Appendix 1 of the IPPC directive. Secondly, to provide a decision-making tool, both for authorities considering whether to issue industrial licences and for managers who must define their environmental policies. BREFs must be informative documents which provide clarity for industrial operators (Hey 2000). However, they do not themselves define a legislative framework with which industrial concerns have to conform (Litten 2002).

BREFs have a number of advantages and drawbacks as listed below (Bartaire 2001):

- Advantages
  - Benchmarking: compares the existing techniques in terms of environmental efficiency (emission limit values).
  - Gathers information about economically viable BATs throughout Europe.
  - Facilitates communication between industrialists and administrators: these documents are a type of collaborative effort between member states, industrial and NGO experts and can be used as reference guides.
- Drawbacks and dangers
  - Sectoral and or national lobbying.
  - Using BAT performance as emission limit values. This practice presents a danger of using emission limit values as reference values in national or local regulations. This might lead to overly strict limits in some sectors whilst at the same time lead to the disuse of needed and effective additional controls or filters in other industries.
  - Misunderstanding such technical documents: misappropriation of the knowledge.
  - Mistranslation: a poor translation could lead to problems of interpretation and application.

A clear method for the impact analysis of the functioning of an enterprise can be integrated in a continuous environmental improvement system linked to an EMA process, and this is considered next.

2.4 Environmental Management Accounting

2.4.1 Definition

Lucarelli (2003) said that "Environmental Management Accounting (EMA) provides a more comprehensive approach to management accounting, with a particular emphasis on costs related to environmental issues and wasted raw materials". One of the objectives of EMA is to influence the decisions which have an impact on both the environmental and financial performance of an organisation. It is useful for applying dynamic and preventive environmental activities, such as BAT or cleaner production (CP). Moreover, Lucarelli (2003) argues that the promotion and achievement of environmental policy goals can be obtained simply by the implementation of EMA by industries.

But what are the costs? The environmental outlays which are first estimated are usually lower than the real costs when these are properly calculated, and can be compared to an iceberg. The visible part is the smallest, and corresponds to the visible expenses associated with wastes such as treatment and elimination. The submerged and therefore invisible part is the largest, and corresponds to the hidden costs to the environment. A total identification, collection, estimation and analysis of environmental and energy data is needed.

The potential advantages of EMA for businesses are (Lucarelli 2003):

- The ability to accurately:
  - Rack and manage the use and flows of energy and materials, including the volume, types, and final resting places, of wastes
  - Identify, estimate, allocate and reduce expenditures
- More accurate and comprehensive information, to:
  - Support the establishment of and participation in voluntary, cost-effective programs to improve the environmental balance
  - Measure and report environmental performance

2.4.2 BAT and the Implementation of Cleaner Production

BAT and CP represent viable preventive environmental approaches for the reduction of pollution at source. These two concepts are more or less the same. The greatest difference is that an end-of-pipe solution (for instance, a waste water treatment plant) can be a BAT but not a CP strategy. CP is the continuous use of industrial processes and products to increase efficiency and to diminish their impact on humans and the environment. The assessment process is not one-off but is ongoing, continuously enhancing and adjusting.

An optimised approach is necessary to improve the implementation of CP. Moreover, as mentioned, CP approaches are not static but must evolve. They must follow some kind of continuous improvement system. Once the assessment has been made and a BAT adopted, the results must be monitored, evaluated, and acted upon. This appraisal will provide feedback to improve the introduced innovation and will also suggest new areas for the application of CP concepts. At this point, the assessment cycle begins again.

Different kinds of CP programs have been published which more or less conform to this definition. Figure 2.1 provides an example of one which uses a closed-loop for continuous improvement (UNEP 1994; Russ 1997).

The ISO 14001 Standard's method for environmental management systems (EMS) has more-or-less the same structure as that outlined in Fig. 2.1. In practice, it is possible to obtain an EMA system with a program based on an add-on technology to support environmental management. CP, and more particularly BAT, can offer added value to an EMS by addressing the root causes of the environmental problems.

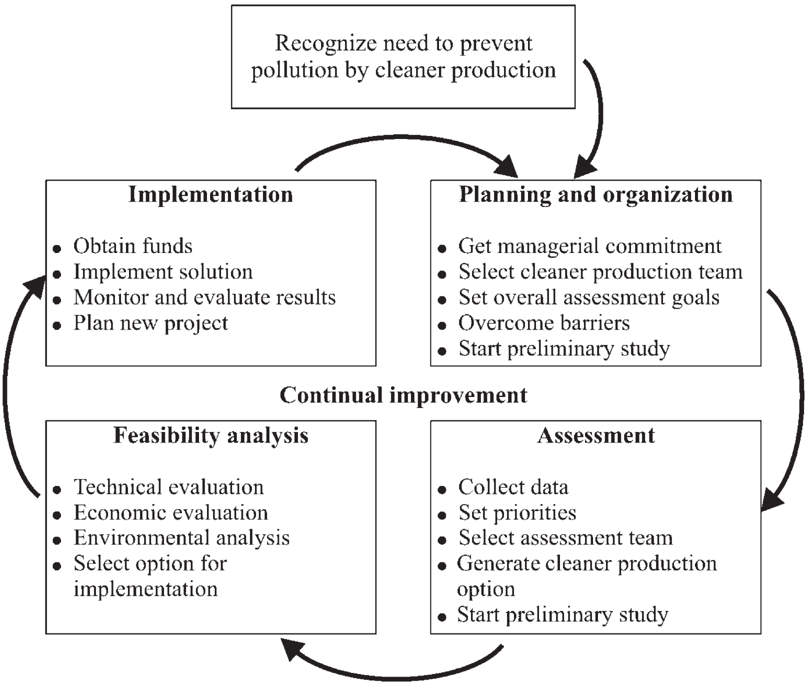

Fig. 2.1 Adopted approach to cleaner production

Each step of the implementation method is important to the success of a CP program. BAT implementation needs to be monitored and measured. Indeed, it is necessary to have procedures to monitor operational processes and progress towards targets and objectives, as well as to comply with the law. These will help to improve the position of the enterprise by specifying new management commitments based on any improvements in the results.

BAT varies considerably over time, so BAT reference documents must be regularly updated. At present, this update should occur at least every 5 years in order to take into account the latest technological, cultural and economic changes (MEDEF 2006).

What are the definition and selection criteria for BAT practices, and in particular for BREF documents? In effect, according to Appendix 4 of the IPPC directive, BAT selection must be based on the 12 considerations listed in Table 2.1. But as de Chefdebien (2001) mentions, these considerations are not easy to apply.

Regrettably, these considerations are relatively unclear for the selection of the technology to apply. Having read certain BREF documents, specifically those concerning cement, textiles and the surface treatment of metals and plastics, the determination and selection of BAT practices seem to be based not on scientific indicators or criteria derived from IPPC rather on broader criteria such as industrial feasibility of the technology considered or environmental perceptions within each European Union country.

To clarify the meaning of each consideration and assess the technology, a preliminary study was carried out to establish a selection method based on these 12 considerations. This study began within the framework of the European project ENVIREDOX (IPS-2000-00035) and with researchers at the Sciences, Information and Technology for the Environment Division of the Ecole Nationale Supérieure des Mines de Saint-Etienne in France. Currently, this preliminary study is still

Table 2.1 Considerations for the selection of BAT (directive 1996)

1.	Use of low-waste technology
2.	Use of less hazardous substances
3.	Furthering the recovery and recycling of substances generated and used in the process, and of wastes, where appropriate
4.	Comparable processes, facilities or methods of operation which have been tried with success on an industrial scale
5.	Technological advances and changes in scientific knowledge and understanding
6.	Nature, effects and volume of the emissions concerned
7.	Commissioning dates for new or existing installations
8.	Length of time needed to introduce the BAT
9.	Consumption and nature of raw materials (including water) used in the process and their energy efficiency
10.	Need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it
11.	Need to prevent accidents and minimise the consequences for the environment
12.	Information published by the Commission pursuant to Article 16 (2) or by international Organisations

progressing with the participation of French institutions (DRIRE, Agences de l'Eau, INERIS) and notably with the French Ministry of Ecology and Sustainable Development.

To achieve an EMA, an environmental impact assessment is needed. To do so, the first step is to set up a multi-criteria assessment grid for environmental aspects. The second step is to evaluate the related costs, bringing together in an EMA system the physical and monetary elements of concern. The method proposed aims to identify environmental criteria based on the IPPC directive considerations. A tool will provide information on raw materials used and wasted, waste generation rates, energy used, etc. This tool also aims to be useful for pollution prevention within the framework of IPPC directive and the implementation of BAT.

2.5 Preliminary Study and Analysis of Results

The preliminary study assessed the degree of clarity in these considerations. The objectives were twofold: to elucidate these considerations and thus improve their utilisation, and to provide definitions that help develop the selection method for techniques based on environmental criteria.

With these aims in view, a questionnaire was devised comprising two simple questions, and distributed to the sample population. Having listed the 12 considerations, participants were then asked:

- To rank the considerations in order of importance; and
- To define each consideration with words or terms

The people who answered the questionnaire are from different fields but are all deeply involved in environmental issues, but few knew about BAT or the IPPC directive. The sample was composed of industrial representatives, researchers, public or para-public institutions, technical centres and associations.

To have an effective response and to simplify the process, participants were asked to choose 6 considerations from the 12 proposed and to rank them in order of their importance. In this way, participants eliminate the considerations that are not important to them.

2.5.1 Classification

In total, 40 questionnaires were obtained from the survey. Only 6 respondents put in order the 6 considerations chosen from the 12 proposed. 11 respondents classified 9 considerations, 1 put 7 in order, 1 classified 8, and 19 classified all 12. Where more than 6 considerations were classified it was assumed that every questionnaire received was accep-table. Two questionnaires were unusable

Table 2.2 Classification of the considerations from the questionnaires

C1	**10**	**9**	**1**	**11**	**6**	**2**	**3**	**4**	**5**	**7**	**8**	**12**
C2	10	1	9	2	11	3	6	4	5	8	7	12
C3	10	1	9	2	11	3	6	4	5	8	7	12
C4	10	1	9	2	11	3	6	4	5	8	7	12
C5	10	1	3	9	11	2	6	4	5	8	7	12

because of inappropriate answers (they provided no classification or any words other than merely stating the inaccuracy of the questionnaire).

Because of the differing number of considerations taken into account by the participants, five categories were created to analyse the responses. Table 2.2 presents the results obtained by compiling the answers, with C1, C2, C3, C4 and C5 corresponding to the five classifications:

- C1: the first 6 considerations of each answer
- C2: the first 6 considerations of each answer with weight given to each response
- C3: all classifications, with weight given to each response
- C4: all classifications, and giving a rank number to complete the grid
- C5: questionnaires which classified all 12 considerations

Note that in Table 2.2 from C1 to C5, the results are similar. The results show that consideration numbers 4, 5, 7, 8 and 12 have less importance than the other, which appear in a relatively similar order whatever kind of analysis of the responses is used. Given the sample, a precise final order of importance for the considerations cannot be established. Nevertheless, the most important identifiable considerations seem to be 10/1/9 and 2/11/3/6.

2.5.2 Analysis of the Responses

Based on content analysis methods, both a quantitative and qualitative analysis of the answers used in the questionnaire was carried out to define the considerations (Krippendorff 2004).

The unit of analysis is the word. The quantitative analysis was based on counting the number of words given by all participants for each consideration. The analysis and the classification are facilitated because each answer is words rather than sentences.

Note that each consideration is independent. In line with Krippendorff (2004), it is assumed that the better an issue or consideration is understood, the greater the number of words generated. Figure 2.2 presents the number of words for each consideration, those having the fewest words being 4/5/7/8 and 12. It can be concluded that, the higher the consideration in the classification, the higher the number of terms cited.

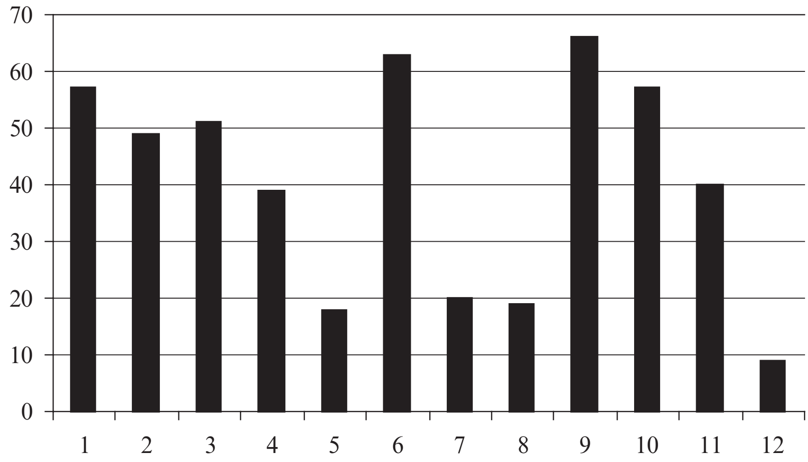

Fig. 2.2 Representation of the number of terms by consideration

The study indicates that a similarity exists in the rankings between the respondents' classifications and the number of words. This could be explained firstly by fewer answers being provided for considerations of lower importance, and perhaps secondly by the participants' poorer comprehension of these considerations.

Some considerations appear to be very well-known and understood, notably 1/2/3/6/9/10/11, for which some terms were derived from those stated in the 12 considerations.For the qualitative analysis, attention focused on the words which elucidate the considerations. The results which were obtained show a lack of homogeneity in the phrases used by participants. For instance, the terms given for consideration number 6 are: furthering of techniques, industrial profile, the degree of danger of emission, waste quantities and toxicity. This seems to reflect the lack of the homogeneity of the considerations in the IPPC directive and their imprecise nature as regards the ease of selection techniques.

To continue to develop the method, the qualitative analysis of the preliminary study was carried out in two stages:

- How best to define the terms
- Classification and grouping

2.5.2.1 Definition of the Terms

To proceed to the organisation of information (words or phases by consideration), various terms were categorised hierarchically. A 4-level classification was defined–objectives, criteria, indicators, and parameters. The definitions are (Maystre 1999):

- Objective: Aim to attain (BAT)
- Criteria: Areas in relation to which the assessment to reach the objectives will be carried out

- Indicators: Quantitative or relative qualitative values, derived from parameters and or measures
- Parameters: Measured or estimated data used to construct the information contained in the indicators

2.5.2.2 Classification and Grouping

Group of Coders and Methodologies

Coding analysis is based on the set rules considered below. A coder is a person who reads, interprets, observes and analyses questionnaires.

To classify and group every term obtained through the questionnaires, a coding group, as defined by Krippendorff (2004), was established. It was composed of a person with appropriate background and qualifications in the thematic approach (researchers, industries, associations), and six other people.

To understand the method and rules to follow for the classification, coders trained themselves on a sample of ten questionnaires. Once the rules were finally determined, the 34 last questionnaires were analysed.

The common rules used by the coders are described below.

Rules and Results

In the first step, the classification was conducted according to each consideration. Terms appearing several times for the same consideration were grouped. The hypothesis was that the more frequently the word appears the greater the importance that the word seems to have in the definition of the subject since it should reflect the general importance of the term for the people questioned. Examples of the terms and their appearance are: waste quantity (10), nature of wastes (5), toxicity (3), source reduction (2), risk, and waste quantity per unit of output (i.e. per product). This number of appearances might be used to represent the weight of the terms in the selection method. Indeed, research has shown that the frequency with which a topic occurs in a stream of messages can be taken to indicate the weight or the importance of it (Krippendorff 2004).

To simplify the system, some words were grouped together. Terms with similar meanings were associated; for instance, "pollution" and "environmental criteria".

Hierarchical ranking makes it possible to carry out successive rearrangements. The categories of information (objectives–criteria–indicators–parameters) can be represented in sets composed of elements and the relations between these elements. Each element of a system can be regarded as an individual system whose elements are in their turn a system, and so on. This provides an intellectual construction of hierarchical ranking.

The trilogy "criterion—indicator—parameter" is known as "sliding" i.e. it is dependent on the level of globality or contrary detail at which one places oneself (Maystre 1999). Figure 2.3 presents the successive process of fit.

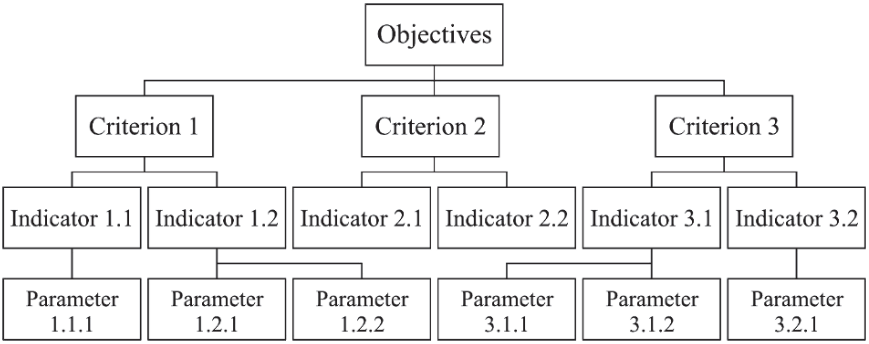

Fig. 2.3 Hierarchical ranking of defined categories (objectives, criterion, indicator and parameter)

Table 2.3 Terms classification extract: Questionnaire results for considerations 1 and 3

Conside-ration	Objectives	Criteria	Indicators	Parameters
1	Waste volume reduction	Economic	Waste de-struction costs	Limit values
			Waste quantities	Critical values
	Source reduction	Environmen-tal (pollution)		Measure
			Waste nature	Nomenclatures
3		Waste valorization[a] ways	Valorization yield	Matter balance
				Ultimate wastes Volume
		Waste elimination channels	Energetic valorization	
		Economic	Valorization costs	

[a]Valorisation: Generic term for regeneration, recycling or reuse of mat

Within the four categories, the method of classification is as follows: at the outset, the classification of a term is guided first by intuition, so that a word can appear in several categories and can account for several considerations. Then, the terms are classified in accordance with a guideline observed from the objectives for the parameters.

However, having organised the terms, an incomplete table was obtained for objectives, criteria, indicators and parameters (Table 2.3). As a result supplementary work was carried out so that this organisation could be used as a basis for the selection method (Table 2.4).

Table 2.4 Completed table extract for considerations 1 and 3

Consideration	Objectives	Criteria	Indicators	Parameters
1	Waste volume reduction	Economic	Economical balance	Destruction costs Return of investment
	Source reduction	Environmental (pollution)	Waste treatability Waste nature	Waste characterization Waste quantity Nomenclature
3	Valorization	Waste valorization channel	Internal valorization yield External valorization yield	Material balances
		Elimination channel	Elimination yield Energetic valorization	Ultimate waste volume Transport costs
		Economic	Economic balance	Elimination costs Valorization costs

2.5.2.3 Classification of the Considerations

In parallel to this study and owing to the heterogeneity of the considerations observed, they have been set out in relation to the previously defined structure.

Table 2.5 highlights the point that not every consideration belongs to the same category, or necessarily corresponds to an objective. Moreover, the same consideration can be divided into several sub-categories in different categories in the classification (Table 2.6). For example in consideration 6: “the nature, effects and volume of the emissions concerned”, “effects of the emissions” are classified as a criterion, “nature of the emissions” as an indicator and “volume of the emissions” as a parameter.

This classification corroborates the results already expressed regarding the heterogeneity of considerations and the complexity for their use within the framework of the selection of BAT.

Table 2.5 Classification of BAT selection considerations given by Appendix IV of the IPPC Directive

Objectives	Criteria	Indicators	Parameters	Others
1				
	2			
	3			
		4		
		5		
	6.b	6.a	6.c	
			7	
			8	
		9.b	9.a	
			9.c	
10.a				
10.b				
11.a				
11.b				
				12

Table 2.6 Extract from the considerations in Table 2.5

Considerations	Sub considerations
6. The nature, effects and volume of the emissions concerned	6.a Nature of the emissions concerned 6.b Effects of the emissions concerned 6.c Volume of the emissions concerned
9. The consumption and nature of raw materials (including water) used in the process and their energy efficiency	9.a Consumption of raw materials (including water) used in the process 9.b Nature of raw materials (including water) used in the process 9.c Energy efficiency
10. The need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it	10.a The need to prevent or reduce to a minimum the overall impact of the emissions on the environment 10.b The need to prevent or reduce to a minimum the risks on the environment
11. The need to prevent accidents and to minimise the consequences for the environment	11.a The need to prevent accidents 11.b The need to minimise the consequences for the environment

2.6 Objectives Proposed

BAT practice selection is not easily obtained just by using the considerations of the IPPC directive. Moreover, “As a rule, humans cannot keep the meanings of more than seven (plus or minus two) alternatives in mind simultaneously. Larger numbers encourage coding habits to form and allow preferences to develop" (Krippendorff 2004, 135).

On the basis of the preliminary work previously presented and the suggestion of Krippendorff, seven objectives have been defined and presented on the order determined in Section 5.1:

1. Limitation of the environmental impact
2. Economy of raw materials and energy
3. Improvement of safety and risk minimisation
4. Waste volume reduction
5. Valorisation
6. Benchmarking
7. Innovation

Each of the suggested objectives is used in the feasibility analysis step of the EMS applied to BAT implementation (Fig. 2.1). The basis of these objectives must be in measurable term to apply a quantitative analysis, and appropriate indicators have to be defined.

2.7 Method Base

For each defined objective, criteria, indicators and parameters have been determined. Table 2.7 gathers all information and could be the first step in the elaboration of a performance assessment method for BAT practices.

This grid could be used as a step to analyse the feasibility for EMA. Indeed, this grid is a decision aid which can help to comply with the criteria needed to evaluate the options for choosing the best techniques and evaluate their impact and with the IPPC directive, comparing the performance of in-process techniques and options identified.

2.8 Conclusion and Discussion

The method developed is based on the IPPC directive, to comply with the regulations and to contribute to the achievement of EMA by using a CP strategy.

The study reveals redundancies and heterogeneity in the considerations contained in Appendix IV of the IPPC directive. The considerations need to be simplified, and a method is proposed. Simplification is needed to encourage wide implementation and use in Europe. Seven pertinent objectives were identified or defined: limitation of the environmental impact, thriftiness in the use of raw materials and energy, improvement of safety and/or risk minimisation, waste volume reduction, valorisation, benchmarking and innovation.

Table 2.7 Analysis grid for the environmental assessment of BAT technology

Criteria	Indicators	Parameters
Objective 1: Limitation of the environmental impact		
Prevention	Conformance with regulation	Regulation (Yes/No)
	Nature of emissions	Toxicity (Lethal amount 50/Lethal concentration 50); Risk phrases
		Safety phrases; Emission characteristics; Composition; Flow; Physical state
Immediate environment	Receiving media quality	Impact study (Yes/No)
Objective 2: Economy of the environmental impact		
Economic	Economic balance	Raw material costs; Energy costs
Environmental	Incoming characteristics	Quantity; Energy consumption; Raw materials consumption; Water consumption; Nature; Raw material; Water; Energy
	Efficiency	Incoming quantity in the product/Incoming quantity in the process
	Outputs	Nature; Wastes; Products; Quantity; Waste; Recycling scrap; Non-recycling scrap
	Recycling rate	Raw materials quantity/Scrap quantity
Objective 3: Improvement of safety and risk minimisation		
Substance nature	Hazardous substance	Substance characteristics: Risk phrases; Safety phrases; Toxicity sanitary measures; Quantity; Physical state; Storage
Accident prevention	Risk level	Accident number
	Regulation conformity	Regulation identification (Yes/No)
	Safety level	Accident number
	Maintenance	Formation; Awareness courses
	Prevention measure	Awareness courses; Formation; Danger study (Yes/No)
Objective 4: Waste volume reduction		
Economic	Economic balance	Destruction costs; Return on investment; Investment
Environmental	Waste characteristics	Nomenclature; Toxicity (Lethal amount 50/Lethal concentration 50/Risk and safety phrases, etc.)
	Waste treatability	Waste flow; Waste physical characteristics (solid, liquid, gas); Waste physico-chemical characteristics (chemical oxygen demand, biologic oxygen demand, pH, metals, etc.); Existence of techniques to render inert

Objective 5: Valorisation		
Valorisation channels	External valorisation rate	Matter balance; incoming quantity; outcome quantity; Quantity reuse outside
	Internal valorisation rate	Matter balance; Incoming quantity; Outcome quantity; Quantity reuse inside
Elimination channels	Elimination rate	Matter balance; Incoming quantity; Outcome quantity; Eliminated waste quantity
Economic	Economic balance	Valorisation costs; Elimination costs; Transport costs; Gain of raw material, water, energy
Objective 6: Benchmarking		
Industrial feasibility	Compatibility with existing techniques	Site age; Technology age
	Industrial experiment and know-how	Installation number; Number of maintenance operations
	Technical feasibility	Installation number; Number of breakdowns; Technical performance; Number of maintenance operations
	Economic feasibility	Installation number; Economic balance
	Best available reference document	Environmental performance; Industrial results
	Facility of installation	Life period; Downtime of the production; Duration of installation
Objective 7: Innovation		
Technology maturity	Local scientific skills	
Experimental level	Diffusion and technology transfer coming from researches	Research and development costs
Information	Best available reference document	Emerging techniques (Yes/No)

The perspective of this work is, first of all, to create and allot weight to a hierarchy of criteria to apply a multi-criteria analysis method, after which quantitative assessments can be undertaken. Finally, equations for evaluating the cost need to be set up. Today, research in this field is being established in close collaboration with: the SITE division of the Ecole Nationale Superieure des Mines de Saint-Etienne; French institutions, notably the Ministry of the Ecology and Sustainable Development; the Water Agency; and environmental policy agencies. This collaboration will improve and complete the evaluation method for processes studied. Moreover, this work has a secondary objective—to provide support for industry and government authorities in the application of French environmental regulations and standards.

The method, based on environmental and energy indicators, helps to gather information as an input into an EMA system. Moreover, the potential benefits of such EMAs to businesses show that the BAT indicators presented would be suitable in a decision-making process.

Finally, this method will support the management of the environment by tracking and managing the impacts, by helping to assess the costs, and then by evaluating environmental performance.

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Chapter 3
Estimating Environmental Impact in the Early Stages of the Product Innovation Process

Claus Lang-Koetz, Severin Beucker, and Daniel Heubach

Abstract During the early stages of a company's innovation process (e.g. orientation and generation of ideas), sustainability concerns are only taken into account in the form of strategic guidelines. In contrast, many different methods, tools for design, and impact assessment, support the decision-makers at the end of the innovation process (e.g. in the phases of realization and product development).

An approach for environmental impact estimation of product ideas based on the guiding barrier concept by Fichter and Paech (2003) is presented. The approach uses the stage gate methodology by Cooper (2001) and action strategies for the reduction of environmental impacts of a product by Brezet and van Hemel (1997, 139). These action strategies are attributed to the different phases of the stage gate process and are supported by practical questions.

The approach thereby makes use of the widespread assumption that there is a high degree of influence on product properties and corresponding environmental impacts at the early phases of the innovation process.

The estimation of environmental impacts in the early phases of the innovation process is based on information about substances, materials and processes. This information can be obtained in part from the internet as an external information source. Search strategies are described how such information retrieval can be facilitated. It is based on using search engines and publicly available internet databases on environmental impacts of substances, materials and processes.

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3.1 Introduction

The work presented in this paper has been conducted within the publicly funded research *Project Nova-net* (nova-net is funded by the German Federal Ministry of Education and Research BMBF; for more information see the projects website: www.nova-net.de), which focuses on the support of decision-making processes within companies in the early phases of sustainable innovation processes. One of the central assumptions of the project is that early innovation phases suffer from a disaccord of imprecise knowledge on the potential product or service on one hand and the need to make significant decisions on future financial, social or environmental effects of a product or a service on the other hand. Another important assumption is that the internet and software play an important role for the gathering, transfer and analysis of information needed in early innovation phases.

One of three main focuses of the project deals with the retrieval and integration of orientation-based knowledge on possible environmental effects in the early stages of innovation phases of producing companies. This project focus is called *Life-Cycle e-Valuation* and can be considered as a contribution to the conceptual integration of life cycle thinking into a company's innovation process. In terms of production research, *Life-Cycle e-Valuation* can be seen as an approach that supports decision-making process situated before the actual product development. In terms of innovation research, the concept contributes to the early phases of orientation and idea generation. Thus, the main research questions addressed are:

- How can product ideas and rough product concepts be assessed from an environmental perspective in the early phases of the innovation process?
- How can such an environmental assessment be integrated into the innovation process?
- How can required information be retrieved and prepared for such an assessment?

An approach to answer these questions will be presented in the following sections.

3.2 The Early Phases of the Innovation Process

The early phases of the innovation process can be characterised by a high degree of market and technical uncertainty (see e.g. Leifer et al. 2000, 11 or Herstatt and Verworn 2003, 3). Nevertheless, within these phases, the onset of costs and environmental effects are initiated as important decisions on the shape of the future product are taken. Approximately 75–85% of the life-cycle costs are fixed in early innovation phases (Bürgel and Zeller 1998), as well as most future direct and indirect social and environmental effects (Fichter and Paech 2003, 12). For example, attributes like energy consumption or recyclability are determined by decisions on material choice, product design and configuration. However, the missing clarity on the final composition of the product makes an environmental assessment difficult. Yet, despite this uncertainty and limited knowledge about the features and attributes

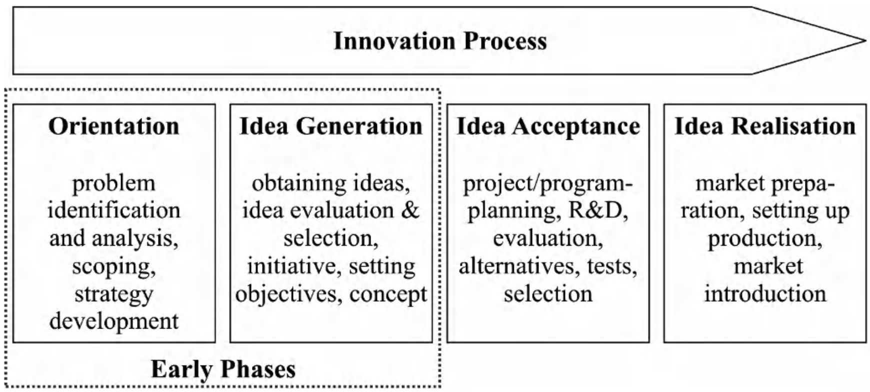

Fig. 3.1 Phases of the innovation process (Source: Fichter and Paech 2003, 31)

of the future product, product ideas have to be evaluated according to market, technical and environmental aspects.

The innovation process has been described and structured by many authors (see e.g. Rothwell 1992 or Van de Ven et al. 1999). According to an extended interpretation of corporate innovation suggested by Fichter and Paech (2003, 19) (Fig. 3.1), the innovation process can be understood as an iterative sequence of the following four phases: (1) orientation, (2) idea generation, (3) idea acceptance and (4) idea realisation (see Fichter and Paech 2003, 31).

Following this interpretation, the early phases of the innovation process comprise the orientation phase and the idea generation phase that can result in a first concretion of a product idea as a rough concept—before starting a specific development project (Verworn and Herstatt 2002, 2003). Idea generation in that specific interpretation means ideas have to be obtained, evaluated and selected. Moreover, goals have to be set, a first product concept has to be developed and finally the initiative for a specific innovation project has to be taken, involving different actors from inside and outside the company. To obtain a clear picture of market possibilities, a first market analysis should be conducted. In order to lay out the further process, product planning has to be carried out. This is generally accompanied by a clear specification of the product and the design of the product architecture.

3.3 The Stage Gate Process

The stage gate process was developed by Cooper based on an extensive empirical research project (see Cooper and Kleinschmidt 1986). A detailed description can be found in Cooper's (2001) book, *Winning at New Products*. The stage-gate process is mainly used in companies that intend to support and structure the development of incremental innovations (see Herstatt and Verworn 2003, 3). Incremental innovations address contemporary and extended markets and are based on base or key technologies (Pleschak and Sabisch 1996, 3). Market and technical uncertainty can

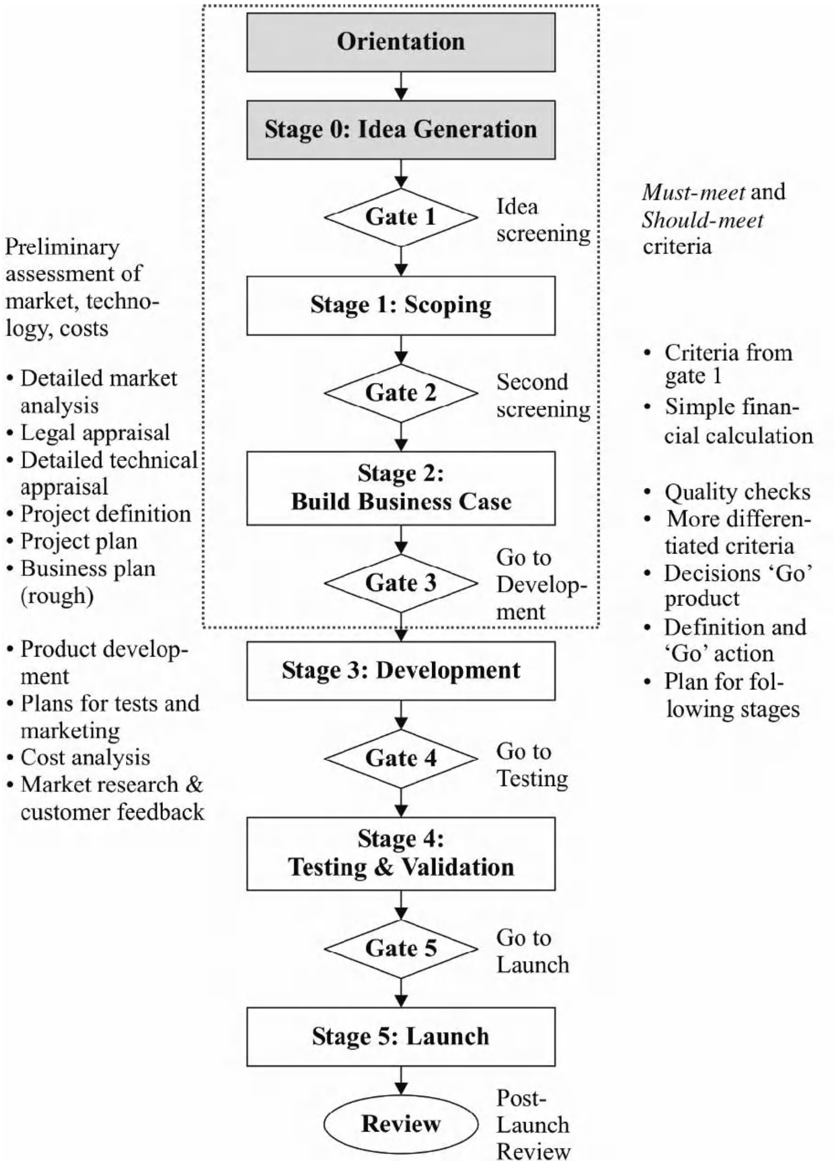

Fig. 3.2 The stage-gate process according to Cooper (Adapted from Cooper 2001 and Kleinschmidt et al. 1996. (Early phases of the innovation process are marked with dotted box))

be assumed as low. The effects of the innovation on core concepts of single components or assembly groups of a product or the relation on the components to each other are rather weak (Gerybadze 2004). Hence, when dealing with incremental innovations, basic information on the product idea and its possible implementation in the company already exists. In the following sections, an overview on the underlying methodology is given.

According to Cooper (2001), the innovation process can be structured into phases, the so-called stages. Each stage consists of cross-functional and parallel activities comprising technical and market aspects. Each stage starts with a gate where a decision is made, whether the project will be continued or cancelled. Thus, the gates serve as quality control measures.

In each stage of the process, information is gathered. The information reduces uncertainty and serves as a decision base for the continuation of the project. Each stage is cross-functional with activities from research and development (R&D) as well as marketing. At the beginning, the effort for gathering the required information is low. However, the effort continuously increases from stage to stage as existing information has to be checked, information detail is increased and new information is gathered. Cooper speaks of a typical effort of 10 person days at the maximum for stage 1 and about 10–20 person days for stage 2.

Each stage is followed by a gate, where the interdisciplinary project team decides whether the project will be continued or cancelled. This decision is based on the gathered information and previously defined criteria. Required *must-meet* characteristics are used to check whether a project fits into the business strategy and if environmental, health and safety requirements are met. Desired *should-meet* characteristics deal with the expected income and market attractivity, and the ability to use core competencies of the company in the project. Future activities are determined and priorities are set, as well as deadlines and responsibilities. Furthermore, financial means personnel resources are allocated and released.

An ideal stage gate process is shown in Fig. 3.2. It has to be adapted specifically for each company. The standard process should be structured in a simple way. Four to six stages have been proven as practical in corporate practice (Kleinschmidt et al. 1996).

To conclude, the stage gate process provides a systematic approach to reach an improved market and customer orientation and to reduce the inherent risks of the innovation process.

3.4 Environmental Impact Assessment in the Innovation Process

3.4.1 Life-Cycle Assessment and Life-Cycle Thinking

The environmental impact of a product results from its interaction with the environment. Environmental effects can be caused e.g. by material and energy flows that depend on the selection of materials, the design, the production, the use and the end-of-life-phase of a product. In order to estimate the environmental impact of a product idea, it must not only be regarded from the perspective of product development, production, and distribution. The holistic examination of a product idea from the perspective of its life-cycle, from the material and component selection, production, distribution, use phase-through-end-of-life can help to estimate the interaction of the future product with the environment (a product in the context is understood here as consisting of subject material—rather than services or product services. Hence, the text focuses on producing companies). This change of perspective is described by the term life-cycle thinking (Jensen et al. 1997).

A wide range of approaches and methods covering different types of environmental impacts and different stages of the life-cycle have been discussed since the concept of life-cycle assessment has first been mentioned in the early 1970s (for a short description of Life-Cycle Assessment history see http://www.ecobilan.com/uk). The following references can only give an incomplete insight into the variety of approaches. Among the most complex methods are systemic life-cycle assessment (LCA) approaches, which analyse and evaluate raw materials and components, the underlying technologies, the function and the use of the product, e.g. LCA (ISO 14040), Simplified LCA (Christiansen 1997) and Matrix Approach (Schaltegger and Burritt 2000, 250). *Eco Design* approaches focus specifically on the technical and creative development of the product itself (Brezet and van Hemel 1997, 139; Wimmer and Züst 2001), while concepts such as *Eco-Effectiveness* (McDonough and Braungart 2002) and *Material Intensity per Service Unit* (MIPS) (Fussler 1996; Schmidt-Bleek 1998, 1999) concentrate on specific indicators like toxic substances or resource productivity.

Most of the named approaches require specific information and data on the composition of a product, its estimated use and life-cycle in order to conduct a thorough assessment with consistent results. Thus, methods of environmental impact assessment like LCA are difficult to apply, since they require a relatively detailed specification of the product to be developed. The complexity of existing approaches and the resulting requirement for data make a complete evaluation of product ideas nearly impossible (Staudt and Schrott 2001).

Within the early innovation phases of orientation and idea generation, a method of low complexity is needed allowing credible and quick conclusions on possible environmental impacts of development options. Since the early innovation phases consist of a search and evaluation process of new ideas, information on the future product with alternatives are not yet clear and its life-cycle is not yet well defined. Thus, a detailed examination of the different life-cycle phases cannot be conducted and the potential interaction of the future product with the environment can hardly be estimated.

However, sketching the expected life-cycle can lead to a reflexion of possible environmental impact and a sensitisation. At the same time, the most important activities from an environmental perspective can be identified.

3.4.2 Guiding Barrier Concept for Orientation

A helpful approach to ensure that a company is on the right course with decisions made in the early innovation phases is the so-called guiding barrier concept, derived from the German term *Leitplankenkonzept*, by Fichter and Paech (2003, 157).

In its original form, the external guiding barrier symbolises the interaction with societal actors, stakeholders, networks or potential users, while the internal guiding barrier supplies a process-related innovation management with internal tasks, methods and instruments for sustainable innovations. Guiding barriers can be understood as an organisation's internal or external limitations or corridors for an innovation process.

In the case of environmentally sound innovations, these barriers can be formed by general principles aiming at avoiding resource and energy consumption, reducing toxic materials, etc., (see next paragraph). The guiding barriers lead the decision-maker to *course soundness* in a product development process taking environmental or sustainability aims into account. Guiding barriers can therefore lead towards the right direction in the innovation process and reduce inherent risks in the process (see Fig. 3.3, for an overview on how to handle environmental risk in general, see Burritt 2005).

To apply the guiding barrier concept in early innovation phases, information is needed which can function as influence parameters for the creation of environmentally sound decisions. This information serves as evaluation criteria for the expected risks and environmental impact and should be retrieved with little effort and time. It can be provided from internal information sources within the company or external sources such as the internet (see Section 3.5.4).

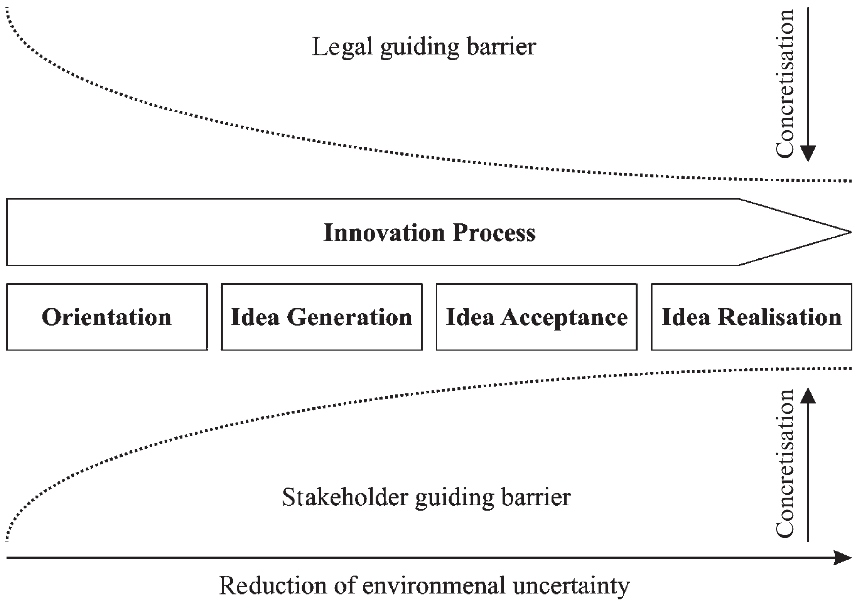

Fig. 3.3 Legal and stakeholder guiding barriers in the innovation process

3.5 Integrating Environmental Impact Assessment into the Early Phases of the Innovation Process

The consideration of environmental or sustainability aspects in the innovation process of firms has been addressed from different perspectives (see Fichter et al. 2006 for an extensive overview). Most prevalent concepts for innovation management focus on transition management (Kemp 2004; Kemp and Loorbach 2003), the integration of stakeholders (WBCSD 2002), innovation as a non-linear 'adventure journey' (Bierter and Fichter 2002) or the concept of *course soundness* mentioned above (Fichter and Paech 2003). Industry practitioners focus on the application of environmental assessment methods for products and services in many different industry branches such as chemical industry (see e.g. Saling et al. 2005), electronic industry (see Reichl et al. 2004 for an extensive overview) or automobile industry (see e.g. Krinke and Goldmann 2004).

However, the question how an environmental assessment of product ideas can be conducted in and integrated into the early phases of the innovation process has not been sufficiently addressed yet.

Thus, it will be shown in the following section, about how elements of environmental impact assessment can be applied and integrated into the corporate innovation process. The objective is to ensure course soundness of a product development with respect to sustainable development and to reduce ecological uncertainty in the innovation process. As a conceptual base, the stage-gate method is extended by the use of action strategies for the reduction of environmental impacts.

3.5.1 Action Strategies for the Reduction of Environmental Impacts

In order to reduce environmental impacts of a product or service, the use of action strategies has been well established in practice. They can give useful indications and impulses to take possible environmental impacts of a product into account or can supply starting points for further research. When applied for the first time, the action strategies are based on rough estimations. They should then be repeatedly applied with more thoroughness during the innovation process to obtain reliable information for a dependable assessment.

In the following sections, eight action strategies from the so-called *EcoDesign Strategy Wheel* concept developed by Brezet and van Hemel (1997, 139) are used. They are oriented along the life-cycle of a product and can be used to minimise the environmental impact of a product:

1. Selection of low impact materials: Use materials with low material intensity, renewable materials, recycled materials, materials that are recyclable and easy to dispose of or materials with low environmental impact and low hazard potential (i.e. toxicity).
2. Reduction of material usage (dematerialisation): Use of new materials to reduce weight and transport volume (leading to less resource consumption during product transport).

3. Optimisation of production and process chain: Optimisation of corporate material and energy flows and production processes, e.g. through alternative resource and energy efficient production technologies, less production steps, and the reduction of production waste.
4. Optimisation of the distribution system: Optimisation of product distribution through energy efficient transport or improved packaging (less mass, environmentally sound and recyclable components).
5. Minimisation of environmental impacts during use: Minimisation of resource consumption during the use phase of the product, e.g. when using auxiliary and operating materials (e.g. lubricants) during operation and service.
6. Extension of product lifetime: Extension of the lifetime of the product through higher reliability and longevity, easier maintenance, improved capabilities to repair the product, a modular product structure, classic design and in general a close product user relationship.
7. Optimisation of end-of-life of product: At its end-of-life, the product should be re-used, re-processed, re-cycled or re-exploited.
8. Development of a new product concept (or strategy), new function and environmentally sound product concepts: This can comprise function integration (integration of multiple functions in one product, e.g. a combined printer, scanner and fax machine), function optimisation (e.g. reducing the risk of faulty operation in washing machines by automatic dosage of needed water and detergent amount based on the laundry weight) or dematerialisation (product use through services or multiple use of the product, e.g. for cars or machinery).

Contemporary and future requirements from environmental regulations and laws as well as requirements from stakeholders are often unclear in advance, yet they have to be met when using a pro-active approach. The action strategies presented above are accepted as a comprehensive set in *ecodesign*, serve as the basis for practical product development concepts, and are especially suited for practitioners in industry (see the extensive collection in Birkhofer et al. 2000, or Wimmer et al. 2004). Thus, they can be used as practical means to stay within the guiding barriers in the product innovation process as described in the following paragraphs.

3.5.1.1 Action Strategies to Consider Legal Requirements (*Legal Guiding Barrier*)

In past years, new directives and regulations from the *European Union* (EU) leading to an increased responsibility of companies for their products have been enacted. Legal requirements relate to constituent substances and materials (e.g. EU directive on the restriction of hazardous substances—RoHS (Directive 2002/95/EC)), the end-of-life consideration of automobiles and electric/electronic devices (Directive 2000/53/EC and WEEE-Directive 2002/96/EC). Respective requirements can be met by choosing the right materials for the prospective product and by planning ahead how the end-of-life of the product can be formulated, i.e. by applying action strategy 1 ‘selection of low-impact materials’ and action strategy 7 ‘optimisation of end-of-life of product’ during the innovation process.

3.5.1.2 Action Strategies to Consider Stakeholder Requirements *(Stakeholder Guiding Barrier)*

Stakeholder requirements on a company are specific and depend on the actual economic and cultural background. Hence, they are sometimes hard to foresee. An anticipatory consideration according to the precautionary principle can be ensured by an input oriented approach aiming at minimising material intensity and avoiding constituent materials with high environmental impacts. This can be implemented by action strategy 1 ‘selection of low-impact materials’ and action strategy 2 ‘reduction of material usage (dematerialisation)’.

3.5.2 Question-Based Application of Action Strategies

Expected environmental impacts of the product idea can be addressed by using the action strategies for the reduction of environmental impacts presented in Section 3.5.1.

By addressing the issues raised with questions, the users are guided towards implementation possibilities of the respective action strategy. Examples for questions for the selection of low impact materials (action strategy 1) are:

- Are all legally regulated hazardous substances avoided?
- Will the product be free of halogenated materials (bromine, chlorine)?
- Are materials that can lead to toxic impact when burning or when in contact with water avoided?
- Can materials and components with low material intensity be used?
- Can renewable, recyclable or recycled materials be used?
- Can the number of components or materials be reduced?
- Is the number of composite materials as low as possible (especially for products with low-life)?
- Are product weight, size, area, demand, and volume as small as possible?

The action strategies are each applied by a respective set of questions and are integrated into the stage-gate process with different application intensities.

3.5.3 Application Intensity of the Action Strategies for the Reduction of Environmental Impacts

In the following paragraphs, it will be described how the different action strategies for the reduction of environmental impact can be attributed to the early phases of the stage-gate process (also see Fig. 3.4). The action strategies can readily be applied when the product idea is still relatively imprecise. In part, simple estimations can be performed with little effort, such as calculating the share of recyclable material of the estimated product weight.

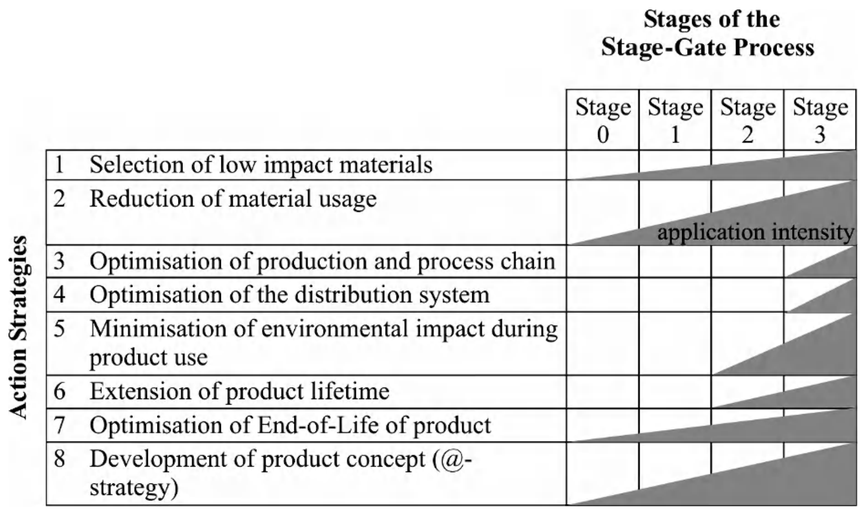

Fig. 3.4 Application of action strategies for the reduction of environmental impacts (According to Brezet and van Hemel (1997) in the stage-gate process)

While identifying and collecting product ideas within idea generation (phase 0), first deliberations are made for material selection (action strategy 1), for the optimisation of the product's end-of-life (action strategy 7), and for a new product concept (action strategy 8). The issue of dematerialisation (action strategy 2) should also be addressed in phase 0, e.g. by considering resource savings by using new materials or new technologies.

Action strategies 5 and 6 for the optimisation of the use phase and the prolongation of product life relate mainly to aspects of construction, product usability and design. They are based on a design concept, which is often roughly known in the build business case phase of the innovation process.

Production and distribution can only be optimised if manufacturing and logistics are planned. In practice, this is only known in the product development phase. Thus, action strategies 3 and 4 can only be applied in that phase of the stage-gate process.

3.5.4 Retrieving Information on Environmental Impact of Materials and Processes

To apply the action strategies for the reduction of environmental impacts, information on substances, material and processes are required. One possibility to supply such information is to use the internet as an external information source.

A survey conducted among German industry in the nova-net project showed that the internet is the most important information source for innovation managers (see Springer 2006). Seventy-five percent of the companies who answered the survey gather information from the internet, 72% from professional journals and magazines, and 64% from visits of exhibitions. Most sought information related to the economic environment, e.g. customers and users (74%), competitors (61%), other companies in the industry sector (58%) or suppliers (54%).

The internet comprises a multitude of technologies, applications and services. Information retrieval methods without charge are used most frequently, especially search engines. Seventy-five percent of interviewed companies use such tools. It was shown in the survey that product innovators use the internet much more often than non-innovators. Search engines reach a use-rate of 92% with innovators, and barely under 50% with non-innovators (Springer 2006).

For a first estimation of expected environmental impacts and risks of a product idea, the internet can be used as a broad and inexpensive information base. This applies especially when only limited internal information is available. For example, useful information can be:

- Information on environmental impacts of substances, material, processes and technologies
- Information on physical, chemical, and biological properties of substances
- Work safety and health measures for substances, materials and processes
- Information on new environmentally friendly substances, materials, technologies, or related R&D activities
- Laws, directives, and other legal information on environmental issues
- Studies on expected future developments
- Contact details of experts who could evaluate the environmental impacts of complex systems

The plethora of information in the internet complicates the targeted research for useful results. In consequence, such research is time consuming and often leads to a multitude of dispensable information. Different search strategies can be applied.

3.5.4.1 Unspecific Search

The unspecific search approach is based on a hierarchical-thematic search with search catalogues, a search with environmental link lists and a search in free encyclopaedias. It rarely supplies information with high detail and applicability. However, the retrieved knowledge can be used for the subsequent specific search, e.g. by improving keywords.

3.5.4.2 Specific Search

The specific search can be used to retrieve environmental impacts and risks of substances, materials, and processes and if needed alternatives for their substitution.

The search is performed by using search engines and material and process databases in the internet.

Material and process databases can supply information on environmental impacts of substances, materials and processes. This comprises information on material intensity, toxicity, or relevant human health issues. Several such databases are available on the internet (see overview in Table 3.1). Some of them supply a multitude of complex information for LCA and are only suited for experts. Other databases provide information on environmental impact that are easy to interpret for non-professionals, yet with a limited number of datasets (see e.g. Möller et al. 2006).

Table 3.1 Internet databases on environmental impact of substances, material and processes

Name and provider	Comment	Internet address (URL)
OekoPro chemical database Institute for Environmental Research, University of Dortmund, Germany	Free of charge, extensive data on physical-technical. ecological and toxicological properties of chemicals with a focus on colours, varnishes, paper, print products, batteries, tires, textiles and rubber products, developer chemicals, chemicals in metal finishing	www.oekopro.de
MIPS online Wuppertal Institute for Climate, Environment, Energy	Free of charge, data on material intensity of raw materials (ecological rucksack)	www.wupperinst.org/Projekte/mipsonline
Global Emission Model for Integrated Systems Öko-Institut, Institute for Applied Ecology, Freiburg, Germany	Free downloadable tool for modelling environmental impact along the life cycle of materials and processes, contains many life-cycle inventory (LCI) datasets	www.oeko.de/service/gemis
Ecospecifier Griffith University, Australia	Database on environmental materials and products	www.ecospecifier.org
Material Connexion MaterialConnexion, New York, USA	Material database	www.materialconnexion.com
Material Explorer Materia, Rotterdam, Netherlands	Free of charge, registration required, material search engine, especially suited for product designers and materials, who look for materials for a specific application	www.materialexplorer.com
ProBas— process oriented base data for environmental management instruments Umweltbundesamt (Federal Environment Agency), Dessau, Germany	Free of charge, many life-cycle inventory (LCI) datasets, only suited for experts	www.probas.umweltbundesamt.de
Convent centre—Swiss centre for life-cycle inventories,	Extensive database on life-cycle inventory data, focus on Switzerland, only suited for experts	www.ecoinvent.ch
Life-Cycle Inventory Database NREL & U.S. Department of Energy, USA	Free of charge, database on life-cycle inventory data, focus on USA, only suited for experts	www.nrel.gov/lci

The mentioned search strategies can provide some help to retrieve required environmental information from the internet. However, further research should examine how the reliability and the timely supply of the (sometimes changing) information can be assured, how a search could be at least partially automated and how the required information can be prepared specifically to the different users' needs.

3.6 Conclusion and Outlook

In the early phases of the product innovation process, products can be substantially influenced towards achieving a sustainable and environmentally-friendly design. While some scientific work has been performed on innovation processes and its early phases as well as on the systematic integration of environmental impact assessment and life-cycle thinking, the integration of both views is still an area worth further research.

The achievement of this article is to conceptually link Cooper's well-known stage-gate methodology for innovation processes with environmental impact assessment and life-cycle thinking. It is shown how action strategies for the reduction of environmental impacts can be attributed to the different phases of the stage-gate process. The strategies can be applied by practical questions that sensitise and guide the users towards environmental issues. More research is needed to further link this approach to the ongoing discussion of product life-cycle management (see e.g. Grieves 2005; Subrahmanian et al., 2005). Furthermore, the presented concept has to be tested in practical applications or with case studies.

Furthermore, it is shown how information on substances, materials, and processes can be obtained by using information sources internal or external to the company. Search strategies are explained to demonstrate how the internet as a useful external information source can be used to retrieve information for estimation of environmental impacts of future products. However, due to the enormous amount of information in the web, such information retrieval can be a time-consuming process. In this case, more research should be conducted on the retrieval and verification of information from the internet as well as the user-specific preparation of information (see e.g. Eppler 2006).

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Chapter 4
Unravelling the Impacts of Supply Chains—A New Triple-Bottom-Line Accounting Approach and Software Tool

Thomas Wiedmann and Manfred Lenzen

Abstract Companies wishing to realise broader societal and environmental objectives often choose Triple-Bottom-Line (TBL) accounting as a reporting approach. TBL accounting covers social, economic and environmental indicators and thus enables decision-makers to quantify trade-offs between different facets of sustainability. Two issues are critical when considering TBL accounting. Firstly, indicators must include both the direct (on-site, immediate) effects of the company as well as the indirect (off-site, upstream, embodied) effects associated with purchasing from a potentially large and distant web of suppliers. The incorporation of all indirect or upstream impacts removes problems related to the choice of boundaries. Secondly, it is important to address the question of how to assign responsibility for the indirect impacts as these are shared between partners in a supply chain and must not be double-counted.

The research question of this work is therefore how can corporate sustainability performance be quantified and compared in practice whilst taking into account the responsibility-sharing nature of trading and avoiding double-counting of impacts? We (a) describe the analytical approach to measure the indirect impacts of a comprehensive TBL account of a producing entity; (b) present a quantitative concept of shared responsibility as a solution to assigning responsibility to both producers and consumers in a mutually exclusive and collectively exhaustive way; and (c) demonstrate practical applications in examples of quantification of indirect impacts, supply chain contributions, and shared responsibility.

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4.1 Introduction

4.1.1 Corporate Sustainability Reporting and the Triple Bottom Line

A broadly agreed definition of sustainability is "practices and development that meet the needs of the current generation without compromising the ability of future generations to meet their own needs" (WCED 1987). Although this definition has been widely accepted, applying it in a meaningful way to all levels of society is a major intellectual and governance challenge. Sustainability is ultimately an absolute condition: a country, community, or company is either sustainable or it is not. However, un-sustainability may be less recognisable over immediate or short time scales that are at odds with the accepted principle of sustainability defined in terms of future generations. Therefore, in an operational sense and with our current limited knowledge, sustainability is best viewed as a process. It is likely, therefore, that the sustainability 'goal posts' will be continually moved as our understanding of the importance of social and natural capital increases. Whilst it is difficult to make an absolute assessment of what sustainability means, proxy indicators of sustainability, many of which are currently in use, are essential for determining relative performance.

Corporations are beginning to apply the concept of sustainability at a practical level in terms of environmental and sustainability accounting and reporting (von Ahsen et al. 2004; Schaltegger et al. 2006; Taplin et al. 2006; Daub 2007), thus addressing the various "corporate sustainability challenges" (Schaltegger et al. 2003). Since companies began publishing the first environmental reports in the late 1980s, there has been "a clear tendency towards the inclusion of societal, and sometimes also financial, issues and benchmarking of performance" (Kolk 2004). Corporate sustainability accounts and reports must contain qualitative and quantitative information on economic, environmental and social effectiveness and efficiency, and integrate these aspects in a sustainability management system (Schaltegger and Wagner 2006).

Companies wishing to realise broader societal and environmental objectives often choose TBL accounting as a reporting approach. TBL covers all three dimensions of sustainability and thus enables decision-makers to quantify trade-offs between different facets of sustainability. "Triple Bottom Line" is a term originally coined by John Elkington in 1994 to describe corporations moving beyond reporting on only their financial "bottom line", to assessing and reporting on the three spheres of sustainability: economic, social and environmental (Elkington's 1997 book "Cannibals with Forks: The Triple Bottom Line of 21st Century Business" introduced the concept of the TBL to a wider audience, asking whether capitalism itself was sustainable and looking at the ways in which TBL thinking would transform (financial) accounting). TBL can be viewed as a reporting device (e.g. information presented in annual reports) and/or an approach to improving decision-making and the fundamental functioning of organisations (e.g. the provision of tools and frameworks for considering the economic, environmental and social implications of decisions, products, operations, future plans, etc.).

TBL provides a framework for measuring and reporting corporate performance against economic, social and environmental benchmarks. Reporting on the Triple-Bottom-Line makes transparent the organisation's decisions that explicitly take into consideration impacts on the environment and on people, as well as on financial capital. The TBL process can reduce risk, assist in delivering better outcomes for employees, shareholders, customers and clients, and enhance reputation. These benefits can help to produce a healthy operating environment and a reasonable expectation of company longevity beyond the quarterly report of key performance indicators. It has been recognised that managing sustainability performance and successfully integrating social, environmental and economic objectives in proactive operational strategies go hand-in-hand with the competitiveness of the business (Schaltegger et al. 2006; Schaltegger and Wagner 2006).

The concepts of TBL and associated systems and reporting frameworks are increasingly being taken up by companies worldwide as the Global Reporting Initiative (GRI, http://www.globalreporting.org) and the work of bodies such as the OECD building momentum. In the wake of this work, national and international regulations are changing and companies are increasingly being required to report their environmental and wider sustainability performance (The EU Accounts Modernisation Directive—AMD). For example, AMD introduces requirements for (large) companies to include a balanced and comprehensive analysis of the development and performance of the business in their Directors' Report. The analysis should "include both financial and, where appropriate, non-financial key perfor-mance indicators relevant to the particular business, including information relating to environmental and employee matters". This part of the AMD is effective for financial years beginning on or after 1 April 2005). This brings with it a need for standardisation of accounting frameworks (Steven 2004). However, there are no strict guidelines or standards yet with which businesses have to comply. Although the GRI has chosen the notion of the TBL in laying the groundwork for such guidelines (Global Reporting Initiative 2002), the TBL accounting procedures envisaged by the GRI are still fraught with inconsistencies, amongst which is the so-called boundary problem (Global Reporting Initiative 2005). This problem can be solved by a comprehensive input-output based life-cycle approach that can be integrated into a TBL framework and applied to supply chain management issues at a wide range of organisational scales (Foran et al. 2005a).

Accounting which is free of boundary problems and of double-counting is particularly important when it comes to quantifying environmental, social and economic impacts, as corporate sustainability performance can be measured and compared only if indicators can be quantified in a robust and reproducible way (see also Krajnc and Glavic 2005). Two issues are particularly critical when considering quantitative TBL accounting. Firstly, indicators must include both the direct (on-site, immediate) effects of a company as well as the indirect (off-site, upstream, embodied) effects associated with purchasing from a potentially large and distant web of suppliers. Only when adopting this life-cycle perspective can accurate comparisons of performance become possible. Problems related to the choice of boundaries can be avoided by incorporating all possible indirect or upstream impacts. Secondly, it is important to address the question of how to assign responsibility for these indirect impacts as all partners in a supply chain are involved in their creation and reporting on them must avoid double-counting. These two issues form the central theme of this article. We suggest undertaking an input-output-based life-cycle assessment across social, economic and environmental indicators spanning the entire supply chain of business operations to enumerate corporate TBL impacts in a holistic way. We describe the concept of 'shared responsibility' (Section 1.2) and explain with a simplified supply chain example how it can be applied in practical circumstances (Section 3.2).

Perhaps the first of such a consistent and comprehensive life-cycle TBL study of the industrial sectors of an entire economy is the analysis of the Australian economy (Foran et al. 2005b). This analysis—called "Balancing Act"—uses the economic National Accounts, environmental accounts, physical satellite accounts, and input-output techniques to characterise 135 industry sectors in terms of 4 financial, 3 social and 4 environmental indicators. For each of the 135 sectors, every indicator is enumerated in a supply-chain context in which all up-stream impacts are included.

Researchers at the University of Sydney developed the underlying methodology for the Balancing Act study and created a TBL software tool, termed Bottomline^3 ("BL-cubed", currently, there is an Australian, www.bottomline3.com, and a United Kingdom version, www.bottomline3.co.uk, of this tool available). A company's financial accounts, together with on-site impact data, act as input. Software outputs include aggregate figures, detailed breakdowns and rankings of economic, social, and environmental indicators. Sector benchmarking, structural path analysis (up-stream supply chain analysis) and production layer decomposition are available for all TBL indicators. Quantification of shared responsibility is realised by delineating impacts into mutually exclusive and collectively exhaustive portions of responsibility to be shared by all agents along a supply chain. In this contribution we use examples of outputs from the tool to demonstrate how TBL impacts arising from a business's operations can be quantified in a systematic and comparable way. The tool has also been applied in a number of case studies: (Wiedmann and Lenzen 2006a; Wiedmann and Lenzen 2006b; Lenzen 2007; Wiedmann et al. 2007).

The need for such robust tools and information for quantitative environmental and sustainability reporting is growing rapidly and will persist in the future. A recent report from the London-based environmental consultancy Trucost, published by the UK Department for the Environment, Food and Rural Affairs (DEFRA 2006), hints at significant gaps:

- there is still a lack of quantification in most reporting. The Environment Agency study of Annual Reports and Accounts of the FTSE All Share companies noted that the majority of reports lack depth, rigour or quantification. The study concluded that quantified environmental disclosure levels in Annual Reports and Accounts were found to be low (p. 14), and

- Most business will have supply chain impacts that they should understand and consider reporting. There is no single, quantifiable measure that companies can use as a [Key Performance Indicator] (KPI) for the effect of their up-stream supply chain on the environment. (p. 63).

In the following Section (1.2) we provide the reader with a background for the concept of shared responsibility before we outline the purpose of this particular work (Section 1.3).

4.1.2 The Concept of Shared-Responsibility

It is perhaps because of the tendency of economic policy in market-driven economies not to interfere with consumers' preferences that the producer-centric representation is the dominant form of viewing the environmental impacts of industrial production. In statistics on energy, emissions, water etc., impacts are almost always presented as attributes of industries ('on-site' or 'direct' allocation) rather than as attributes of the life-cycles of products for consumers. On a smaller scale, most existing schemes for corporate sustainability reporting include only impacts that arise out of operations controlled by the reporting company, and not life-cycle/supply-chain impacts (WBCSD and WRI 2004). Note that the terms 'life-cycle' and 'supply-chain' do not mean exactly the same (Seuring 2004, contains a suggestion on how to distinguish between the two terms). For the purpose of this article we refer to 'life-cycles' as life stages of a product or service (e.g. "cradle-to-gate" or "cradle-to-grave") and we use this term in context with methodologies such as LCA. When using the term 'supply-chain' we explicitly refer to agents along an economic (supply) chains to demonstrate that businesses (people) are involved with their decisions, activities, etc. According to this world view, "up-stream and down-stream [environmental] impacts are […] allocated to their immediate producers. The institutional setting and the different actors' spheres of influence are not reflected" (Spangenberg and Lorek 2002:131).

On the other hand, a number of studies have highlighted that final consumption and affluence, especially in the industrialised world, are the main drivers for the level and growth of environmental pressure. Even though these studies provide a clear incentive for complementing producer-focused environmental policy with some consideration for consumption-related aspects, demand-side measures to environmental problems are rarely exploited (Princen 1999:348).

The nexus created by the different views on impacts caused by industrial production is exemplified by several contributions to the discussion about producer versus consumer responsibility for greenhouse gas emissions (Munksgaard and Pedersen 2001; Bastianoni et al. 2004; Lenzen et al. 2004; Munksgaard et al. 2008). Emissions data are reported to the IPCC as contributions of producing industries located in a particular country (Task Force on National Greenhouse Gas Inventories 1996), rather than as embodiments in products which are consumed by a particular population irrespective of productive origin. However, especially for open economies, if the greenhouse gases embodied in internationally traded commodities are taken into account, this can have a considerable influence on national greenhouse gas balance sheets (e.g. Peters and Hertwich 2006; Wiedmann et al. 2007a). Assuming consumer responsibility, exports have to be subtracted from, and imports added to, national greenhouse gas inventories.

Similarly at the company level, "when adopting the concept of eco-efficiency and the scope of an environmental management system stated in, for example, ISO 14001, it is insufficient to merely report on the carbon-dioxide emissions limited to the judicial borders of the company" (Cerin 2002:59). "Companies must recognise their wider responsibility and manage the entire life-cycle of their products … Insisting on high environmental standards from suppliers and ensuring that raw materials are extracted or produced in an environmentally conscious way provides a start" (Welford 1996). The need for capturing impacts across the entire up-stream and down-stream supply chain (the boundary problem) is of particular importance and has, therefore, been noted in the Guidelines of the Global Reporting Initiative (GRI) and by the World Business Council on Sustainable Development (Global Reporting Initiative 2002; Global Reporting Initiative 2005).

A life-cycle perspective is also taken in Extended Producer Responsibility (EPR) frameworks: "Producers of products should bear a significant degree of responsibility (physical and/or financial), not only for the environmental impacts of their products downstream from the treatment and disposal of their product, but also for their up-stream activities inherent in the selection of materials and in the design of products" (OECD 2001:21–22). "The major impetus for EPR came from northern European countries in the late 1980s and early 1990s, as they were facing severe landfill shortages [… As a result,] EPR is generally applied to post-consumer wastes which place increasing physical and financial demands on municipal waste management" (EPA NSW 2003:2–4).

As practical implementations of EPR various environmental management concepts have evolved that directly address the flow of materials (and information) along life-cycles or supply-chains and thereby relate to inter-organisational management aspects. According to Seuring (2004), these include "industrial ecology (IE), life-cycle management, closed-loop supply-chains, integrated chain management and green/environmental or sustainable supply-chain management." Life-cycle-wide management based on TBL accounting can be added to this list (Foran et al. 2005a).

The Chartered Institute of Purchasing and Supply UK have launched voluntary guidelines for environmental purchasing and recommends achieving seven goals (CIPS 1999; CIPS 2000; CIPS 2002): (1) establishment of a business case to make environmental purchasing viable and part of day-to-day operations, (2) an understanding of the environmental issues affecting the organisation and its supply-chain, (3) the development of a purchasing policy which addresses environmental issues, (4) environmental criteria for ranking suppliers, (5) improved communications with suppliers, (6) suitable methods for collecting relevant information, and (7) agreed targets for further environmental performance improvements.

Recently, a range of companies have implemented policies that aim at reducing CO_2 emissions or other environmental impacts from up-stream suppliers. This is reflected in recent conferences on the subject of supply-chain (carbon) impacts and management (e.g. 'ENDS Corporate Carbon Footprint Conference', London, April 2007; 'Carbon Footprint Supply Chain Summit', London, May 2007; 'Corporate Climate Response', London, May 2007; or 'Measuring and Reducing Corporate Carbon Across Your Product Lifecycle or Supply Chain Conference', Brussels 2007), in case studies (e.g. Carbon Trust 2006), in Government guidelines (e.g. DEFRA 2006:63) and in developments in carbon footprint estimation methods (see e.g. the discussion in Wiedmann and Minx 2008).

On the down-stream side of a supply chain, the concept of product stewardship "suggests that all parties with a role in designing, producing, selling, or using a product are responsible for minimising the environmental impact of the product over its life" (McKerlie et al. 2006:620). In practice, this "shared responsibility" extends beyond the producers and users of a product to include local governments and general taxpayers who incur the expense of managing products at their end-of-life as part of the residential waste stream. This shared approach does not clearly designate responsibility to any one party, thus diluting the incentive to advance waste prevention. Indeed at present, most extended-responsibility initiatives proceed in a more or less qualitative and ad-hoc, rather than quantitative and systematic, way in selecting, screening, ranking, or influencing other actors in their supply-chain. In any case, credible ranking of suppliers and their sustainability impacts is possible only if a robust and reproducible quantitative rating is at hand.

4.1.3 Purpose of This Work

When thinking about environmental and wider sustainability impacts of producers and consumers, crucial questions arise such as: who is responsible for what and how is the responsibility to be shared, if at all? For example, should a firm have to improve the eco-friendliness of its products, or is it up to the consumer to buy or not to buy? And further, should the firm be held responsible for only the down-stream consequences of the use of its products, or—through its procurement decisions—also for the implications of its inputs from up-stream suppliers? And if so, how far should the down-stream and up-stream spheres of responsibility extend? Similar questions can be phrased for the problem of deciding who takes the credits for job creation or successful abatement measures that involve producers and consumers: who has the best knowledge of, or the most influence over, how to increase social benefits or reduce adverse impacts associated with the transfer of a product from producer to consumer?

The underlying research question of this work is "how can corporate sustainability performance be quantified and compared in practice, whilst taking into account the responsibility-sharing nature of trading (within and across supply-chains) and avoiding double-counting of impacts?" This more technical question aims at finding a consistent and reproducible method by which sustainability impacts can be assigned in a quantitative way to agents of trading transactions. This study

- Describes the analytical approach to measure the indirect impacts of a comprehensive TBL account of a producing entity
- Presents a quantitative concept of shared responsibility as a solution to assigning responsibility to both producers and consumers in a mutually exclusive and collectively exhaustive way, and
- Demonstrates practical applications in examples of quantification of indirect impacts, supply-chain contributions, and shared responsibility

The rest of the paper is organised as follows. Section 2 explains the methodology and provides further references for the reader interested in mathematical details. Section 3 introduces the concept of shared responsibility with a practical example and Section 4 presents and discusses the results of exemplary TBL life-cycle assessments. Section 5 concludes.

4.2 Methodology

4.2.1 Measuring All Indirect Impacts

In this study, the principle of TBL is assessed using input-output analysis (IOA). IOA is a top-down economic technique which uses sectoral monetary transactions data to account for the complex interdependencies of industries in modern economies. The result of generalised IOA's is a $f \times n$ matrix of TBL factor multipliers, that is embodiments of f TBL indicators (such as exports, labour, energy, etc.,) per unit of final demand of commodities produced by n industry sectors. A multiplier matrix M can be calculated from a $f \times n$ matrix Q containing the direct, sectoral TBL indicator scores (e.g. from national economic, social, and environmental accounts), and from a $n \times n$ direct requirements matrix A according to

$$\mathrm{M} = \mathrm{Q}(\mathrm{I} - \mathrm{A})^{-1} \tag{4.1}$$

where I is the $n \times n$ unity matrix. For many countries, the direct requirements matrix A can be compiled from the input-output tables published by the national statistical agencies.

The $f \times 1$ TBL inventory F of a given sectoral final demand represented by an $n \times 1$ commodity vector y is then simply

$$\mathrm{F} = \mathrm{My} \tag{4.2}$$

An introduction to the input–output method and its application to environmental problems can be found in Leontief and Ford 1970; Proops 1977; Miller and Blair 1985; Lenzen 2001.

Input-output theory was pioneered by Nobel Prize-winning economist Wassily Leontief in the 1940s and applied by Herendeen and others (Herendeen 1973, 1974, 1978, 1981; Herendeen and Sebald 1975; Herendeen and Tanaka 1976) to many energy analysis problems from the mid-1970s to today. It had always been Leontief's intention that IOA be extended from purely financial considerations to a range of social and physical elements (Leontief and Ford 1970). However, such methods have not been widely employed in government planning and policy circles, except for the European NAMEA movement, in which physical tables are set up as satellite accounts to the National Accounts (de Haan and Keuning 1996; de Haan 1999; Stahmer 2000; Statistisches Bundesamt 2001). These physical accounts and our work aim to integrate the structure and function of the financial economy (as described by the national IO tables) with other national social and environmental accounts such as energy, greenhouse emissions, water, land use, employment, etc.

There is a well-known precedent for IOA techniques improving assessment processes: in life-cycle assessment (LCA), which aims to calculate the total environmental burdens associated with a product. In LCA, IOA has played a significant role in overcoming what is known as the boundary problem, or the problem of incompleteness of an LCA inventory due to the arbitrary truncation of the system by a subjectively set boundary (Suh et al. 2004), thus preventing decision-makers from overlooking important hidden up-stream impacts.

In an empirical application, the IO formalism was applied by researchers at the University of Sydney to compile a comprehensive TBL account of the Australian economy. National-level and state-level economic sector level data for 344 sectors of the Australian economy were compiled, using input-output tables and additional data. A part of these accounts are published (http://www.isa.org.usyd.edu.au/publications/balance.shtml, see also Foran et al. 2005a, b) and contain information on the aggregate and average performance of 135 economic sectors for ten TBL indicators together with their main data sources. The ten macro TBL indicators published were: primary energy, greenhouse gas emissions, water use, land disturbance, value of imports, value of exports, surplus, government revenue, employment (hours) and income. However, the extended data set features many more indicators than the published set: it also includes material flows, the Ecological Footprint, emissions of more than 100 toxic, ozone-depleting, acidifying and eutrophicating substances to air, water and soil, and two prominent Dutch LCA sets (the CML midpoint set and PRé's endpoint Eco-indicator99). In total the whole database distinguishes 1,270 indicators for 344 industry sectors (http://www.isa.org.usyd.edu.au/research/ISA_TBL_Indicators.pdf). The synthesis of disparate data sources is a major component of the development of a generalised IOA framework.

The Australian TBL sector accounts also describe, in hard numbers, economic, social and environmental indicators against a common unit of one dollar of final demand. The latter constitutes a convenient and meaningful numeraire because it is the destination of GDP, the common measure of national economic performance. As Adam Smith concluded in 1776, it is "the sole end and purpose of all production". Thus economic indicators of surplus, exports, and imports can be reported as "dollars of surplus per dollar of final demand". Social indicators such as employment, wages, and government revenue can be described as "the minutes of employment generated per dollar of final demand". Environmental indicators such as greenhouse gas emissions, water requirement, and land disturbance can be described as "kilograms of carbon dioxide equivalent emissions per dollar of final demand" or the like. However, the presentation of such complex analyses is always fraught with the tension between simplicity and complexity.

4.2.2 Unravelling Supply Chains

The boundary within which an organisation accounts for its environmental, social, and economic effects is usually defined as that over which the company has direct influence and can exercise control. However, such a definition faces a number of challenges. The level of influence and control will vary from organisation to organisation, and from year to year, invalidating comparisons within and between organisations. Moreover, extending the boundary beyond the immediate control of the organisation still begs the question of exactly where to draw the line. Decisions will differ between organisations and over time. Establishing a clear boundary for an analysis that is consistent across all indicators seems at first sight to be almost impossible.

Notwithstanding these challenges, the boundary problem can be solved by taking a full life-cycle perspective and by taking into account the structure of the economic system as described in the national input-output tables. This structure is best depicted as an ever-expanding "tree of interdependence" that starts at a particular economic entity, and stretches across up-stream production layers, containing sectors at different production stages linked together by supply-chains. Thus a particular impact associated with a good or a service cascades from primary industries which produce raw materials, via secondary (manufacturing) industries into the sector or company that delivers the final product to the consumer.

The general decomposition approach described in the following was introduced into economics and regional science in 1984 under the name 'structural path analysis' (Crama et al. 1984; Defourny and Thorbecke 1984). To systematically determine environmentally important production chains, the total factor multipliers derived in Equation 4.1 above can be decomposed into contributions from all input paths, by 'unravelling' the Leontief inverse using a series expansion. A multiplier m_i for industry i can then be derived, representing the sum over a direct factor input q_i, occurring in industry i itself, and higher order input paths (for details see Lenzen 2002, 2003).

Such a structural path analysis covers the entire up-stream supply-chain. It "unravels" a company's impacts into single contributing supply paths. It gives extensive detail of the impact of a sector's or company's activities. It allows investigation of the location of impacts within the supply-chain. In the case of a company, the control over the input procurement process then provides the possibility of substituting impact-intensive suppliers with more sustainable suppliers.

Detailed outputs derived from the application of structural path analysis include:

- A description of the path
- The path value (e.g. the greenhouse gas impact in grams of CO_2-equivalent per $ of final output of business management services)
- The path order (that is, from which up-stream supply layer the path originates)
- The path coverage, that is, the relative contribution (in %) to the total TBL impact of the company

4.3 Assigning Responsibility Along Supply-Chains

4.3.1 Full-Producer and Consumer-Responsibility

Traditional company environmental reports and national environmental statistics accounts are based on a producer-responsibility perspective. Companies usually report on-site emissions to air and water, and other direct impacts such as noise, waste, direct use of energy and resources etc., (see e.g. DEFRA 2006). The national Environmental Accounts are compiled following the same principles, summing up all the emissions, resources use etc., that can be directly attributed to specific industrial sectors (see e.g. ONS 2007).

In the following example we compare this production-based approach with the consumption-based perspective taken in LCA. Consider the carbon-dioxide emissions caused by one particular economic chain: the production and consumption of glass containers and their food contents. This is a purely illustrative example with fictitious numbers, and, for the sake of simplicity, we assume that the participants of this economic chain do not supply anyone other than the next actor in the chain. According to the traditional perspective of producer responsibility accounting, we note the direct (on-site) emissions of each member of the supply-chain (Fig. 4.1 and Table 4.1). The final consumer does not emit CO_2 in this particular process, and therefore no emissions are attributed to them.

Note that there would be double-counting if the producers of glass, containers, and food used traditional LCA to calculate and publicise their CO_2 emissions. This is because the full 'life-cycle' from 'cradle-to-gate' would be taken into account. The emissions caused by the sand-miner, the glass-maker and the glass-container maker would appear in the food company's CO_2 emission account as they are all suppliers. Hence the 'embodied' CO_2 emissions of this final production stage, derived by traditional LCA, would be 8,400 t (the total of all actors' emissions). It is hence multiple-counted.

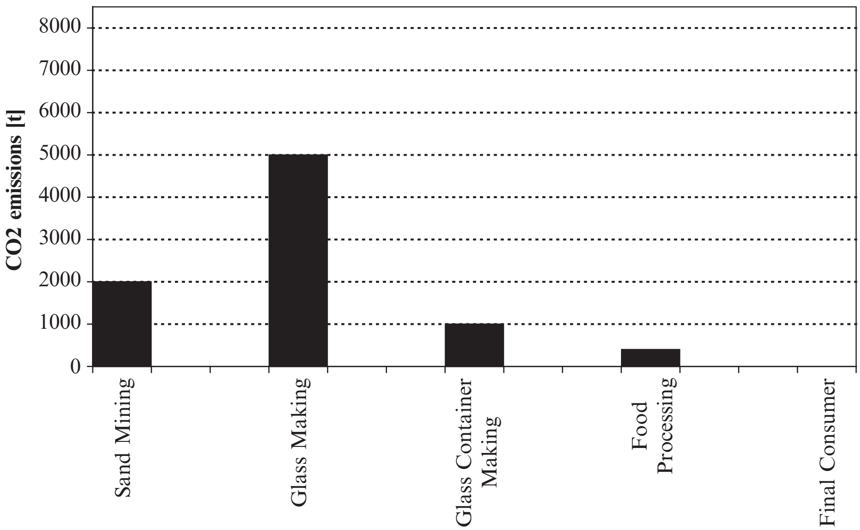

Fig. 4.1 Example for a full producer responsibility account of direct CO_2 emissions along a supply chain

Table 4.1 Quantitative example of allocating CO_2 emissions in a (hypothetical) supply-chain by applying the shared responsibility approach described in Lenzen et al. (2007)

	Sand Mining	Glass Making	Glass Container Making	Food Processing	Final Consumer
Value added (VA) [$m]	0.4	1.6	2.1	16.0	
Net output (NO) [$m]	1.6	3.2	5.3	21.3	
$1 - \alpha$ = VA/NO	0.25	0.50	0.40	0.75	
Responsibility share	25% (retained) -75% (passed on)	50% (retained) -50% (passed on)	40% (retained) -60% (passed on)	75%(retained) -25% (passed on)	
On-site CO_2 emissions [t]	2,000	5,000	1,000	400	
CO_2 received [t]		1,500	3,250	2,550	738
CO_2 retained [t]	500	3,250	1,684	2,228	738
CO_2 passed on [t]	1,500	3,250	2,566	738	

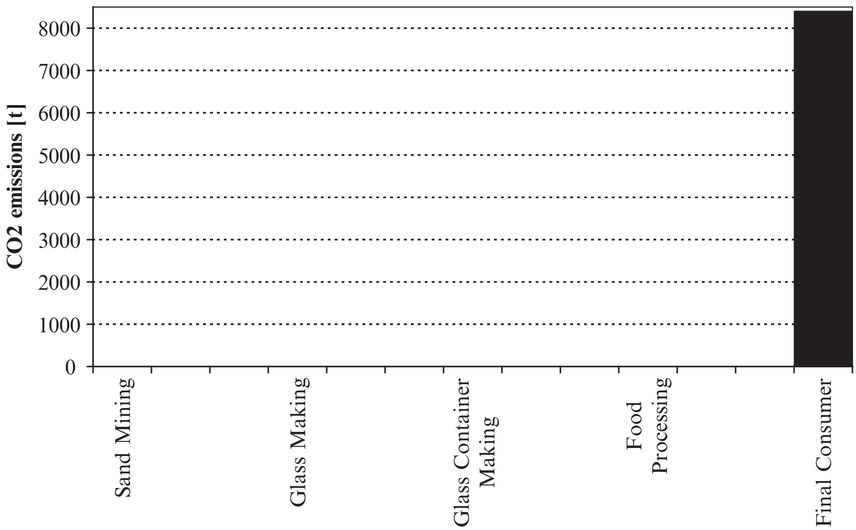

Fig. 4.2 Example of a full consumer responsibility account of all CO_2 emissions along a supply-chain

LCA is a method that assumes full consumer responsibility. In life-cycle thinking, the consumer of products is placed at the very end of the supply-chain and all impacts incurred during production are attributed to them. Therefore if double-counting is to be avoided, LCA can be used only for the final consumers in an economy: the impacts of any producer must be zero (this is also the perspective taken by traditional Ecological Footprint estimates such as the National Footprint Accounts (e.g. Lenzen and Murray 2003; Wackernagel et al. 2005; Wiedmann et al. 2006; WWF et al. 2006). This is a full consumer responsibility account as depicted in Fig. 4.2.

A particular disadvantage of full producer or consumer responsibility is that neither allows for both producers and consumers to evaluate their TBL impacts without double-counting. Full-producer and consumer-responsibility therefore appear somewhat unrealistic. Both producers and consumers wish to report their respective part of the impact, and it is intuitively clear that responsibility is somehow to be shared between the supplier and the recipient of a commodity, because the supplier has directly caused the impacts, but the recipient has demanded that the supplier do so.

4.3.2 Quantifying Shares of Responsibility

As with many other allocation problems, an acceptable consensus probably lies somewhere between producer and consumer responsibility. To assign responsibility to actors participating in these transactions, one has to know the respective supply-chains or inter-industry relations. Hence, a problem poses itself in the form of the question: How can one devise an accounting method that allows environmental (or other TBL) impacts to be apportioned to both producers and consumers whilst avoiding double-counting? This problem has been addressed in two recent publications (Gallego and Lenzen 2005; Lenzen et al. 2007).

The result is that in reality, both the final consumers and their up-stream suppliers play some role in causing environmental impacts. The suppliers use resources and energy to produce, and make decisions on how much and what type of resources and energy they use. Consumers decide to spend their money on products coming from those upstream suppliers. This role-sharing probably holds for many more situations in business and in life. The concept of shared responsibility recognises that there are always two people, or groups of people, who play a role in commodities produced and impacts caused, and two perspectives involved in every transaction: the supplier's and the recipient's. Hence, responsibility for impacts can be shared between them. Naturally, this applies to both benefits and burdens, and therefore to all positive and negative TBL indicators.

The idea of shared responsibility is not new. However, shared responsibility has only recently been consistently and quantitatively conceptualised by Gallego and Lenzen (2005), see also Rodrigues et al. (2006) for the definition of an indicator of environmental responsibility that accounts for transactions between countries in a 'fair' manner, and Lenzen et al., (2007) for a discussion.

Sharing impacts between each pair of subsequent supply-chain stages gets rid of the double-counting problem described above. One question that remained unresolved in the exposition by Gallego and Lenzen (2005) was in what proportion impacts should be shared between supplier and recipient in an economic chain. One possibility could be a 50–50% split, where 50% of an on-site impact is retained by the producer and 50% is passed on to the producer's downstream client. However, as outlined in Lenzen et al., (2007) a 50–50% share leads to a methodological inconsistency: the part of the impact that is passed on and eventually reaches the final consumer is dependent on the number of participants in a supply chain. This dependence of responsibility allocations on the vertical integration of sectors is inconsistent and undesirable because it creates incentives for de-merging in reporting practice.

A solution to this problem, as suggested by Lenzen et al., (2007) is to peg the percentage split of responsibility retained by the supplier ($1 - \alpha$) to a quantity that is independent of sector classification. Value-added is such a quantity: no matter whether a supply-chain is represented as many or few stages, total value-added is always the same at the end of the chain. Lenzen et al., (2007) therefore propose to use:

$$1-\alpha_{ij} = \frac{v_i}{X_i - T_{ii}} \tag{4.3}$$

where v_i is the value added by industry sector i, and $x_i - T_{ii}$ is gross output minus intra-industry transactions, in other words net output. Intra-industry transactions T_{ii} have to be understood as transactions between different branches of the same industry sector.

Using the supply-chain from above, we apply Equation 4.3 with examples of values for value-added (VA) and net output (NO) for each supplier as shown in Table 4.1.

Assume the sand-mine supplies \$1.6 million-worth of sand to the glass-maker, to which the latter adds \$1.6 million of value to produce \$3.2 million worth of glass net output. To this, the glass-container manufacturer adds \$2.1 million of value, producing \$5.3 million worth of glass containers. To this, the food manufacturer adds \$16 million of value producing \$21.3 million worth of food.

The sand-mine adds 25% of value to sandstone by turning it into sand. It will hence retain a shared responsibility of 25% of their CO_2 emissions (500 t out of 2,000 t) and send the remaining 75% (1,500 t) down the supply-chain to the glass manufacturer. The glass-maker will add 50% of value to sand by turning it into glass. The glass-maker is hence assigned 50% of 1,500 t of CO_2 passed down from sand, plus 50% of 5,000 t used while manufacturing glass. The remainder (3,250 t) is passed on to glass containers. The glass-container manufacturer will add 40% of value to glass, and is thus assigned 40% of the emissions embodied in glass containers, and so on. Finally, the food manufacturer adds 75% of value to glass containers, and is therefore assigned 75% of emissions embodied in packed food. Final consumers (households, the government) are at the end of the supply-chain, and receive the remainder (738 t of CO_2). This process of sharing responsibility by using a VA/NO allocation is depicted in Fig. 4.3; the final results are shown in Fig. 4.4.

The logic of this allocation scheme (as opposed to a 50–50% split) is that an organisation that controls its production to a high extent. It retains a high share of

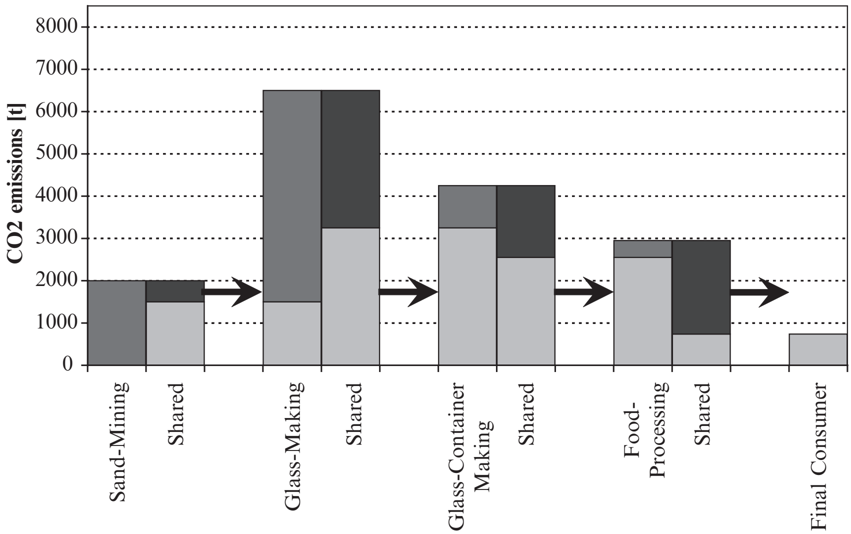

Fig. 4.3 Process of applying shared, value-added-allocated responsibility to CO_2 emissions in one particular supply chain (medium-grey columns = on-site impact; light-grey columns = share that is passed on from one supplier to the next; dark-grey columns = retained impact)

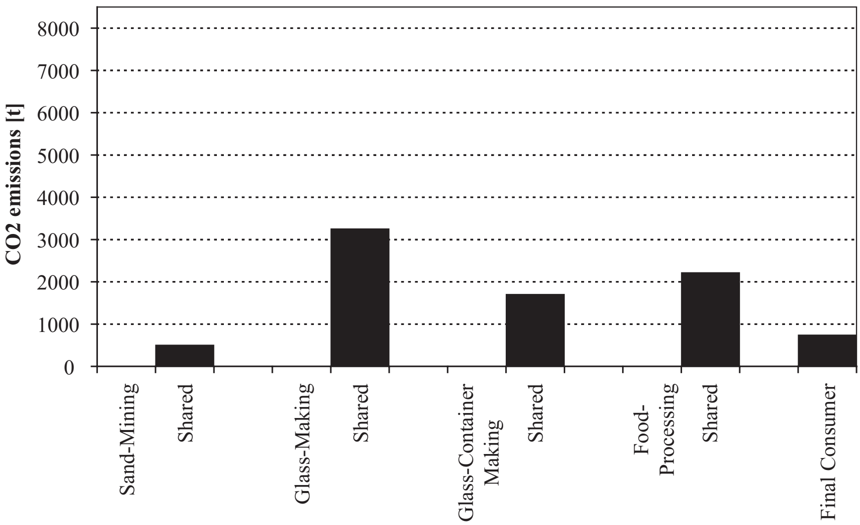

Fig. 4.4 Results of applying shared, value-added-allocated responsibility to CO_2 emissions in one particular supply chain (identical to the dark grey columns in Fig. 4.3)

the responsibility for the emissions. High control, or influence over the product, can be approximated by high value-added: production processes that add a high percentage of value to inputs usually transform these to a high extent, while low-value adding entities operate more as an "agent" of their inputs.

4.4 Example Analyses

At the University of Sydney, TBL accounting has been formulated as a quantitative framework using an input-output-based LCA method. This framework has been applied to dozens of organisations in reporting on their sustainability performance—companies, government departments, NGOs (http://www.isa.org.usyd.edu.au/research/tbl.shtml). Experiences were collected in a 3-year pilot project. It became clear that the data collection burden for the organisation has to be as small as possible. As a result, a software tool was developed in collaboration with these organisations, enabling users to create a comprehensive sustainability report solely by importing their existing financial accounts. This software tool is called Bottomline^3, or short BL^3 ("BL-cubed"; http://www.bottomline3.com and http://www.bottomline3.co.uk).

The model framework is described in Foran et al., (2005b) with a summary available in Foran et al., (2005a). A short summary of the methodology can also be found in Wiedmann and Lenzen (2006a). The IOA and TBL framework of BL^3 can be adapted to any economy with adequate data from economic and environmental accounts. The UK version of Bottomline^3, for example, is based on a static, single-region, open, basic-price, 76-sector industry-by-industry input-output model of the

UK economy augmented with a database of environmental, social, and economic indicators. The TBL indicator set of BL[3] UK features a number of economic, social, and environmental indicators, including greenhouse gases; toxic, ozone-creating, acidifying and eutrophicating air pollutants; heavy metals; energy and resources use; the Ecological Footprint; and materials flows. In total, the whole database distinguishes well over 100 indicators. Financial transaction data are derived from UK National Accounts Supply and Use Tables (Wiedmann et al., 2006; ONS 2006), employment data from the UK Annual Business Inquiry (http://www.statistics.gov.uk/abi/whole_econ.asp), sectoral emission and resources use data from UK Environmental Accounts (ONS 2007), material flow data from SEI et al., (2006) and Ecological Footprint data per sector were derived by using the method described in Wiedmann et al. (2006).

Two types of input data from the organisation under investigation are required for the calculation of TBL impacts with Bottomline[3], financial accounts and on-site impact data. Financial accounts include all expenditure and revenue data from one year, ideally as detailed as possible. This consists of all financial transactions required to operate the business, from the purchase of materials, goods and services through to financing and insuring. On-site data include fuel, land, and resources used directly by the company, e.g. the consumption of fossil fuels needed for processing, heating and driving or direct (on-site) appropriation of built land. For the indicator 'employment', the 'on-site impact' is the number of people directly employed by the company. On-site impact data should be in physical units, e.g. kilowatt-hours or litres of fuels or hectares of built land.

Software outputs include aggregate figures, detailed breakdowns, sector benchmarking and rankings of indicators into supply chain contributions. As an example of how results from a TBL analysis with BL[3] look, we show four results for a hypothetical food company in the following graphs (note that this example is different from the one in Section 3.2 as we now look at a wider range of TBL impacts, not only CO_2 emissions; and at all possible supply paths to the food company, not only the one delivering glass containers).

TBL impacts of the food company can be compared in a meaningful way with other enterprises in the same sector if they are normalised to the business size. This can be done by dividing the absolute impact (e.g. tonnes of CO_2 emitted) by the company's total expenditure in the same time period (normally one financial year). For benchmarking purposes the resulting impact intensities (e.g. in t CO_2/\$) can be directly compared to those from the sector-average. All necessary sector benchmark data are derived directly from the national data inherent in the BL[3] tool. Depicted in a spider diagram, the ratios of business-to-sector intensities then elegantly convey in a single visual representation an overview of the business's TBL performance on a number of economic, social, and environmental indicators. The ratios divide business-intensity by sector-intensity for indicators that are deemed negative ("less is good", e.g. CO_2 emissions), so that better performance leads to lower ratios. For indicators that are deemed positive ("more is good", e.g. employment), these ratios are inversed, so that better performance leads to lower ratios (A similar representation is proposed by Krajnc and Glavic (2005). In their diagram, however, a larger

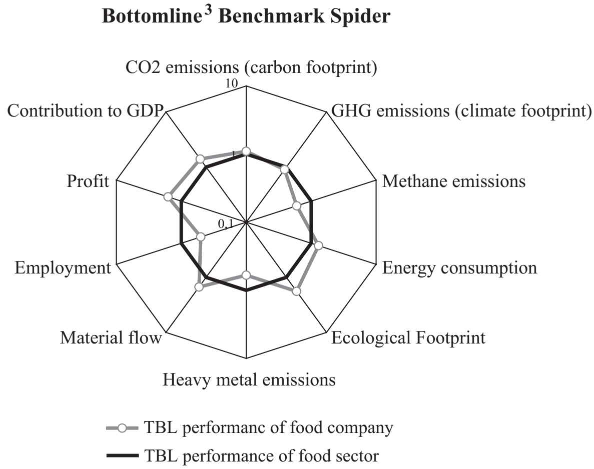

Fig. 4.5 A spider diagram presentation of TBL performance of the key financial, social, and environmental indicators (red line) of an exemplary company from the food sector. The regular polygon in the centre of the diagram (thick black line) shows the average TBL performance of the food sector as a whole across the economy, allowing a benchmark comparison between the company and its sector. Indicators with above-average performance are closer to the centre, while below-average indicators are positioned closer to the outside boundary, i.e. the centre locates ten-times-better performance (not ten-times-lower), the outer rim ten-times-worse performance (not ten-times-higher) (for an explanation of TBL indicators see Foran et al., (2005b)).

'amoeba' indicates a higher "probability of sustainable development"). The TBL spider diagram is hence—within limits—interpretable as "dents are good, spikes are bad". An example of a spider diagram is shown in Fig. 4.5.

Figure 4.6 shows an example of a software output of the total material flows (for an explanation of this indicator see e.g. Eurostat 2001; National Academy of Sciences 2004). that are needed to sustain the operations of an exemplary company. Similar to the procedure explained in Section 3.2, the total impact (which is the sum of on-site plus indirect impacts embodied in up-stream production) is divided into one part that is retained by the company and another part that is passed on further down the supply-chain. BL^3 further breaks down the latter part and distinguishes two recipients of impacts, the final consumer and other businesses to which the company sells products.

An analytical technique called Production Layer Decomposition shows whether overall impacts are caused directly by suppliers to the business (proximate effects), or indirectly by suppliers of suppliers (remote, supply-chain effects). This is depicted for a hypothetical carbon footprint analysis of a food company in Fig. 4.7. On-site impacts (layer 1, showing direct emissions from the company) amount to around 50 t CO_2-equivalent and are allocated to the 'Food' category, because our exemplary company is part of this category. Amongst the company's direct suppliers (layer 2), major emitters are within Agriculture, Fuels (refineries and distribution), and Transport & Communication. At layer 3, suppliers of suppliers to the

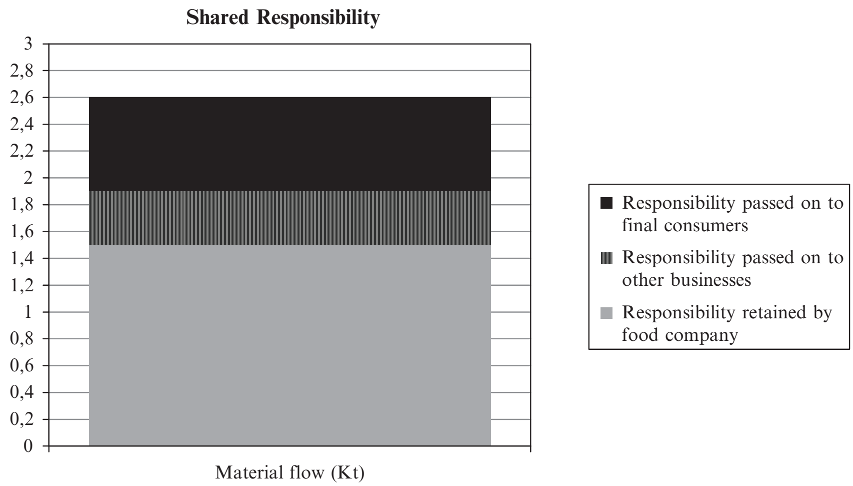

Fig. 4.6 Responsibility shares of the material flow impact of an example (food) company. 1.5 Kt of the total impact of 2.6 Kt are retained by the company whereas 1.1 Kt are passed on further down the supply-chain (0.4 Kt to other businesses and 0.7 Kt to final consumers).

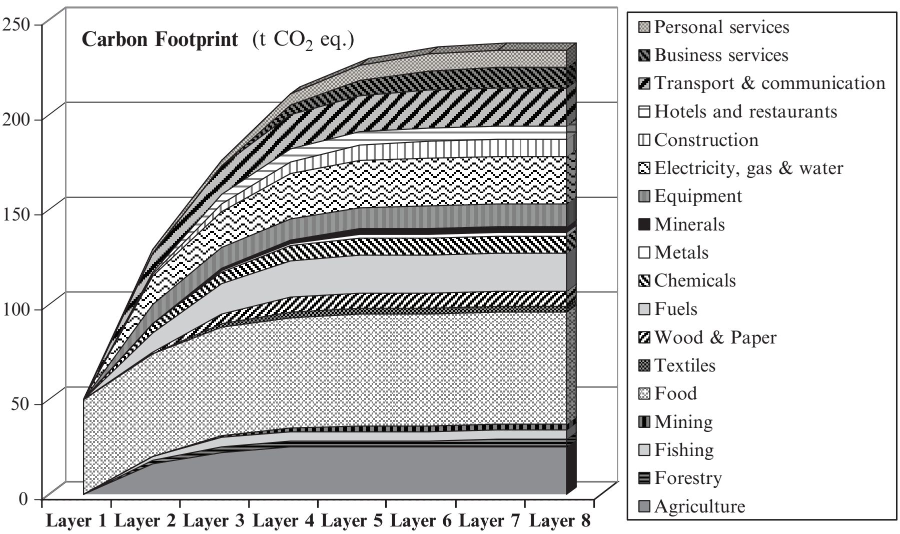

Fig. 4.7 An example of a production layer diagram showing the direct and indirect carbon footprint (CF) as well as its origin for a (fictitious) food company. ‘Layer 1’ represents for the company itself, i.e. it shows its direct CF caused by direct emissions from heating and driving. ‘Layer 2’ represents the “suppliers” to the company, ‘Layer 3’ the “suppliers of the suppliers” and so on. In other words, Layers 2 to 8 show the indirect CF that is embodied in the products and services purchased by the food company. In this example, the main contributors to the indirect CF are Agriculture, Fuels, and Transport & Communication. This diagram looks different for each TBL indicator.

company enter the picture: amongst these are, for example, service-providers. One example of a contribution from layer 3 could be a sand-mine which supplies sand to a glass company which makes bottles for the food company (our previous example from Section 3.2). Towards higher-order layers, contributions to the total carbon footprint become smaller and the total impact eventually saturates at around 220 t CO_2-eq.

Finally, a Structural Path Analysis unravels the entire TBL impact into single paths that make up the supply-chain system just as branches make up a tree. This is the most detailed representation of a business's supply-chain impacts. Table 4.2

Table 4.2 Results of a BL³ structural path analysis of the Ecological Footprint of an example (food) company. The total Ecological Footprint embodied in the supplies from up-stream producers is broken down into contributions from the supplying sectors (gha = global hectares). The list shows path values and orders (i.e. how large and how far away the impacts are).

Rank	Path Description	Path value	Path order	Percentage in total impact
1	Company (on-site impacts)	29.6 gha	1	51.2%
2	Electricity > Company	6.70 gha	2	11.6%
3	Agriculture > Company	4.85 gha	2	8.41%
4	Food and drink > Company	3.52 gha	2	6.10%
5	Pulp and paper > Company	1.97 gha	2	3.41%
6	Electrical machinery and equipment > Company	1.09 gha	2	1.88%
7	Agriculture > Food and drink > Company	0.69 gha	3	1.19%
8	Pulp and paper > Pulp and paper > Company	0.48 gha	3	0.83%
9	Gas distribution > Company	0.46 gha	2	0.79%
10	Electricity > Food and drink > Company	0.38 gha	3	0.67%
11	Fishing > Food and drink > Company	0.37 gha	3	0.65%
12	Iron and steel > Electrical machinery and equipment > Company	0.37 gha	3	0.65%
13	Pulp and paper > Food and drink > Company	0.34 gha	3	0.59%
14	Electricity > Gas distribution > Company	0.32 gha	3	0.56%
15	Oil and gas extraction > Gas distribution > Company	0.27 gha	3	0.46%
16	Non-ferrous metals > Electrical machinery and equipment > Company	0.26 gha	3	0.45%
17	Food and drink > Food and drink > Company	0.26 gha	3	0.45%
18	Plastic products > Food and drink > Company	0.24 gha	3	0.41%
19	Electricity > Electrical machinery and equipment > Company	0.22 gha	3	0.39%
20	Electricity > Electricity > Company	0.21 gha	3	0.36%

shows the 20 most important paths that contribute to the total Ecological Footprint (for background information on this indicator see e.g. Wiedmann et al., 2006) of a hypothetical food company. On-site impacts make up about half of the total Ecological Footprint due to the consumption of fossil fuels.

These examples show outputs that make it possible to determine:

- Which of the operating inputs embody the largest impacts,
- Whether these impacts occur at direct suppliers, or at more remote supply chain locations, and;
- Which single input paths carry the largest impacts (through structural path analysis)

The latter information in particular is very helpful in informing organisational planning and priority-setting for action towards financial, social, and environmental sustainability. The results show whether addressing proximate impacts from the company or from direct suppliers reaps more, or less, benefits than addressing more distant supply-chain impacts, e.g. through procurement decisions.

4.5 Conclusions

The methodology and the tool described in this work were developed to address a lack of accurate quantification and comparability of impacts in corporate sustainability reporting. We are able to allocate TBL loadings amongst the actors of economic chains, including all producers and consumers of commodities, in a mutually exclusive and collectively exhaustive way without double-counting impacts. As a result, we introduce the concept of shared-responsibility to the overarching theme of corporate responsibility and demonstrate its applicability with practical examples.

The main differences between the principle of shared-responsibility and that of either full-producer or full-consumer responsibility are:

- In contrast to full producer responsibility, in shared responsibility every member of the supply-chain is affected by their up-stream supplier and in turn affects their down-stream recipient. Hence it is in all actors' interest to enter into a dialogue about what to do to improve supply-chain performance. There is no incentive for such a dialogue in full-producer responsibility. In shared-responsibility, producers are not alone in addressing the issue of TBL impacts, because their downstream customers play a role, too.
- In contrast to full-consumer responsibility, shared-responsibility provides an incentive for producers and consumers to enter into a dialogue about what to do to improve the profile of consumer products. It gives consumers information about where the impacts occur that are embodied in the products they buy.

It is important to harmonise this analytical approach and its strengths of integration and lack of boundaries with international approaches which are rapidly gaining headway such as the 'Global Reporting Initiative' and the 'Equator Principles'.

These approaches have widespread support through many globalised companies and national governments. However, they are currently orientated to a 'within the factory fence' approach, and do acknowledge a number of higher-order issues such as the origin of water and energy, and the labour practices used to supply intermediate inputs to production. Part of the harmonisation process will require the development of indicator datasets that match the requirements of these initiatives, and collaborating in the development of international software tools that enable the fluent use of whole economy accounting without boundaries.

The approach which has been presented answers the research question posed at the beginning. It is science-based, consistent, and robust. It uses regularly published and publicly available National Accounts data. It ensures that the real bottom-line is quantified, not a figure determined by an arbitrary cut-off point that could be different in different organisations. Reporting on the real bottom-line can deliver the full benefits of TBL reporting, including the ability to make comparisons within and between organisations; completely transparent communication of an organisation's impacts to all stakeholders; and detailed information across the whole supply-chain as a basis for strategic decision-making, e.g. environmental purchasing policies.

Numerate TBL accounting at the company-level highlights a number of key issues important to the sustainable development agenda. In particular, if all up-stream impacts stemming from a web of supply-chains are taken into account, new insights and useful information for corporate decision-making can be gained. The TBL accounting framework presented in this work increases abatement options, enables meaningful benchmarking, avoids loopholes in reporting, and provides information about real risk.

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Chapter 5
Life-Cycle Based Sustainability Assessment of Products

Walter Klöpffer and Isa Renner

Abstract Sustainability was adopted by United Nations Environment Programme (UNEP) in Rio de Janiero as the main political goal for the future development of humankind. It should also be the ultimate aim of product development. According to the well-known interpretation of the original definition given in the Brundtland Report, sustainability comprises three components: environment, economy, and social aspects. These components or 'pillars' of sustainability have to be properly assessed and balanced if a new product is to be designed or an existing one be improved.

Depending on the systems to be improved, in the sense of better sustainability, and to the audience(s), i.e. actors or stakeholders, different scientific and practical approaches are being developed. There are notably two directions which can be distinguished: one based on accounting (*Environmental Accounting* and *Environmental Management Accounting*—EMA) and another one based on the *Life-Cycle Assessment* (LCA) of products. In this article, the latter approach is described in the hope of improving the mutual understanding of the two communities and their assessment/accounting tools. The responsibility of the researchers involved in the assessment of sustainability is to provide appropriate, reliable, and up-to-date instruments. For the environmental part, there is already an internationally standardised tool: *Life-Cycle Assessment* (LCA). *Life-Cycle Costing* (LCC) is the logical counterpart of LCA for the economic assessment. LCC surpasses the purely economic accounting and cost calculation by taking into account the use- and end-of-life phases and hidden costs. For this component, a guideline is being developed by The Society of Environmental Toxicology and Chemistry (SETAC). It is a very important point that different life-cycle based methods (including *Social Life-Cycle Assessment* 'SLCA') for sustainability assessment use consistent system boundaries.

SLCA has been neglected in the past, mainly due to great methodological difficulties, but is now beginning to be developed. The central problems seem to be

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how to relate the social indicators (social impact assessment) quantitatively to the functional unit of the product-system, and how to restrict to a manageable number the many social indicators proposed. Furthermore, a better regional resolution of the *Life-Cycle Inventory*, compared to conventional LCA, has to be achieved since the social conditions vary geographically much more than, the core element of LCA industrial production.

5.1 Introduction

The sustainable development of humankind (Section 5.2) has to embrace all kinds of human activities, including the manufacture, use- and disposal of products. To achieve this important goal, many human structures and processes have to be improved or replaced and this improvement has to be measured. Different methods have to be compared and the progress—if any—has to be documented as quantitatively as possible. Why is this necessary? The main reason is to make sure that we are going in the right direction. Another one is, given the limited amount of capital available, to make the best use of it in developing new sustainable industries and products.

Depending on the human activities, structures, products, management systems and the angle under which we are assessing and finally the improvement (this has been called 'attribution' by Heijungs 2001), different methods have to be and are being developed. One group of methods is the economic tradition of accounting and *Environmental Accounting* and *Environmental Management Accounting* (EMA, see previous books of this series Bennett et al., 2002, 2003; Rikhardsson et al., 2005; Schaltegger et al., 2006) and the programmatic survey by Burritt et al., (2003). The second group of methods is based on life-cycle (*cradle-to-grave*) thinking (SETAC 1993). Life-cycle based sustainability assessment of product systems is considered here as an extension of Life-Cycle Assessment (LCA). It deals with the comparative assessment of goods and services (products). Problems connected with macroeconomic systems are avoided. This is in-line with the original definition and use of LCA as a comparative method of environmental product assessment (ISO 1997; SETAC 1993).

It was decided at the first *Society of Environmental Toxicology and Chemistry* (SETAC) *Europe LCA Symposium* in Leiden, December 1991, which the acronym LCA stands (silently) for environmental *Life-Cycle Assessment*. It was clear from the beginning, however, that a full sustainability assessment would require at least two further dimensions, the social and the economic. The problem of the missing dimensions finally surfaced again, about 15 years and two UNEP world conferences later. The problem is now how to complement LCA in such a way that the economic and the social dimensions are compatible with the environmental.

In the following, sustainability assessment will be treated from the life-cycle perspective in the hope that the environmental accounting community will recognise some potential synergies and common goals as well as problems (allocation, data quality, system boundaries etc.,). Potential links to EMA will be mentioned where appropriate. It is curious to note that the hiatus between monetary and physical assessment (Burritt et al., 2003) can be recognised in the world of life-cycle thinking and is widely discussed. It is the belief of the authors that environmental (not financial) effects are better described in physical terms, although a monetary quantification is possible in relatively simple, i.e. short-term cause-effect chains and economic end-points.

5.2 Sustainable Products

5.2.1 What Is Sustainability?

In German-speaking countries, there is a strong inclination toward the forests. Therefore, the definition of *Nachhaltigkeit* (sustainability) starts with the good practice of cultivating forests. This means that only as much wood is removed from the forests as will grow and restore to previous levels in the long-run. Cultivation and care are the prerequisites of sustainable forestry. Over-exploitation is the main enemy. The most influential pioneering book in this field—*Sylvicultura Oeconomica*—was written by Hans-Carl von Carlowitz in the German language (Carlowitz 1713). The author was not a forester but the superintendent of the Saxonian silver mines, a senior manager in modern language. In his position, he required a substantial amount of timber and noticed that the forests in Germany were badly depleted. Forestry was the life-long hobby of Carlowitz. Put in modern language he even recognised the relationship of environmental, economic, and social factors and may therefore be considered a pioneer of sustainability.

In modern times, *sustainability* surfaced as a term related to global development (Brundtland 1987). The famous definition of sustainable development in the report—'[s]ustainable development is development that meets the needs of present without compromising the ability of future generations to meet their own needs' (Brundtland 1987)—points to the responsibility humankind has toward future generations. Although this claim is somewhat vague and not easy to operationalise, it is well-accepted in environmental politics.

5.2.2 Sustainability and the United Nations Environmental Programme

The *United Nations* reclaimed sustainability the guiding principle for the 21st century at the *World Conference* in Rio de Janeiro and promoted a concrete action plan, the *Agenda 21* (UNEP 1992). The confirmation, 10 years later at the follow-up conference in Johannesburg, introduced the life-cycle idea, perhaps not only LCA as a well-defined and standardised quantitative method but also qualitative life-cycle thinking and *Life-Cycle Management* (LCM).

The joint *UNEP/SETAC Life-Cycle Initiative* in Prague started in the same year of the Johannesburg conference (Töpfer 2002). This initiative aims at promoting global distribution and use of LCA and LCM and can be seen as an outcome—and partly also as incentive—of the high-level endeavours by the *United Nations*.

5.2.3 Quantification of Sustainability

Despite of all successes in the political arena there remains the need for quantification or operationalisation of sustainability. The standard model, which is well-accepted by industry and often called *triple-bottom-line*, is the 'three pillars' or 'three dimensions' of sustainability. It emphasises that environmental, economic, and social aspects have to be aligned with each other. This interpretation was known at the first SETAC Europe LCA symposium 1991 but this concept existed before. One of the first uses of three dimensions in a life-cycle method was *Produktlinienanalyse* (Ökoinstitut 1987). This *Product-Line Analysis* was a proto-LCA, i.e. a *Life-Cycle Assessment* before harmonisation of the different methods started around 1990 (Klöpffer 2006). It includes an impact assessment component with three (environmental) dimensions instead of one. This means the three pillars interpretation of sustainability is neither new, nor an invention of industry. It is, therefore, rather straightforward—not to say trivial—to propose the following scheme (5.1) for sustainability assessment (SustAss).

$$\text{SustAss} = \text{LCA} + \text{LCC} + \text{SLCA} \tag{5.1}$$

LCA is the environmental LCA (SETAC 1993; ISO 1997, 1998, 2000a, b, 2006a, b).
LCC is an LCA-type Life Cycle Costing (Hunkeler et al. 2007).
SLCA stands for societal LCA.

There are some prerequisites, however, which have to be fulfilled in using Equation 5.1: the most important prerequisite is that the system boundaries of the three assessments are consistent. This includes, of course, that in LCC the physical (as opposed to the marketing) life-cycle is used for the *Life-Cycle Inventory* (LCI) (ISO 1998, 2006b). The ideal solution would be the use of one identical LCI for all three components. We agree with Hunkeler (2006), however, that the societal LCI will be more demanding with regard to regional resolution compared to the environmental LCI.

The justification of life cycle based sustainability assessment methods (LCC and SLCA) is to allow trade-offs to be recognised or avoided (Klöpffer 2003). Life-cycle thinking is the prerequisite for any sound sustainability assessment. It does not make any sense at all to improve (environmentally, economically, socially) one part of the system in one country, in one step of the life-cycle or in one environmental compartment if this improvement has negative consequences for other parts of the system which may outweigh the advantages. Furthermore, the problems shall not be shifted into the future.

This last point, avoiding the shifting of problems into the future, is of paramount importance due to the request for inter-generational fairness (Brundtland 1987). Life-cycle thinking alone is not enough, however. To estimate the magnitude of the trade-offs, the instruments required have to be as quantitative as possible. Since we are living in a global economy, the system boundaries used in the methods have to be global. Also in this context, the UNEP/SETAC life-cycle initiative deserves a high-degree of attention and support (UNEP/SETAC 2006).

5.3 Status of Development

5.3.1 Life-Cycle Assessment

In the introduction of ISO 14040 (ISO 2006a), 'LCA addresses the environmental aspects and potential impacts (e.g. resource use and environmental consequences of releases) throughout a product life-cycle from material acquisition through production, use, and disposal (i.e. cradle-to-grave)'. This standard (ISO 1997, 2006a) defines LCA as the 'compilation and evaluation of the inputs, outputs and the potential impacts of a product system throughout its life cycle.'

LCA is the only internationally standardised environmental assessment method (ISO 1997, 1998, 2000a, b). The *historical* development of LCA since the proto-LCAs of the 1970s and 1980s has recently been summarised (Klöpffer 2006) with special emphasis on the role of SETAC in this process. The international standards have been slightly revised and updated (ISO 2006a, b; Finkbeiner et al., 2006); the revised standards superseded the old series used prior to October 2006. On the other hand, LCA is an active research field where further methodological developments are to be expected. A recent textbook on LCA summarises the development and provides an overview of the method and the most important applications (Baumann and Tillman 2004). The Dutch LCA guidelines can be considered as a comprehensive monograph based on the ISO series of LCA standards (Guinée 2002).

The basic principles of LCA which distinguish this method from other environmental assessment methods are:

- The analysis is conducted from cradle-to-grave.
- All mass- and energy-flows, resource- and land-use etc., and the potential impacts connected with these *interventions* are set in relation to a functional unit as a quantitative measure of the benefit of the system(s).
- LCA is essentially a comparative method (comparing the present state of the system to a future state).

In short, two, or more systems are compared to each other on the basis of a common benefit in a holistic way. The advantage (at least theoretical) of completeness is partly offset by the uncertainty about where and when processes, emissions, etc., occur, which ecosystems or how many humans may be harmed, whether or not thresholds of effects are really surpassed due to the emissions, or other effects which can be attributed to the system(s) studied. Furthermore, the magnitude of the functional unit is usually fixed arbitrarily in wide margins. For instance, the functional unit for comparing different containers for beverages may be the filling of 1,100 or 1,000 or more litres (but not one bottle or barrel!). As a consequence, the absolute amount of the interventions (i.e. emissions, use of resources) have no meaning and concentrations of emitted substances cannot be calculated. As a consequence proper risk assessment cannot be made. The additional use of other, often complimentary—albeit not standardised—methods (e.g. risk assessment, material- and substance-flow analysis) is therefore recommended to aid decision-making. It is difficult, however, to integrate such additional methods directly into LCA studies. This may be seen as a disadvantage but it is outweighed by the advantages of a standardised LCA, e.g. a clear structure. This structure goes back to a very similar scheme proposed by SETAC (1993) and now consists of the following four components (ISO 1997, 2006a):

- Goal and scope definition
- Inventory analysis
- Impact assessment
- Interpretation

If comparative assertions (system A is better than or equal to system B under environmental aspects) are part of an LCA and are intended to be made available to the public, a critical review is mandatory (ISO 1997, 2006a) according to the panel method (at least three reviewers). This and many other obstacles were built into the ISO-series of LCA standards to prevent the misuse, especially false public claims based on inadequate LCAs. As a consequence of these preventive measures, a full LCA becomes a lengthy procedure. Of course, the learning process, which is perhaps more important than applications in marketing, is more rewarding in a long and carefully conducted LCA study compared to a 'quick and dirty' one. On the other hand, during the design phase, the time limit makes simplified comparative methods more attractive (Hunt et al., 1998).

In *Design for environment*, a compromise has to be made between a reasonably comprehensive coverage of the life-cycle and the time needed for data collection and modelling. The actual calculation process is fast due to the elaborate LCA software now available. More and better data have recently become available (Frischknecht et al., 2005). It should also be noted that the standards are much more flexible and less demanding if the results are used internally. In this case, the critical review is optional and can be performed by a single internal or external expert instead of a panel (ISO 2006a, b). Weighing between results of different impact categories is allowed.

5.3.2 Life-Cycle Costing

The economic counterpart of LCA is known under several names, as *Life-Cycle Costing* (LCC), *Full-Cost Accounting* (FCA), *Total-Cost Assessment* (TCA) (White et al., 1996; Norris 2001; Shapiro 2001; Hunkeler and Rebitzer 2001; Hunkeler et al., 2007).

Conventional cost accounting of products also includes life-cycle aspects, since the costs of raw and intermediate materials enter into the calculation of the final product. However, costs involved in the use of products and in waste removal or recycling generally do not show up in cost accounting (with the exception that in special cases the producer may have to take back the product or pay for the waste collection, as in the case of the German *Green Dot* system of packaging recycling). Other main differences between conventional cost accounting and LCC consist in accounting for hidden or less tangible costs in LCC, including costs for environmental protection (White et al., 1996; Shapiro 2001). These costs are captured in conventional cost accounting, mostly in the form of overheads, but they are generally not attributed directly to a product. As in LCA, this clear attribution to a product system is important for assessment to estimate the true costs (LCC) or true environmental interventions (LCA) of the product (system) to be compared with another which fulfils the same function or has the same benefit. The basis of comparison in LCC is the same as in LCA, the functional unit.

White et al., (1996) define *Total-Cost Assessment* as the ‘long-term, comprehensive analysis of the full-range of internal costs and savings resulting from pollution prevention projects and other environmental projects undertaken by a firm.’ In this method, the economic benefits of pollution control measures are included whereas in conventional accounting only the costs of pollution prevention would be taken into account. This inclusion of positive trade-offs clearly indicates life-cycle thinking. The term life-cycle, however, is often defined in another way in the economic sciences, namely as the sequence of product development—production—marketing/sale—end of economic product live. As noted by Norris (2001), this economic life-cycle may be even shorter in some products than the physical life-cycle (cradle-to-grave) used in LCA.

In a further step, external costs due to environmental damages connected with the products may be included (White et al., 1996; Shapiro 2001). These costs are not incurred to the company, rather by society or even future generations. The quantification of these costs is difficult since it is often not clear what damages are—or will be—connected to the interventions caused by a product system. Short-term damages in a well-defined area might, at least at first sight, be calculated if a clear cause-effect chain can be established. This has been tried for the case of the much debated forest die-back in the 1980s. The result that the financial loss of the forest owners could be estimated but the loss in biodiversity and beauty could not. It can, therefore, be concluded that some damages (e.g. ethical and aesthetic) cannot be expressed in monetary terms or even the attempt to monetise sounds clearly repulsive (e.g. the inclusion of human life in such calculations).

LCC is older than LCA, but it is not yet standardised. It has great potential for extending the scope of LCA in the direction of sustainability assessment (Hunkeler and Rebitzer 2001; Klöpffer 2003; Norris 2001; Rebitzer 2002). A SETAC Europe working group prepared a manuscript for publication (Hunkeler et al., 2007). A short guideline, about the size of the *Sesimbra Code of Practice* (SETAC 1993) will be distilled out of the book and is expected to be ready for a final round of discussion at the next SETAC world congress in Sydney, 2008. The LCC guideline working group started in May 2006 during the *SETAC Europe Annual Meeting* in *The Hague* under the chairmanship of David Hunkeler. This LCA-type LCC is based on the physical life-cycle used in LCA and avoids the miniaturisation of externalities since this would mean a double-counting: environmental impacts are quantified in the *Life-Cycle Impact Assessment* (LCIA) component of LCA in physical units (ISO 2000a, 2006b).

It should be noted that LCC includes the use- and end-of-life phases (cradle-to-grave as LCA), so that the result cannot be approximated by the price of a product (cradle-to-factory gate or cradle-to-point of sale). LCC is an assessment method not an economic cost-accounting method. This does not mean that the two research communities cannot learn from each other (see Section 5.4).

5.3.3 Societal Life-Cycle Assessment

The *Societal Life-Cycle Assessment* (SLCA) is generally considered to be still in its infancy, although the idea is not new (Ökoinstitut 1987, O'Brian et al., 1996). Quite to the contrary, an astonishing increase in papers published and submitted for publication can be observed. Without going into details, we would like to summarise these papers as follows:

- Dreyer et al., (2006) aim at assessing the responsibility of the companies involved although the products are the point of reference. This necessarily gives more weight to the foreground activities and to the people involved.
- Labuschagne and Brent (2006) strive for completeness of the social indicators to be used in a social impact assessment.
- Weidema (2006) includes elements of *Cost Benefit Analysis* (CBA) and proposes *Quality Adjusted Life Years* (QALY) as the main measure of human health and well-being (a common end-point for toxic and social health impacts). Weidema holds the view that social impacts should be treated within LCA as a special section of impact assessment, i.e. a common inventory (LCI) would be required.
- Norris (2006) considers social and socio-economic impacts leading to bad health. *Life-Cycle Attribute Assessment* as a web-based instrument should complement classical life-cycle assessment methods.
- Hunkeler (2006) deals with the connection of societal indicators as functional units. This is a daunting task given the qualitative nature of societal indicators and the need for quantification in comparative assessments. A possible solution is now emerging; taking the working hours spent per functional unit as the link. Furthermore, regional income per hour and the number of working hours needed to satisfy important social needs (education, heath care etc.,) are used to quantify the different social development status of the regions. The higher regional resolution needed for the establishment of *Societal Life-Cycle Inventories* (SLCIs) will be a challenge for the LCA community. On the other hand, there are researchers claiming much better regional resolution in LCA/LCIA (Potting and Hauschild 2006).

Similar to the case of (environmental) LCA, it will not be possible to quantify all social impacts related to a product system. In LCA, the important impact category 'biodiversity' can hardly be quantified with a suitable indicator. The same is (still) true for invasive species which are probably a greater threat to the ecosystems than the chemical emissions. Finally, indicators will be chosen to assess a quantitative correlation with the functional unit. Indicators related to the work place (including agricultural and other 'open-air' places) will be preferred over indicators related to general political issues of a region or country.

5.4 Discussion

5.4.1 One Life-Cycle Assessment or Three?

There are two options to include the social aspects into a life-cycle based sustainability assessment. The first option corresponds to Equation 5.1 and is based on three separate life-cycle assessments with consistent, ideally, even identical system boundaries (Klöpffer 2003). A formal weighting between the three pillars, although possible, should not be performed. The main advantage of this approach is its transparency—no meaningless sustainability points. The attribution of advantages and disadvantages in comparative assessments is clear in this variant. There is no compensation between the three pillars. As a consequence, a favourable (economic) LCC result for a given product cannot outweigh less favourable or even bad results in (environmental) LCA and SLCA. Such an overweighing of the economic part would perpetuate the largely unsustainable status quo.

The second option can be written as Equation 5.2:

$$\begin{aligned}\text{SustAss} = \text{LCA (new) (including elements of LCC}\\ \text{and SLCA as additional impacts in LCIA)}\end{aligned} \tag{5.2}$$

Option 2 means that one LCI is followed by up to three impact assessments covering potential environmental, economic, and social impacts per functional unit of the product system studied. The advantage of option 2 would be that one and the same LCI has to be used for all three impact assessments, solving the system boundary problem. Such a solution seems preferred by Weidema (2006). Disregarding, for the moment, the danger of mixing up the three dimensions there remains the question whether or not option 2 is compatible with the ISO.

According to the revised framework ISO 14040, 'LCA addresses the environmental aspects and potential impacts … [and] LCA typically does not address the economic or social aspects of a product, but the life-cycle approach and methodologies described in this International Standard may be applied to these other aspects (ISO 2006a).' These statements favour, in our view, option one and future separate standardizations of LCC and SLCA would be a logical consequence. On the other hand, ISO 14040 and 14044 could be revised in the future and possibly accommodate economic and societal impact assessments within LCIA. Since this revision will certainly not start soon, we should use the time for discussing the best way to formalise sustainability assessment.

With regard to SLCA, more experience with the new indicators will be needed especially the best method to link them unambiguously to the functional unit of a product system. Selection and quantification of the most appropriate indicators per functional unit will be the main scientific problem regardless whether option 1 or 2 will be followed.

5.4.2 Links to Environmental Management Accounting

Methods based on accounting and methods based on life-cycle thinking/assessment ultimately aim at improving the environmental performance (and finally the sustainability) of industrial systems. There are great differences, however, with regard to the systems considered. The focus of the accounting methods seems to be the company level, especially the information needs of the management in compliance with the environmental laws and the costs involved. The life-cycle based methods mostly aim at the comparison of products including the use- and end-of-life phases, production processes, and clearly go beyond compliance. The company level is only involved via the responsibility of the producers for their products—the analysis (LCI) goes far beyond the individual production site and even with the inclusion of the supply-chains do not fully describe the systems.

There are nevertheless overlaps, most obviously with regard to the data needs. According to Burritt et al., (2003), two different approaches of Environmental Management Accounting (EMA) can be distinguished: Monetary Environmental Management Accounting (MEMA) and Physical Environmental Management Accounting (PEMA). The basis of this analysis is the fact that conventional accounting systems provide separate information about monetary and physical aspects of the company's activities. MEMA and PEMA can be seen as extensions of the conventional accounting, focusing on environmental issues. Information provided by MEMA is given in monetary units, whereas PEMA relies on physical units. Without going into details there seems to be a possible connection of LCC with MEMA and LCA with PEMA. Actually, eco-efficiency, environmental life-cycle costing, life-cycle inventories and LCAs of specific products are mentioned by Burritt et al., (2003) in the comprehensive framework of EMA proposed. This clearly shows there is an overlap between the two groups of methods which therefore should be considered as complimentary and serving different information needs. Data quality and exchangeability will play an important role in the common use of the collected data. Questions of units and system boundaries, allocation (e.g. to specific product systems) etc., may sound trivial, but they are not.

If a full sustainability accounting is strived for, similar difficulties will arise in the accounting community as observed in the world of life-cycle assessment. It seems to be much easier, however, to relate social indicators to companies when compared to functional units. The necessary data should be available since information about the working place, including salaries, data about health and accidents etc., should belong to the basic information in any company. It is important to note, however, that data about suppliers (worldwide) are important. The value added by the final assembler in the car-manufacturing is only about 20% of the total cost of the car. This problem can be considered as a special case of the system boundary problem which is extensively discussed in the life-cycle community.

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Chapter 6
Environmental Statements on the Internet—From a Mere EMAS Requirement to an On-line Environmental Communication Tool

Ralf Isenmann

Abstract The contribution describes an information management approach that elevates the orthodox "one size fits all" disclosure practice of environmental reports to a sophisticated digital stage, using environmental statements according to the European Union Eco-Management and Audit Scheme (EMAS) as an example. The information management approach is illustrated along three basic elements: (1) stakeholder analysis and information requirement analysis (representing information demand); (2) XML-based document engineering (modelling information supply); and (3) an IT-supported reporting system (cross-matching information supply and demand). As a result, environmental statements could be developed from universal documents on print media, and thus a mere EMAS requirement, to valuable environmental communication vehicles that provide substantial and reliable information in a tailored fashion and are available on various media—due to an underlying single source cross-media principle.

6.1 Introduction to Corporate Environmental Reporting

According to a recent contribution to corporate environmental reporting (Marshall and Brown 2005), it is merely a question of how to report on environmental issues, and no longer whether to report at all. Marshall and Brown (2005) argue that environmental reporting is becoming part of corporate' daily affairs, even entering the business mainstream. Regardless of nationality and differences in country results, this is true not only for organisations with environmental management systems in place, environmental pioneers, and sector leaders, but also for many global players and multinationals (Sustainability and UNEP 2002; Raar 2002; KPMG 2005). Furthermore, an increasing number of medium-sized and even small companies

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(European Commission 2002) whose activities result in high environmental impacts or are suspected of causing them (Remmert 2001; Clausen et al. 2001). Examples abound in the pharmaceuticals, chemicals, mining, transport, electronics, and automotive sectors (FEA 2001; Kolk 2004; Reddy 2005). Consequently, environmental reporting has competitive relevance (Fichter 1998) and strategic importance (Larsen 2000), at least in certain industries, and also for small and medium-sized enterprises.

Among the number of vehicles that companies are using to communicate environmental issues (Brophy and Starkey 1996) reports can be seen as the primary and leading instruments. Reports are playing a pivotal role because of their unique credibility and the reliability that stakeholders ascribe to them. This is perhaps also because they usually combine qualitative data providing descriptions with quantitative data offering facts and figures.

Due to their voluntary status in most countries and a lack of generally accepted standards over contents and structure different approaches of environmental reports are currently emerging. For example, the ACCA (2001) identified seven major types such as:

- Compliance-based environmental reports
- Toxic release inventory-based reports
- Eco-balance reports
- Performance-based environmental reports
- Product-focused environmental reports
- Environmental and social reports
- Sustainability reports as an integrated communication (triple-bottom-line)

The differences between these approaches depend, in part, on nationality, and the degree to which environmental issues are supplemented with social and financial issues.

Probably one of the approaches which is most applied in Europe—especially in German-speaking areas—are 'environmental statements' prepared according to the European Union Eco-Management and Audit Scheme (EMAS). Currently more than 5,000 sites are EMAS-registered (European Commission 2007). Environmental statements can be understood as environmental reports that fulfil the EMAS requirements and include a minimum of required content. Their overall structure is defined and standardised and is usually based on underlying environmental management accounting systems.

Despite the fact that the uptake of EMAS in many countries has not been a success the features above make environmental statements an excellent source. Therefore, they are regarded as offering a good starting point for moving towards integrated approaches such as sustainability reports as these assess a company's integrated performance (Schaltegger and Burritt 2000). For example, they address environmental aspects in monetary terms, and measure a company's impact on nature in physical terms (Burritt et al., 2002). Reports based on environmental management accounting systems serve as a solid basis for reliable information.

These underlying systems are needed to provide integrated performance indicators such as eco-efficiency.

6.2 Reporting Requirements According to EMAS

The European Union Eco-Management and Audit Scheme (EMAS) is a voluntary policy instrument and management tool which acknowledges organisations that improve their environmental performance on a continuous basis. EMAS-registered organisations are legally compliant run an environment management system, and evaluate and report on their environmental performance through the publication of an independently verified environmental statement. These publications are recognised by the EMAS logo which guarantees the reliability of the information provided (European Communities 2001).

EMAS was first implemented in 1993 and then revised in 2001. Since its early applications, EMAS has rapidly grown to a field of research with increasing relevance to companies, general public, and administration, even through the eyes of non-participants (Clausen et al., 2002). Through an environmental statement organisation communicates their environmental performance to interested parties, target groups, and other stakeholders. An environmental statement must include a number of detailed requirements specified in EMAS II Annex III, point 3.2. An environmental statement must include at least:

- a clear and unambiguous description of the organisation registering under EMAS and a summary of its activities, products, and services and its relationship to any parent organisations as appropriate
- the environmental policy and a brief description of the environmental management system of the organisation
- a description of the environmental objectives and targets in relation to the significant environmental aspects and impacts
- a summary of the data available on the performance of the organisation against its environmental objectives and targets with respect to its significant environmental impacts. The summary may include figures on pollutant emissions, waste generation, consumption of raw material, energy and water, noise as well as other aspects indicated in Annex VI. The data should allow for year-by-year comparison to assess the development of the environmental performance of the organisation
- a description of all the significant direct and indirect environmental aspects which result in significant environmental impacts of the organisation and an explanation of the nature of the impacts as related to these aspects (Annex VI)
- other factors regarding environmental performance including performance against legal provisions with respect to their significant impacts

- the name and accreditation number of the environmental verifier and the date of validation

6.3 Environmental Reporting Challenges from an Information Management Perspective

Environmental reporting is a multi-faceted and rapidly developing field influencing a company's communication strategy and image profile as well as its organisation, staff, accounting systems, and particularly its underlying information management and IT capabilities (Isenmann and Marx-Gómez 2004a). Despite certain difficulties with which companies are struggling at present there are three trends of strategic relevance for information management which face EMAS-registered organisations and environmental reporters today or at least in the near future (Isenmann 2004):

- Integration of financial and social issues into environmental reports
- Provision of reports on various media
- Fine-tuning reports according to users' needs and preferences and exactly meeting numerous standards, guidelines, and recommendations

Today, an orthodox disclosure practice which merely provides isolated environmental statements and stand-alone environmental reporting instruments on printed media does not seem sufficient. A substantial amount of information, matters of communication style, and the provision of tailored reporting instruments and customised communication vehicles on various media are required (Braun et al., 2001; Isenmann and Kim 2006). Further, environmental reporting is successful only if the underlying information management and accounting systems are appropriate.

6.4 Information Management Approach for Sophisticated Environmental Reporting

From a business information systems perspective an information management approach to sophisticated environmental reporting consists of at least three elements (Isenmann and Marx Gómez 2004b) (Fig. 6.1):

- Information demand: Stakeholder analysis and information requirement analysis
- Information supply: XML-based document engineering
- Cross matching: IT-supported reporting system

6.4.1 Information Demand: Stakeholder Analysis and Information Requirement Analysis

The starting point of any information management approach is a stakeholder analysis which identifies the primary users, and typically asks who are relevant stakeholders,

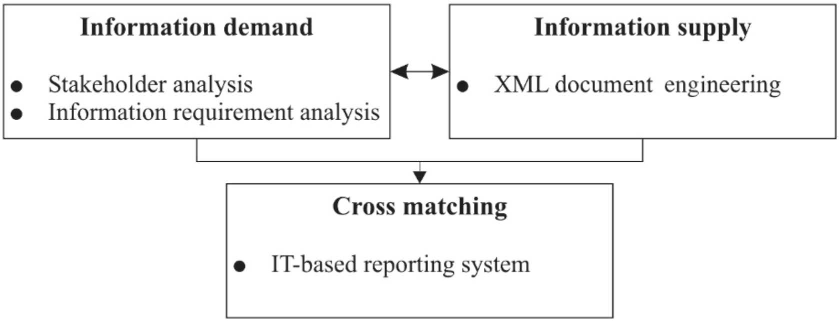


Fig. 6.1 Information management for sophisticated (environmental) online reporting

especially critical ones? Which key target groups inside and outside the company require information via environmental reporting? Generally, there are two ways of identification either a deductive approach, or an inductive approach combined with a deductive approach.

With the deductive approach all stakeholders could initially be considered relevant or called a target group who are involved in or affected by a company's environmental impacts and activities. Perhaps, as certain stakeholders claim some exclusive information rights, they may be seen as specific users (Lange et al., 2001). For example, this is true for senior managers who hold ultimate liability; local authorities who have a specific right to know, and also for banks and insurers who require confidential information. Regardless of information rights, it could be fruitful to address these groups as users in any case.

Despite its proven usefulness, the deductive approach should be combined with an inductive one for this task. Stakeholder analysis represents a company-specific task influenced by certain circumstances such as size, industry, products, processes, location, environmental impacts, stakeholder relations, communications strategy, environmental management, and strategic goals. Hence, an empirical analysis could validate the number of relevant stakeholders found through the deductive approach. According to Lenz (2003) the primary target groups interested in environmental reports can be arranged in a stakeholder map with four clusters:

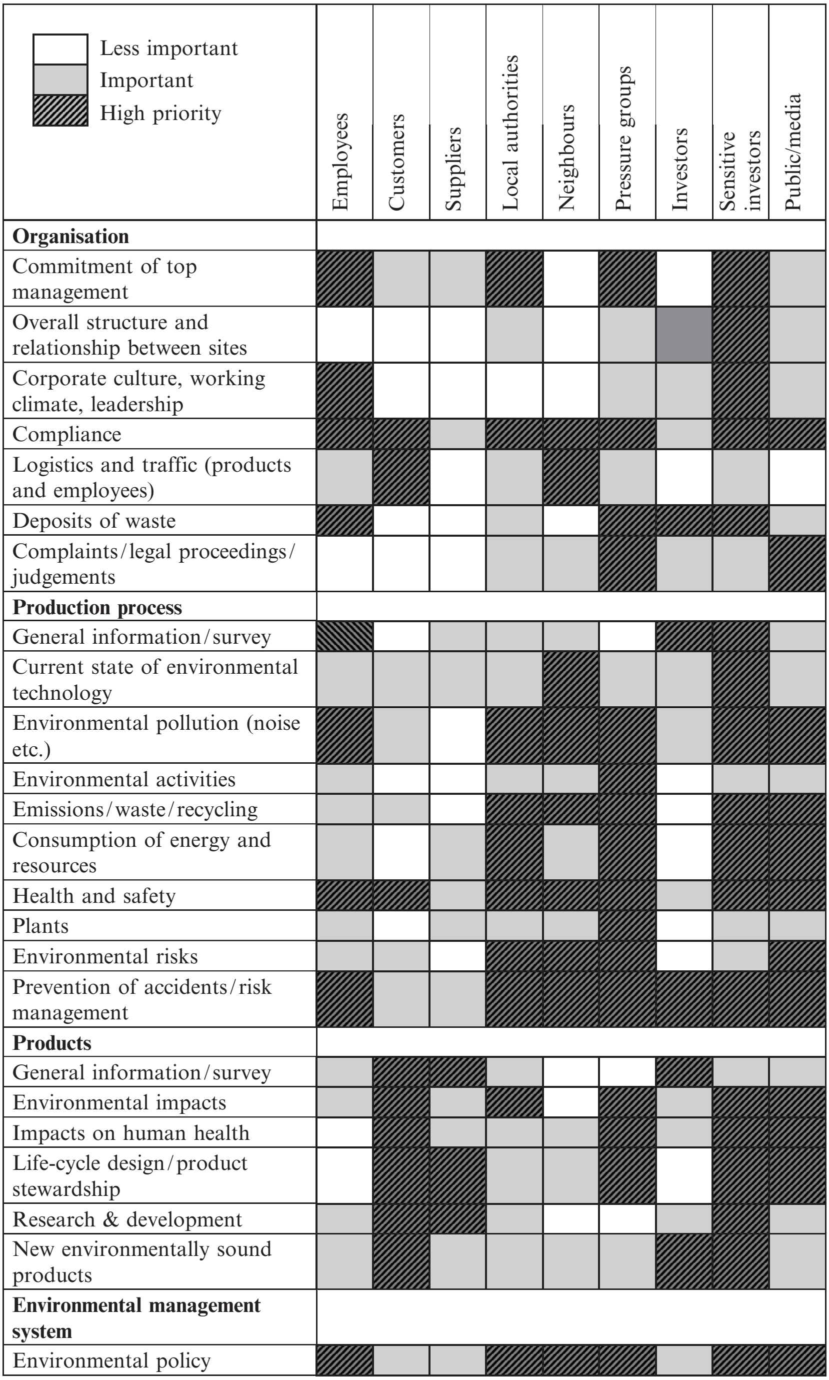
- Financial community, including investors, insurance agents, and financial analysts
- Business partners, including employees, customers, and suppliers
- Diffuse groups, including media representatives, neighbours, and consultants
- Normative groups, including local authorities, respective legislators, pressure groups, and standard-setting institutions

To some extent the users within a certain cluster have fairly homogeneous information needs. Following stakeholder analysis and identification of primary users a reporting organisation should study information needs and other preferences which are expected to be met in report form and content. Analysis of stakeholder information requirements is meant to determine relevant contents that target-groups expect and the preferences they require regarding form, layout, design, media, and distribution channel. There is consensus that meeting users' needs is needed for successful environmental reporting (e.g. EMAS II, Annex III, point 3.6).

In contrast to its wide acceptance in frameworks and guidelines, however, current practice shows another picture, with significant room for improvement for even the best reporters (Isenmann and Kim 2006). At present, little work has been done to conceptualise users' information needs especially concerning distribution channels, presentation styles, and media preferences (Azzone et al., 1997; van Dalen 1997). A considerable analysis of stakeholder information requirements may help to answer this need (Lenz 2003) (Fig. 6.2):

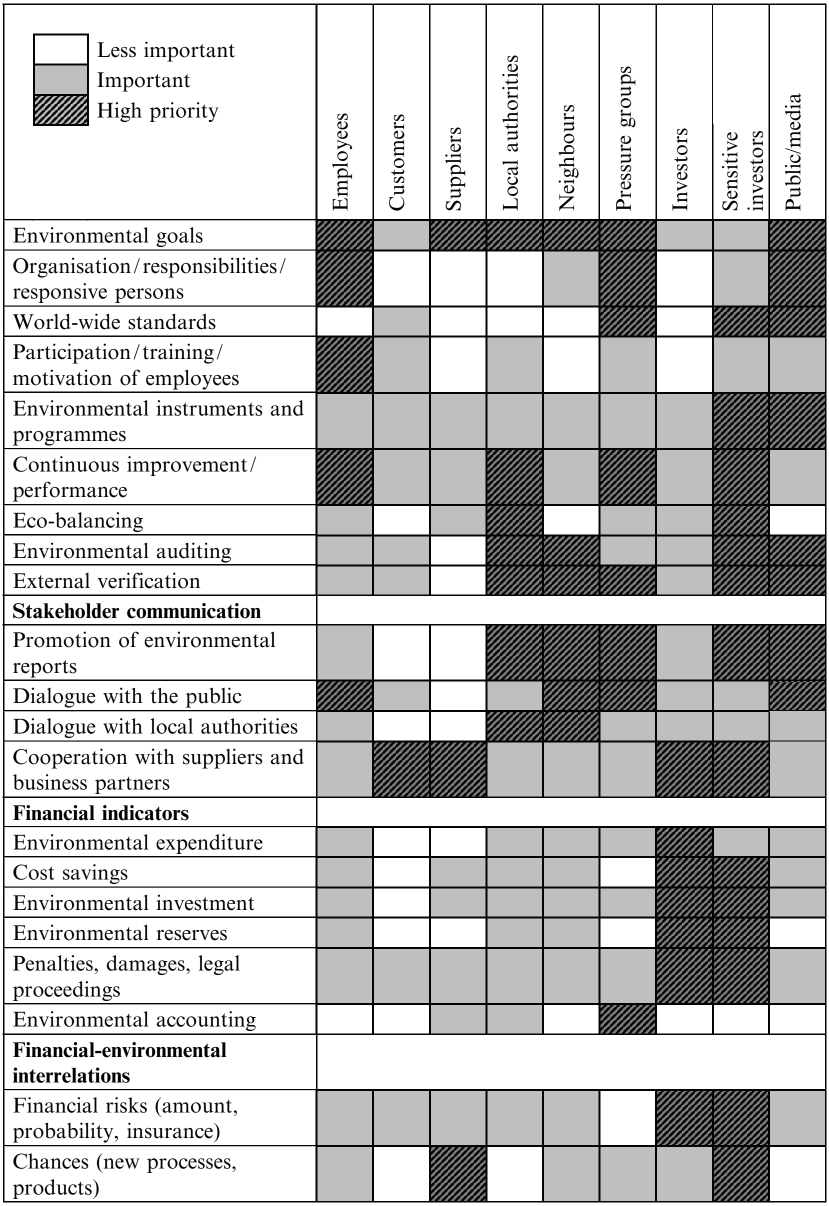
- For example, with growing general environmental awareness, *employees* are interested in the environmental performance of their employers and want to be informed about targets and activities related to the environmental management system. Further, they want to understand how companies are seen by local community groups. Employees wish to see their company as a going-concern, recognising that environmental performance might have some influence on this.
- In supply-chains and other manufacturing networks, *suppliers* exchange information with participating business partners. Establishing partnerships implies extensive environmental communication along the whole supply-chain or network. These groups need environmental information regarding resource efficiency, regulatory compliance, new product and service opportunities, especially in terms of extended product stewardship, and other environmental liabilities.
- *Investors*, including institutional and private shareholders, financial analysts and investment consultants are increasingly interested in environmental issues and their financial interrelations since they notice that environmental reports make good business and environmental sense (Australian Government 2003). A number of investors expect environmental performance to influence financial performance and shareholder value. For example, in November 2000, a group of 39 financial investors, managing combined assets in excess of $140 billion, sent a letter to CEOs of the 500 largest US companies urging them to provide sustainability reports (SocialFunds 2000).

Together, the analysis of stakeholder information requirements clearly demonstrates that employees, customers, suppliers, local authorities, legislators, neighbours, consultants, financial analysts, investors, insurance agents, media representatives and members of rating and ranking organisations have heterogeneous information needs. These different needs cannot be fully satisfied or easily met just by "reporting as usual" through orthodox practice, via one universal document (on print media), mostly produced as a "one size fits all" report. Users increasingly expect reporting instruments tailored to specific target-groups, individualised or even personalised. To identify their needs and preferences it is necessary to determine what target-groups want.



a

Fig. 6.2 Stakeholders' information needs for environmental reporting (Lenz 2003, p. 232)



b

Fig. 6.2 (continued)

6.4.2 Information Supply: XML-Based Document Engineering

The results of stakeholder analysis and deeper insights of stakeholder information requirements are used for document engineering indicating the IT-heavy area where contents, structures, procedures, and the design of reporting instruments and other communication vehicles are defined. This leads to the questions how should an advanced environmental report look? What content should be included? Who should be addressed? On what devices should the report be available? Which standards or guidelines need to be adhered to? Here, certain aspects of report structure, content, and layout are explicitly considered.

Computer scientists (Arndt and Günther 2000), IT experts (Glushko and McGrath 2005) and other reporting professionals (DiPiazza and Eccles 2002) propose the eXtensible Markup Language (XML) as the preferred data format for any advanced reporting approach. The suitability of XML is particularly based on the separation between contents (semantics), report structure (logical order), and representation (layout and style) (Fig. 6.3).

The core of XML-based document engineering is the development of XML schema. A schema defines the semantics and overall pool of contents in a basic structure for a certain group of documents; in this case for advanced environmental reports particularly those meeting the needs of EMAS. From this pool of structured contents tailored reports which exactly meet the requirements of certain users, user groups, or guidelines (including EMAS) can be prepared in an

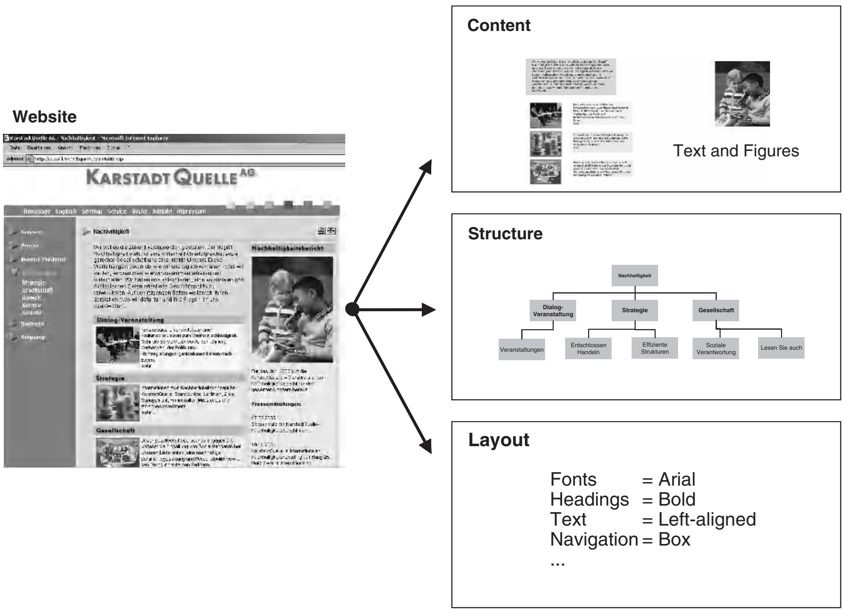


Fig. 6.3 Separation between content, structure, and layout of a report using XML

automated manner by machine processing. In terms of document engineering, a schema consists of several elements representing the contents and corresponding attributes specifying the semantics and indicating the elements. Consequently, a schema determines what elements can be used within a XML document. Further, a schema describes how elements can be arranged and which attributes certain elements may carry.

The development of a schema is a sophisticated task for which a sound methodology is needed (Brosowski et al., 2004). There are five major steps (Fig. 6.4):

1. Definition of the main target. The objective is to develop a schema for XML-based environmental reports which simultaneously incorporates a variety of issues and the requirements of relevant regulations, standards, guidelines and manuals especially at the European level (i.e. EMAS).
2. Identification of possible semantic components. Depending on the objective a multitude of resources need to be analysed to extract possible content from relevant regulations, standards, guidelines, already available reports and users' needs and preferences, e.g. the EMAS II, the international standard ISO 14001 on "environmental management systems" (DIN 1996), the German standard DIN 33922 "environmental reports for the public" (DIN 1997), the early international guideline on "company environmental reporting" (UNEP and SustainAbility 1994), its German counterpart "environmental reports—environmental statements" (future e.V. and IÖW 1994), and a publicly available specification (PAS) on "data exchange between enterprise resource planning (ERP) systems and environmental information systems" (Lang et al., 2003). This task identifies the pool of possible components the schema may contain. Further, for all resources taken into account the data types have to be identified and specified.
3. Selection of relevant components. From the pool of possible semantic components, a catalogue of 115 semantic components which are actually relevant, specified through certain data types, was identified (Fig. 6.5) and then arranged into a model (Fig. 6.6). Using the EMAS II requirements, 48 semantic components are needed to create an environmental statement. In addition, all data types for a certain semantic component have to be determined and analysed through a verification procedure in terms of redundancy. The result is a catalogue of relevant contents specified by data types.
4. Design of the schema: Based on the catalogue above, the schema has to be designed. Therefore, all selected components can be organised in a hierarchy which is typical for XML documents (see Fig. 6.5).
5. Implementation of the document type model: Finally, the schema needs to be implemented, i.e. noted according to XML and transformed into an XML Schema Definition (XSD), and documentation should be prepared.

Currently, this schema is blended into an already-existing XBRL Financial Reporting Taxonomies Architecture (FRTA 2005). This reference architecture for sustainability reports based on XBRL (eXtensible Business Reporting Language) will also meet the requirements of Global Reporting Initiative's G3 (GRI 2006),

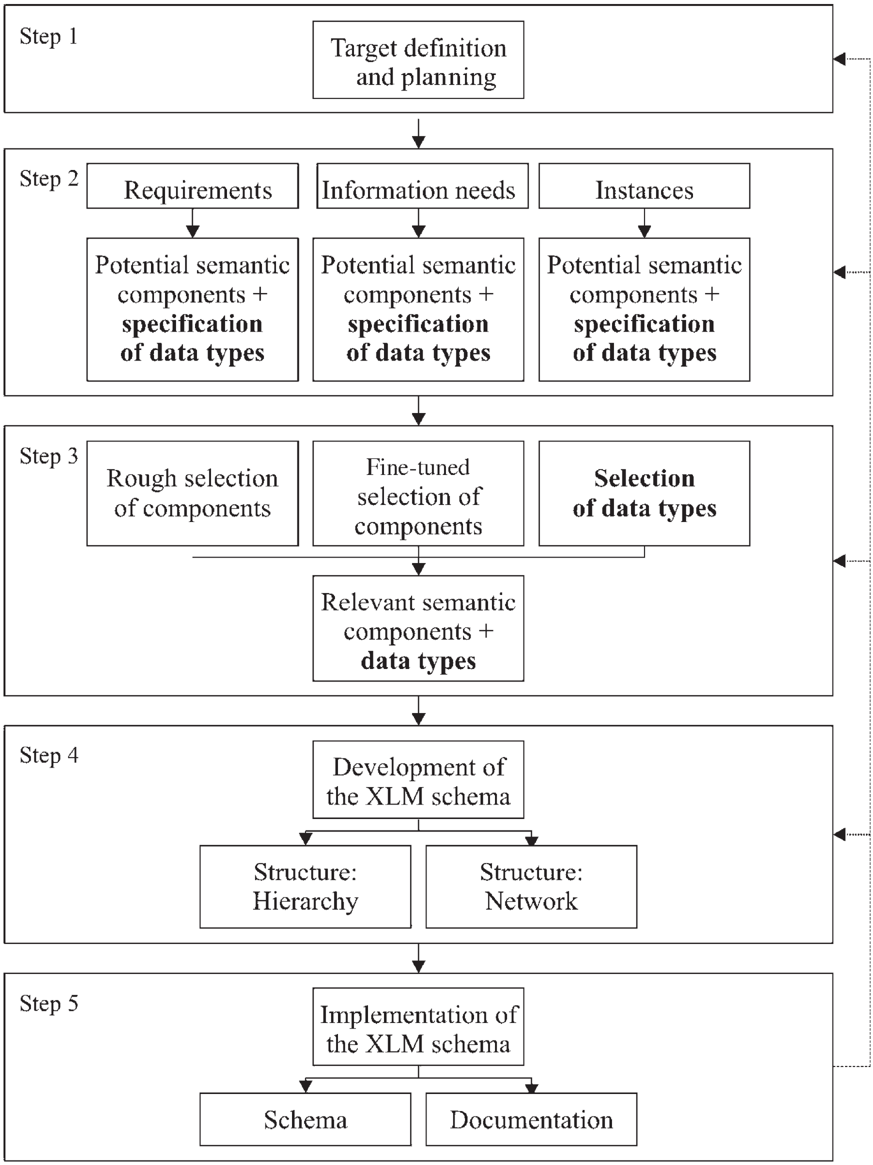


Fig. 6.4 Methodology for the development of XML schema

the third generation of GRI guidelines (Arndt et al., 2006) (Fig. 6.6). The development of XBRL has been primarily pushed by the American Institute for Certified Public Accountants (AICPA) and is intended to improve financial reporting in all its different procedures and processes, both inside and outside a reporting organisation. The XML schema "sustainability.xsd" is the core and represents the pivotal document of the sustainability reporting taxonomy. Any concepts of the GRI-Disclosure-Items

ID	Description	r/o	Source	Generic Identity
1	Foreword	o	Future 6.1, II	Foreword
2	Organisation	r	EMAS II, A III, 3.2	Organisation
3	Organisation description	o	Instances	Org Description
4	Corporate culture	o	Users	Corporate Culture
5	Relationship to parent organisation	o	EMAS II, A III, 3.2	Parent Org
6	Sites	o	Future 6.1, I	Sites
	…	…	…	...
98	Economic-environmental interdependences	o	Users	EconEnvInterdep
99	Financial risks	o	Users	Financial Risks
100	Financial chances	o	Users	Financial Chances
101	Formalities	r	EMAS II, A III, 3.2	Formalities
102	Imprint	o	Instances	Imprint
103	Publisher/author/originator	o	DIN 33922 , 5.6, instances	Author Originator
104	Publication Date	o	Instances	Publication Date
105	Reporting period	o	DIN 33922 , 5.6	Temporal Coverage
106	Date of next report	o	Future 6.1, X	Next Report
107	Responsibility and participation in env. rep.	o	Future 6.1, III	Report Team
108	Contact	o	DIN 33922 , 5.6	Contact
109	Verification	o	UNO 5, I, 11	Verification
110	Verifier name	r	EMAS II, A III, 3.2	Verifier Name
111	Verifier accreditation number	r	EMAS II, A III, 3.2	Verifier Accred No
112	Verifier address	o	DIN 33922 , 5.6	Verifier Address
113	Verifier statement	o	Future 6.1, X	Verifier Statement
114	Verification date	r	EMAS II, A III, 3.2	Verification Date
115	Additional information	o	Future 6.1, X	Additional Info

Fig. 6.5 115 relevant semantic components for environmental reports (extract)

are represented as XML-elements in this document as well as any *link base* references. Figure 6.6 and 6.7 provides an impression of the sustainability discoverable taxonomy set (Sustainability DTS) highlighting the various relations between link bases and taxonomy schema (XSD).

Fig. 6.6 Schema for advanced environmental reports, illustrated

The Global Reporting Initiative (GRI) is a non-governmental international organisation launched in 1997 as a joint initiative of the Coalition for Environmentally Responsible Economics (CERES) and the United Nations Environment Programme (UNEP). The goal of GRI is to enhance the quality, rigour, and utility of sustainability reporting particularly through the development of globally applicable guidelines. Despite the voluntary nature of its guidelines the GRI is proving itself to be a catalyst towards a standardised approach in the field and Morhardt (2002) therefore expects that "its guideline will become the *de facto* standard for sustainability reporting worldwide". Further, he concludes, organisations "almost cannot avoid meeting the GRI standard in any case" (Morhardt 2002).

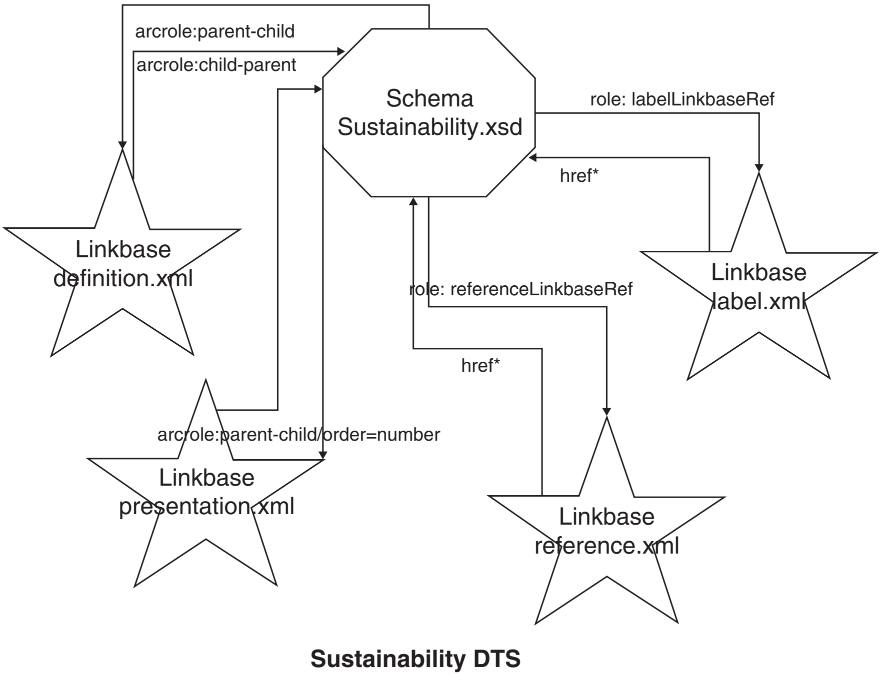


Fig. 6.7 Reference architecture for sustainability reports (Sustainability DTS)

Employing an XML schema offers an impressive array of benefits, improves a company's information management, supports its reporting workflow, allocates its resources efficiently, exactly meets requirements proposed by emerging guidelines, and helps to communicate with target-groups in a meaningful way. This is achieved by providing interactivity, producing tailor-made reports, and facilitating stakeholder dialogue (Isenmann and Kim 2006). In total, on the basis of a schema, companies are enabled to provide integrated and customised environmental reports prepared by machine processing and generated in an automated manner.

6.4.3 Cross Matching: IT-Supported Reporting System

An IT-supported reporting system has to carry out the cross-matching between information supply and demand. A number of software tools are available for this such as doWEB Online Reporting and Analysis (doCOUNT Gmbh), Enablon Sustainable Development (enablon), Corporate Sustainability Management Software (Proventia Solutions), or SoFi (PE Europe GmbH). There is a need to define an environmental reporting system "that develops … disclosures in a *holistic* manner in *all* media" (based on Jones and Walton 1999, p. 416, own emphasis).

To meet this need, a promising IT-supported reporting system has been developed as a practical application (Isenmann et al., 2005). This development is a joint project embedded in and promoted through the technical committee and community "Informatics for Environmental Protection, Sustainable Development and Risk Management" of the German Society for Informatics (Isenmann et al., 2007). Currently, the reporting system is implemented as a software prototype using current internet technologies and services. At the heart of its IT architecture is *Cocoon*, a Java-based, modular-structured Open Source publishing framework, able to process XML schemas and transform and format XML documents. It is thus suitable to perform single-source cross-media reporting. Environmental reports *à la carte* are made possible, prepared by machine processing, and generated in an automated manner. The underlying IT architecture allows report content to be stored, retrieved, edited, updated, controlled, and output cross-media in a variety of ways (the single-source cross-media principle).

At present, a set of interfaces are being developed with the aim that report contents can be taken from accounting records or extracted from other information sources and IT systems such as Enterprise Resource Planning Systems (ERP) like mySAP and SAP R3, Environmental Information Systems (EIS) like Umberto, or Web Content Management Systems (WCM) like RedDot.

Applying the multitude of new opportunities that could be taken from the information management approach offers an array of benefits for upgrading environmental reporting generally and especially for the provision of environmental statements (Table 6.1). These benefits can be described in relation to seven objectives which environmental statements may fulfil (European Communities 2001).

Table 6.1 Support for the provision of environmental statements

Objectives	Benefits from internet support
Documentation	Ease of updating, multi-usability, exchangeability, comfortable retrieval, powerful search facilities, hypertext document structure
Information	Increasing relevance and value for decision-making, e.g. through customization, multi-usability of contents, availability in computer-based media
Communication	Opportunities for interactivity and dialogue instead of strict monologue and one-way-communication, e.g. through e-mail, chat, newsgroup, forum, on-line communities etc.
Innovation	Opportunities for learning mechanisms, stakeholder input, continuous exchange of ideas and knowledge, e.g. through on-line relationships with a number of key target-groups
Commitment	More transparency, e.g. through global access around the world and public availability usually without extra costs
Accountability	Incorporation of accounting and reporting despite different data sources and without media clashes
Public Relations	Transition to a "quasi public effort" of engaging and involving stakeholders, e.g. through feedback forms, stakeholder commentaries or on-line "challenger reports"

6.5 Conclusions

Numerous target-groups are no longer satisfied solely with environmental statements and other reporting instruments on print media or mere electronic duplicates. Environmental reporting is becoming increasingly relevant for decision-making and responding to multiple inquiries that a variety of stakeholder groups are making is time-consuming and costly (Axelrod 2000). Rather than endure these procedures companies are recognising the value of having a readily available information management system to provide the data needed. Pioneering companies have started, or will start to implement in the near future, internet-based applications. Verie Sandborg, Baxter International's manager of environmental health and safety requirements regards a good environmental or sustainability report as an excellent source for responding to formalised requests for environmental or sustainability information (Axelrod 2000). Many of the questions asked are already answered in meaningful reports.

Hence, it would be helpful to have a proper software tool supported through efficient information management. Users could extract the information they need from a publishing database and create an tailored report themselves, i.e. users could generate "reports à la carte" simply by selecting keywords, clicking on preferences in a menu, or choosing a certain guideline—perhaps creating an environmental statement according to EMAS or having a comprehensive sustainability report at one's fingertips.

An environmental statement could be an excellent source and is-therefore-regarded as a core element of a new corporate performance evaluation system (Perrini and Tencati 2006) including an integrated reporting approach such as sustainability reporting (GFEM and GFEA 2006) whether this is available on print media or posted on the world wide web:

- First, it provides a "true and fair view" (a reporting principle borrowed from financial reporting) as it guarantees the reliability of the information provided. Environmental statements are independently verified which for sustainability reporting is still an open question.
- Second, an environmental statement includes integrated performance indicators such as eco-efficiency. Such quantitative data are crucial to uncover and highlight the interrelations between environmental, social, and financial aspects. They are essential to make the integrated performance transparent and help conceptualise the "triple bottom line" (Elkington 1997), i.e. the core theme for corporate sustainability.

For example, a German company in the pharmaceutical industry (Weleda 2003) and a German public utility and transportation service (Heidelberger Versorgungs- und Verkehrsbetriebe GmbH 2005) are adopting this strategy. In doing so, they have integrated a validated environmental statement into their sustainability report.

Use and benefits of the information management approach are not restricted only to environmental disclosure practice and reporting methods. Due to its generic nature the approach provides guidance for any document-related reporting domain whether this is traditional isolated reporting like financial and social reporting or sustainability and Corporate Social Responsibility (CSR) reporting as emerging integrated examples.

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Chapter 7
Phenomenological Model of Cleaner Production

Zygfryd A. Nowak and Michal J. Cichy

Abstract This article covers the results of a research project concerning the phenomenological model of Cleaner Production (CP). The model presents trends, calculated as a function of time, that describe changes in environmental impacts per unit of production. The elaborated procedure of the model was verified with numeric data collected from Polish companies participating in the *Polish Cleaner Production Programme*. The model was verified for all companies participating in the programme (CP Companies) from the research group (the so called Overall Industry Model) and the Polish energy sector (exemplary Branch Model). The model can be used for benchmarking and formulating co' measurable environmental goals. Environmental performance of these CP Companies was also compared to analogous results achieved by the Polish industry (based on data published by the *Central Statistical Office of Poland*). The results showed that CP Companies reduced their negative environmental impacts quicker than Polish industry in general. This work was funded as a research project by the *Polish Ministry of Science and Information Society Technologies* in 2003–2005.

7.1 Introduction

The *World Cleaner Production Programme* was initiated by the *United Nations Environment Programme* (UNEP) in 1989 during the UNEP seminar in Warsaw (Nowak 1993, 1996, 2000). The well-known contemporary definition of Cleaner Production (CP)—the continuous application of an integrated, preventive environmental strategy to processes, products and services, to increase overall efficiency, and reduce

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risks to humans and the environment—was then introduced (UNEP 2006). Realisation of the CP strategy can also generate financial savings as a result of environmental costs reduction, e.g. by the reduction of environmental fees, reduced materials consumption or lower costs of waste management (Nowak 2001). Today, UNEP's CP programme is also known under the acronym SCP (*Sustainable Consumption and Production*) emphasising the essential consumption of sustainable development.

The Polish CP programme was initiated at the same UNEP seminar in Warsaw in 1989 (Nowak 1996, 2000). The Polish CP programme consisted of three parallel levels of implementation:

- Training and education to disseminate information on CP and organise CP Experts to deliver training in industry and education at universities
- Follow up activities to extend continual application of the CP strategy in companies and local governments participating in the CP programme
- Introduction of Voluntary Environmental Agreements Scheme based on CP strategy (CP EVA) with yearly environmental reporting

In 1995 the capacity building phase developed into CP EVA. Production and service companies and local governments can participate in the scheme voluntarily by obliging themselves to continual reduction of their negative environmental impacts per unit of production (focusing on preventive techniques in accordance with the UNEP definition of CP). These organisations, called CP Companies or CP Local Governments, voluntarily introduce a mission of continual (year-by-year) environmental improvement and follow the so-called dynamic approach in environmental protection (Nowak 1993; Nowak et al., 2005; second section of this article). On the basis of this approach yearly environmental reporting of CP Companies has been introduced with a verification process conducted by experts from the *Polish Cleaner Production Centre* (Polish CP Centre in Katowice is the co-ordinating body of the Polish CP Programme).

The CP EVA scheme can be applied as an environmental management system (EMS) itself according to the procedures of EMS implementation developed by the Polish CP programme. Or it might be a good preparation for further standardisation work like ISO 14001 or EMAS (however, they are much more expensive and more formal than CP EVA).

To secure continuity and get appropriate marketing for the CP strategy the Polish CP programme changed the name to The Polish CP movement and was registered in 1999 as an association called The Polish Cleaner Production Movement Society.

7.2 The Dynamic Approach in Environmental Protection and the Dematerialisation Concept

The generic model of the dynamic approach in environmental protection is schematically shown in Fig. 7.1. It visualises the CP philosophy of continual improvement in production and service operations.

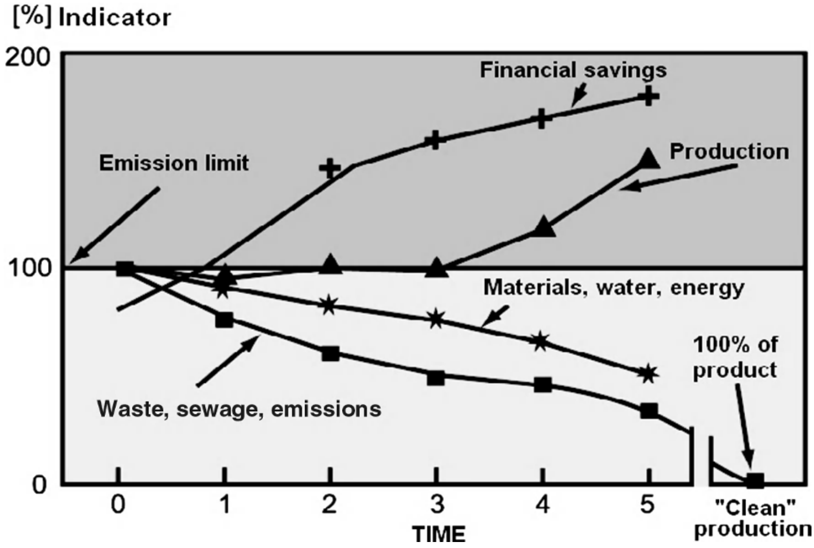

Fig. 7.1 Dynamic approach in environmental protection (Nowak 2001)

The idea of the dynamic approach is opposite to the so-called static approach which stands for passively meeting the legal requirements concerning environmental issues (emission limits).

The dynamic approach assumes improvement by continual reduction of negative environmental impacts—both on the input (use of materials, water and energy) and output (production of waste, sewage, emissions). It enables practical introduction of the dematerialisation concept into production processes (Schmidt-Bleek 1998; Nowak 2001; Nowak et al., 2005).

The driving force for continual improvement is the constitutional obligation of environmental protection pursuant to the principles of Sustainable Development from *The Constitution of the Republic of Poland* and the environmental law based on the *Constitution* and *European Union* (EU) regulations. Nevertheless, the dynamic approach can be undertaken by companies voluntarily as it assumes reaching lower environmental impacts than staying with the emission limits required by the law. Other drivers for this approach include economical savings from environmental improvements (an important argument for company directors starting environmental changes) and improved environmental image.

In Fig. 7.1, reductions of environmental impacts are measured in units of impact per unit of production (intensity indicators). Lines representing the intensity indicators of environmental impacts (waste production, emissions, etc.) are calculated as percentages of the base year ‘0’ (values in the base year = 100%). Production is also in percentages but its value is calculated as the change in the real value of the company’s turnover or group of products. This is shown on the chart to enable comparison of changes in production volume to changes in environmental impact intensities. Additionally, savings from environmental investments are included in Fig. 7.1 as the obvious benefit from CP. The accounting scheme for costs and benefits resulting from the application of the CP strategy contains the following elements:

- Reduced purchase of input material e.g. water, energy, raw materials, due to CP improvements
- Lower costs of waste and emission treatment and reduced costs of obligatory environmental fees and environmental fines
- Social costs, expressed in a qualitative (descriptive) manner, if possible

The long-term goal of the dynamic approach is to move as close as possible to a theoretical point in which all input materials are converted into product—e.g. through recycling to achieve closed material cycles with no waste (Nowak 2001; Nowak et al., 2005). This approach is the essence and aim of today's industrial ecology. In view of the present scientific knowledge and the requirements of industrial processes it is unlikely that the 'zero waste' point can be reached at this stage. Nevertheless, the zero point, shown in Fig. 7.1 shows the direction and target to reduce environmental impacts to an absolute minimum.

The dynamic approach is beneficial to any entity using the preventive strategy of CP. This approach forms the basis for creating the phenomenological CP Model described in this chapter.

7.3 The Polish CP Environmental Voluntary Agreements Scheme

The CP EVA scheme was created in 1995. After the first 6 years of training and case/demo implementations (1990–1995) the Polish CP programme established a procedure enabling Polish companies to voluntarily participate in the scheme which today consists of (Cichy and Nowak 2002; Nowak et al., 2005; Nowak 2000, 2001):

- Reporting a company's environmental performance and presenting the prognosis for the next 3 years—which are measurable goals to be voluntarily met in this period of time (according to a unified CP Environmental Report format). The reported environmental implementations, current performance, and objectives are subject to external verification in terms of reliability and adequacy provided by experts from the Polish CP programme.
- CP Company's Certificate (temporary CP Certificate)—companies participating in the scheme must meet all requirements including the application of CP in the company's EMS and initial verification of reported data. Laureates of the Certificate are allowed to use the CP logo in their marketing. They are included in the publicly available "Book of CP Companies" and have priority status for gaining financial resources for environmental investments e.g. from environmental funds. 230 Polish companies have been included in the Book until 2006.
- Formal verification of meeting measurable goals and implementation of planned environmental investments as well as meeting all legal requirements concerning

environmental protection. CP Companies should apply for their verification within 3 years of receiving the temporary CP Certificate.

- Statement of the candidate for the Register to comply with the United Nations' Global Compact declaration.
- Register verified companies in the official Polish Register of Cleaner Production and Responsible Entrepreneurship (PRCP&RE) which is a formal environmental body with a High-Level Jury. The jury consists of representatives from the Polish government, intermediary organisations (NGOs, governmental agencies, etc.,) and Polish industry (presidents of companies who became the so-called CP Leaders—laureates of the annual prize of the Polish CP programme for the most active CP Companies). Laureates of PRCP&RE retain all privileges accompanied with the temporary CP Certificate which is then replaced by the Diploma of Acknowledgement for Implementation of CP as a strategy of Environmental Management System—see Fig. 7.2. Seventy-five Polish companies have been registered until 2006.
- Continual annual reporting of CP Companies' environmental performance including both historical data (meeting measurable goals) and prognoses for the next 3 years. The reporting, using the unified form of Environmental Report, is an obligatory condition of keeping the company in the Register.

A simplified procedure of the CP EVA scheme is shown in Fig. 7.3.

The form of *Environmental Report* that every participating company must complete and submit to the Polish CP Centre every year currently consists of:

- General information on the company (name, address, contact persons, main products, participation in environmental initiatives, etc.)
- Current environmental policy
- List of environmental investments which have been finalised or commenced last year with a one-page short description of each improvement and its results
- Numeric data from at least 3 previous years and prognosis for the next 3 years

(a) Environmental data with separate sections on:

- Waste management
- Water and sewage
- Energy consumption and production
- Emission to the air
- Other environmental impacts

(b) Economic data including:

- Production in monetary and physical units
- Environmental fees and fines
- Environmental investments
- Savings from environmental improvements
- Employment rate

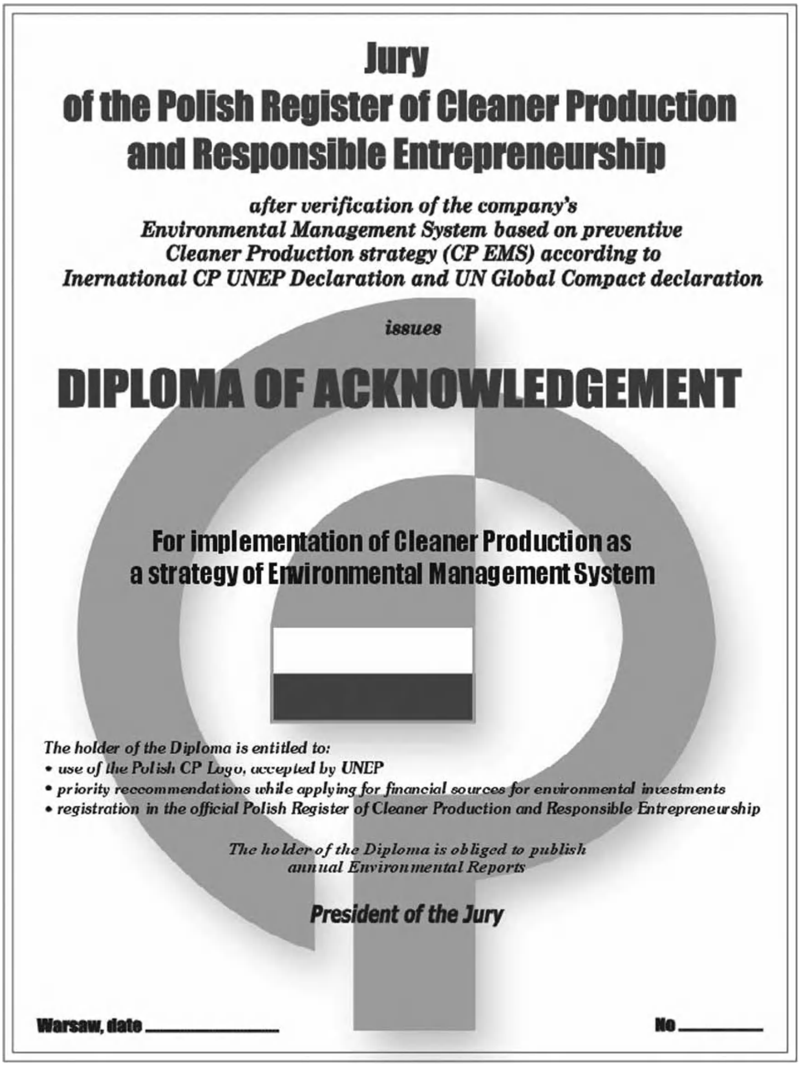

Fig. 7.2 Diploma of acknowledgement for the implementation of cleaner production as a strategy

- List of investments to be implemented in the near future and their expected results
- Questionnaire relating to meeting legal requirements
- Remarks and feedback section

System boundary of the report confines with the processes of the reporting company than the full life cycle of products (numeric data and indicators cover these processes). Nevertheless, the life-cycle thinking is present in CP Companies that undertake investments in not only manufacturing processes but also in supply (e.g. selection of materials and fuels), distribution and use (e.g. minimisation of losses during transportation, product and package improvement, possibilities of recycling).

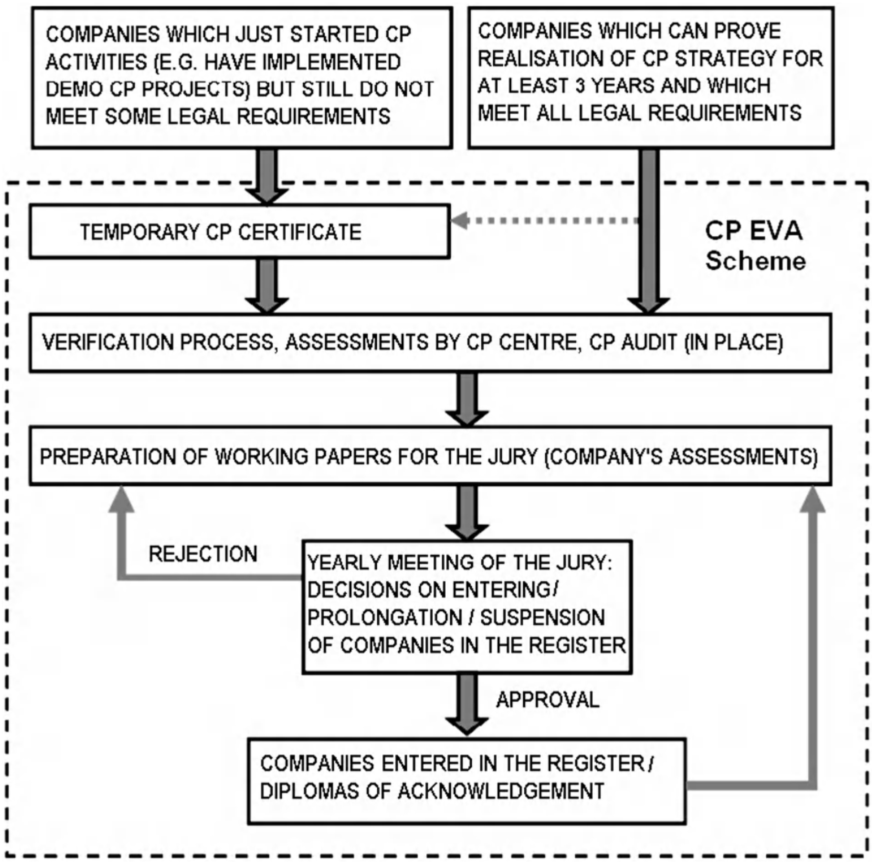

Fig. 7.3 Procedure of the Polish CP EVA (Nowak et al. 2005)

The Environmental Report is a summary of CP Company's internal environmental accounting results and the basis for environmental performance assessment (mentioned in Fig. 7.3) which is managed by the Polish CP Centre. An important part of CP Companies' environmental performance assessment is testing the compliance of the performance with the dynamic approach. Exemplary results of such an analysis (with only a few selected aggregated indicators) prepared for one of CP Companies are presented in Fig. 7.4.

Analogously to what was discussed in Chapter 2 of this article while describing the dynamic approach idea the top line shows the dynamics of sold production (turnover in monetary units). Other lines show the intensities of particular environmental impacts (per unit of sold production). Columns show financial savings from environmental improvements (cumulated as a function of time). Taking monetary values of production has the disadvantage of not differentiating the effects of inflation from market changes. But so far, it has been the only way of comparing different branches of industry and various products; taking into account

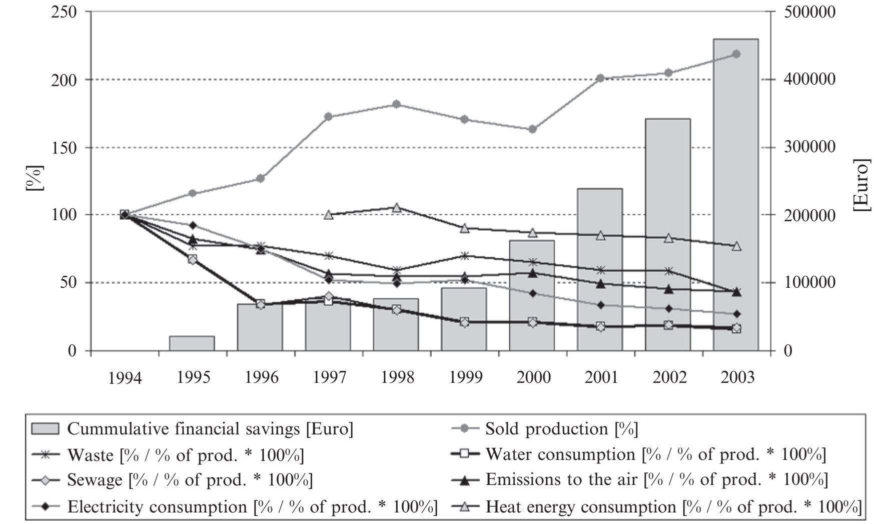

Fig. 7.4 Exemplary analysis of compliance of a company's environmental performance with the dynamic approach to environmental protection

data reported by CP companies. For similar products physical values can be taken. The problem of price changes in time was taken into account in the research presented in Section 7.4.

A large project team has been involved in this activity for many years; in the creation and continuous improvement of the CP EVA Scheme and CP Companies' environmental performance assessment methods, and format of reporting and collection of the CP Companies' data. Such analyses as shown in Fig. 7.4 was prepared for 230 CP Companies participating in the CP EVA scheme. Nevertheless, no prior comprehensive collective review and assessment of CP Companies' environmental performance was made. No common approximate trends were calculated (showing the phenomenological form of the system) which would show the benefits to be gained from the CP strategy planning. This gap has been filled by the research presented in the next section.

7.4 Phenomenological Analysis of the CP Eva Scheme

7.4.1 Goals of the Research

The main goal of the research was to build a phenomenological, functional model of CP. Its verification is based on data collected from Polish CP Companies participating in CP EVA. Specific goals include:

- Creation of the model
- Verification of the model on the basis of data collected from all CP Companies selected for the research (Overall Industry Model) and from a selected group of CP Companies representing one branch of industry (exemplary Branch Model)
- Comparison of CP Companies' environmental performance and analogous results of the Polish industry in general

7.4.2 Collected Data Used in the Research

The data were collected on 230 CP Companies participating in CP EVA using forms of annual *Environmental Reports* (CP Reports 1996–2003). To meet the requirements of statistical analysis 79 companies with the longest reporting histories were selected. The time period of the research was set for 1994–2003 taking into account the availability of data.

The following data were used:

- Environmental data:

  Aggregated on:

  – Overall production of waste [Mg]
  – Overall water consumption [m^3]
  – Overall wastewater discharge [m^3]
  – Overall electricity consumption [MWh]
  – Overall heat energy consumption [GJ]
  – Overall emissions to the air excluding CO_2 [Mg]

  Data on specific emissions to the air of the following substances:

  – CO_2 [Mg]
  – CO [Mg]
  – NOX [Mg]
  – SO_2 [Mg]
  – Dust [Mg]

- Economic data:

  – Sold production [in Polish Zlotys—PLZ]
  – Net profit [PLZ]
  – Added value [PLZ]
  – Cumulated financial savings from environmental improvements [PLZ]
  – Production amount (in physical units [Mg], [m^3], [MWh], etc.)

The Polish *Zloty*, PLZ was converted to Euros using the exchange rate of 1 Euro = 4 PLZ.

7.4.3 Environmental Indicators Used in the Model

The scheme for creating environmental indicators used in the research is presented in Fig. 7.5.

An Intensity Indicator (*II*) was chosen for the construction of the model. The indicator compares environmental data to the scale of production and thereby satisfies the dynamic approach assumptions (described in Chapter 2 of this article)—see Equation 7.1.

$$II_i = \frac{SEI_i}{BV_i}, \quad i = 1, 2, \ldots, n \tag{7.1}$$

where

i—number of a calendar year (e.g. 1994)
II_i—Intensity Indicator's value in year "i"
SEI_i—Scale of Environmental Impact (e.g. 1,000 m^3 of water used) in year "i"
BV_i—Base Value, showing scale of production (e.g. 15,000 PLZ of sold production or 4,000 Mg of products) in year "i"

All available economic data were considered as potential base values (*BV*) for the indicator (*II*). The value of sold production was selected as *BV*. Crucial for the decision was the universality and comparability of monetary units while making common research on companies with diverse production or representing different branches of industry (products expressed in different units). Another important factor was data availability.

To eliminate the effect of inflation production values were deflated for particular branches of industry using published annually by the *Central Statistical Office of Poland*—CSO (Official Polish name: *Glowny Urzad Statystyczny*—GUS). After this adjustment production values were expressed in constant prices.

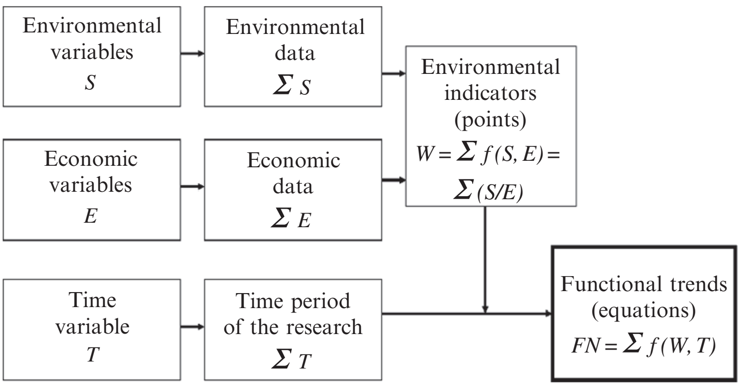

Fig. 7.5 Scheme for creating environmental indicators in the research

7.4.4 Procedure of Model Building

The procedure for calculating the functional form of the model is presented in Fig. 7.6. The procedure has to be run separately for each environmental impact (water, waste, electricity, etc.,).

Based on environmental data (particular impact values—*SEI*) and economic data (corrected sold production—*BV*) Intensity Indicators (*II*) are calculated (for particular companies in particular years). Next, descriptive statistics are calculated for data from particular years (quartiles, amongst others). Then distribution fitting of all indicator values is tested. If the distribution is normal the data can be input directly into linear regression. If the data is not normally distributed all indicator values must be transformed mathematically to normal distribution (e.g. logarithmic transformation if the distribution is log-normal or exponential). After the transformation has been made two previous steps (descriptive statistics, distribution fitting) must be repeated to verify the data normality.

The next steps are linear regression of all indicator values in function of time and linear regression of quartiles as a function of time. If the transformation mentioned

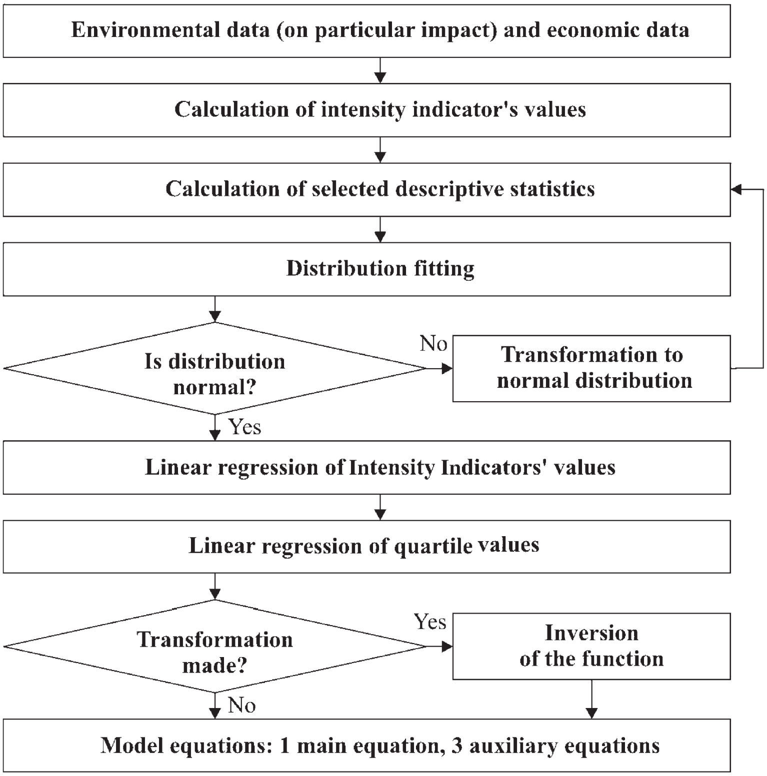

Fig. 7.6 Simplified procedure of the Phenomenological CP Model building

in the previous paragraph is not needed the obtained equations are the results of the model (for particular impacts). If the transformation has been made before then an inverse operation must be made to restore the input units of the indicators (e.g. if the transformation was logarithmic the obtained linear functions must be turned to exponential).

The final result for each environmental impact consists of two types of equations:

- One main equation—the result of linear regression for all indicator's values which shows approximate trend of its changes in time
- Three auxiliary equations—trends of quartiles which could be used as additional points of reference in benchmarking and planning of measurable environmental goals

7.4.5 Exemplary Result of the Model's Building Procedure and its Interpretation

Graphical presentation of the exemplary model equations (the procedure results)—for water use—is presented in Fig. 7.7. Results (equations) were also calculated for other environmental impacts mentioned in Section 7.4.2, both in terms of Overall Industry Model (based on data collected from all 79 CP Companies) and of exemplary Branch Model (data from 11 CP Companies from the Polish energy sector). As 11 environmental impacts were selected for the research (see Section 7.4.2) and two models were built (for all companies and for the energy sector), generally 22 analogous results were achieved—11 per model.

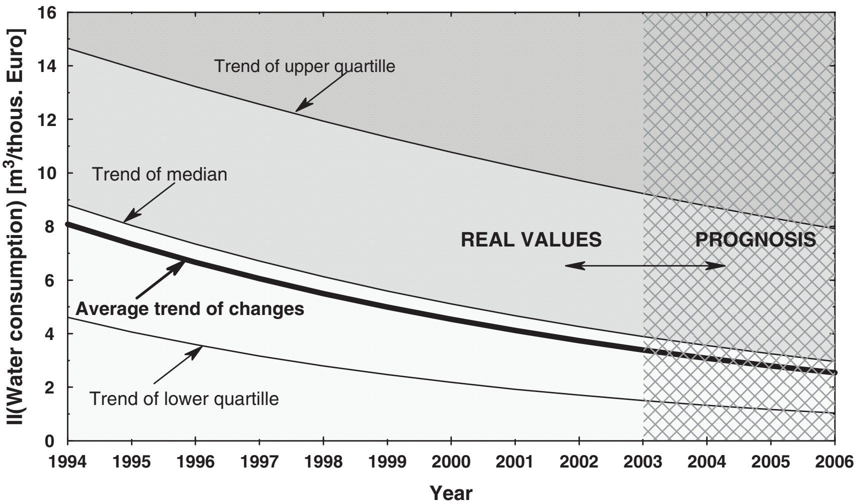

Fig. 7.7 Graphical presentation of CP Phenomenological Overall Industry Model, for water use

In Fig. 7.7, the Y-axis is the Intensity Indicator (*II*) for water consumption while the X-axis is time (1994–2006). The main equation is represented by the thick line. Trends of quartiles cut the whole chart into four areas marked with different shade patterns. The bottom area (the lightest one) contains about 25% of the best results (lowest indicator's values) in particular years. The top area (the darkest one) contains about 25% of the worst results (highest indicator's values) in particular years. The trend of the median divides the rest of the area into two parts (lighter and darker), containing about 25% of lower, and about 25% of higher results than the median's trend. The whole area is divided into two time-sections:

- Real values—calculated trends
- Prognosis—prolongation of calculated trends for the next few years

Figure 7.7 clearly shows that the analysed 79 CP Companies generally reduced their water consumption intensity from about 8 [m^3/thousand Euro] in 1994 to less than 4 [m^3/thousand Euro] in 2003. Furthermore, the analyses of other negative environmental impacts (i.e. waste, emissions, etc.,) show, in general, reductions in their intensities. Unfortunately, the statistical value of the achieved results are not significant because of the relatively small number of companies which could be admitted to the research (particularly in the case of the exemplary Branch Model, where only 11 companies were analysed).

The presented model is in the phenomenological form—it shows the recognised state (environmental results) with no analysis on the ways of achieving it. Nevertheless, additional analyses of implemented CP investments prove that the achieved environmental performance of CP Companies is the result of implementation of CP strategy and permanent realisation of many environmental improvements, in compliant with CP principles.

7.4.6 Possible Application of the Phenomenological CP Model

If a company calculates its own values for Intensity Indicators (*II*) and compares them with the Phenomenological CP Model results the comparison should show how far these results are from the average or from the best results of CP Companies. That is how the model can be used for benchmarking purposes. Both CP and non-CP Companies can recognise how their environmental performance compares to analogous average results of CP Companies. For many companies this would be a strong incentive to review and improve their processes—they could try to catch up with best-practices. It would be particularly useful in the case of Branch Models as companies from the same branch of industry usually have comparable production processes. For instance, many companies use much less water than the company in question—for comparable production processes—should encourage this company to improve, both for the environment and for financial savings.

The prognosis section would help a company establish future measurable environmental goals. For example, if a company's intensity of water use is much worse than the average trend of CP Companies the goal can be set on the level of the expected value of the model's main equation (prognosis) after, say, 3 years. That is how model equations could be used as a baseline for planning.

7.5 CP Intensity of the Polish Industry

No study comparing average achievements of Polish CP Companies to analogous results of the Polish industry in general has been previously conducted. To show differences between environmental results of those two groups an additional study was prepared based on empirical data from:

- CP Companies' Environmental Reports—79 CP Companies chosen for the research
- CSO publications—the Polish industry in general (CSO 1995–2004; CSO publishes aggregated data collected by a questionnaire sent each year to the companies most burdensome on the environment)

CSO publishes aggregated data (e.g. the amount of waste produced by companies in Poland or by all companies representing particular branches of industry). In this part of the research to achieve comparable results data collected from CP Companies were also aggregated (total waste produced by all CP Companies, total water usage, total production, etc.)—see Equation 7.2.

$$AII_i = \frac{\sum_{j=1}^{m} SEI_{i,j}}{\frac{ARII_i}{100} \sum_{j=1}^{m} SSP_{i.j}}; \; i = 1,2,...,n; \; j = 1,2,...,m \tag{7.2}$$

where:

i—number of the calendar year (e.g. 1994, 1995)
j—number of the company
AII_i—Aggregated Intensity Indicator's value in year "i"
SEI_{ij}—Scale of Environmental Impact (e.g. 1,000 m^3 of water used) for a company"j" in year "i"
$SSPj_{ij}$—Scale of Sold Production for a company no."j" in year "i" [PLZ]
$ARII_i$—Aggregated Rate of Inflation in Industry according to CSO in year "i" [%]

Because of significant differences in the structure of both groups—CP Companies and the Polish industry (e.g. different industry sectors represented)—it made no sense to compare values of the indicator which would lead to wrong conclusions (e.g. in the group of CP Companies there are many large companies from the energy sector with large scale production). The comparison was based on the dynamics of *AII* values as a function of time—see Equation 7.3. Values of *AII* in particular years are always compared to the same base year (the year '0', 1994).

$$DI_i = \frac{AII_i}{AII_0} \cdot 100 \ [\%]; \ i = 0, 1, \ldots, n \qquad (7.3)$$

Where:

i—number of the calendar year (e.g. 1994, 1995)
DI_i—Dynamics Indicator's value in year "i" [%]
AII_i—Aggregated Intensity Indicator's value in year "i"
AII_0—Aggregated Intensity Indicator's value in the base year "0"

Comparison of *DI* trends would show which group is quicker to reduce negative environmental impacts. Exemplary comparison—for water consumption—is presented in Fig. 7.8. In general, 20 such comparisons were made for particular environmental impacts using the method of linear regression (no comparison was made for heat-energy consumption due to a lack of data in CSO publications). The figure also shows the difference between *DI* indicator values calculated for CP Companies and the Polish industry, reached in the year 2003 starting from 1994: 22%.

Results of this study are summed in the following two tables:

- Table 7.1—79 CP Companies and the whole Polish industry
- Table 7.2—11 CP Companies from the energy sector and the Polish energy branch

As shown in Tables 7.1 and 7.2 the negative environmental impacts are reduced quicker by CP Companies. One exception is electricity consumption which is almost

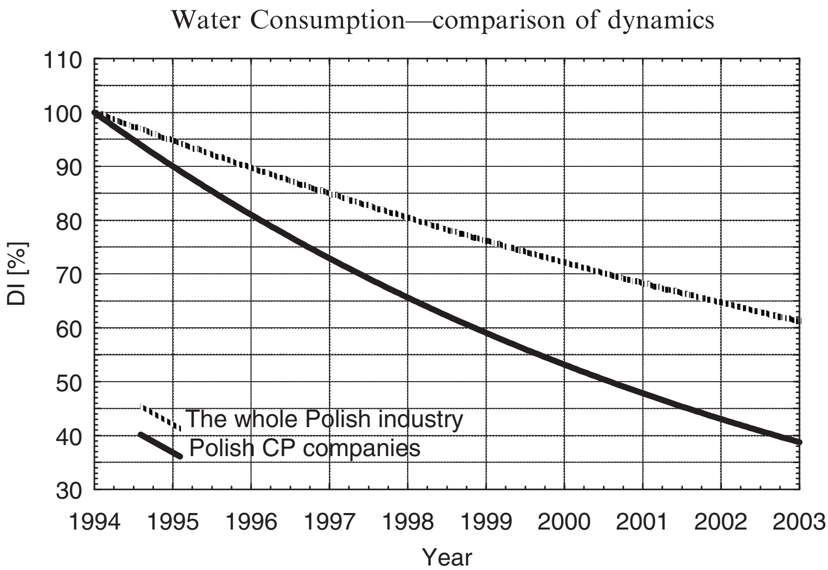

Fig. 7.8 Comparison of water-use intensity dynamics by CP Companies and the Polish industry in general

Table 7.1 Comparison of environmental impacts' reduction by 79 Polish CP Companies (CP)

No	Environmental impact	Reduction of impact [%]		Difference [%]
		CP	CSO	(CP-CSO)
1	CO_2 emission	53	26	27
2	Water consumption	61	39	22
3	CO emission	79	57	22
4	Emissions (excl. CO_2)	81	61	20
5	Production of waste	56	39	17
6	Sewage discharge	52	37	15
7	NO_X emission	75	61	14
8	SO_2 emission	79	67	12
9	Dust emission	90	84	6
10	Electricity consumption	36	37	-1

Table 7.2 Comparison of environmental impacts reduction by 11 Polish CP Companies from energy sector (CP) and the Polish energy sector (CSO)

No	Environmental impact	Reduction of impact [%]		Difference [%]
		CP	CSO	(CP-CSO)
1	Production of waste	56	13	43
2	CO emission	54	21	33
3	Electricity consumption	45	14	31
4	Sewage discharge	58	28	30
5	CO_2 emission	52	23	29
6	SO_2 emission	81	64	17
7	Emissions (excl. CO_2)	80	65	15
8	NO_X emission	77	68	9
9	Water consumption	37	29	8
10	Dust emission	89	82	7

1% higher in CP Companies than in the Polish industry. The group of Polish industry also includes CP Companies which could influence the final results.

It is also worth mentioning that data for the Polish industry (form CSO) covered 'companies most burdensome for the environment' and this group had much more to do with environmental protection than many other companies in Poland (these companies have to report their impacts to CSO every year). It is clear that taking all Polish companies into account (if only possible) would show an even bigger gap in environmental results between CP Companies and the Polish industry in general.

7.6 Conclusion

The presented phenomenological CP Model may be a useful tool for environmental management. It could be used not only for calculating approximate trends of environmental impact intensities (showing effects possible to be achieved by the CP strategy) and making short-term prognoses but also for benchmarking (comparing environmental results of companies to the model) and planning (helping with establishing measurable environmental goals).

The comparison of environmental achievements of CP Companies and the Polish industry clearly shows that CP Companies are quicker to reduce their negative environmental impacts—which justifies wide implementation of CP strategy in industry. The cost-benefit analysis of the applied investments supported this statement.

Future research of the phenomenological model should aim at integration of the model with new concepts of environmental indicators and with sustainability reporting.

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Part III
EMA Support for Cleaner Production—Case Studies

Chapter 8
Using EMA to Benchmark Environmental Costs—Theory and Experience from Four Countries Through the UNIDO TEST Project

Maria Csutora and Roberta de Palma

Abstract The paper reports the results of the UNIDO TEST project (De Palma and Dobes 2003) as a consequence of simultaneously introducing environmental management accounting (EMA), cleaner production assessment (CPA). and environmental management systems (EMS) in four countries of the Danube river basin. The implementation of CPA was instrumental in identifying non-product output costs. The analysis of materials and energy flows provided the basis for assessing and comparing the performance of the production processes against the standards defined by the technical specifications of the existing technology and against the standards of best available technology (BAT) or theoretical standards. This categorization showed which part of the non-product output costs could be controlled in the short-term, medium-term, and long-term. On the basis of this analysis, companies were enabled to make strategic decisions such as to phase out products and plan new investments in environmental technologies through a step-by-step approach. Broadening the scope of EMA and developing the necessary information system within the framework of the EMS were immediate results of the project.

8.1 Introduction

When approaching a company to sell environmental management accounting (EMA) the first question faced is what the company can gain by using it? Knowing process costs and product costs better is usually an insufficient answer as it may sound vague and offer uncertain benefits. For this reason the authors of this paper have developed a concept that tells accountants how much they can save on

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environmental costs with particular emphasis on non-product output costs. This makes environmental management accounting (EMA) more meaningful for managers when making decisions and links EMA with cleaner production (CP). The concept was tested during the UNIDO TEST project and received good feedback and the theory was then further developed based on the experience gained. This will be explained in more detail in the following.

8.2 Using Benchmarks to Measure Inefficiencies

"A benchmark study is a systematic search for processes that yield superior performance. These benchmarks are then compared against current activities to gain insight on how to improve" (MacLean 2004:12). Benchmarking is derived from management research but is widely used in environmental management to compare corporate social responsibility, environmental performance, or the performance of the environmental, health and safety functions of the organisation (see for example Chousa and Castro 2006a; McDaniel et al., 2000; Schaltegger 2006).

Relative measures for assessing the losses caused by inefficient operations by companies are also well-known in environmental accounting literature. Schaltegger and Burritt (2000) proposed eco-efficiency indicators that relate the value added by a company to the environmental damage caused by these activities. Figge and Hahn (2006) have introduced a new concept for measuring sustainable value-added which includes environmental value-added. According to their definition, "environmental value-added corresponds to the economic value that is created by a level of eco-efficiency above the benchmark" (Figge and Hahn 2006:148). These concepts are, however, most usable at national or company level and are less informative about how much a company can save by improving specific technologies. This stems from their scope as previous concepts have not focused on the limits of eco-efficiency improvements built into technologies. The approach which will be introduced in this paper can make the above-mentioned concepts more operational at a technology level by providing estimates of the maximum amount of financial savings that could be achieved through improving eco-efficiency for certain technologies. This helps company accountants and managers make decisions on how to carry out innovations that result in reduced resource-use.

8.3 Rationale for Choosing Benchmarks

Managers are interested in cost-reduction options at least as much as in the level of costs. In the shorter term, however, cost-reduction options are limited by the existing technology. It is unlikely that any technology which had been purchased only 1 or 2 years previously would be replaced by a superior one only for environmental, or even economic, reasons. When benchmarking environmental costs we, therefore, have to take into account the life-cycle of the technologies as well as the time-horizon.

In the short-term, until the end of the technological life-cycle is reached, only minor changes of processes and improved housekeeping measures make sense. In the medium-term, the company can change technology and get closer to the state-of-the art of the industry. In the long-term even the state-of-the art may improve and get closer to the ideal world in which no harmful emissions are produced and all inputs become part of the product.

The benchmarks used in this project are therefore technically determined:

- Technological standards show the best way that current technology can be used. Eco-efficiency is maximised in the short-term provided the technological discipline of line-workers is strong. This can be approached by better housekeeping measures, reducing rejects, avoiding wastage of materials, etc. The technology can only be changed when it is close to the end of its life-cycle which can be much longer than the depreciation period. Any CP consultant has an opportunity to push major innovations through the company when this life-span has almost expired. The technological life-cycle can be 5–7 years or longer depending on the industry and the company itself. This horizon limits certain innovation decisions.
- We can also benchmark eco-efficiency to the best-practice in the industry (state-of-the-art). In the paper industry in Central and Eastern Europe (CEE) most companies have a worse ratio of fresh water usage per unit of output than the equivalents of their Western competitors against which they constantly compare their own ratio and work on reducing the gap. Approaching the state-of-the art however requires replacement of the technology a medium-term decision. Our BAT standard will reflect the best-practice in the industry.
- Finally, even state-of-the art may improve in the long-term by approaching the ideal of a zero-waste world. Leading companies are working on inventing new technologies that will change the conditions for the whole industry sector (see for example the initiatives of the Japanese Denso Group for "zero emission processes" or the QUEST program developed by Interface Corp. in the U.S, (Interface Corp. 2007)). This development has a long time-horizon. The theoretical standards will reflect this ideal world with no waste. We will see later that certain by-products are inevitable even in an ideal world although these should not be confused with waste.

8.4 Benchmarking Non-Product Output Costs

According to the UNDSD methodology (UNDSD 2001) the total cost of non-product output includes the materials purchase value of wastes, the costs of processing, handling and warehousing wastes, treatment and disposal. "Waste in this context is used as a general term for solid waste, waste water and air emission, and thus comprises all non-product output" (UNDSD 2001:12). The materials purchase-value of waste is the overwhelming majority of the costs. The approach taken in this project focused on non-product output costs in each company. This is the area that offers greater benefits in terms of revealing potential savings. Non-product outputs were compared against three benchmarks: the technical process flowcharts defined by the manual, best available technology or state-of-the art where available, and theoretical non-product costs. The actual material flows and discharge values therefore need to be quantified. Real material flows might differ from those suggested in the technological flowchart in the manual compiled by the designers of the technology. This was done within the detailed analysis of the cleaner production assessment (CPA). The common practice for calculating non-product output costs takes into consideration the entire value of the material/energy inputs that do not become integral parts of the final product. It is the correct approach from a theoretical point of view. However, this approach ignores the fact that not all wastes and emissions can be eliminated even when state-of-the-art technology is in use. Companies usually consider this approach too punative. They need a practical concept and gradual approach to classify environmental costs as controllable in the short-, medium- and long-term. To promote the use of EMA in managing environmental costs to support managers in their selection of CP measures, and in planning investments in new cleaner technologies it was found useful to create three benchmarks against which companies could compare their actual non-product output costs and savings. This means that the environmental value added as defined by the American EMA literature (Gibson and Martin 2004; McDaniel et al., 2000) or the shareholder value defined by Schaltegger (Schaltegger et al., 2003) can be addressed better. The project therefore developed a methodology for classifying non-product output costs based on their controllability, with product and non-product output costs being classified into five categories (Fig. 8.1).

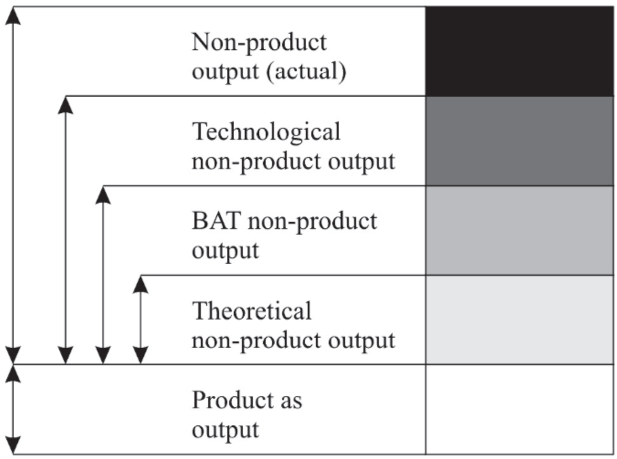

Fig. 8.1 Controlling non-product costs

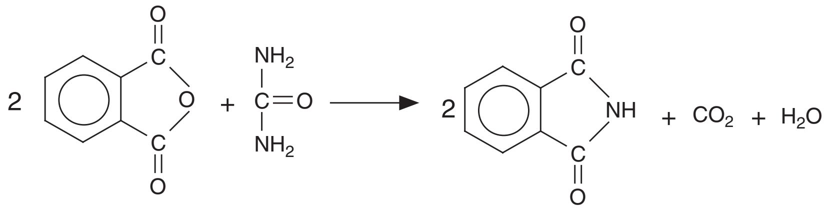

Fig. 8.2 Reaction equation of phatlimide production

Theoretical product costs can be defined in the chemicals industry as the costs of the materials which are needed to produce the final product according to the reaction equation assuming 100% efficiency in the use of production inputs. Some non-product outputs or by-products of the chemical reaction may still be produced (see Fig. 8.2).

In reality theoretical product costs cannot be achieved by any technology only approximated. For example, the ammonia needed for this reaction is not readily available but must be produced from raw materials which leads to further non-product output. Fuel is also needed to maintain the temperature etc. The technological descriptions contain these details.

Non-product output costs tend to be very high when they are calculated in relation to theoretical standards. This is firstly because 100% efficiency is not achievable and secondly because in the chemicals industry in particular some production inputs are auxiliaries or "helpers" in the process and so inevitably become 100% waste. For example, catalysts are needed in most chemical reactions but 100% of these become non-product output costs because they do become part of the final product but eventually become spent and have to be replaced. Another example is the energy which is needed to maintain the temperature required for the chemical reaction.

Only materials which become part of the final product should be taken into account when calculating the product costs. Product costs can be reduced only by changing the product itself, for example, by producing lighter products with less material content that fulfil the same function. Modern computers or cars, for example, are lighter than older versions. They require less materials from the environment. This can be a desirable goal from a green perspective. "From an all-embracing systems viewpoint, companies are subsystems of the economy, the economy is a subsystem of society and society is a subsystem of the natural environment. … Every use of the environment could be seen as a 'consumption of goods and services' and could be expressed as an environmental costs" (Schaltegger and Burritt 2003:96). From a'deep green' perspective even product costs (which are seen as proxies for the materials included in the final product) can be seen as environmental costs. Progress made towards developing products with less weight and containing less materials should be welcome. But in most cases this approach is not feasible. Therefore, this concept will not be used in the following discussion.

Best available technology non-product output costs are the costs of materials and energy inputs that do not go into the final product when Best Available Technology (BAT) is used. For certain industrial sectors BAT is defined at a European level. Where BAT standards are not available state-of-the-art technology could be used as a benchmark for each industrial sector. This is a less stringent reference point than theoretical standards. Nevertheless, BAT non-product costs are controllable only in the long-term when technological innovation produces an improved BAT Technology. Using this benchmark to calculate non-product output costs a company is signalling that it could switch to the best available technology or at-least-implement technological changes and move closer to BAT levels. The use of this benchmark recognises that some waste and pollution will always be generated even when using state-of-the-art technology. The difference between the actual and the BAT production inputs per product defines the savings for switching to BAT. As technology develops BAT will change and align more closely to the theoretical standard efficiency levels so the gap between these two benchmarks will progressively narrow.

Technological non-product output costs are the non-product output costs generated when the existing technology is operated as indicated in the technical manual and corresponds to the technical specifications. These costs can be controlled in the medium-term by changing the technology and approaching BAT. This is the least stringent benchmark and allows wastes, emissions- and scrap outputs that cannot be avoided even when the existing technology is operated in the most efficient way. Values for technological standards can be found in engineering design specifications, operating parameters, manufacturers' technical manuals, and process flow diagrams. Technological standards should reflect materials consumption standards when technology is operated in the best possible way rather than reflecting some existing sub-optimal practice.

Most good housekeeping measures of CP focus on getting closer to the technological non-product output costs. Some 5–10% or even more of the savings can be realised by better monitoring and controlling raw material consumption by avoiding leaking pipes, wasting energy, etc.

Technological standards are familiar to accountants from the standard costing system. A task analysis of the processes and resources for manufacturing a product would determine the standard cost. Even in activity-based costing, when accounting for planning purposes, some kind of standards can be set.

Actual non-product output costs are the actual non-product output costs generated by the existing technology. In the short-term these costs can be controlled by operating the existing technology better (through periodic maintenance and operational control, for example). If a technology is well-operated then the actual non-product costs are close to the technological non-product output costs. But this is often not the case when the existing technology is out-dated.

For the purpose of operational control the companies participating in the TEST project were mostly interested in the difference between the actual non-product output costs and the technological non-product output costs. This information revealed the amount of deviation from the technological standards and the savings if operating the existing technology in accordance with its technical specifications. Technological non-product output costs can highlight those areas where a company can reduce wastes and emissions by better housekeeping, better monitoring of raw materials consumption, avoiding waste/scrap, and reducing energy and water consumption. A small variation from technical standards might result in a disproportionate increase in environmental costs. Companies need this information on a monthly basis.

The difference between actual non-product costs and BAT non-product output costs was also important for the companies but on a less frequent basis. The difference reveals the feasible range to perform technological improvements. This information is important when a company considers changing technology. So it must be calculated every time such a decision is made, probably every 3–7 years, depending on the technological life-cycle of the equipment. There is much less fluctuation in these types of costs than in the case of technological standards. The savings potential is, however, much higher. For example, in the paper industry of most CEE countries in the 1990s water consumption per kilo of paper produced were sometimes 3–5 times higher than in western European countries. In 1997, companies in the European Union (EU) used 15 m^3 freshwater per ton of paper produced as compared to the Hungarian average of 51 m^3 (Dunapack 1999). Dunapack, the biggest Hungarian paper company, has reduced its freshwater consumption from 70 m^3 per ton in 1993 to just 7.85 m^3 per ton by 2006 (Dunapack 2006) Kappa, reduced water consumption in cardboard production from 120 m^3 per ton in 2001 to 76 m^3 per ton in 2002 (De Palma and Dobes 2003:211). By applying state-of-the-art technologies, tremendous savings could be realised. This technological change was motivated by rising water prices.

Non-product costs tend to be very high when compared to theoretical standards or product output. This comparison can be discouraging for companies because the difference between the two quantities are considered inevitable and difficult to control. On the other hand it provides strong motivation for innovative thinking and can spur adoption of or even improvements to technologies. Theoretical standards can also be used when BAT standards are not available or too complicated to use. For the relationship between non-product output costs, controllability, and potential savings see Table 8.1.

The results of the application of EMA principles were linked to the results of the CPA, the environmental management system (EMS) and served to define the internal information system for controlling environmental costs. The classification of non-product output costs as described above was very effective in demonstrating the savings by applying short- and/or long-term CP measures. Finally, a procedure and a set of working instructions were integrated within the EMS documentation to facilitate the collection and processing of material and energy flows data for the routine monitoring of non-product output costs.

Table 8.1 Relationship between non-product output costs, controllability, and potential savings

	Ability to control cost	Method of controlling costs	Potential cost savings
Non-product output *less* technological standards	Short-term	Good housekeeping measures	Small to medium
Technological standard cost *less* state-of-the-art standards	Medium-term	Switch to state-of-the-art technology	Medium to large
State-of-the-art costs *less* theoretical costs	Long-term	Technological invention	Medium to large
Theoretical cost (chemicals industry)	Medium- to long-term	Switch to other raw materials and technology	Small to large
Product costs	Long-term	Product modifications	Small to large

8.5 Using Technological Flowcharts for Setting Standards

Setting proper standards is a key issue in analyzing non-product costs. Hilton (1991) distinguishes between two methods of setting cost standards: analysis of historical data and task analysis. Task analysis is based on scrutinizing the manufacturing process and is more suitable for our purpose than historical data based cost setting. CP analysis can serve as a starting-point by revealing which raw materials streams end up in the final products and which are wasted. CP analysis and EMA should, therefore, be connected at the phase when current standards are set or reviewed. Historical data analysis has a potential drawback in that it may legitimate past bad practices. For the same reason perfection/improvement standards are preferred to practical standards when non-product output is potentially a high-cost.

This approach is relevant for industry sectors such as paper and intermediary chemicals products in which production volumes are high and input costs dominate product costs and where the company follows a cost leadership strategy. Companies here need to apply tight cost control as any wastage of materials could jeopardise the profit objective. In contrast a different approach is needed, when quality requirements dominate cost-reduction.

There is a further consideration which is specific to CEE countries. Fully depreciated, old ‘archaic’ technologies are still in use in some companies. At first sight, running costs are low since no depreciation costs are incurred. However, they impose high maintenance expenditure, cause frequent interruptions to production, and use resources less efficiently. These problems would be masked if historical data analysis were used for setting standards especially practical standards. As the technology becomes older wastage of materials increasing. A practical standard based on historical data would merely capture this practice and establish it as a normal way of doing business. Standards would then increasingly depart from the original prescriptions and the system would be unable to show how much the company was losing. A task standard based on CP, however, would be able to reveal the problem and forecast diminishing profitability before it becomes too late.

According to Hilton's categories technological standards, as referred in this paper, are a type of perfection/improvement task standards. They can be used as cost standards or simply as benchmarks when defining cost standards. They encourage better performance provided that they are updated from time to time to reflect new inventions that lead to process changes. Higher raw materials costs compared to those prescribed by technological standards, higher energy costs, maintenance needs, or higher level of undesired output, are all warning signs of inefficiencies. In Nitrokémia 2000 (see section 8.8), however, we found that actual environmental costs for one product were below that defined by technological standards. The interpretation for this phenomenon is that technological descriptions were not updated and did not reflect certain process changes and minor innovations.

In activity-based costing actual costs are used rather than standard costs but technological non-output costs can still be used as a benchmark to compare against actual costs for a given period so that potentials for process improvements and their financial consequences can be revealed and analyzed. BAT and theoretical standards can also be used for these purposes.

Kaizen costing would encourage further innovations and savings in raw materials, energy, undesired output, rejects, maintenance costs, etc. (see Monden 1995 or Kaplan and Atkinson 2003). This new approach seems, however, too radical for most companies in the region.

BAT standards and theoretical standards are benchmarks which are not closely linked to accounting terms. They can be used for long-term planning purposes. These two standards can help the making of decisions in technological innovations or switches to new technologies. Theoretical standards show indicate potential cost-savings in switching to new and more efficient technology. Although they can be neither used for operational control nor be regarded as accounting standards in strict sense they can still be used for long-term cost-related decisions.

8.6 Specifics for the CEE Region

Most of the highly polluting heavy industry in the CEE went bankrupt during the transition period in the 1990s. Some were cleared of environmental liabilities, taken over by the state and privatised. Inflows of foreign capital assured the technical modernization of those companies so that in recent times they have operated with updated technologies and reduced environmental impacts.

Some of the old companies, however, survived, without major changes in their technology and operation. Nitrokémia 2000 is a good example. These companies were fortunate not to lose their market during transition as their market orientation turned towards Western Europe rather than the Eastern region. They inherited outdated technologies from the past some of which were fully depreciated. Innovation was not crucial for them.

The intermediate chemicals industry generates homogenous mass products. The pollution generated in their production is not apparent in the products. So these companies were able to generate cash and profitable. There was no pressure to change their technology or obtain further injections of capital. Despite this the operating costs of the outdated technologies become increasingly high over time due to extended maintenance requirements that reduce profitability in the long-term. If these companies cannot accumulate enough capital for innovation their future will be in question. They also struggle with a high-level of pollution and bear a heavier burden of environmental regulation. In the past, exceeding environmental limits would result in a fine. Joining the European Union means that, nowadays, the operational permit is at stake. The above-mentioned factors reduce the economic value added as defined by McDaniel et al., (2000), as well as the shareholder value as defined by Schaltegger and Buritt (2000) and broken down by Chousa and Castro (2006a, b). These changes are, however, not always captured by the accounting system since low levels of depreciation and historical cost standards based on bad practices may conceal problems. After this project was closed Nitrokémia became insolvent due to exchange rate changes, growing competition, and legal ownership problems of a new investor in Great Britain. Although still in operation, under the control of liquidator, the company must search for new investors to survive.

Certain companies generate products that are increasingly unacceptable for environmental reasons. The atrazine plant of Herbos is a typical dirty cash-cow continuing to generate cash as long as possible without making important investments (see Schaltegger et al., 2003). Its major product, atrazine, has already been withdrawn from several European markets because of its high environmental impact. Nevertheless, it is still sold in many countries. Decline rather than expansion of the market can be expected in the future. The production process itself is very polluting. The company has been using outdated accounting methods to track financial performance. Major innovation is in doubt for the atrazine plant since its future is in question. However, some improvement in waste water treatment practice will still be required by law. The plant can operate only so long as its product is saleable on the market.

Eco-efficiency (Schaltegger et al., 2003:65) is lower in many companies than those operating in western European countries. For example, economic value creation per unit of fresh water consumption is improving but still significantly lower than the west European companies. In Rumania, companies pay only a nominal price for fresh water which does not encourage efficient use. Prices, however, rise rapidly and the old practices are improving. 'Low-hanging fruits' or 'win-win' solutions can often be identified in the region.

Finally, small- and medium-sized companies still use less efficient, outdated technologies due to limited access to financial resources for innovations (Kerekes 1997). Moreover, they are almost invisible to environmental authorities because the pollution caused is often aggregated into residential or communal statistics. They do not always follow regulatory requirements due to a low probability of being audited. Furthermore, they also lack practical knowledge and experience to make pro-active changes to reduce environmental waste. Their collective pollution is estimated to be high. Nevertheless, they are less interested in environmental projects. This SME problem is common in other countries too. Similar phenomena was reported by Venturelli and Pilisi (2003) in Italy and by Heupel and Wendisch (2003) in Germany.

8.7 Making Decisions on Environmental Projects

So far we have focused on the operational savings that could be achieved by improving eco-efficiency. After this, however, innovation options must be created and analyzed. So far we have ignored the investment costs of innovation as and other related costs such as training, increases in personnel, but have focused instead on savings in operational costs being realised through the reduced use of raw materials. When making decisions about technological modifications, however, all costs must be taken into consideration so profitability analysis is required to decide for or against the innovation. Different tools are needed, however, depending on the type of the project. Our aim in this project was to produce reliable results and to keep the analysis as simple as possible.

Environmental projects can be classified into categories with different financial analysis tools being needed depending on the nature of the project. This section will present how we have dealt with projects depending on their behaviour in terms of necessity and profitability (Table 8.2).

There are measures necessary to comply with laws and regulations which will be referred to here as "must-do" projects. Omission of these projects would result in disruption of normal business activities, e.g. suspension of the operating permit.

Table 8.2 Types of environmental projects

Project type	Profitability	Analysis tool
"Must do" projects (to achieve compliance)	Not important	Cost-efficiency analysis includes all environmental costs and savings
Environmental projects with financial return	Yes	Usual profitability indicators (NPV, IRR, payback)
Environmental projects with financial return when environmental costs are correctly accounted	Yes	Profitability indicators supplemented with environmental costs
Environmental projects at the margin	Close to being profitable	Profitability indicators supplemented with environmental costs and qualitative descriptions of unquantifiable costs and sensitivity analysis
Environmental projects that never pay back	No	Unlikely to be implemented

Such projects have to be completed regardless of profitability so their financial analysis will be based on cost efficiency rather than on profitability. If there were several alternatives that would all ensure compliance how we should choose among them? Cost efficiency dictates that we should select the option that realises the required result at the least possible cost. This is different from the profitability criterion since we do not expect the alternatives to pay-back.

The next category embraces projects that are so good they appear profitable even when using conventional profitability criteria in a narrow way in which hidden costs and liability costs are omitted and the importance of image value is unrecognised. Many recycling projects belong to this category. The company has no reason to refuse the implementation of these measures since they produce financial results which are as good as any other business investment. It is unfortunate that many managers presume that all environmental projects result in a loss to the company and do not bother to carry out a financial analysis. At the same time environmental managers are not normally competent to carry out the financial calculations. Regardless of this the use of financial profitability indicators to convince executives to treat these projects in the same way as other business projects should definitely be pursued. Description of hidden contingent liability and image costs is suggested although not all of these have to be monetised.

The next project type is characterised by being unprofitable according to conventional indicators but resulting in significant hidden and contingent liability cost savings or image improvement. The projects seem profitable when all environmental benefits and costs are included in our financial analysis. It is here that the application of environmental accounting produces the biggest gain to the company. The following chapters will show how hidden costs and contingent liability costs should be quantified and built into the profitability analysis. This methodology will supply a more accurate profitability analysis of environmental projects and will lead to the implementation of a larger number of CP measures.

There are measures that do not pay-back even when all quantifiable environmental effects are expressed in monetary terms although they are very close to the threshold value. They are not profitable but are “at the margin” with a slightly negative net present value or their internal rate of return is somewhat below the required rate. The direction of these impacts on profitability, whether positive or negative, must be considered too. Detailed description of all non-quantifiable environmental impacts is inevitable here. Carrying out a sensitivity analysis is especially important for this group to estimate how calculated profitability would result following a change in economic conditions. For example, increasing electricity prices might shift the financial indicators of an energy-saving project that had once been rejected so that it could be approved.

Finally, there are measures which appear unprofitable even when the most sophisticated tools for estimating their benefits are used. Such measures are unlikely to be implemented since after a certain point the environmental department has to acknowledge the business interests of the company and accept that not all benign but costly projects can be completed. Leading companies sometimes give a green signal to non-profitable environmental projects but this cannot be expected to occur for each project.

8.8 The UNIDO TEST EMA Project

The United Nations Industrial Development Organisation (UNIDO) developed a program to promote the Transfer of Environmentally Sound Technologies (TEST) that incorporates the principles of Environmental Management Accounting (EMA) (De Palma and Dobes 2003). The first TEST project targeted the industrial hot spots of five countries of the Danube River Basin and was implemented between 2001 and 2004. The project's partners in these countries that provided technical assistance were: the Hungarian Cleaner Production Centre (Hungary), the Slovak Cleaner Production Centre (Slovakia), the Croatian Cleaner Production Centre (Croatia), the Institute for Industrial Ecology (ECOIND—Romania), and the Technical University of Sofia (Bulgaria).

The TEST approach uses a methodology designed to combine simultaneously the introduction of several environmental management tools such as EMA, CPA and EMS to achieve a sustainable enterprise. The method demonstrates how combining these tools within an integrated framework can generate positive synergies and better results. The authors of this paper were directly involved in the execution of this project.[1]

The TEST project was implemented in 18 industrial hot spots in the Danube river basin with a different degree of participation in each module of the project driven by the particular situation diagnosed at the start. The following summarises the results that were obtained in four of the participating companies which were most relevant to the aim of this paper. These companies are:

- Nitrokémia 2000 Corporation operates in the Hungarian chemicals industry, employs 700–800 people and has revenues of 42 million Euros. It was founded in 1997 as a 100% subsidiary of Nitrokémia an old state-owned chemicals company. Nitrokémia 2000 was established as an entirely new legal entity in 2000 and thus avoided inheriting the environmental liabilities of its parent but was left operating with most of the former obsolete technologies. (Kerekes et al., 2003; Csutora and Kajdacsy 2003).
- Herbos d.d. is a Croatian joint stock company founded in 1946 manufacturing pest control products, construction materials, paints and coatings, and re-agents

[1] Dr. Csutora worked as international consultant for the EMA component of the TEST project by providing training and advice to project partners as well as developing EMA methodology for controlling costs. She was also responsible for implementing EMA in the Hungarian company, and co-authored the published results in 2003. Ms. De Palma was the project manager of the UNIDO-TEST project and was responsible for developing the theoretical and methodological framework of the TEST approach and its pilot demonstration in the Danube Region.

for clinical diagnostics. Its annual revenue is 20 million Euros and it employs 340 people. The main environmental problem at HERBOS is wastewater discharge from atrazine synthesis. Atrazine itself is a problematic product still sold in many countries but forbidden in others.

- Somes Dej is a Romanian pulp and paper plant with turnover of 34 million Euros and 1,184 employees. The bleaching unit was identified as the area causing most significant environmental impacts. Raw materials prices especially for water were very low in Rumania and this had important consequences for the evaluation of non-product output costs. (Timar et al., 2003).
- Kappa Sturovo is a Slovak pulp and paper company with 825 employees and a turnover of 72 million Euros. In 1992 the company was converted to a joint stock company and a new strategic investor made the company a member of one of the most important multinational corporations in the field of wood and cardboard production (Blaskovic et al., 2003).

8.9 Use of EMA for Controlling Costs

The EMA principles introduced into the TEST project were based on previous outstanding research in the field. Schaltegger and Burritt's (2000) concept of allocating environment costs using different allocation keys was used, and the UNDSD methodology (UNDSD 2001) (adopted by the International Federation of Accountants 2005) was applied for identifying environmental costs. The research of Bennett and James (1998) and the P2Finance model developed by the *Tellus Institute* for analyzing project alternatives (White et al., 1993) and case studies by practitioners were also used during the project (Bailey and Soyka 1991; Bouma 1998; Ditz et al., 1995; De Palma and Dobes 2003). The approach adopted can be classified as a kind of flow cost accounting (Loew 2003; Jasch 2003).

The first step in introducing the TEST-integrated approach to enterprises was to carry out a CPA. The information generated was essential to quantify non-product output costs. The EMA was introduced in selected enterprises only after completing detailed CPA of materials and energy flows (Schnitzer 1999).

EMA principles were first introduced to companies and local consultants in a 3-day training session and then followed up by on-the job activities. Two additional interactive workshops were held during the project for presenting and discussing work in progress and final results and to enable *ad hoc* exchanges of experiences between the project's partners and the provision of technical assistance as needed.

Scoping EMA focused on the most problematic areas taking into consideration the limitations originating from the selected types of industry and the existing cost control systems as well as the project's financial resources. Two of the four above-mentioned companies represented the chemicals sector manufacturing several products and operating many technological processes. The cost and time would required to analyze some 50 technologies in each company would have been prohibitive so the project focused on strategic areas. The scope of EMA was restricted to the reallocation of environmental costs and recalculation of product costs in two companies. In Herbos the EMA focused on the calculation of those environmental costs in the production process with highest environmental impact. It was not possible to allocate environmental costs to products since at the time of the project there was no cost accounting system in place. Moreover, the overheads ratio was extremely high suggesting that the control of product costs was sub-optimal. In Nitrokémia 2000 re-calculation and re-Organisation of environmental costs within the already-existing cost-centre structure was chosen as the focus of this project.

8.10 Results of the Project

The application of EMA in the selected enterprises showed that the total environmental costs ranged from 4.58% to 7% of production costs with non-product output costs usually exceeding treatment costs. In the chemicals industry (Nitrokemia 2000), however, products were identified with 47% (fumaric acid) and 20% (ferrous fumerate) of respective variable costs being environmental. It is notable that compared to other products these are still the most saleable and profitable which underlines the importance of scoping EMA properly and focusing on the most problematic areas. Low or moderate levels of overall environmental costs at a company may disguise problem areas with an excessive environmental burden.

The paper industry is water intensive with water consumption per unit of product much higher in CEE countries than in the EU-15. EU-15 refers to member countries in the European Union prior to the accession of ten candidate countries on 1 May 2004. Project results at Kappa revealed environmental costs five times higher than previously estimated (Fig. 8.3) due mainly to the high water consumption of the sector. Kappa's water consumption per unit of product is several times higher than in the EU-15 countries.

EMA has put this inefficiency into monetary terms by highlighting the potential savings of a better technology. Despite an extremely low water price in Romania the non-product output costs calculated at Somes bleaching unit exceeded waste treatment costs even when technological standards were used as a benchmark (Fig. 8.4) which suggests some short-term potential for savings. Using separate cost accounting lines for non-product output costs which had previously been included in direct production costs and shifting allocation keys from labour or production value to volume of pollution and toxicity to reflect environmental load better has resulted in a major change in the break-down of environmental costs between departments and cost-centres.

By the end of the project SOMES management decided to extend the EMA analysis to the whole company. The results of the EMA have been fully integrated into its internal cost accounting system.

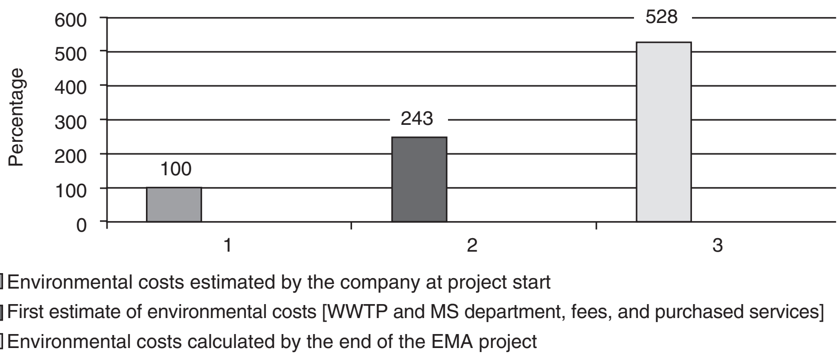

Fig. 8.3 Environmental costs at Kappa before and after the TEST EMA project

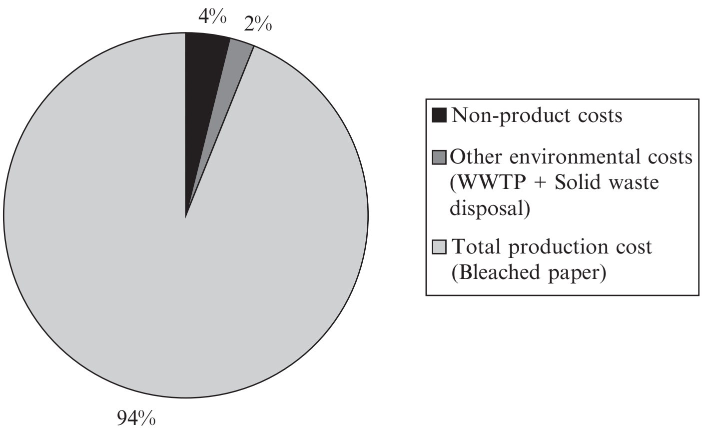

Fig. 8.4 SOMES product cost structure for the bleaching unit

Nitrokémia 2000 decided to extend the EMA to additional products under the scope of EMA which led to a decision to phase out two processes. Using two different benchmarks (technological and theoretical standards) revealed that for the three processes analyzed savings could be realised only through technological innovation (Fig. 8.5). The analysis showed that there is a limited margin to reduce non-product output costs by implementing good housekeeping measures. Nitrokémia 2000 also hired a chemical engineer to study the options.

Two of the companies have further broadened the scope of EMA after the project finished which indicates the success of the project. Both companies have conducted product-level analyses of environmental costs, and, based on EMA information made important decisions including phasing out processes.

	Environmental Costs based on Theoretical Costs			Environmental Costs based on Technological Norms		
	Fumaric Acid	Ferrous Fumarate	Phthalimide	Fumaric Acid	Ferrous Fumarate	Phthalimide
Waste and Emission Treatment Costs						
Emission Treatment Costs	29,054	15,858	7,430	29,054	15,858	7,430
Waste Disposal		3,450			3,450	
Waste water Fine	1,200	2,400	500	1,200	2,400	500
Energy Costs of Environmental Equipment	240	240	0	240	240	0
Material Purchase Value of Non-Product Output						
Purchase Cost of Non-Product Output	15,133	21,337	3,433	83	457	−1,718
Environmental Part of Indirect Material	310	2,520	50	310	2,520	50
Total Environmental Costs	45,937	45,805	11,413	30,887	24,925	6,226
Actual Variable Production Cost	98,766	227,080	150,409	98,766	227,080	150,409
Environmental Costs (%) of Variable Costs	47	20	8	32	11	4

Fig. 8.5 Environmental costs at Nitrokémia 2000

No management accounting existed in Herbos when the project was started though its financial department liked the idea of using EMA and variable costing (for non-environmental costs). However, at the time, the company was awaiting major changes and the department could not influence the issue.

In general, accountants involved in the project found separating non-product output costs from direct production costs by creating a separate account the most useful part of the EMA practice. Both the chemicals and paper industries are highly competitive and under cost pressure so controlling costs and wastes is an important step towards cost leadership and competitiveness.

Technological standards were found useful for operational control when they are properly set. In the companies participating in the project variances from standards are monitored on a monthly basis. BAT and theoretical standards are benchmarks for medium- or long-term innovations and were found to be very useful during sensitivity analysis as a method of screening various alternative projects requiring high investments in cleaner technologies.

8.11 Barriers and Challenges

One of the surprising results of the TEST project is that EMA as a management tool is much easier to "sell" to enterprise managers than, for example, CPA. It seems that money speaks for itself so it appeared that EMA is effective in marketing CP.

Environmental managers seemed to be more enthusiastic than expected as they received a tool for increasing their bargaining power at the enterprise's decision-making level. At the start of the project environmental managers were initially more interested and supportive than accountants and most enquiries for EMA applications came from environmental rather than accounting professionals. Nevertheless, it is of the utmost importance for the sustainability of an EMA application that accountants be part of the EMA project team.

EMA can be applied to any company but the benefits that can be gained vary considerably depending on their particular conditions. High production input prices create good framework conditions for the application of EMA as more significant costs and savings can be realised at these companies. Experience from the TEST project showed that even though the framework conditions in CEE are as yet non-optimal compared to the EU-15 countries (e.g. water prices in Romania are negligible compared to other production inputs) non-output costs still exceeded other kinds of environmental costs though this difference would be even greater if prices for production inputs were higher.

A step-by-step implementation of EMA for the calculation of non-product-output costs can be followed in certain industries while impossible in others. The advantage of incremental implementation of the EMA concept as applied in the TEST project is that it gives a good balance of EMA benefits and administration costs: the higher the environmental costs the higher the potential benefits for the company in controlling them. The administrative burden might undermine the benefits of EMA for processes with a relatively low level of environmental burden. There is a trade-off between theoretical perfection and practical benefits.

In Nitrokemia 2000 this project analyzed three of the 54 technologies. When the company's management realised the advantages gained they broadened the scope of EMA to other processes. This approach worked reasonably well in the chemicals industry where one process defines one product so that each technology and associated costs can be isolated and analyzed independently of other technologies. Introducing EMA for all 54 technologies at the same time was not feasible as costs were prohibitive and for products with relatively small environmental loads the potential benefits were too small. In the paper industry, however, a number of different products are manufactured within the same technological processes. For these production systems EMA should be applied at a full-scale level since products and technologies interrelate to a large extent.

Setting technological standards that reflect the best possible operation of the technology rather than some existing practice is a key issue. Operations manuals help identify these standards but some problems arise for technologies invented or developed by the companies themselves.

The information system was a key issue within companies. The lack of information flow between the environmental and the accounting managers was sometimes the only reason why the wrong keys were used in allocating environmental costs to cost-centres and between products. The accounting department was simply unaware that data on exact amounts of discharges or toxicity are readily available from the environmental department so instead they often used machine hours or labour costs, etc., as allocation keys. Once practitioners of different fields came to together the issue of correct allocation keys for production costs was solved almost immediately.

EMA is somewhat bound by the existing rules of accounting, particularly, when the company is a subsidiary or part of a larger group. Variable costing provides the best climate for environmental accounting but EMA should be adapted so it fits into the existing system. There were significant differences in the accounting methods practiced by the different participating companies; from having a house system that differs from those that are internationally recognised through to absorption costing and variable costing. EMA could offer definite benefits in each system.

Strict environmental regulations and enforcement encourage the use of EMA as savings can be realised from reduced environmental fines, fees, and a lower level of liability. Lax, or, frequently relaxed regulation and enforcement discourages its use. Relaxed environmental regulations were a problem in most of the TEST project countries but things changed quickly due to the prospect of European Union Accession. Thus sensitivity analysis must be a crucial part of the financial analysis of costs revealing how environmental costs increase in a changing business environment.

8.12 Conclusions

The combined application of EMA, CPA, and EMS that was undertaken in 4 of the 18 companies participating in the TEST project generated more positive outcomes than in the remaining companies that introduced only CPA or EMS. The best time at which to start an EMA project is just after the CPA detailed analysis. EMA on the other hand helps to quantify monetary benefits that could be gained through different CP options. This information could then be built into the EMS especially when significant environmental aspects are identified and objectives are defined. The use of EMA has therefore positively contributed to enhancing the sustainability of the CPA/EMS projects by increasing awareness of economic implications of environmental aspects and, in particular, of non-product output costs and by providing a system for controlling them in the short-, medium-, and long-term.

Two of the companies broadened the scope of EMA beyond that originally delineated extending the analysis to other technological processes. Important decisions, including phasing out products and making new investments, were made on the basis of the results of the EMA and of the TEST approach in general.

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Chapter 9
Sustainable Development in the South African Mining Industry: The Role of Cleaner Production and EMA

Maryna Möhr-Swart, Faan Coetzee, and James Blignaut

Abstract The South African mining industry is increasingly embracing cleaner production (CP), albeit at a slow pace. *Environmental management accounting* (EMA) is still poor, in spite of increased awareness of the concept of triple bottom-line accounting. This paper investigates how CP and EMA, by means of examples in the gold mining sector, can assist towards sustainable development.

Mining and sustainable development are not contradictory terms. This paper will examine how the sustainable development principles are applicable within the SA mining industry. The future of the extractive industry is inseparable from the global pursuit of sustainable development. The mining industry is contributing to sustained growth and prosperity of current and future generations through the integration of economic progress, responsible social development and effective environmental management.

South Africa is particularly rich in mineral resources and is one of the leading raw material exporters in the world. South Africa on the other hand, is a water scarce country with mining activities often located in areas with limited water resources. The main challenges faced by the mining industry include proper water and electricity management among others. The implementation of cleaner technologies could be a solution to these challenges. Environmental management accounting and sustainability reporting are tools available to assist the mining industry to successfully achieve sustainable development.

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9.1 Introduction

Since humans first started to use tools, they have been dependent on minerals contained in or on the earth. This dependence has increased as we have evolved to our present industrialised status, to the point today where our livelihood is utterly dependent on mining. Mining companies worldwide and especially in mineral-blessed South Africa, are entrusted with the task of satisfying this demand from minerals.

Mining is a huge industry world-wide. The term 'mining' includes operations employing tens of thousands of people and moving millions of tons of ore and waste rock per month. Mining is carried out in almost all-conceivable locations, from tropical jungles to the high Arctic, from 4,000 m above sea level to almost 4,000 m below surface. A vast range of minerals is mined, requiring very different extraction and processing operations (Möhr-Swart 2007).

Mining by its very nature is financially expensive, environmentally invasive and socially intrusive, yet many countries have successfully managed to convert their mineral assets into national wealth providing countries with the economic means to address its environmental problems and social aspirations. By its nature, mining can have a deleterious effect on land, water, flora, fauna and communities surrounding a mine (Chamber of Mines of South Africa 2004).

Coal slag heaps, tailings dams, disused mine shafts, dried out evaporation dams and degraded mine infrastructure dotting the South African countryside are a few examples of the remnants of mining that took place over the last century. These remind one of how inconsiderate the mining industry has been toward the historically pristine environment. There have been significant changes since then. Not only has mining legislation compelled companies to be more environmentally and socially responsible, mining operations themselves have also recognised and embraced modern mining methods that take into consideration the impact of the industry on its surroundings (Chamber of Mines of South Africa 2004).

Wells et al. (2003) argue that mining can only take place where minerals occur, which in turn implies that mitigation of environmental impacts by moving a mine to a more environmentally suitable site cannot be considered. Given that mining is a true extractive industry with deposits being finite, it is important to evaluate all the impacts of mining, both negative and positive, to arrive at a true measure of the overall impacts. The residual impact results from a comparison of the 'before' and 'after' conditions rather than comparing the 'before' and 'during' situation. The overall impact must also, therefore, consider the environmental, economic and social impacts of a mining operation. The complexity of the mining and minerals cycle, as illustrated in Fig. 9.1 must be considered when the residual impacts of mining are evaluated in terms of sustainable development.

Mining is associated with numerous environmental impacts. Some factors determining environmental impacts, according to Möhr-Swart (2007) are the site characteristics, the amount and type of material that must be moved, the depth of the deposit and the chemical composition of the ore and surrounding rocks. The extraction processes, the scale of activities and the environmental management practices of the mines will also determine the residual impacts. These potential impacts,

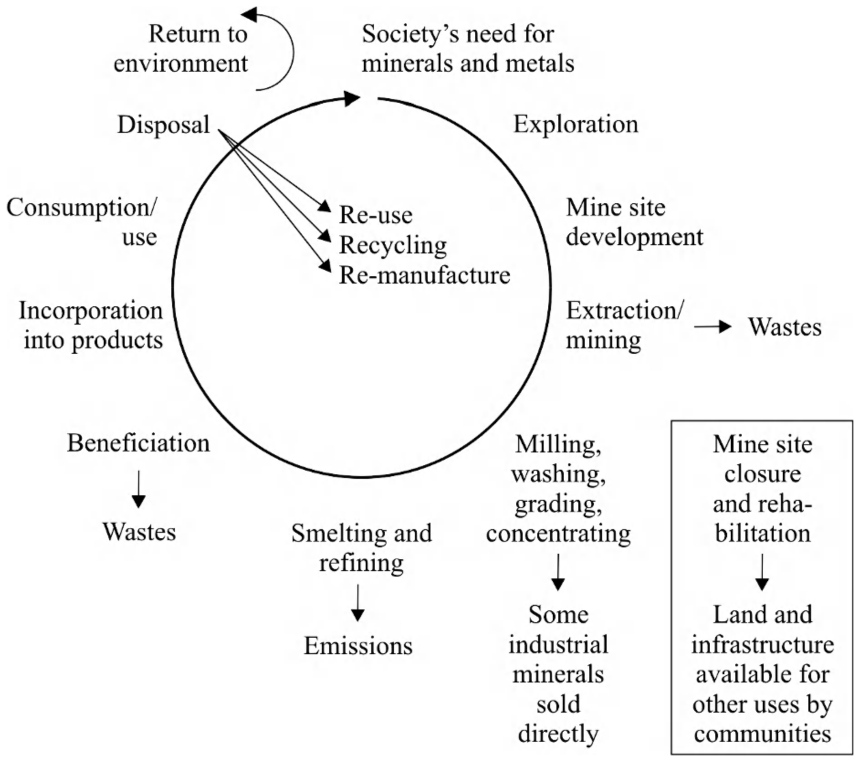

Fig. 9.1 The mining and minerals cycle. Source: Adapted from MMSD (2002)

normally associated with the mining processes, might occur at every stage of an operation. Some of the environmental impacts of mining, which will be linked to sustainable development and cleaner production (CP), are the following (Möhr-Swart 2007):

1. Destruction of habitat and biodiversity at the mine site and adjacent land with associated visual impact and loss of land for specific land-use
2. Accumulation of mine waste, tailings disposal and the possible failure of tailings facilities
3. Air pollution in the form of emissions (with associated effects on climate change), dust fallout, noise and radiation
4. Water pollution including siltation and changes in river regimes and groundwater alteration or contamination
5. Production of hazardous wastes and chemical residues impacting on public health and urban settlements adjacent to mines.

The environment and associated environmental impacts may also be closely linked to many social and political issues. The challenge for the mining industry in South Africa is to contribute to human welfare and well being. This is possible if the mining industry strives to ensure a fair distribution of the costs and benefits of development for all stakeholders and through good governance optimise the economic return to the community (Hermanus 2007; MMSD 2002; Möhr-Swart 2007).

The SA mining industry fully supports sustainable development by means of social equity, environmental protection, economic development and the development of effective governance structures. De Jager (2006) supports this statement by explaining the business case for sustainable development in the mining industry. He states that mining is about making money safely, having due care for the environment, operating in a socially responsible manner resulting in the community being better off from [mining] having taken place. The upholding of all the sustainable development pillars is the only way to ensure the long-term sustainability of the industry.

The current state of CP, although not a new concept, is currently still poor within the SA mining industry. However, although the SA mining industry is implementing new technologies, it is not seen in the context of cleaner production. The industry should acknowledge the fact that they are practising CP when changing to new technologies and strategies with the intention to benefit both the environment and the company's bottom line. CP in related to mining will be discussed in more detail in Section 9.5 of this paper.

EMA is, in the same sense, also in its infancy within the SA mining industry. During 2001, KPMG surveyed 19 companies from the following industry sectors—mining and metals (7), parastatals and utilities (5), oil and chemicals (4) and motor manufacturing (3) (KPMG 2001). The findings of the survey suggested that there is a growing awareness of the significant financial implications of environmental performance and that environmental accounting practices are gradually increasing. The current application of environmental accounting, however, was shown to be at extremely low levels.

The survey findings showed that only seven companies (37%) claimed to have any environmental cost savings information, while only five companies (26%) responded with actual financial data on environmental costs savings, cost avoidance and revenue. This probably reflects the current lack of formal environmental accounting systems, which would enable such information to be constantly tracked and easily accessible (KPMG 2001).

To the author's knowledge, the survey done by KPMG was the only formal survey done with regard to environmental accounting practices in South Africa and to date, none of the mining companies in South Africa have implemented environmental accounting systems. EMA will be discussed in more detail in Section 9.6.1.

9.2 Mining and Sustainable Development

Mining and sustainable development are not contradictory terms. Although individual operations are finite, the contribution that mining can make to sustainable development can and does have profound and long-term effects (Chamber of Mines of South Africa 2005). Sustainable development in the mining and metals sector, according to the *Minerals Council of Australia* (2004), means that investments in minerals projects should be financially profitable, technically appropriate, environmentally sound and socially responsible. Alignment of a range of key industry initiatives is critical to ensuring the successful implementation of sustainable development principles and objectives across the minerals sector.

The pressures directing the extractive industries towards sustainable development are captured and addressed by mining industries in different countries. South Africa reports on sustainability and transformation in the *Chamber of Mines 2005 Annual Report* and how the industry has performed against set targets. Both Australia and Canada have embarked on sustainable development initiatives. The Canadian initiative, *Towards Sustainable Mining (TSM)*, is built on guiding principles, which is also a condition of membership of the *Mining Association of Canada*. The members must endorse the TSM principles and report on key performance areas within three years (Mining Association of Canada 2004). *Enduring Value* (EV) forms the Australian Minerals Industry framework for sustainable development and is built on the *International Council on Mining and Metals'* (ICMM) set of sustainable development principles. Commitment to EV is compulsory for full membership of the Minerals Council of Australia (Minerals Council of Australia 2004).

The ICMM principles, which form the basis for sustainable development in the mining industry, include the following:

1. Implement and maintain ethical business practices and sound systems of corporate governance
2. Integrate sustainable development considerations within the corporate decision-making process
3. Uphold fundamental human rights and respect cultures, customs, values in dealings with employees and others who are affected by our activities
4. Seek continual improvement of our health and safety performance
5. Seek continual improvement of our environmental performance
6. Contribute to conservation of biodiversity and integrated approaches to land use planning
7. Facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products
8. Contribute to the social, economic and institutional development of the communities in which we operate
9. Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

Putting these principles into perspective, Hermanus (2007) describes what is expected of mining companies in South Africa:

1. Companies can contribute to biodiversity conservation by developing nature conservation inventories as well as the criteria for establishing and maintaining protected areas.
2. Mining companies must also develop integrated approaches to occupational health and safety, public health and environmental protection.

3. Thorough land use planning and decision-making, as well as enhancing methodologies for assessing land use options will enable companies to support and develop multiple and sequential land use strategies.
4. Maximising the life of mineral resources by means of recycling and reclamation will strengthen the economic pillar of sustainable development.
5. Economies can also be sustained by replacing depleting mineral assets with new forms of wealth, e.g. capacity building and workforce skills development.
6. High standards of environmental performance are possible through the protection of life-support systems e.g. water, air, soil, flora and fauna, by minimising the ecological footprint on land and by rehabilitating the disturbed land to an agreed upon usefulness.
7. Companies can assist in optimising economic return to community affected by mining by supporting training and education.
8. Some specific ways of managing renewable and non-renewable resources consistent with sustainable development principles are carbon sequestration, energy efficiency and waste minimisation.
9. Finally, mining companies can be means of good governance, that is transparency and rejection of corruption and bribery, contribute to reducing mineral related conflicts.

The mining industry in South Africa is also fully aware that development, which is sustainable in the long-term, will not be possible without the socio-economic transformation of the mining industry. Broad based legislative changes and regulatory shifts have been introduced during the last 15 years. The Broad-based Socio-economic Empowerment Charter for the SA mining industry was developed alongside other legislative changes to form the basis of the social pillar of sustainable development (Chamber of Mines of South Africa 2005). The Charter has, as one of its objectives, the socio-economic development of the areas in which mining takes place. This is done by means of a *Social and Labour Plan* (SLP) which is a regulatory requirement specified by government. To meet this requirement, industry has spent hundreds of millions of SAR and on social projects, much of it on rural development. The requirements for the SLP for the mining industry include working to ameliorate the impact of mining on communities affected by the industry (Chamber of Mines of South Africa 2004). It is therefore clear that the social pillar of sustainable development forms one of the major objectives of growth and development within the mining industry in South Africa.

However, in a corporate context, according to the King Committee (2002), 'sustainability' means that each enterprise must balance the need for long-term viability and prosperity [of the enterprise itself and the societies and environment upon which it relies for its ability to generate economic value] with the requirement for short-term competitiveness and financial gain. Schaltegger and Wagner (2006) point out that the ability to manage non-market issues can be crucial to the existence and economic success of a mining company.

A range of schemes or tools is available to facilitate the implementation of corporate sustainable development principles and objectives. Managers therefore need to identify and select the most appropriate range of tools to achieve sustainable development. Figure 9.2 provides a summary of the inter-relationship of the various initiatives or schemes which form the basis of the business case for sustainable

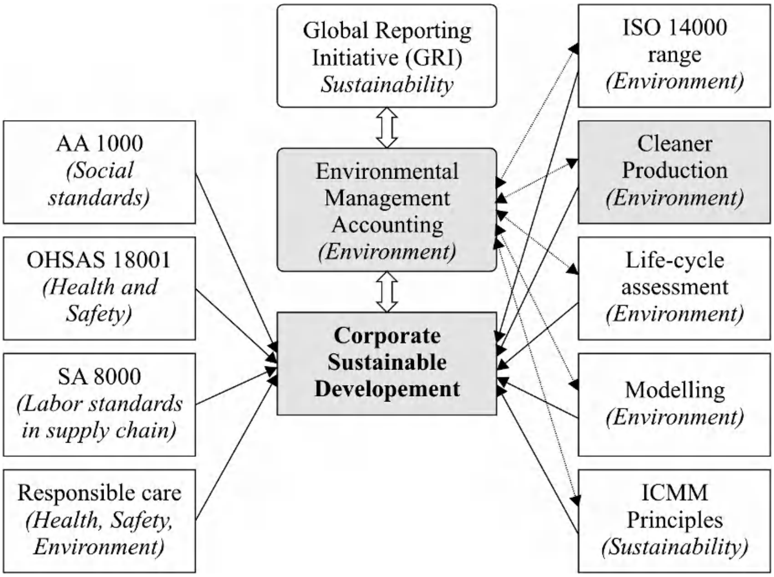

Fig. 9.2 Sustainability inter-relationships. Adapted from AICC (2002)

development in the mining sector. The solid lines show the different drivers and tools which have a direct influence in sustainable development, while the dotted lines show the inter-relationship between environmental management accounting (EMA) and other environmental management tools.

To improve the sustainable development of mining companies, management must be informed about the relevant environmentally and socially induced financial impacts on the company as well as environmental and social impacts added by corporate activities. In this regard, financial accounting is the central economic information management system for most companies. It forms the basis for integrated planning and is a core element in most integrated corporate monitoring and control systems. Reporting, in closing the loop, must therefore also include all the challenging issues associated with achieving sustainable development.

Sustainable development in the extractive industry is therefore, as described earlier, also complemented by a range of tools, guidelines, principles and activities to support sound corporate governance, ethical business practices and responsible extraction of natural resources.

9.3 Challenges Faced by the South African Mining Industry

South Africa is particularly rich in mineral resources and is one of the leading raw material exporters in the world. The main minerals are gold, diamonds, platinum, chromium, vanadium, manganese, uranium, iron ore and coal. There are, however, challenges facing the mining industry, which will determine the sustainable development successes.

The most fundamental challenges, according to Baxter (2005), faced by the SA mining industry are the productivity rate of labour, the cost of capital and their impact on the cost of mining and extracting minerals. For most minerals, South African producers are 'price takers', as the prices are set on international markets. To remain competitive, particularly with many low-cost emergent world producers, South Africa's mining industry has to focus on productivity and cost trends. Operating margins have to remain at current levels, or become competitive to attract investment into the industry and to sustain existing operations.

These low cost producers of the future will have to be lean and efficient; they will have to ensure low operating costs (well below $250/oz gold produced), utilise cutting edge technology, have highly skilled staff and will be able to remain profitable possibly at costs as low as $200/oz gold produced. There are not many South African companies that are likely to be able to adjust their operations to achieve these types of outcomes. There has already been a major decrease in the number of gold mining companies—between 1990 and 1999 the number dropped from 37 to 10 (Baxter 2005; Mbendi 2003).

The South African minerals sector also possesses specific characteristics, which render it sensitive to certain developments in the global mineral industry (WWF 1999). These factors could either be supportive of or inhibit sustainable development:

- Continued downward pressure on the gold price
- Continuing uncertainty in some emerging market economies causing continued fluctuations in demand for growth-related minerals and mineral products
- Economic incentives and environmental regulations which force the recycling and re-use of minerals
- Changing legislative framework.

9.3.1 Key Cost Drivers in the South African Mining Industry

Gold, as an example, is the largest mineral foreign income earner in South Africa, contributing 27.4% in mineral revenues. The substantial decline in the gold price over the past two to three years has impacted heavily on the sector in South Africa. The reasons for the fall in the gold price are many and varied and have their roots in the global economic changes that have been described previously. While the current decline in the gold price has been triggered by central bank selling, a long-term trend of a lower gold price does appear to have been factored into the operations of the gold mining industry (Baxter 2005).

The following key cost drivers, among others, have a cumulative effect on the input costs, according to Baxter (2005) and therefore ultimately have an effect on the profitability of the mining industry:

- Raw material costs (explosives, timber, clothing)
- Indirect taxes, Unemployment Insurance Funds, Skills Development funding

- Waste water discharge charge system (disincentive charges, taxes)
- Costs related to meeting the requirements of the Mining Charter and to the application of Social Plan (not yet costed)
- Electricity and water cost increases (average 9% increase per annum)
- Impact of the stronger Rand (cost of lost foreign revenue)
- Wage negotiation outcomes (job grading, pension fund contributions, wage increase, annual leave, housing allowance) ≈10% increase
- Potential costs for healthcare funding.

Most of these cost drivers are also determining factors when looking at sustainable development options within the mining industry. The most prominent of these factors are water, energy and labour.

9.3.2 Water as Input Resource

South Africa is a water-stressed country, with some geographical areas characterised by water scarcity. Water is therefore one of the fundamental resources to consider when the mining industry develop technologies for more effective extraction of minerals.

Water sources utilised during mining activities vary significantly between operations, from purchased raw water, to ground water supplies, to rivers and salt lakes. Generally, the quantity of water purchased by operations is taken as the first yardstick to assess water consumption from billed water sources (Gold Fields 2004). Mines can and invariably do, undertake mass balance calculations for water and pollutants. This however does not always account for all the water on a mine (WWF 1999).

9.3.2.1 Energy Sources

The cost of electricity in South Africa is considered to be relatively low by international standards. However, the growing energy demand will require South Africa to make significant investment in electricity-generation capacity, which will, inevitably, result in higher electricity prices.

Energy utilisation is an integral part of the mining process, whether it is in the form of diesel for transport and equipment, or electricity for pumping and refrigeration. The type of energy used by and the relative significance of energy costs in mining operations in South Africa are related to the type of mining operation. Electricity is by far the most significant source of energy used by the mining sector. Out of all commodities, gold mining purchases the most electricity (WWF 1999).

Energy efficiency of South African mining has been called into question in the past, due to the relatively low price of electricity as an input to production (DME 2005). International comparison of energy efficiency is difficult due to the differing conditions under which mining takes place in other parts of the world. Nowhere else in the world is gold mined at such deep levels and from such hard ore.

The mining industry depends heavily on electricity, with 87% of its energy use coming from this source. South Africa's mining industry has generally not used the latest energy-efficiency technologies. This is mainly a result of relatively low energy costs, large coal reserves, its fuel mix (with South Africa having amongst the world's highest uses of coal and the lowest of fuel oil and gas for electricity generation) and the use of older, less efficient power plants (Mining 2003).

9.3.2.2 Labour

Labour, as a resource, is a challenge to manage in South Africa. During the last few years, there has been an increase in union demands, some resulting in economically disastrous strikes. Companies have traditionally been able to manage the link between environmental performance and economic success better than the link between social performance and economic success (Schaltegger and Wagner 2006).

Labour is the most significant resource in mining and more specifically in gold mining, as operation is still dependent on human labour during the mining process. The gold industry is also responsible for 56% of South Africa's mine labour force. Labour issues clearly fall within the focus of the Mining Charter as described in Section 9.2.

In the drive to lower costs and become more internationally competitive the mining industry shed thousands of jobs during the last two decades (WWF 1999). An estimated 34,818 people were retrenched from the sector between December 1996 and December 1997 and a further 15,000 between January and April in 1998. While many companies have been through the worst of their downsizing, more recent pressure on the gold price in 1999 is likely to result in further job losses at marginal mines due to an inability to reduce costs further (DME 2005).

The three issues mentioned (water, energy and labour) and their importance with regard to sustainable development are discussed further within the South African gold mining context.

9.4 Gold Mining Context

This section looks at the gold mining industry and examines the pressures and drivers that influence the sustainable development of the sector. These factors ultimately also link to possible cleaner production initiatives.

Gold mining in South Africa still holds a special position in the economy with 40% of the world's gold reserves found in the Witwatersrand area. Although the relative importance of gold mining has fluctuated over the last decade with the performance of the gold price, the gold mining industry will continue to play a substantial role in the economy of South Africa. The gold sector also remains the major contributor to the mining industry, contributing to 3.5% of GDP, which again constitutes nearly half of the total contribution of the mining industry to GDP (WWF 1999).

Table 9.1 Total unit gold production costs per country (Behrmann 1999)

Gold producing countries	Total costs (including production, amortisation, depreciation and finance expenses)
Australia	\$261/oz
Canada	\$267/oz
South Africa	\$273/oz
United States	\$257/oz
World average	\$261/oz

Table 9.2 Gold production comparison (2004; AngloGold Ashanti 2004a, b; Gold Fields 2004)

	Gold fields	AngloGold Ashanti
Gold produced (000)	2,800 oz	3,079 oz
Cash cost	\$251/oz	\$291/oz
Water use	36,100,000 m^3/year	49,629 937 m^3/year
Electricity kWh/oz (gold produced)	4,620 kWh/oz	5,416 kWh/oz
Total employees	43,000	44,867

The development of the technical capacity to mine deep-level gold ore bodies has led to gold mining becoming even more capital intensive. This is because of the massive capital requirement for ventilation, cooling, hoisting, underground tunnelling and surface processing plant. Other reasons are the need to have large numbers of workers operating in the mines and the changing costs of resources.

It is relatively expensive to mine gold in South Africa. Total production costs are higher than the average for Australia, Canada and the USA and the world average as shown in Table 9.1 (Behrmann 1999). South Africa, however, by virtue of the extent and quality of its deposits the country offers good long-term investment opportunities (WWF 1999). High production costs in South Africa are primarily because of the deep levels at which gold is mined and the exceptionally hard ore from which it must be extracted. Approximately half of the operational costs of gold mining are labour related and as such good labour relations are the key to success in the industry. Owing to its high unit costs, South Africa is particularly vulnerable to downturns in the gold price. The cost of production is directly linked to cleaner technology options and also a determining factor with regard to sustainable development.

About 95% of South Africa's gold mines are underground operations, reaching depths of over 3.8 km. Coupled with declining grades, increased depth of mining and a slide in the gold price, costs have begun to rise and as a result production has been steadily falling. However, in order to cut costs, mines have undergone major business restructuring and have reduced costs dramatically. Unfortunately, this process involved several thousand workers being retrenched (Mbendi 2003). Table 9.2 gives a summary of the resource costs, the quantity ore mined and total number of employees as comparison of two major mining companies in South Africa. The comparison aims to illustrate the different input factors when calculating the cost of production and emphasise the complexity of business case for sustainable development.

Although the difference in gold produced for the year 2004, between the two companies was approximately 10%, AngloGold Ashanti used approximately 33% more water than Gold Field and also approximately 17% more electricity. The influence of the higher water and electricity consumption as well as the higher labour total is visible in the high cash cost of AngloGold Ashanti. The reasons for the high water and energy consumption can be attributed to some of the AngloGold Ashanti mines being very deep. The average cost ($271/oz) is still within the range as discussed under Table 9.1.

9.4.1 Water

To understand the importance of water as resource the costing structures of water in South Africa should be discussed. When assessing water use costs in mining operations it can be divided in three main categories (Wimberley 2006):

(a) Normal costs

The normal costs are based on water prices as set by the Department of Water Affairs and Forestry (DWAF).

(b) Taxes, permits and indirect costs

These costs include the following:

- Water use authorisation costs
- Cost of application, time and effort, uncertainty
- Waste discharge charge system costs.

The waste discharge charge system (WDCS), for example, is based on the polluter-pays principle and aims to:

- Promote the sustainable development and efficient use of water resources
- Promote the internalisation of environmental costs by waste dischargers
- Recover costs associated with mitigating resource quality impacts of waste discharge
- Create financial incentives for waste dischargers to reduce waste and use water resources in a more optimal manner (DWAF 2005).

The WDCS provides an economic instrument to support the management of water quality, where problems have been identified through the processes of classifying the water resource and developing a catchment management strategy. The WDCS consists of two distinct *water use charges*, either or both of which may be applied in a specific catchment, plus a *management cost*:

- Charges that provide a disincentive or deterrent to the discharge of waste, based on the use of the resource as a means of disposing waste (incentive charge)

- Charges to cover the quantifiable costs of administratively implemented measures for the mitigation of waste discharge related impacts (mitigation charge)
- Predetermined management cost (DWAF 2003)

The effect of the WDCS has been tested in two catchment areas. The testing suggests that waste discharge charges in the Crocodile (West) catchment (Hartebeespoort Dam) would be in the order of R25–R115 ($4–$18)/kg $PO_{4/}$annum, while those in the Olifants River catchment (Witbank Dam) would be in the order of R3,000–R10,250 ($485–$1,650)/t SO_4/annum. It is therefore clear that these charges will have a significant impact on the total water costs as it may add up to approximately R10 million ($1.6 million) total annual waste discharge charge for a single mining operation.

(c) Possible future costs

The additional costs that mines might have to pay in future will further increase the total operational costs. Possible future costs are:

- Trading of water use authorisation
- Water conservation and demand management cost

It is important to note that most gold mining companies only assume water consumption during the mining operation in their financial planning, without taking all the additional costs into account, to determine the TOTAL cost of water. This gives an unrealistic cost of total water use. Environmental management accounting (EMA) and the proper accounting of all the water costs can address this problem. Cleaner technologies must also be considered in the future development of mining operations to reduce potential water discharge costs.

9.4.2 Energy Costs

Although energy costs in South Africa are still well below the world average, mining companies have additional costs with regard to energy use. These additional costs will initially add up to a substantial increase in total energy costs incurred by the mines. One example of these costs is linked to the South African government's new Energy Efficiency Strategy.

The Government of South Africa issued the Energy Efficiency Strategy of the Republic of South Africa in March 2005. One element of this Strategy is the encouragement of business-led, voluntary initiatives to improve energy efficiency. This Accord stands as a commitment between government and industry to support this specific objective of the Strategy. Energy efficiency commitments should not be seen in isolation of the national imperatives of increased investment, economic growth and job creation or the business drivers of efficiency, competitiveness and safety standards (DME 2005).

Industry signatories acknowledge the targets set in terms of the Energy Efficiency Strategy of the Republic of South Africa, to reduce the national final energy demand by 12% by 2015, expressed as a percentage reduction against the projected national energy use in 2015, with a final energy demand reduction target for the industry and mining sector as a whole of 15% by 2015.

This reduction in energy will require changes in technology and processes and linked to these changes, a rise in capital expenditures. These costs have not been calculated yet, but must be carefully incorporated in the total costing calculations. It can be stated once more that both EMA and cleaner technologies could assist in addressing energy reduction issues.

9.4.3 Labour Costs

Labour costs contribute to 50% of the total costs of a gold mine. Any changes in labour costs will therefore have a significant impact on the total costs incurred by the mine (Nwendo 2006).

The year 2005 was a particularly difficult year because of wage negotiations with unions and strikes by the miners awaiting the outcomes of the negotiations. The strikes alone had a negative effect on the production and revenues of the mines.

Following negotiations, according to Nwendo (2006), that lasted 2.5 months, a two-year gold wage agreement was signed on Tuesday, 23 August 2005. Amongst other matters, the final agreement covered the following:

- Wage increases of 7% for Category three and four employees, 6.5% for Category five to eight employees and 6% for other categories of employees
- Living-out allowances to be increased to R800 ($130) with effect from 1 July 2005. They will be increased further to R900 ($145) on 1 July 2006 and to R1,000 ($162) as from 1 September 2006
- An additional contribution of 0.5% towards risk benefits within the Mineworkers Provident Fund (MPF) as from 1 July 2005 and another 0.5% with effect from 1 July 2006.

Table 9.3 gives a summary of the employee cost breakdown. These costs are important when comparing total production costs. The employee costs do not include a breakdown with regard to environment related labour and EMA could address this provided that the mines have the correct information and breakdown available.

The impact of the wage increases on unit costs for the different companies is the following:

- Gold Fields: It is estimated that Gold Fields' SA wage bill will increase from R3,360 million to R3,790 million, implying an increase of $8.30/oz on 2005 actual group costs.
- AngloGold Ashanti: It is estimated that AngloGold Ashanti's SA wage bill will increase from R3,700 million to R3,950 million, implying an increase of $5.90/oz on 2005 actual group costs.

Table 9.3 Employee costs breakdown across the SA gold majors (2005; Adapted from Company data; Deutsche Securities estimates 2005)

(2005 figures)	Gold Fields	AngloGold-Ashanti
SA production (000oz)	2,824	2,827
Total SA costs (Rm)	6,720	6,727
Total SA labour costs (Rm)	3,360	3,700
SA labour as % of SA costs	50	55
Number of SA employees	45,200	43,000
Average costs per SA employee (R/employee/year)	78,144	81,859
Absolute increase in SA wage bill ($m)	35	39
Increase on SA cash costs ($/oz)	12.44	13.68
Labour equivalent to increase in wages costs (employees)	2,881	3,028

The wage increases also have an indirect effect on the valuation of gold shares. Furthermore and more importantly, the pending restructuring of the SA portfolio by the SA gold majors will offset these recent increases. AngloGold Ashanti, for example, will probably shed 2,500–3,000 employees as the result of a marginal mine closing. Gold Fields will probably rationalise its labour force through a process of natural attrition.

This example clearly gives a summarised description of the most important factors which determine the cost of gold production. Water and energy should be the target input resources to consider when deciding on new technologies aimed at cleaner production and sustainable development.

9.5 Cleaner Production

According to Ecosteps (2003) and Environment Australia (2000) cleaner production (CP) means using the UNEP definition, 'the continuous application of an integrated, preventative environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment'.

Its application to mining can be described as a key part of the continuous improvement process aimed at maximising resource usage and operational efficiency over the entire life cycle and continuously minimising waste disposal and rehabilitation requirements. It is a process of continuous improvement in environmental and economic performance (Environment Australia 2000). CP successfully integrates and implements a range of well known concepts of good environmental practice—pollution prevention, waste minimisation, recycling and re-using of waste resources as a new product.

The CP approach most effectively addresses the wasting of natural resources and thus environmental impacts. According to Parker (1998), a number of cases have shown that such an approach often leads to improved economic performance in companies due to reduced waste, reduced costs for control and legal issues and better stakeholder relations. The studies have also shown a connection between environmental and financial performance linked to cleaner production practices. Scavonne (2005) indicates that financial analysis for cleaner production differs in several ways from typical project analysis: it uses a significantly larger cost inventory, including costs of waste and emission and regulatory compliance. Cleaner production also almost always reduces risk and therefore a lower discount rate should be used for estimating the net present value of future cash flows. This means that the future savings will be worth more.

Cleaner technology can be described as that part of cleaner production, which relates to installed equipment and machinery used. Cleaner technology, according to Marr et al. (2004), does not encompass equipment added onto the process to meet legislative guidelines, but it means modified equipment or new technology that prevents emissions. The authors further explain that although a process engineer can design the proposed plant to minimise emissions, factors such as good housekeeping practices lie with the operational staff. Some cleaner production aspects cannot be addressed during the design phase, but could include re-use or recycling of materials within the process.

It is important to note that in the extractive industry, the ore body being exploited and the mining method being adopted generally determine the feed materials or input materials. Auxiliary materials used during the process do, however, provide some scope for substitution.

9.5.1 Cleaner Production in the Mining Industry

The International Council on Mining and Metals (ICMM), representing leading international mining and metals companies as well as global commodities associations, sets general direction, policies and priorities for the mining sector. The ICMM has adopted a Sustainable Development Charter that contains management principles in four key areas: environmental stewardship; product stewardship; community responsibility and general corporate responsibilities (ICMM 2006). The ICMM's mission statement supports the concept of sustainable development within the global context and includes the following: 'To be the clear and authoritative global voice of the world's mining and metals industries, developing and articulating their sustainable development case, discovering and promoting best practice on sustainable development issues within the industries and acting as the principle point of engagement with the industries for stakeholders at the global level. To assist the industries to align their economic, social and environmental goals as to maximise their contribution to meeting the challenges of sustainable development'.

Although not all SA mining companies are members of the ICMM, it clearly sets the scene for sustainable development and therefore the embedded cleaner production principles.

Hilson (2003) discusses the definitions of CP and Pollution Prevention in terms of the mining industry. The mining sector has the ability to cause widespread environmental damage on numerous fronts. The mining industry has traditionally viewed sustainability as including a combination of environmental best practice and improved levels of socio-economic performance. This poses two problems:

- The exact application of environmental management terminology in the mining context
- The ability of the mining industry to avoid environmental impacts altogether.

In the mining context, CP has increasingly been associated with environmental improvements resulting mainly from technological diffusion and modification. The tendency to view technological change as the sole catalyst for achieving CP in the mining industry has resulted in an abandonment of non-technical opportunities such as training, education and alterations in managerial practices, which is capable of contributing equally to environmental improvements (Hilson 2003).

It is important according to Hilson (2003) to clarify that complete pollution prevention cannot be achieved in the mining industry because of unavoidable disturbances (e.g. erosion, sedimentation, deforestation, etc.), all part of the mining process, the bulk of which can only be addressed following closure. Nevertheless, numerous pollution prevention opportunities present themselves during the course of operation. Hilson (2003) also argues that pollution prevention in the mining industry should involve:

- The continuous integration of highly effective environmental technologies during the course of operation
- Implementation of sound process control and improved site design
- The complete reclamation of a mine following abandonment

Marr et al. (2004), carried out a study to determine to what extent the concept of cleaner technology, allied to that of cleaner production, was understood and used by design engineers in the SA mining and metallurgical sector. The researchers concluded that the concept of cleaner technology has not been sufficiently disseminated to process designers. Only approximately 10% demonstrated an advanced understanding of the concept. They also concluded that it was encouraging to note a widespread recognition of the importance of environmental considerations in design and examples of installed cleaner technologies. Only a small number of the participants discussed the use of full cost accounting, including both capital and operating costs in considering a process of option.

9.5.2 Cleaner Production Possibilities Identified by the Gold Mining Industry

Some mining companies, during the last couple of years, have considered cleaner production. It is seemingly an easy and logical way of looking at cost savings and minimising environmental impacts. Having said this, it is still obvious that the mining industry can do much more and most of the time small interventions can realise big change. During a survey done by the Chamber of Mines of South Africa, the environmental managers of some gold mining companies suggested some changes to be considered.

Water, being one of the major issues of concern, was identified as the most important input resource taken into account when considering cleaner production options. Firstly, mining operators need to compile proper and complete water balances for all phases during the mining operations. This will include the mapping of all pipelines (especially old pipelines) as well as installing additional water meters and calibrating existing water meters. Mines should use, or develop, cleaner technology to abstract clean underground water before it becomes polluted or effected. Other options might include the installation of two phase water pumps (this will benefit both water usage and energy savings), obtaining adequate storage capacity for storm water to be recycled in the operational process and the upgrade of sewerage effluent plants across mine properties.

Energy was listed as the second input resource that should be considered and cleaner production options were deemed necessary for efficient energy use. Once again the need for proper energy balances (not only electricity balances) and better maintenance of equipment were emphasised. Other suggested changes were:

- The replacement of all housing/hostel electric geysers with solar energy geysers
- Lighting systems changes (i.e. install timers on lights, replace old light bulbs and fluorescent tubes with energy saving bulbs, educate workers about switching off lights)
- Installation of timers and thermostats on air-conditioning systems.

Environmental trading, in the form of carbon trading and clean development mechanisms (CDM) are also relevant to the SA mining industry in terms of CP. The SA mining industry, according to the Chamber of Mines of South Africa (2007), is a major source of greenhouse gases, both directly through mining and minerals beneficiation activities and indirectly through the production of coal. Mineral beneficiation alone contributes more than 60% to SA's total industrial greenhouse gas emissions, a high percentage of which comes form the burning of fossil fuels of use of electricity. The largest single source of greenhouse gas emissions in the industry is methane emitted from coal mines, but significant amounts are also generated by other kinds of mining activities, for example, consumption of electricity to run motors for hoists, compressors, pumps and fans as well as for transport (Chamber of Mines of South Africa 2007).

Most potential CDM projects in the mining industry will fall into a few basic categories:

- Reduction of emissions of methane gas, either directly from coal seams, or indirectly from industrial processes
- Reduction of the consumption of fossil fuels
- Reduction in the use of electricity
- Improvement of the efficiency of mineral extraction or processing.

The mining companies also suggested other changes regarded as cleaner production options:

- Improve the management of oil usage (conduct proper oil balances and install effective oil traps)
- Introduce incentive schemes for all employees with practical, effective cleaner production suggestions.

In a recent study of CP opportunities in the SA coal mining industry, concluded that there are several barriers hindering the adoption of CP. These barriers were echoed by the gold mines and include the following:

- Economic barriers—access to capital
- Technological barriers—lack of CP knowledge, lack of infrastructure and acceptance of novel or unproven technologies
- Managerial barriers—shortage or the lack of relevant information, poor documentation of information and the absence of dedicated CP staff
- Legislative barriers—continuous changing of mining-related legislation and the current exclusion of CP in legislation.

It is clear that some relative easy changes could lead to huge improvements with regard to environmental impacts and have cost saving as medium to long term benefits. These suggested cleaner production options could be solutions to some of the challenges in the mining industry as already described.

9.5.3 Practical Cleaner Production Examples in the Gold Mining Industry

9.5.3.1 Water Treatment Technology

The SA mining industry, as discussed already, is facing major problems with regard to the management and treatment of contaminated mine water. These problems exist with regard to operational mines and, importantly, they also exist for mines which have ceased operations and which have long-term water quality problems. It is therefore essential that the mining industry support the development and use of cleaner technologies to solve some of the water problems.

Currently available effluent treatment technology, according to Pulles et al. (2004) for dealing with water quality problems is primarily of a chemical or physical nature. Although this technology is generally effective, it typically has very high capital and operating costs and intensive, ongoing, long-term maintenance requirements. This is a particular problem for those mines that have ceased operations and where it is not practical or cost-effective to construct an active treatment plant that requires constant supervision and maintenance.

An urgent need was therefore identified to develop low cost, self-sustaining, low maintenance passive treatment systems to address the problems of acidification and salinisation (in terms of sulphate) at operating, defunct and closed mines in South Africa, particularly as sulphate levels in discharged mine waters are regulated in South Africa. Passive treatment is defined as follows: a water treatment system that utilises naturally available energy sources such as topographical gradient, microbial metabolic energy, photosynthesis and chemical energy and requires regular but infrequent maintenance to operate successfully over its design life.

A major 10-year research programme was undertaken by *Pulles Howard & de Lange et al. Incorporated* together with various other research institutions, with funding from various agencies. This research commenced in 1995 resulting in the registration of a patent application in 2001 (Patent No ZA 2001/3493 'Passive Water Treatment', Pulles and Rose).

The major advances of the passive water treatment technology, according to Pulles et al. (2004), are:

- The carbon sources, in the form of lignocellulose, may be provided from manure, straw, hay, sewage sludge, wood chips and other agricultural solid residues (i.e. waste products)
- The technology can be adapted to site-specific conditions
- The technology is low maintenance
- The technology is cost effective.

The use of this passive water treatment technology by the gold mines as a CP intervention could therefore address water as input resource, the cost of treatment as well as the environmental issues associated with wastewater.

9.5.3.2 Energy Management Examples

Energy being the second most important input resource, is one of the issues identified by the gold mining industry to be addressed by means of CP technologies. The first step in the process of energy saving, according to various gold mine environmental managers, is training of employees to be more aware of energy use and the saving thereof. Secondly, reduction of energy consumption is possible by changing to more energy efficient machinery. A third CP initiative identified is the management of oil consumption.

The design of mining machinery to reduce oil losses, according to Grobler (2007), is a practical cleaner production option to have cost savings and environmental advantages. An example of such an initiative is to change from conventional pump manifolds, hydraulic filter manifolds and valve blocks to new integrated designs. The result would be approximately 20% less piping because of the location of the manifolds being central, a reduction in the number of adapter fittings, bolts, name plates, etc. and simplified circuits. All these changes will reduce costs and have better energy management as results.

Another form of energy management is oil management and recovery. Oil loss has cost implications and also impacts on the environment when leaking into the soil and groundwater. Used oil recovery from mechanical mining equipment, according to Van der Berg (2007), is less than 30% and oil contamination can be caused by rock drilling using inefficient equipment. Using electric drills and changing hydraulic pipe-work with special fittings can partly solve these problems. Van der Berg (2007) further proposed the use of an Erichson dam oil separator to capture spilled oil from contaminated water streams. The methodology involves the gravitational separation of oil from water due to the differences in densities and the size of the oil globules, which is critical to determine the rate of rise of the oil to the surface.

These examples could be successfully used by the gold mines to reduce costs and negative environmental impacts over the long run.

9.6 Environmental Management Tools

9.6.1 Environmental Management Accounting

According to IFAC (2005), *Environmental Management Accounting* (EMA) is defined as ‘the management of environmental and economic performance through the development and implementation of appropriate environmental-related accounting systems and practices. While this may include reporting and auditing in some companies, EMA typically involves life-cycle costing, full-cost accounting, benefits assessment, and strategic planning for environmental management’.

The *United Nations Expert Working Group on EMA* (UNDSD 2001) defines EMA as the identification, collection, analysis and use of two types of information for internal decision making:

- Physical information on the use, flow and destinies of energy, water and materials (including wastes)
- Monetary information on environmental-related costs, earnings and savings.

These two definitions highlight the broad types of information companies typically should consider under EMA and the relevance of EMA to cleaner production in terms of material flows and the costs thereof. The main problem, according to Jasch (2003), which is involved in attempting to carry out systematic identification of the potential for materials efficiency improvements [cleaner production] lies in traditional cost accounting systems, which are unable to provide relevant information on the company’s physical structure or materials flow. EMA is able to address this problem.

According to Gale (2006) and as previously discussed, CP is a management strategy to reduce resource use, waste production and pollution. It is a preventative strategy to minimise the impact of production and products on the environment. Gale further explains that the proper implementation of CP depends on an understanding of environmental costs in organisations and overcoming the broader challenges and barriers that conventional accounting represents to new accounting initiatives.

Gale (2006) suggests that EMA can be used as a tool in CP to provide decision makers with more accurate costing on which to base operational decisions, including decisions about capital investment and the benefits and costs of new technologies.

EMA promotes positive change within CP initiatives; it leads to strategies of structural reform rather than superficial change in company operations.

The ultimate problem that the mining industry faces is that the current financial measure of success of the industry captures little, if anything, of the costs of environmental management and compliance and environmental damage (Gray 2001). This is because accounting and economics measures generally only recognise objects or activities to which a monetary value can be attached. Consequently the mining industry may be sending messages of economic and financial wellbeing while destroying natural resources.

The mining industry can ensure that the correct message with regard to the growth and the associated costs are communicated correctly, and used appropriately for decision-making, by:

- Identifying areas of environmental spending and specific environmental costs on, for example, energy, wastes and raw material use
- Offering different interpretations of financial information that provide a better support for decision making that is responsive to environmental concerns in capital expenditure decisions
- Identifying and costing potential areas of environmental risk in such areas as acquisitions or new projects
- Costing out new alternatives in the light of changes in environmental legislation, possible taxation or subsidies
- Reconfiguring aspects of the performance appraisal systems so that environmental performance is explicitly recognised as a performance issue
- Specifically identifying new categories of costs for environmental contingency liabilities and provisions

The principle aim of EMA should be accounting for sustainable development. Companies within the SA mining industry should therefore recognise that their long-term future and sustainability is inescapably linked to their ability to reduce their environmental impacts and continuously improve their overall environmental performance. Being aware of their environmental costs (and benefits), the company's exposure to potential environmental problems can assist the managers in their strategic planning and help them to reduce the company's exposure to future environmental risks and liabilities (Howes 2001). Without adequate and appropriate systems to account for such environmental costs, it is unlikely that companies will be able to meet the future expectations of their customers and stakeholders toward sustainable development and the requirements of more stringent environmental legislation.

The mining industry could improve the accuracy of its balance sheet and investment project calculations by adopting more rigorous costing (that is environmental management accounting) to keep track of actual costs of their waste management efforts including lost resources, mine closure and site rehabilitation (UNEP 2002). Using environmental management accounting to carefully track, account for and report cleaner production initiatives, will ultimately force management to recognise both CP and EMA as useful and essential environmental management tools.

Sustainability reporting could be one of the management tools to enable managers to disclose environmental costs linked to both cleaner production initiatives and sustainable development.

9.6.2 Sustainability Reporting

Environmental reporting, as it was known for the past few years, is no longer comprehensive enough if used to reflect sustainable development objectives. A KPMG (2002) survey shows that more companies are, in addition to their annual financial report, preparing reports on their sustainability performance.

Reichardt (2005) reviewed the sustainability reports, 2001–2004 reporting cycles, of ten major South African-based gold and platinum group metals mines. These results were compared against two of the largest mining multinationals with significant South African presence and recognised leaders in terms of performance and reporting. Reichardt (2005) concluded that while most of the company reports consistently cover a wide range of sustainable development topics, less than half of this coverage, in terms of topics covered, is supported by quantitative data whose year-on-year comparison would allow stakeholders to assess company progress in achieving sustainable development objectives. This suggests that the majority of the sustainability reporting of SA mining companies is still not providing information that would allow their stakeholders to judge more than selected aspects of their sustainability performance over time. Reichardt did not report on the monetary data linked to the sustainability topics, which suggests that this information is not available.

Rogers (2005) describes the environmental financial reporting as the activities associated with the presentation of financial and non-financial environmental information in financial statements, these being the balance sheet and the income statement. The balance sheet shows at a particular point in time the resources owned by the reporting entity (assets) and what the entity owes to other parties (liabilities). The income statement provides a perspective on the financial performance of the enterprise over the accounting period. The income statement shows the source of income (revenue), the associated costs to generate that income (expenses) and the resulting profit or loss (net income).

Voluntary reporting of non-financial information, according to Rogers (2005), concerning an enterprise's social responsibility or environmental impact is an increasingly important consideration for large public companies. Standards such as the Global Reporting Initiative (GRI) now exist for voluntary use by organisations for reporting on the economic, environmental and social aspects of their activities, products and services.

It is therefore clear that monetary reporting with regard to sustainable development performance, and linking the performance to CP, needs to be developed and put into practice. Reporting environmental and sustainability performance in monetary terms will enable the mining companies to communicate valuable information to shareholders and other stakeholders about the implementation of CP options. Improved management of sustainable development and the reporting thereof is, however, dependent on a change in management styles and strategies.

Management and organisational behaviour styles have changed dramatically during the last decade. Although the basic management functions have stayed the same, the characteristics of the additional functions and focus have changed. Management focusing solely on making a profit without taking the environment and sustainability principles into account in the mining sector is no longer acceptable. Mining organisations must proactively embrace environmental and sustainability principles and objectives to gain or sustain their competitive advantage. Managing with sustainable development as the fundamental criteria will also contribute to legal compliance, customer loyalty, shareholder satisfaction and increased profitability.

The King Committee (2002) on corporate governance in South Africa suggests that there is a definite move by organisations from the single to the triple bottom line, which embraces the economic, environmental and social aspects of a company's activities. Companies should take cognisance of the financial implications of safety, health and environmental (SHE) issues and their possible impact on the sustainability of the company. SHE issues should be dealt with at board [management] level and should guide and approve the necessary policy, strategy and structure to manage SHE issues (King Committee 2002).

According to Gale (2006), the long-term potential of EMA and CP to promote corporate sustainability is about industry transformation. EMA contributes to corporate sustainability by acting as a catalyst for performance-based environmental management accounting and reporting systems. Schaltegger and Burritt (2000) also confirm that the purpose of environmental accounting is to enhance corporate sustainability and eco-efficiency. Schaltegger and Burritt (2006) explain that apart from the ethical motivation of some managers and the importance of accounting for sustainable development of a company there are at least three reasons that encourage managers to establish a corporate accounting and reporting system that provide information for assessing corporate actions on sustainability issues. These are legislative pressures, self-regulation (a voluntary action) and managing the business case for sustainability (this is to identify and realise the economic potential of voluntary social and environmental activities). The management of sustainable development therefore includes activities and systems designed to classify, record, analyse and report on the environmentally induced financial and ecological impacts of the organisation and the use of cleaner technologies to assist in achieving sustainability.

9.7 Conclusion

The mining industry in South Africa, which includes all commodities, is faced with many challenges while embarking on the road to sustainable development. These challenges include environmental issues (natural resources usage), social issues (labour) and economic issues (cost of production and cost savings).

The most common challenges faced by the mining industry are water and energy management and the cost of labour. Although the price of water and electricity is relatively low, South Africa is a water scarce country and the mining industry should not let low water and energy prices influence their attitude towards the importance of the correct accounting of water and energy costs. Water and energy savings are possible by implementing CP options. This, however, is still dependent on a mindset change that most managers have to make.

Labour, on the other hand, is a very visible and emotive issue in South Africa. Labour, as a resource in the gold mining industry, accounts for approximately 50% of total costs incurred by mines. Increases in labour costs will therefore have a significant cost increase even if the increments are small. Labour issues should be resolved with sustainable development principles as a starting point.

Although most of the SA mining industry is already operating in accordance with sustainable development principles, the sector can, learn a great deal from international initiatives such as the Canadian *Towards Sustainable Mining* initiative and the Australian *Enduring Value framework for sustainable development*. Mines can operate in a more sustainable manner if all the different aspects of sustainable development are integrated into mining management and mining operations.

By using proper accounting systems and obtaining all the relevant cost information, most environmental cost changes will be shown to have significant effects on the sustainable development strategies of the mining industry. In the same manner it will be possible to show that the implementation of CP technologies and principles could have long-term cost benefits. The mining industry, being the economic backbone of South Africa, does not have a choice but to seriously start implementing CP technologies as well as EMA systems to strengthen the drive towards sustainable development.

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Chapter 10
Environmental Management Accounting in the Metal Finishing Industry

Michael Koefoed

Abstract The article describes an environmental management accounting tool and its application in the metal finishing industry. The benchmarking tool which uses both absolute values and a relative index, monitors resource utilisation and waste production at process-line level and plant level. The tool format is Excel, a Microsoft spreadsheet program. The applied common denominator is the surface area of products, and units are either physical or financial.

The empirical data for the study is provided by a donor-financed cleaner production demonstration project in South Africa which ran from 2000 to 2004. The benchmarking of the metal finishing enterprises indicated potential water savings of 60–90% and savings of chemicals of 20–50%. Modifications of selected full scale plant for national demonstration confirmed these savings and the metal finishing enterprises have moved into the environmental sustainable production chain in South Africa and abroad.

The main challenges in implementing the modifications were social barriers, data retrieval from existing production and cash flow constraints for plant construction.

The principles and methodology described here can also be applied in other wet industries such as the paint, chemicals, wood, plastic, consumer products and hardware products industry sectors, in both South Africa and other emerging economies.

10.1 Metal Finishing Industry

The general metal finishing process includes the sub-processes of cleaning, pretreatment (pickling), application of metal (plating) and surface sealing (passivating). Between these sub-processes, the items are rinsed as shown in Fig. 10.1. The metal finishing plants are either in-house plants which are part of a more complex manufacturing process, or plants in individual job-shops which specialise in metal finishing.

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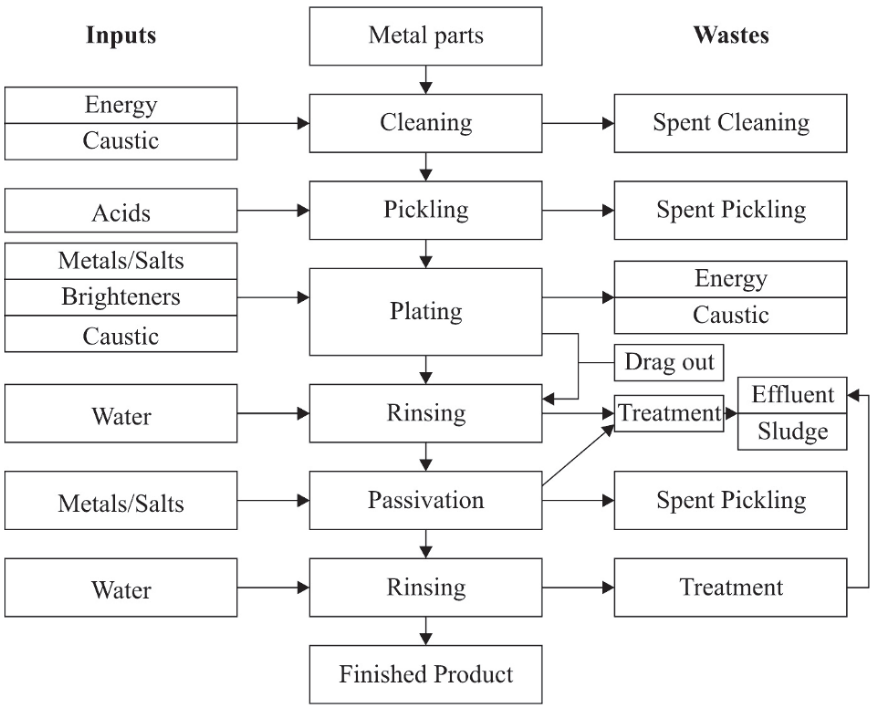

Fig. 10.1 Metal finishing process flow chart (US EPA 1996)

Metal finishing covers a wide array of various processes and products, from the bulk treatment of small items such as nails and bolts to the decoration of large unique items such as artwork or items for advertisement purposes. In order to optimise production flow, it is usual to treat many items together in the process baths. For optimal plant design and operation, the total surface area of the items is used as the common denominator. In plants which manufacture bulk products in standard sizes, product weight can be used as the common denominator, by using as the key factor the specific area per unit of weight of the products.

Some of the challenges in monitoring and applying environmental management accounting (EMA) in the metal finishing industry (MFI) are:

- Many chemicals are used in many different process baths.
- Water is consumed in all processes.
- Estimating the wastes generated in processes is difficult.

Metal finishing processes result in a variety of wastes and emissions which have a potential for human and environmental harm (Kothuis et al. 2000). A substantial proportion of the raw materials (chemicals) which are used in metal finishing processes and thus the waste which is generated, are hazardous (EMG 1993). Of particular concern are those that are highly toxic or contain carcinogenic ingredients that are difficult to destroy or stabilise, such as cadmium, cyanide, chromium and lead.

The rinsing process is the primary source of waste generated in metal finishing. This process is necessary in order to remove the drag-out from racks, parts or drums after removing them from the process baths (US Environmental Protection Agency 1996). This results in process chemicals and heavy metals being dragged-in and discharged with the wastewater.

Another source of wasted resources is the process baths that need to be discharged periodically, when they lose their effectiveness due to chemical depletion or contamination ("spent baths"). In order to comply with effluent discharge regulations, the MFI's response has been to develop end-of-pipe technologies, which in turn give rise to the generation of toxic sludge which requires careful disposal (Van der Meer 1998). Wastewater treatment sludge is usually the major solid waste stream from metal finishing (Cushnie 1994).

Conventional waste water treatment systems consist of the preliminary treatment of cyanide and chromium-bearing wastewaters, followed by hydroxide precipitation, clarification and sometimes filtration or solids de-watering. The hazardous sludge which is generated must be disposed of in an approved landfill (US Environmental Protection Agency 1996). The heavy metals which are contained in industrial wastewater are generally found to cause problems downstream at sewerage treatment plants for a number of reasons:

- Heavy metals are not easily removed from wastewater streams and are present in the effluents discharged to waterways, causing adverse impacts on aquatic life.
- Heavy metal inhibits the biological treatment processes at sewage treatment plants, reducing the plants' treatment efficiency.
- The high concentration of heavy metals such as cadmium which accumulate in sewage sludge and limit disposal and reuse options (UNEP, 1998).

10.2 South African Metal Finishing Industry

Publicly available data about the MFI in South Africa is difficult to retrieve as the registration of enterprises with authorities provides only a partial picture of the size and distribution of the industry (Kothuis et al. 2000).

A private survey and an updated estimate of the MFI indicate that there are between 500 and 600 independent metal finishers in the country and that the total number of firms with significant metal finishing operations may be 1,200 (Janisch 2000; SAMFA 2004), as there are a slightly greater number of independent job shops than in-house metal finishers. With information obtained from 20–25% of the metal finishing sector, the survey is assumed to provide a fair picture of the South African MFI. Some smaller job shops operate from backyard facilities and are not officially registered (Binnie and Partners 1987).

The results indicate that the distribution of processes in South Africa is similar to that in other industrial countries. In each case, painting and powder coating together appear to make up the largest sector (50%) in terms of the total number of firms. Electroplating makes up the next largest group (40%) and is probably the single largest group if painting and powder coating are separated. Other significant sectors are anodising and hot dip galvanizing, though these are much smaller in number (<10%). More than 90% of the metal finishing shops investigated are small and medium-sized enterprises (SMEs). The vast majority have less than 50 employees and 20% have less than 10 employees.

The MFI was identified as one of the most polluting industry sectors in South Africa. The contribution of the sector to the country's total wastes was not large when measured by waste quantity per produced per unit of output, but more than 80% of the waste generated was hazardous (Janisch 2000). Some of the main challenges for an EMA application Tool in the South African MFI were:

- No inventory management of chemicals.
- Low cash flow, no cash funds for investments and high investment interest rates.
- Chemicals management and procurement was outsourced to suppliers in a highly competitive market.
- No formal technical vocational training available for plant staff (no human capital).
- No tradition of sharing information in a highly individual industrial society (no social capital).

Outdated equipment and poor maintenance led to increased water and energy consumption and the generation of unnecessary waste. The most common areas of wastage were excessive water consumption and the loss of chemicals due to drag-out and spillage. These problems were mainly a result of poor house-keeping, often associated with poor worker education and skills. The electroplating, anodising and chemical surface treatment processes were found to be the most water-intensive amongst the metal finishing operations in South Africa and water was not used efficiently in most operations (Binnie and Partners 1987). Approximately 80% of the annual water intake of the MFI is used for rinsing. Table 10.1 summarises the wastes generated by the MFI (Janisch 2000).

The sludge from sewage treatment plants in South Africa was traditionally used as a soil fertiliser on farmlands, but this was often not possible due to this high heavy metal content, with the result that the sludge had to be disposed of to landfill (Barclay et al. 1999). Many of the government or privately owned treatment/disposal sites in South Africa were overloaded and local authorities were concerned about a shortfall in capacity leading to costs for treatment upgrades, site remediation, or the development of new sites. There was particular concern over wastes containing heavy metals in disposal sites. Leaching and mobility rates of heavy metals in these dumps were accelerated by strongly acidic rainfall, a common occurrence in much of South Africa's industrial heartland.

Table 10.1 Toxic metal load from metal finishing industry relative to total load (%; UNEP 1998)

Metals and their proportion of total waste from metal finishing relative to total industry (%)					
Cadmium	Chromium	Copper	Lead	Nickel	Zinc
2	45	45	5	72	43

10.3 Benchmarking a Cleaner Production Tool

The dedicated EMA benchmarking cleaner production tool (BCPT) was developed by Dahl and Jensen (Dahl 2000; Danish Technological Institute 2000). The key principle is the unit operation mass balance principle, which is a very common general approach to cleaner production (CP) assessments (Barclay et al. 1999).

The tool can be applied to most unit operations in metal finishing. The tool is built on a platform of several inter-related spreadsheets, with many support tables which describe the three most important areas of metal finishing: total raw materials consumption, process bath operation and disposal and the rinsing process and economy. This platform has been extended with flowcharts of the process line, tables describing occupational health and safety conditions, a list of suggested clean technology improvements, solid wastes generated, consumption of chemicals for waste water treatment plant and efficiency of same (relative to local effluent requirements). The cleaner production profile of the assessed plant is presented by eight parameters shown in Table 10.2, and Fig. 10.2 presents the audit tool focus points. Figure 10.3 presents the overall result of an EMA audit tool plant score.

The efficiency of the unit processes is calculated as the metals, chemicals and water which are consumed and the wastewater and sludge which are produced per production unit, which here is surface area measured in m^2. In this article the focus will be on the key process parameters, because proper improvements of the manufacturing process will significantly reduce the wastes which are generated and thereby reduce the need for waste water treatment. In the following, principles and examples will be shown for illustration purposes only. For details of the model, including the calculation principles, please refer to Dahl (2000).

10.3.1 Total Raw Materials Utilisation

The total raw materials utilisation as shown in Table 10.3 is prepared for each process (in this case, these are the plating processes). All raw materials such as metal, chemicals and water are listed by name, active ingredient and the quantity consumed in the period, e.g. per year or quarter. For many chemicals there is insufficient

Table 10.2 EMA audit tool focus points

Manufacturing area	Parameter	Format
Input	Total raw materials utilisation	Calculation sheet
Process	Process bath utilisation (spent baths)	Calculation sheet
	Rinsing process quality (waste water)	Calculation sheet
	Occupational health and safety	Rated in table
	Clean technology option list	Check list
Output:	Waste quantity	Listed in table
	Waste water chemicals consumption	Calculation sheet
	Waste water treatment efficiency	Rated in table

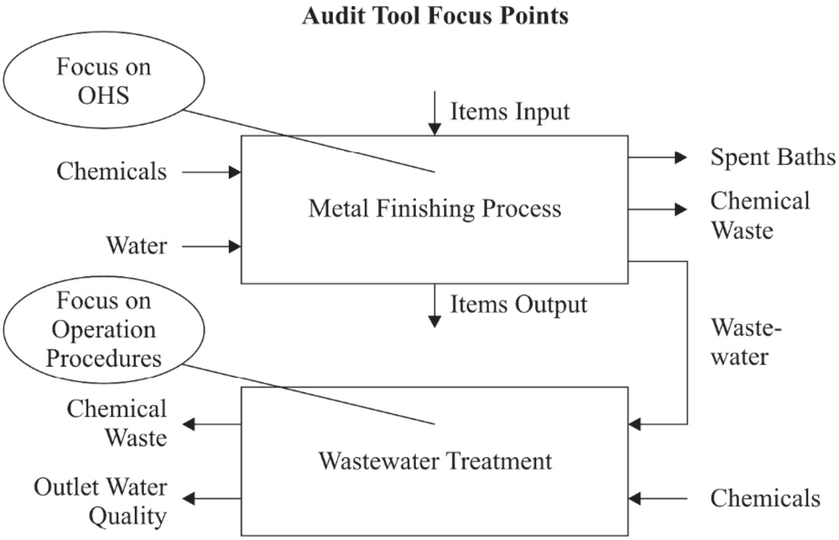

Fig. 10.2 EMA audit tool focus points (Dahl 2000)

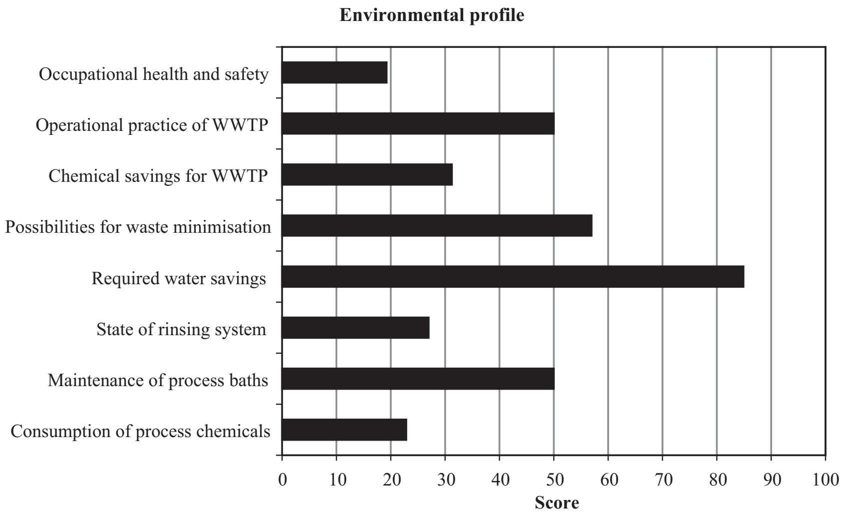

Fig. 10.3 EMA audit tool plant environmental score (Score: 0–20 Unacceptable; 20–50 Bad, 50–80 Promising, 80–100 Good; Dahl 2000)

information about the content of active ingredients, which prohibits comparisons between alternatives.

The thickness of the finishing material (here, plated metal) is a key parameter for product quality, maintenance and also for production economy as metal comprises a significant part of the raw material cost. The thickness can be measured by

Table 10.3 Raw material utilisation, zinc line (Score: 1 = good, 5 = unsatisfactory; Dahl 2000)

Zinc line:	Chemicals			Thickness in µm				Kg chemicals per 1,000 m²		
Process bath	Type	kg/year	€/yearr	Calculated	Estimate	m²/year	m²/h	Calculated	Goal	Score, 1–5
Degreasing	Degreaser salt	825	912			34.236		24.1	25.0	1
Pickling	Hydrocloric acid	4.950	926			34.236		144.6	75.0	4
Zinc bath	Zinc anodes	2.200	3.200		9	34.236	11	64.3		
	Sodium Cyanide	1.100	2.477			34.236		32.1	58.0	1
	Sodium Hydroxide	550	314			34.236		16.1	71.0	1
	Zinc oxide	385	930			34.236		11.2	1.5	
	Brightener	1.100	142			34.236		32.1	13.0	3
Chromating, blue	Powder salts	100	154			17.118		5.8	2.0	2
Chromating, yellow	Concentrate	275	250			17.118		16.1	5.0	3
								0.0		
Sum:		11.659	9.305					9.0		
Operation time: 3080 h/year										

either rather expensive equipment (non-destructive measurements) or by more simple hand tools (destructive tests).

The total product surface area is used as a common denominator in the tool calculation and rating. For bulk productions of standardised items such as nails, the total surface area can easily be measured and calculated. For more irregular shapes and geometries of products, the surface area can be estimated through simple geometric calculations. This area can then be crosschecked against the surface area calculated from the thickness of the finishing layer and the amount of metal consumed. It should be noted that the total surface area calculated can differ as between the various raw materials, as some baths may be shared between several process lines.

From this information, the specific consumption of all raw materials is calculated per unit of product surface area. These figures are then compared with predefined goal values as relative index 1–5. Goal values can be the previous year's results, local industry average values (if known), values set in either national or international standards or recommendations (Best Available Technology, BAT).

10.3.2 Process Bath Utilisation

Table 10.4 presents an important source of loss of chemicals, the amount of pollutants in the process baths. Each process line needs a single table which comprises all the process line baths. Like Table 10.3, this table contains all information about the primary costs of the process baths: raw materials listed by functional ingredient, quantity consumed and cost per period and production load (total area of items processed) for baths (note that some baths are shared between process lines).

The table specifies also the details of the process baths, the maintenance service of the process baths including filtration, treatment with coal treatment or chemicals, precipitation of metals or other regeneration procedures. Process bath disposal methods and cost are specified including external or in house treatment, treatment followed by recycling in-house or by external service provider other disposal. These activities influence strongly the secondary cost of the process baths, the cost of bath disposal. The total cost of the baths is listed and indexed against preset goal values following the principle in Table 10.3.

10.3.3 Rinsing Process Scoring

Table 10.5 presents details of the rinsing process. The rinse water cleans products between the process baths, and removes all contaminants and excess chemicals. The key waste problem and challenge for further wastewater treatment is twofold; many different and non-compliant chemicals are mixed and various volumes of rinse water, with very different concentrations of chemicals are mixed. The result is a huge volume

Table 10.4 Process bath utilisation, zinc line (Dahl 2000) ([a]Service: (1) Full filtration, (2) Some filtration, (3) Active coal, (4) Chemicals, (5) Metal precipitation, (6) Other regeneration; Disposal methods: CT = Central Treatment, IT = Internal treatment, IR/ER = Internal/external recycling & treatment, OD = Other disposal; Score: 1 = good, 5 = unsatisfactory)

Zinc line	Chemicals and Production			Process bath			Baths cost		litre bath per 1,000 m²	
Process bath	Type	€/year	m²/year	l	Service, Disposal	m³/year	€/year	Calculate	Goal	Score 1–5
Degreasing	Salt	912	34.236	3.300	0, ER[a]	17	912	482	75	5
Pickling	Sulfuric acid	0	0				0	0	45	
HCl pickling	Hydrochloric acid	926	34.236	900	ER[a]	3	926	87	30	2
Pickling-degreaser	Sulf. acid	0	0				0	0	45	
Electrolytic cleaner	Clean. salt	0	0				0	0	50	
Pre-treatment	HCl	0	0				0	0	15	
Zinc bath	Zinc anodes	24.200	3.200	8.220	8, ER[a]	1	3.200	24	0	
	Sodium Cyanide	2.477	34.236				2.477	0	0	
	Sodium Hydroxide	314	34.236				314	0	0	
	Zinc oxide	930	34.236							
	Brightener	142	34.236				142	0	0	
Deoxidiser	Nitric acid	0	0				0	0	50	
Chromating, blue	Salts Nitric acid	154	17.118	1.400	0, ER[a]	17	154	981	500	4
Chromating, yellow	Concentrate	250	17.118	1.000	0, ER[a]	6	250	350	75	5
Sum:		71.378		14.820		43.1	89.378	5		4

Table 10.5 Rinse system score, zinc line (Dahl 2000) ([a]1 = OK, 5 = unsatisfactory; [b]1:1 = running rinse, 2 = static rinse, 3 = Spray rinse, 4 = static + running rinse, 5 = static + 2-running rinse; [b]2: 1 = 20 sec., 2 = 15–19 sec., 3 = 10–14 sec., 4 = 5–9 sec., 5 = 1–4 sec.; [b]3: 1 = all water run off, 2 = all w. run off slowly, 3 = moderate run off, 4 = minor run off, 5 = water pockets; [b]4: 1 = agitation and motion, 2 = some agitation and motion, 3 = heavy motion, no agitation, 4 = some motion, no agitation, 5 = no motion, no agitation;).

Rinse data				Rinse system score[a]		Water flow l/h			Water Consumption: l/m^2	
Rinse Tank No.	Rinse System 1[b]	Rinse after	Tank volume litre	Drip time 2[b]	Hang 3[b]	Agitate 4[b]	Real	Goal	Calculated	Goal
2	1	Degreaser	2,400	4	4	3	14	26	1	2
4	2	Pickling	2,400	4	4	3	14	33	1	3
6	3	Zinc plating	9,200	4	4	3	36	57	3	5
8	4	Blue chromate	1,400	4	4	3	11	21	2	4
10	5	Yellow chrome	1,500	4	4	3	9	45	3	16
Sum:							84	183	10	30

with many different kinds of chemicals. The table specifies most of the preventive activities which are included in order to keep the chemicals in the process baths:

- Dripping time for products above baths
- Hanging geometry of the racks for the products
- Agitation of baths to secure the maximum chemical reaction on the product surface

More specific tables include additional factors such as the inlet and outlet geometry of process tanks, rinse water flow control and the risk of back-mix between tanks. Finally the water flow is listed, measured as volume per hour. The water consumption per unit of product surface area is calculated and indexed against pre-set goal values. The final column shows the potential annual water savings, calculated as the difference between present production and production based on goal values.

The rinsing table is interesting because the water consumption needed for a given rinsing quality varies more than a tenfold with the numbers of rinsing tanks (10,000 l for one tank, 100 l for two tanks, and 2.5 l for three tanks)—see Fig. 10.4, which shows the CP rinsing principles (Dahl 2000).

The EMA benchmarking tool was developed for CP assessments in industrialised countries in Europe and newly industrialised countries in Asia like Thailand,

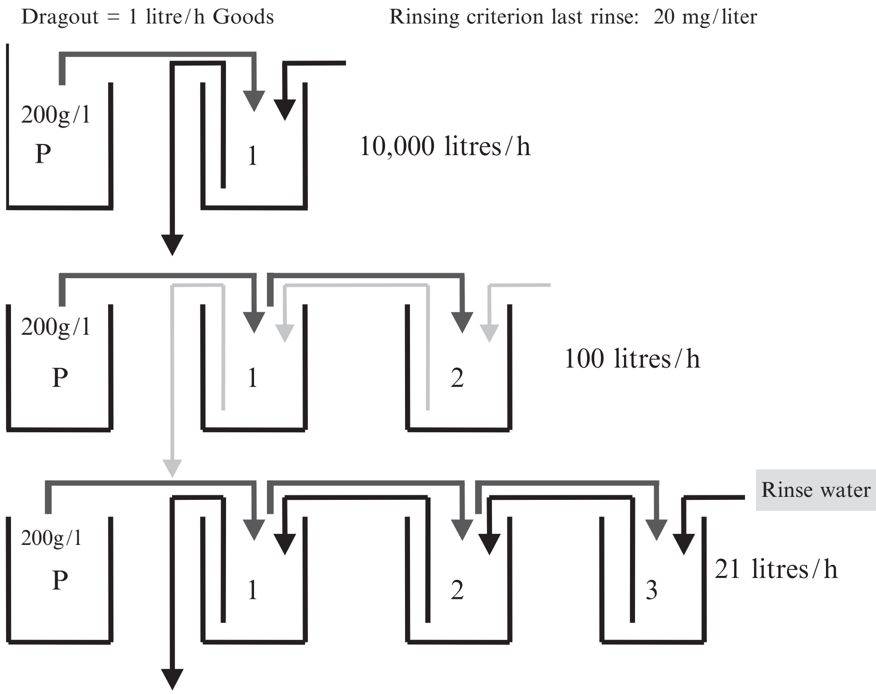

Fig. 10.4 Cleaner production rinsing principles (Dahl 2000)

where detailed data on production loads measured as product surface area and detailed data for the consumption of metals, chemicals and water were available. The benchmarking exercise in South Africa has shown some interesting lessons regarding this data retrieval:

- Few manufacturing companies with in-house metal plating plants had the necessary data available.
- No metal finishing job shops had production load data or consumption data available.
- The tool and its data requirements were too comprehensive to be applied as the initial CP tool. This required an initial screening process and experienced consultants to guide the application.

10.4 Results and Impact

Applying the EMA tool in the metal finishing enterprises has clarified the real cost structure of production, including the huge cost of the wastewater treatment plant which every company built and operated in order to comply with the norms on connecting to the public sewage system.

In the period 2000–2004, 14 full scale metal finishing plants were built. The total investments were €0.6 million, and the average payback time was 18 months. Based on 50 environmental screenings and 35 environmental audits of metal finishing enterprises and the results from 16 feasibility studies of CP metal finishing plants constructed and operated in South Africa, a conservative estimate for the potential national annual savings are (Koefoed and Kryger 2004):

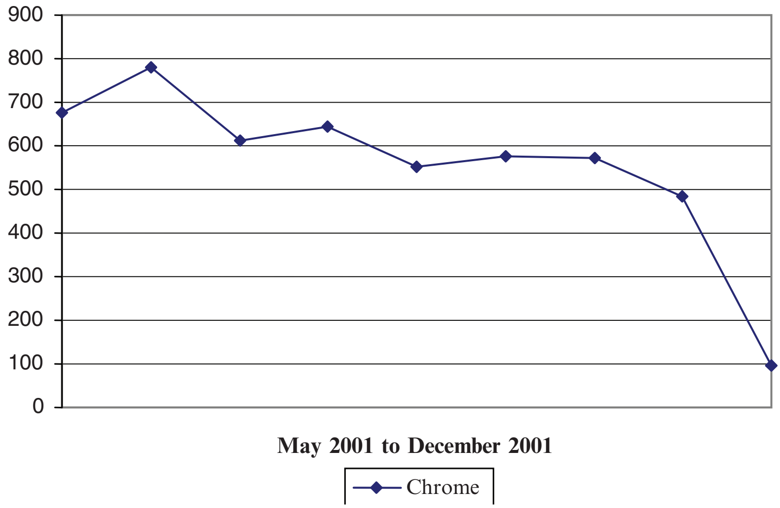

Fig. 10.5 Chrome in sewage works sludge (Burgess 2002)

- Metals €0.5 million
- Chemicals €1.3 million
- Water & effluent €1.0 million
- Total €2.8 million

Since the start of a Cleaner Metal Finishing Industry Production Project, the heavy metal load discharge to the Central Effluent Treatment Plants (CETPs) in Durban Metro have been reduced significantly (Burgess et al. 2002) as illustrated by the chrome reduction of 87% shown in Fig. 10.5.

Many factors contribute to this reduction in heavy metal load, but interviews with eThekwini Metro, metal platers and Metal Finishing Associations show that the Benchmarking Cleaner Production Tool has contributed to this (and other) reduced environmental impacts.

10.5 Conclusion and Recommendations

From the application of the EMA tool to the MFI in South Africa, the following conclusions can be drawn:

1. EMA in MFI requires much data input, which often does not exist. There is a need to develop environmental assessment tools with a more "user friendly" data input (e.g. guidelines and rules of thumb or calculation programs to calculate surface area and coating thickness).
2. The EMA tool needs technical skills and expertise for correct application in the South African MFI. This capacity will need to be developed through vocational training and environmental management capacity-building in order to achieve sustainable development in the sector.
3. The EMA tool was successful in assessing all significant quantitative parameters and in quantifying many qualitative key factors in the metal finishing processes, which previously had been outside EMA due to either lack of skills or of tacit knowledge in the metal finishing enterprises. The results are presented in a clear and user-friendly way.
4. The EMA tool enables enterprises to compare the efficiency of their present production with benchmarked values set by their own goal and ambitions in a bottom-up approach, as illustrated in Fig. 10.6: their own previous production, local industry average production (from the industry association), international standards, Best Available Technology Not Exceeding Excessive Costs (BATNEEC) and world trendsetting values i.e. the Best Available Technology, BAT (Koefoed and Buckley 2001).
5. The principles and methodology of the EMA tool which have been described here can be applied in other wet industries such as the paint, chemicals, wood, plastic, consumer products and hardware products industry sectors, in South Africa and in other emerging economies.

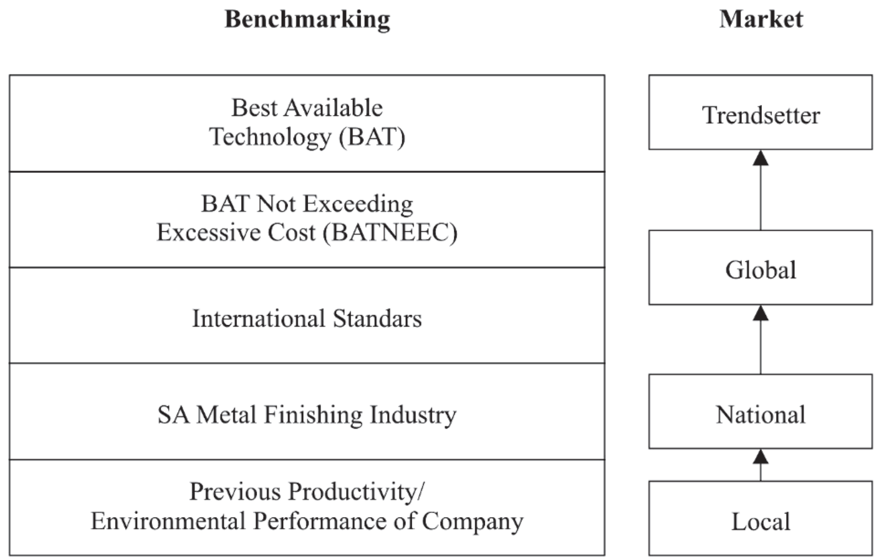

Fig. 10.6 Benchmarking bottom up approach (Koefoed 2001)

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Chapter 11
Chemical Management Services: Safeguarding Environmental Outcomes

Martin Kurdve

Abstract Every year hundreds of new chemicals with uncertain life-cycle impacts on our health and the environment are being developed and introduced to the market. Reducing the amount and volume of chemicals in use is seen as an important option for reducing associated environmental effects. Chemical management services (CMS) is seen by environmental experts as a business strategy that may allow reduction in the volume of chemicals sold, while maintaining profits from use of chemicals for suppliers. In traditional business the user would try to achieve the same reduction with less support from the supplier. The goal of this paper is to investigate how common performance indicators can be used to monitor the environmental performance of different chemical management strategies and how CMS customers and suppliers can safeguard environmental improvements. The paper draws on experiences from implementing CMS in one of Sweden's automotive companies and meetings with European CMS providers.

11.1 Introduction

Chemicals are playing an increasingly important role in our lives. In addition to any useful qualities, they can have adverse effects on the environment and human health. This leads to increasingly more stringent legislation regulating the development and use of chemicals which, in turn, results in increasing costs for chemicals management. The outsourcing trend in chemical-using industries coincides with the trend in the chemical-producing industry for diversifying its range with value-added services, such as chemicals procurement; management of chemical-use, waste management, etc. These initiatives, which can be combined under the name of chemical management services, provide opportunities for finding new ways of generating

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profit for companies selling chemicals, while simultaneously reducing the overall environmental impact of chemical life cycles and improving the environmental performance of companies using chemicals in their processes. This business model is based on close long-term partnerships between CMS providers and users of chemicals who share risks and costs for managing chemicals. This type of relation is believed to allow for a more advanced reduction of both environmental and health impacts and costs of chemicals.

In this article the function provided by chemicals in metalworking production processes and the resulting environmental impact will be described. An evaluation of the performance of a CMS partnership requires inter-disciplinary science involving economical sciences, such as accounting, contracting and chemical engineering. In addition, eco-toxicology and business psychology need to be considered as important factors that influence the outcome. This broad paper introduces many of these factors and investigates whether CMS always lead to a reduction of the environmental risks and costs associated with the use of chemicals, how these results are measured and how the environmental improvements can be safeguarded in CMS relationships.

The paper presents a desktop-study describing the use and management of chemicals and fluids in the metalworking industry in Section 11.2, and reviews existing CMS services and their results in Section 11.3. The second part, covering Sections 11.4 and 11.5, is based on an empirical study of fluid management through CMS within the Volvo Group, including experiences from implementing CMS for fluid management in one of the Volvo Group plants in Sweden, and on meetings with European CMS providers in Section 11.4. It is based on information collected from interviews, participatory observation and environmental reports. Finally, the empirical results are discussed with regard to the desktop-study in Section 11.5. This paper may be of interest for industrial users of chemicals as well as professionals and researchers of CMS.

11.2 Chemicals in the Metalworking Industry

11.2.1 Fluid-Use in Metalworking Operations

The metalworking industry is comprised of different types of operations. In this study we concentrate on processing mainly by cutting, boring, grinding, etc. of founded raw materials of iron, steel, or aluminium. These processes require large volumes of chemicals for washing, cooling and lubrication. The largest volumes of chemicals and hazardous materials stem from the great amount of metal working fluids (MWFs) that are used in machining and grinding operations for cooling, lubrication, and removal of metal particles, at a total cost which is often 5–20% of the total value added in the process. *Daimler Chrysler*, for example, identified MWF-cost to be 16% of the total production cost in metalworking operations in the mid-1980s (IAMS 1995). In addition to MWFs, metalworking processes also need secondary chemicals for cleaning, intermediate rust protection, and lubrication. Since the focus of this article is on secondary or indirect chemicals that are used in process operations, but do not become part of final products, consideration of chemicals for surface treatment and paints is omitted. In addition to being costly, the process fluids and chemicals have adverse health and environmental effects, e.g. they contribute to air and water emissions and generation of hazardous waste (Simpson et al. 2003).

11.2.2 Impact of Fluid-Use on Environment and Health

Chemicals used in the metalworking industry are often hazardous for workers' health and the environment. Managing chemicals is primarily associated with overcoming health issues, since the primary cost of the chemicals is much lower than the cost of possible health and security risks. Estimations of other costs including water, energy and handling and disposal of chemicals demonstrate that the total cost of chemical management may be ten times the initial purchase price (IAMS 1995). The process fluids often contain hazardous substances including carcinogenic hydrocarbons and eco-toxic substances. The fluids emit aerosols and vapour, which are the main reasons for health concerns and emissions of volatile organic compounds (VOC) from metalworking operations (Greaves et al. 1997). Contaminants in MWFs and lubricants affect workers' health, especially the respiratory system and the skin (Simpson et al. 2003; Gordon 2004), give rise to waste and emissions and reduce fluid system lifetime (IAMS 1995). Also, more than 80% of the various corrosion inhibitors used in the fluids are classified as having moderate or higher hazardousness (Pastovskaia 1990). Cleaning agents and surfactants are examples of other substances that are dangerous to personnel. Process water contaminated with cleaning agents is the main source of wastewater from metalworking plants. Besides health effects all the aforementioned process fluids have a great negative impact on eco-efficiency. A majority of the fluids are oil-based and thus require the use of scarce and expensive raw materials. The production processes of these fluids are also energy-intensive, giving rise to negative environmental and economic consequences. They also contribute to air and water emissions and to generation of hazardous waste.

11.2.3 Commonly Used Indicators for Environmental Performance of Fluid-Use in Metalworking Processes

Some indicators often used in environmental reports in the metal working industry are directly affected by the application of process fluids and chemicals. For example:

- Use of process water
- VOC or use of solvents
- Generation of hazardous waste

The use of process water is commonly used as an environmental key performance indicator (KPI) in the industry. It is influenced by the use of water-miscible process fluids and is thus relevant to the environmental performance of the fluid management. In comparisons between plants, the definition of the water used in the process is important, since lowering chemical concentrations and consumption may not show in the figure for process water use. In most cases however, decreased use of process water correlates with a good maintenance and long life of chemicals (IAMS 1995).

Emission of VOC (correlating to solvent use) is another important environmental indicator also related to the work environment and linked to chemical concentration and equipment design. Usually the reported figure on VOC is calculated from the use of chemicals containing volatile solvents. Hazardous waste generation should be directly affected by the use of hazardous material and would be lowered through substitution of less hazardous material.

The aforementioned measures are subject to limitations in production permits etc. and thus considered relevant as indicators of environmental result. Other indicators are the use of chemical concentrates in different categories, some of which will be discussed in Section 11.4.2. In addition to environmental and health concerns, many chemical fluids, especially cleaners and MWFs, severely affect the quality and efficiency of metalworking production (Mont et al. 2006; Simpson et al. 2003). Since process fluids are hazardous substances their use is heavily legislated which increases their control costs and makes the reduction of their usage a financially beneficial measure. These serve as drivers to continual reduction of the volume of process fluids by introducing better filtering and promoting fluid recycling.

11.2.4 General Techniques for Improvement of Fluid-Use in the Metalworking Industry

The above-mentioned situation explains the driving forces for companies to reduce the use of process fluids; environmental and health concerns, quality issues and economic reasons. Cost optimisation of the use of process fluids is comprised of various measures, including improvement of fluid performance, reduction of environmental and occupational hazards and increasing efficiency of waste treatment. The main way to improve the performance of the fluids is to extend chemical life in production systems (IAMS 1995). Costs of handling chemicals and environmental control may be reduced if the number of various process fluid products used in a plant is also reduced, which is why standardisation is an important means in improvement work.

In order to implement the above-mentioned activities to reduce costs of fluid management, sufficient knowledge about the entire process and individual operations where fluids are used is needed (Mont et al. 2003). However, various actors have access to knowledge and expertise in the various parts that constitute processes: chemicals, equipment, machining, etc. The diversity of actors who hold parts of information leads to the need for collaboration, not only between the company using chemicals and the actors along the supply chain, but foremost between representatives of different departments within the company itself. IAMS (1995) suggest that fluid management should be dealt with by a broad fluid management group consisting of representatives from production, maintenance, environmental, purchasing and top-level management. To fully utilise the improvement potential in fluid management, new ways of doing business need to be developed that will not only facilitate improvements of independent parts, but also enable utilisation of potential efficiencies among these parts. The organisation of the management and communication between the actors is critical for the environmental performance in the use of process fluids. In the next section special attention will be devoted to CMS as a business model, which is based on close collaboration between suppliers and customers and may facilitate environmental progress if controlled properly.

11.3 Chemical Management Services and Its Reported Environmental Benefits

11.3.1 What Is CMS?

CMS is a business model where a chemical supplier and a customer engage in a joint, long-term partnership in supplying and managing the customer's chemicals and related services (Votta 2003). The supplier and the user co-operate in a stable CMS business model and share the responsibilities of, and gain from, the total life cycle (Mont et al. 2006). A combined package of products and services, in line with the CMS strategy, may be categorised as a *Product Service System* (PSS). A PSS is 'a marketable set of products and services capable of jointly fulfilling a user's need' (Govt. of Netherlands cited by Votta 2003); it is a system that 'strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models' (Mont 2004). Traditionally users take care of the chemicals during both use and disposal. By increasing their responsibilities over the lifecycle in a CMS partnership, suppliers get larger incentives to work towards a more sustainable development (Fig. 11.1). The innovative combination of product and services in a CMS business relation require a combination of different contractual elements.

11.3.2 Elements Comprising CMS

Traditionally manufacturing companies manage chemical use and end-of-life phases. They pay for the amount of chemicals they buy, use and dispose of and naturally strive to keep chemical volumes and prices down. For many companies from the metalworking industry chemical management is an expensive non-core activity. Studies show that for each dollar spent on purchasing chemicals, companies

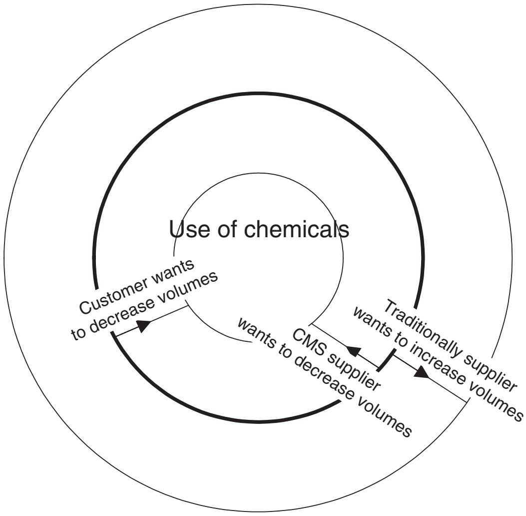

Fig. 11.1 CMS aligning incentives to decrease consumption

may pay up to $10 for managing them (Votta et al. 1999). Suppliers traditionally link profits to the volume of chemicals sold and therefore strive to increase volumes. A recent trend among producers of chemicals, whose core activity was to develop and sell chemicals, is now moving towards managing chemical use by CMS, which allows for keeping their profits up and at the same time reducing chemical users' risks and costs for chemical management. CMS is a business model in which chemical suppliers and customers engage in long-term partnerships for supplying and managing chemicals and related services (Votta 2001). In this model, suppliers' responsibilities over the chemicals' life cycles are extended and the interests of chemical suppliers and users are united. Both parties strive to reduce consumption, since suppliers are not paid per volume but per function the chemicals fulfil (Mont et al. 2006; Votta 2003). For example, instead of being paid for each litre of paint sold, suppliers are instead paid for each car painted. In order to provide CMS, a combination of different elements is needed. Four main elements can be distinguished in a CMS contract: products, services, financial arrangements, and responsibility allocation (Fig. 11.2). Customised partnerships are developed in CMS by combining these four elements.

11.3.2.1 Products

Products offered in CMS packages are typically the different process fluids mentioned in the previous section, but may also include equipment for fluid maintenance.

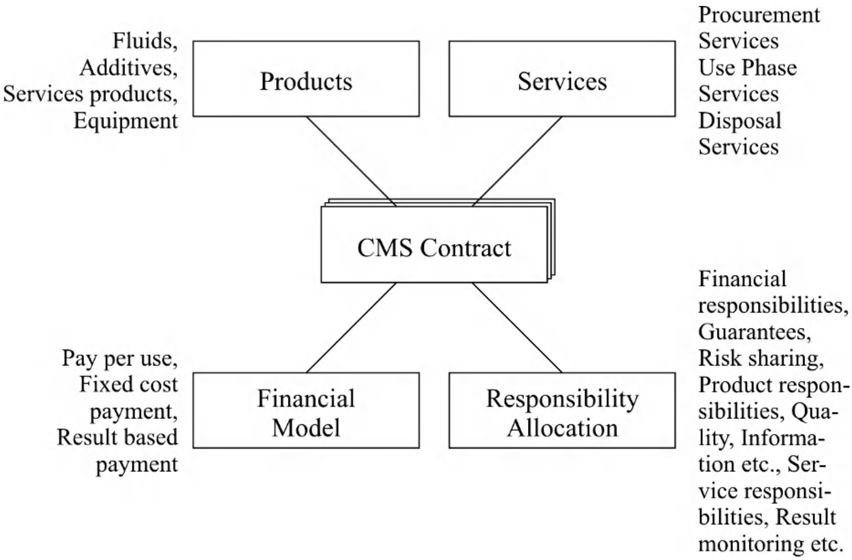

Fig. 11.2 The four main elements of CMS partnership

11.3.2.2 Services

There are a vast amount of services that can be offered alongside the fluids. These are often divided into three groups depending on the lifecycle phase in which they are provided (Nolte 2003):

- Services provided at the procurement and delivery phase may include a selection of products, initial testing, HSE-assessment, price negotiation, purchasing, delivery logistics and storage.
- Services provided at the usage phase include management, monitoring and maintenance services, as well as system cleaning and administration services such as billing and product and process development.
- Services provided at the disposal phase include on- and off-site recycling of fluids, wastewater treatment, outbound transportation, material recycling and final disposal of waste (see Fig. 11.3).

11.3.2.3 Financial Arrangements

The financial agreements can consist of three basic models:

- Pay-per-use is based on payment for how much a product or service is used.
- Fixed price is typically static pay-per-use for services and is not common for consumables.

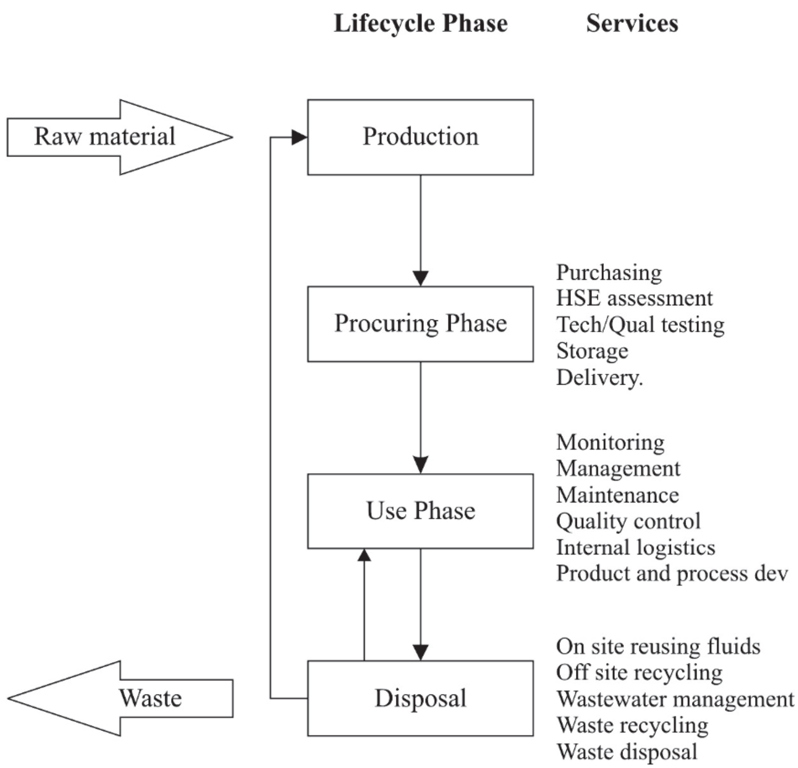

Fig. 11.3 CMS services and life-cycle stages

- Pay-per-function is when products or services are paid for on a results basis. This is the financial arrangement that changes incentives the most. Often called cost per (produced) unit, CPU.

Responsibilities for managing chemicals are shifting from customer to supplier when going from pay-per-use to CPU financial arrangements.

11.3.2.4 Responsibility Allocation

The responsibility allocation in a CMS partnership is an agreement on division of responsibility between suppliers and users and on mechanisms for gain and risk sharing. Each service or product might require special allocation of responsibilities. The suppliers often take on the responsibility of the actual work of fluid maintenance, also called fluid management services (FMS). Correct allocation of responsibilities for each fluid management agreement between the parties is essential for the contract and is a driving force for improving environmental outcomes.

11.3.3 Environmental Performance of CMS

Recent studies on CMS suggest that environmental benefits and efficiency gains can be reached since chemical suppliers may have better expertise in using and managing chemicals than customers, for whom chemical management is a supporting activity (Jakl et al. 2004). The efficiency gain is believed to increase based on two assumptions. The first assumption is that the incentive shift is strong when changing from selling per litre to selling a function. The second is that the supplier would have better expertise of the usage phase (Toffel 2002). According to Votta (2003), CMS is beneficial for the environment since forces to increase chemical use are overcome and knowledge is expected to be shared better in a CMS partnership. For example, Haas reports 30% cost reduction and reduction of VOC emissions (Klocek 2003). Chemical Strategies Partnership (CSP) also demonstrates that CMS users report a reduction of chemical use and an improvement of environmental data management in the US (CSP 2004; Oldham 2003). The questions however remain as to whether CMS always delivers environmental improvements, what factors influence the environmental outcomes and whether this strategy is better than internal chemical management. These issues are discussed in the following sections.

11.3.4 Critical Success Factors for CMS

The environmental outcome is an important part of the total result of the CMS business. The monitoring and control of fluid systems together with everyday maintenance are direct factors influencing the result. There are also several indirect factors that will affect the environmental outcome (see also Section 11.4.4):

- Financial incentives for suppliers to start recycling products and investing in development. The organisation of and the system for improvement work is linked to the financial incentives and will strongly affect how fast the improvements and implementations from process development will occur.
- Knowledge sharing and joint development of solutions in CMS are important for business and environmental success and long-term relations (Toffel 2002). Loss of knowledge and control over own processes is also named by many companies as one of the main barriers to CMS partnerships (Mont et al. 2003). Information sharing between suppliers and customers is vital for fluid monitoring and control and especially for ensuring fluid function.
- Communication and mutual trust is regarded as the most important factor for success of CMS (Oldham 2003). Strongly committed partners have a bigger chance of being satisfied with the outcome of the business relation. Good communication influences the level of satisfaction in partnerships and increases chances of succeeding with environmental tasks.

The next section draws on experiences from a large organisation; the influence of some factors and the environmental results of implementing CMS partnership are studied.

11.4 Environmental Monitoring of CMS in the Volvo Group

11.4.1 Comparison of Internal Chemical Management with CMS

In order to evaluate the environmental outcome of the CMS strategy against internal chemical management, a comparison of environmental reports from plants within the Volvo Group was conducted. The three indicators (volume of process water used, emissions of VOC and hazardous waste) mentioned in Section 11.2.3 were indexed with the value for each plant for the year 2001 and used to benchmark environmental performance during a 3 year period to evaluate various methods of chemical management. Specifically the comparison used five plants, where the supplier had responsibility for fluid management service (FMS), one plant with external fluid management operated by a facility manager (Ext) and four plants with internal management (Int). The indexes are calculated as followed:

$$\text{VOC emission index}: \ I_{VOC}\ [\%] = VOC_{year}\,[kg] / VOC_{2001}\,[kg] \tag{11.1}$$

$$\text{Process water use index}: \ I_{PW}\ [\%] = PW_{year}\left[m^3\right] / PW_{2001}\left[m^3\right] \tag{11.2}$$

$$\text{Hazardous waste index}: \ I_{Haz}\ [\%] = HW_{year}\,[kg] / HW_{2001}\,[kg] \tag{11.3}$$

The comparison shows no clear environmental superiority of one model for managing chemicals over the other (Figs. 11.4 and 11.5) although the trend is slightly better for CMS when looking at process water index. Most plants show improvements in VOC emissions and process water use, regardless of business model as shown in general averages. Two internally managed plants have increasing use of process water, mainly due to a big increase in production and therefore the overall average is slightly higher than the CMS average for process water use. The better result shown for CMS however, is not statistically significant for such a small sample of plants. Similarly, one FMS plant and one internally managed plant show an increase in VOC emissions. In this case, the resulting averages are nearly equal. A corresponding comparison of the hazardous waste index was performed, but could not be used due to changes in the definition of hazardous waste.

The trends of the investigated indexes show environmental improvements in both CMS partnerships and in internal chemical management. Thus, the CMS partnership cannot be shown to be the most environmentally beneficial, but the opposite cannot be shown either. Two possible reasons for this are:

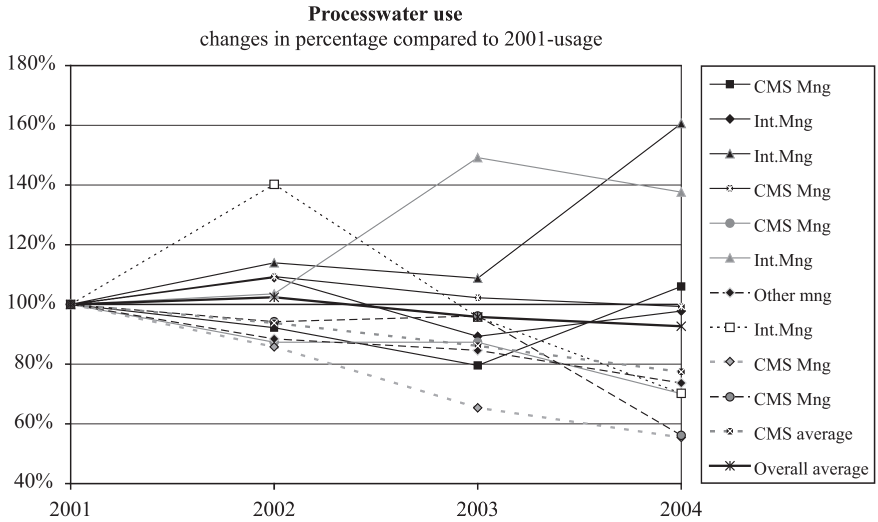

Fig. 11.4 Process water use index at ten plants during a 3 year period (Volvo Group 2004)

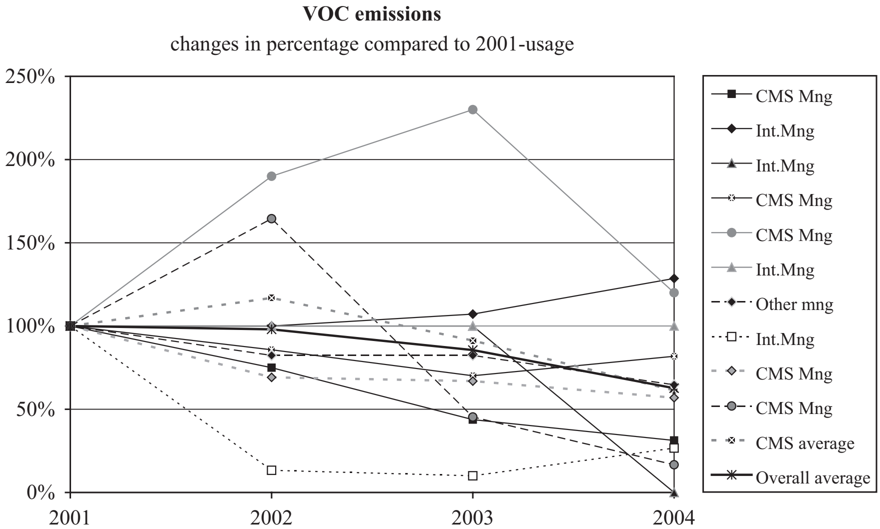

Fig. 11.5 VOC emission index at ten plants during a 3 year period (Volvo Group 2004)

- Financial incentives cannot alone guarantee environmental success of CMS because they may not have been strong enough to compensate for the traditional distribution of responsibility
- Knowledge of CMS suppliers might not have been better than the customer's knowledge of the usage phase

An additional explanation could be that the indexed indicators chosen are not sufficient to monitor the environmental performance of chemical management. To account for this possibility, development of other performance indicators and measuring tools is necessary. Hence, further research on what indicators have been used in other CMS evaluations is needed.

11.4.2 Indexes for Environmental Performance

As seen in Section 11.4.1 the indexed indicators on VOC and process water use do not show environmental performance efficiently enough for an evaluation of fluid management. Neither science nor industry has reached a consistent approach in what concepts and indicators should be used for monitoring eco-efficiency (Penttinen 2006). Since no standardised guidelines are available, an investigation of other useful indices was performed.

11.4.2.1 Relative Performance Indicators

One commonly used reporting parameter is consumption of chemicals by type, i.e. volume of lubricants, coolants, cleaners, etc. It can be used to provide a relative indicator for usage of fluid relative to the production output. It is commonly accepted as denoting the environmental efficiency of each fluid. Generally these types of indicators are formulated by taking the impact parameter of the environmental outcome and dividing it by the production index. The fluid use index, I_{FU}, can thus be formulated from the chemical use volume $V_{product}$ and the production index $I_{production}$, given by:

$$I_{FU}\left(\text{lubricants}\right)^{\circ} = \sum\ V_{\text{product } i}\ /\ I_{\text{production [for all lubricants i] and similarly for the other fluid groups.}} \quad (11.4)$$

This indicator was used at one Volvo plant during CMS contracting reviews to evaluate the performance of chemical management as shown in Fig. 11.6. Two years of CMS management was compared to a baseline (when in fact there was internal management). The Figure shows increased use of cutting oils, which supported the decision to introduce oil recycling by the CMS management.

A multidimensional indicator, such as fluid use per produced unit, is useful for evaluating one plant over time, but is not very useful for comparison between

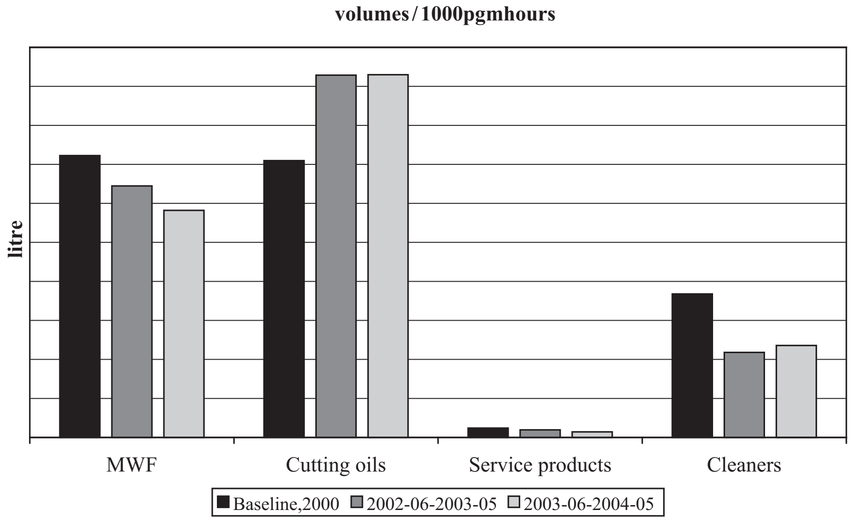

Fig. 11.6 Follow-up on usage of different fluids per production index during a period of increase in production by 20%

plants. A way to get a single comparative figure for the process fluid use is by calculating the total use of hydrocarbons in a plant. This is commonly used in some European CMS's and is reported as the total weight in tonnes of hydrocarbon (HC) per produced unit. This is a rough comparative figure, but is regarded as a better comparison than trying to weigh different fluid types against each other. It is an index that can be used at plant-level and the figure obtained should in many cases correlate somewhat with the reported VOC figure. The total HC-index, I_{HC}, is calculated similarly to the fluid use index with the addition of the hydrocarbon content C_{HC} for each product:

$$HC = \sum V_{\text{product i}} * C_{\text{HC i}} / I_{\text{production [for all chemical products i]}} \tag{11.5}$$

In many cases, it is enough to follow the trend for a plant based on its produced units ($I_{production}$), e.g. per produced engine. If the plant changes production mix or the type of unit produced, this is not valid. A complement to the production index is the weight of removed material ($I_{\text{removed material}}$) measured in tonnes. This will be a figure that has to be calculated for each type of material. Often, however, most departments use only one material type. Most components manufactured in the investigated plants are made of steel, cast iron or aluminium but it may still be difficult to compare similar operations for different materials.

Another efficiency or performance parameter is based on installed system size, it is the turnover time, which is used to evaluate system efficiency for each process fluid system. It is calculated as the system's total installed volume divided by the average consumption of the fluid per year. This index is operation and fluid specific and can be used to monitor and compare performance at operation or department levels. The turnover time gives an indicator on how well each system is maintained.

11.4.2.2 Absolute Indicators

Some environmental impacts are not suitable for evaluation by environmental efficiency indicators. Hazardous emissions and use of some toxic substances must be limited due to their health and environmental impacts. There may be legal, ethical or ecological limits on parameters that should not be exceeded regardless of efficiency or production rates. In these cases absolute indicators should be used in monitoring the performance. Common toxic substances are often evident in many different products and can be added up as a sum of the concentrations, $C_{substance}$, times the volume of each product, $V_{product}$. This has been tested for evaluation of biocide use at one of the plants, as shown in Fig. 11.7. All fluids used contained mixtures of the same biocide substances. The total biocide use in the process fluids is monitored by using a calculation of the total volume of each substance:

$$V_{substance} = \sum V_{product\ i} * C_{substance\ i} \left[\text{for all chemical products i}\right]$$

The goal is to monitor and reduce the overall use of toxic substances used. Field surveys of personnel opinions suggest that biocides, amines and other volatile hazardous substances should be monitored in this way.

With regular monitoring of the environmental performance there is also a need for maintaining control over factors that influence environmental performance. Organisation, financial incentives, development, communication and support systems in the CMS partnership must be reviewed when contracts are renegotiated.

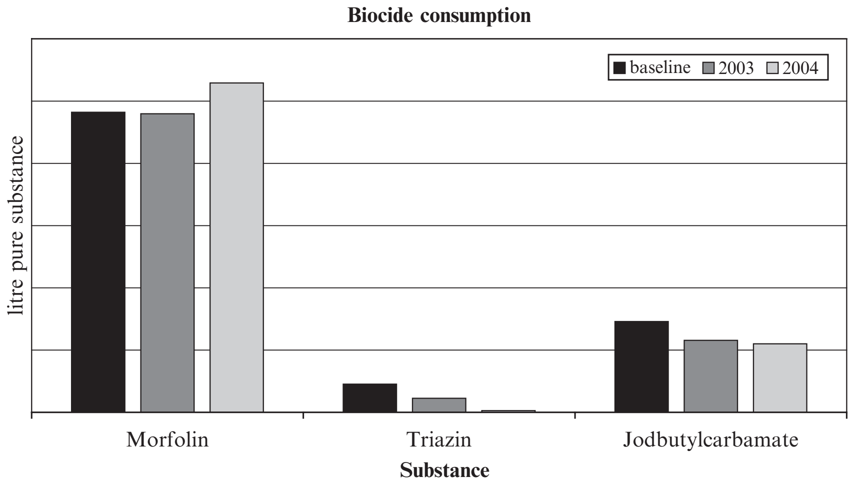

Fig. 11.7 The total use of biocides is monitored and kept at an almost constant level during an increase in production

One approach to create a common baseline for renegotiation is to map the material, energy, and work flow into products, waste and emissions.

11.4.3 Environmental Management Accounting as a Tool for Contract Reviewing

Environmental Management Accounting (EMA) can be a tool for assessing waste reduction potential (Munkøe et al. 2006) and for highlighting the total cost of non-productive material and other non-productive output (NPO) (Jasch 2006). Just as lean manufacturing methods try to lower the amount of work input to non-value adding operations, the EMA concept can be used to lower the amount of material that is wasted in the process and the work related to that waste. In a pilot study of CMS at a Volvo plant, an initial review of the material and labour input and waste and emissions resulting from chemical use, was performed 2001. Figures from both the environmental management and general accounting systems were used together with investigational data. Ideally, a full EMA of the chemical processes at the plant include energy use, but this, together with some secondary labour like R&D, and older inventory depreciation, was omitted from the study. In later renegotiation of the partnership, the omitted parts have proven useful and a full EMA is recommended for the future. Figure 11.8 shows the result of the review of one CMS partnership with six categories according to the International Federation of Accountants guidelines (IFAC 2005). Category 1 productive material is not included since all chemicals are secondary products. Categories 5 and 6 are to a large extent unknown.

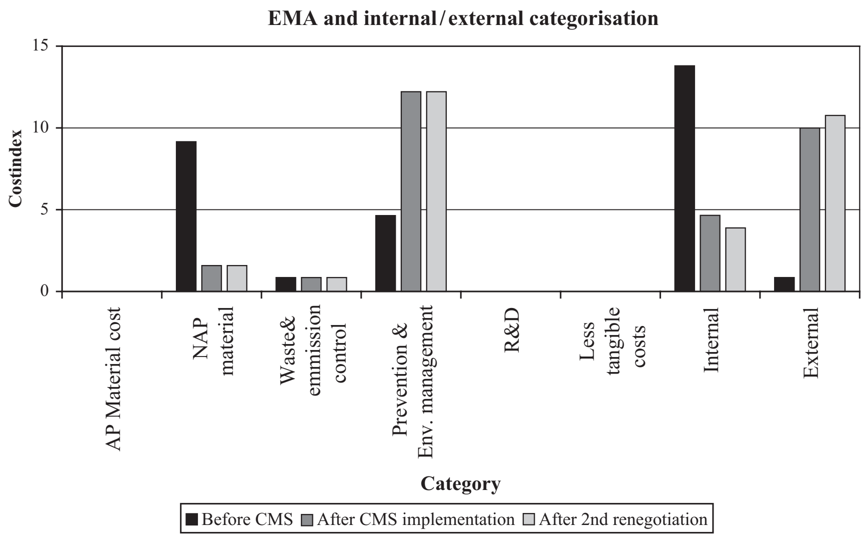

Fig. 11.8 Fluid management material and labour presented in accordance to the IFAC EMA categories—also split between internal and external costs

For process fluid management all material and all work input come under the definition of NPO according to EMA. For plants with internal management EMA can be a way to highlight these costs and track the environmental as well as the economical efficiency. When outsourcing fluid management these costs are automatically highlighted and there is often less need for EMA. The CMS costs will end up in the category of external management costs unless the supplier also reports according to EMA practice. When setting up or reviewing a CMS contract the same input as for an EMA is needed, both for the internal and the external part of chemical use. This makes it advantageous for plants to use EMA and also to demand corresponding reporting from the CMS suppliers. The final part of the research done at Volvo deals with some of the hidden factors of the environmental management, such as information systems and R&D influence on the environmental performance.

11.4.3.1 Influential Improvement Factors

Field surveys conducted at two of the previously mentioned Volvo plants have highlighted factors perceived as the most influential on the environmental performance of the fluid management. These factors affecting the fluid management are complicated and conclusions regarding their impact are difficult to make. Some of the most obvious links are shown in Fig. 11.9. The financial incentives, the supplier organisation and a broad involvement are crucial, but these factors also depend on sub-factors that affect whether the desired results on environmental outcome are reached.

As concluded in Section 11.2 of this article, a broadly supported management that can concentrate on good maintenance and keeping fluids clean, possibly with internal recycling or filtration systems, is beneficial for environmental performance. Also in the surveys clear responsibilities and a broad communication were perceived as important. Inadequate communication can be a critical barrier and thus organisational efforts by all parties are needed to ensure good communication and a clear distribution of responsibilities. Some methods to measure the factors were identified during additional interviews. Communication and trust of the chemical management (CMS as well as internal) has been monitored with surveys. The financial incentive and organisational support for development and improvement of the chemical management can also be evaluated by surveys or subjective grading made by the involved personnel.

The supplier organisation and the support system for fluid management are important for the link to product development and use of suppliers' chemical knowledge in the process development on site. The support system should include tools for follow-up of fluid consumption and monitoring to ensure transfer of knowledge. Fast access to expertise in the supplier company can, together with a good monitoring system, improve problem solving and facilitate a proactive management. Involvement of the supplier in both the usage and disposal phases

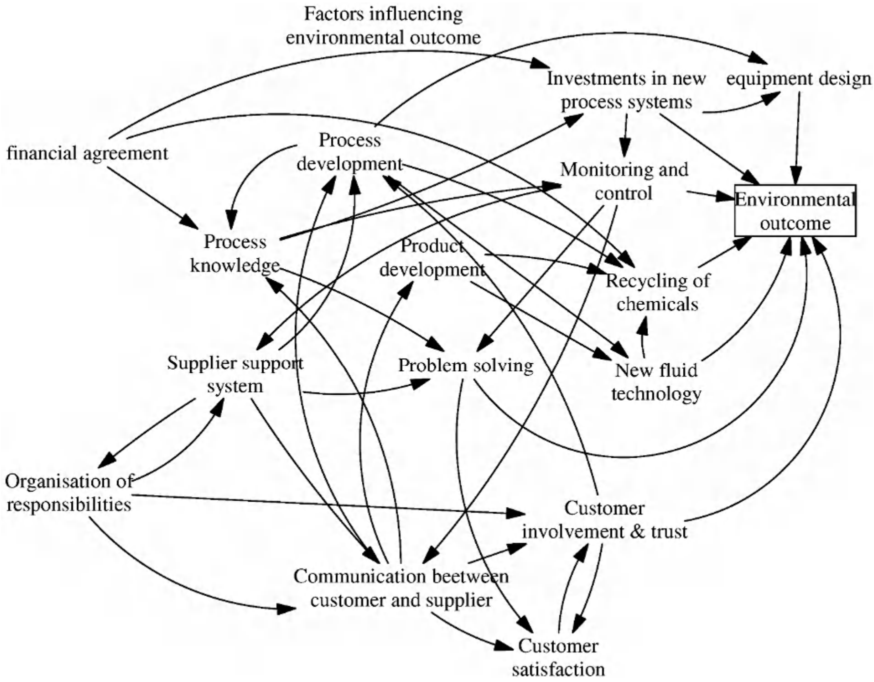

Fig. 11.9 Many interconnected indirect factors influence the direct factors. Two indirect factors (finance and responsibility organisation) are main elements in a partnership contract

improves its incentives to develop products compatible with recycling and to support recycling processes. Monitoring of practice and systems is essential to ensure functionality of the fluids. Consumption within and costs of separate fluid systems can be tracked in a well functioning monitoring system. The supplier must be trusted by the customers, be quick-learning and have good connections with site fluid management to develop the necessary monitoring tools.

Lack of means to invest in equipment is often mentioned as a barrier for development of fluid management. This could be overcome in a CMS partnership if the CMS supplier facilitates pooling or sharing of equipment at several plants. Since fluid usage is greatly affected by machinery design and equipment maintenance, issues and problems at the plant have to be transferred to supplier development and problem-solving departments, preferably involving equipment and tool suppliers in joint projects. The expenditure on research and development of chemical management and equipment and some less tangible costs should be measured or estimated; this can possibly be supported by using EMA.

To push the environmental performance further the most important factors should be evaluated in each partnership. Identification of deficiencies and critical issues can facilitate improvement and develop a well-functioning partnership.

11.5 Safeguarding Environmental Soundness of CMS

11.5.1 Environmental Performance Control and Monitoring

A positive environmental outcome cannot be taken for granted but needs to be designed into the CMS partnership by determining the appropriate conditions in the financial and responsibility agreement as discussed in Section 11.3.2. It is indicated in the surveys discussed in Section 11.4.4 that process development strategies may also have to involve other important suppliers, such as equipment suppliers. To safeguard a positive development of the environmental performance three different instances should be considered.

When setting up or renegotiating a CMS partnership agreement there is need for tools and templates for creating a common baseline, process description, and organisation documentation to assist trust, knowledge-sharing and problem-solving. The setting up of EMA can be one tool for the common baseline regarding material, energy and work flow. There is also need for other tools that support responsibility allocation and creation of improvement procedures. These tools should include setting of performance goals linked to measurable economic and environmental parameters like the ones used in Section 11.4.1

While a CMS partnership is in place common environmental goals with suitable indexed, relative and absolute performance indicators should be set-up and monitored to ensure continuous improvement. As discussed in Sections 11.2.3 and 11.4.1, there may be a need for some KPI's for internal use while others may be more useful for external use and comparisons between plants.

To enhance the development of the partnership and improve the environmental performance critical factors influencing the result should be examined in partnership reviews. In particular, soft factors like knowledge-sharing and mutual trust, as introduced in Section 11.3.4, which may be hard to measure continuously, should be addressed when renewing contracts. Renegotiating of contracts could, in addition to the financial and responsibility review, include revising and monitoring of KPI's. Some suggestions for indexes and measurable parameters that could give an indication of the soft issues are:

- Number of joint projects, R&D-spend on fluid management could be used to measure product and process development.
- Spending on new equipment for fluid management can indicate a trend for investment and equipment renewal.
- Personnel surveys have been used to provide a figure on communication and trust.
- Sum of downtime due to fluid problems is linked to problem-solving performance.
- Recycling can be indicated by looking at number of products and recycling percentage of volumes.

With regard to the incentives of the suppliers, a CMS model supplier relation, where the supplier is paid on a functional result-base and where the supplier responsibilities encompass the entire life cycle, has the best potential for a long-term sustainable development. A successful partnership relies on a proper financial agreement and allocation of responsibilities in accordance with the products and services provided. The customer incentive of buying well-designed machines, tanks and filters may otherwise be lowered by a functional result-based contract. Suppliers also encounter economic risk by letting the CMS business compete by cutting product prices or by using competitor products and thereby give a negative impact on the regular market share. The latter may lower the overall financial incentive but may also be turned into a long-term competitive knowledge advantage.

11.5.2 Further Research of CMS Strategies

To further investigate how to develop the CMS business strategy several issues need to be considered. Firstly, there is a need for analysis of how the relations in various business models are set up. In this respect responsibility allocation, the supplier support organisation and a broad knowledge of and involvement in fluid management are critical factors for safeguarding environmental performance. Probably the most important element for securing continuous environmental improvement is the setting of goals and the development of follow-up systems to ensure continuous positive environmental outcomes. Secondly, there is a need to investigate how the delivery of services related to use of process fluids takes place, i.e. how various parts of the supplier organisation, like problem support and product development are involved in the services. A broad and open communication between development of products and processes is essential. Thirdly, there is also a need for better environmental indicators that may enable comparison between plants. Indicators should differentiate between the performances of different partnership agreements.

11.6 Conclusions and Recommendations

Metalworking processes require large volumes of hazardous chemical fluids. A broadly-supported and communicative management of fluids focusing on cleanliness, good maintenance and the application of internal recycling and filtration is beneficial for the environment, quality and cost. In addition to indicators, such as process water, VOC and waste, additional parameters can be monitored to safeguard environmental performance of fluid management. Some eco-efficiency parameters are suggested. Fluid usage per production index of the different fluids can give a better indication of the efficiency at plant level. In addition, fluid usage per removed metal can be used as a complement. Turnover time can give an indication of efficiency of the fluid management at system or departmental level.

A CMS business model where the supplier is paid by functional result and where the supplier responsibilities encompass the entire life cycle has the best theoretical potential for a positive long-term sustainable development even though this could not be proven for investigated plants. A comparison between Volvo Group CMS and internally managed chemicals provide no straightforward indication of the success of the CMS business model. For a successful partnership it is important to set up a financial agreement and allocate responsibilities in accordance with the products and services provided. A positive environmental outcome cannot be taken for granted. The process development strategy must also involve other important actors, such as equipment suppliers.

To support the continuous improvement of environmental performance of the CMS partnership, factors that influence the performance should be evaluated. The communication and trust may be monitored by surveys. The expenditure on research and development of chemical management, equipment and some less tangible costs should be measured or estimated possibly by using EMA. The factors influencing the environmental outcome of chemical management are complex and interlinked. The responsibility allocation and the financial agreement for each product and service are factors of the utmost importance together with setting up common environmental goals and developing knowledge management support systems. Finally, trust and involvement of all parties is a prerequisite for environmentally sound chemical management. The financial incentives and organisational support for development and improvement of the chemical management should be further researched using improved performance indicators.

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Part IV
Recent Conceptual Developments in EMA and New Areas

Chapter 12
The Development of Environmental Management Accounting: An Institutional View

Wei Qian and Roger Burritt

Abstract This paper explores and synthesises the development of corporate environmental management accounting (EMA) and the possible motivations for EMA from the perspective of institutional theory. The motivation for this paper is a belief that a focus on taxonomy and classification through institutional theory will help to produce better defined theory for scholars to accumulate knowledge about the development of EMA. It considers the possible development of EMA in relation to three pillars: regulatory, normative and cognitive institutions. This leads to an understanding of the development of EMA in four institutional contexts involving (i) direct regulatory pressures, (ii) social environmental movements, (iii) professional structure and inter-professional communication and (iv) environmental mimicry in specific organisational fields. The differences between these institutional influences on the development of EMA are discussed and finally, suggestions are provided about the potential future development of corporate EMA.

12.1 Introduction

Conventional approaches to accounting have long been criticised as being inadequate and inappropriate to meet the needs of environmental and sustainable development, because they place a predominant focus on economic performance and implicitly exclude environmental resource values (Maunders and Burritt 1991; Milne 1991; Schaltegger and Burritt 2000). In recent years, the emergence and development of environmental accounting (EA), especially environmental management accounting (EMA), has improved our understanding of environmentally induced corporate

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costs and impacts (various readings in Russell et al. 1994; Parker 1999; Bennett and James 1998; Schaltegger and Burritt 2000; Burritt 2004; IFAC 2005). EMA tracks environmental information in order to assist with internal planning, control and management decision-making, with the purpose of making the natural environment more visible and corporations more accountable for their environmental impacts (Schaltegger and Burritt 2000). EMA terminology often uses such words as ‘full’, ‘total’, ‘true’, ‘comprehensive’ and ‘life cycle’ to emphasise that conventional corporate management accounting is incomplete in scope because it overlooks important environmental benefits and costs (USEPA 1998).

According to Mathews (2000), since the mid-1990s EA research has predominantly focused on external environmental disclosures rather than on EMA. Although the past decade has seen an increasing number of EMA tools developed (such as full cost accounting, materials flow cost accounting, life cycle costing, etc.) and more companies incorporate environmental costs and impacts into their management decision-making processes, there remains a lack of theoretical explanations for the development of EMA (Bouma and van de Veen 2002). Only a limited number of empirical studies are available to advise these theoretical underpinnings of EMA, with case studies dominating this research, as academics strive to understand the concept and reasoning behind the EMA phenomenon (Burritt 2004). This motivates this paper to deepen the exploration of theoretical explanations for the development and changes of EMA.

Previous literature on explanations for the development of EA or EMA includes two main streams. One stream adopts the economic efficiency perspective and tries to identify the relationship between environmental performance and economic performance which can potentially be measured by EMA (see Klassen and McLaughlin 1996; Bennett et al. 1999:69–71). The purpose is to propose an eco-efficient approach in order to justify and encourage environmental changes (see Helminen 2000). The second stream is based on social theories and tries to identify the relationship between environmental activities and social structure and pressures (see Boons and Strannegard 2000; Ball 2003). This research proposes a social framework to justify and encourage environmental changes (see Delmas and Toffel 2004).

This paper examines the development of EMA from a social perspective, for two reasons. Firstly, the relationship between environmental performance and economic performance is still inconclusive. Although recent steps to provide guidance on EMA have been promoted by some accounting institutions (see IFAC 2005), there is no EMA approach or eco-efficiency approach which is widely accepted and implemented by business organisations. This is despite the argument that environmental information has a more fixed, scientific basis and universal quality than social information (Bennett et al. 1999:34). Secondly, there is a growing view in current environmental research that green actions and activities adopted by business organisations are for the purpose of obtaining congruency with social rules and norms, in order to improve environmental sustainability in the social and organisational field (Boons and Strannegard 2000; Jennings and Zandbergen 1995). Business organisations are seen as important social actors operating in the field coterminous with the boundaries of industries, professions and national societies (DiMaggio and Powell 1983). They are infused with social norms and values beyond the technical requirements of the task at hand (Selznick 1957:16–17). The actions taken by organisations cannot always be explained by the direct demands of organisations' working tasks and economic interests (Scott and Meyer 1983). Therefore, the uptake and development of EMA is inevitably influenced by social institutional elements and changes.

Bouma and van der Veen (2002) argue that it is the social institutional contexts, within which environmental awareness is increasing, that have been influencing organisations' management perceptions and EMA activities. If there is a strong expectation in the institutional context of an organisation that EMA should be implemented, then that organisation has to act, either consciously or unconsciously, in compliance with society's will. Using this institutional view, this paper considers the development of EMA in relation to three institutional pillars: regulatory, normative and cognitive institutions. This leads to the understanding of the development of EMA in four institutional contexts involving (i) direct regulatory pressures, (ii) social environmental movements, (iii) professional structure and inter-professional communication and (iv) environmental mimicry in specific organisational fields. The motivation for this paper is a belief that a focus on taxonomy and classification through one lens which is examined here, institutional theory, will help to produce better-defined theory through theory refinement (Keating 1995:69) to help scholars and practitioners to accumulate and use knowledge about the development of EMA.

The remainder of this paper proceeds as follows. Section two includes a review of literature about the concept of institutional theory which is used as the theoretical foundation for this study. Section three discusses three institutional pillars in relation to the emergence and development of EMA. Some conclusions are drawn in Section four, followed by a number of suggestions about the potential future development of EMA.

12.2 Institution, Institutionalisation and Institutional Change

'Institutions', as the 'institutionalise' Walton Hamilton stated (1932:84), connote 'a way of thought or action of some prevalence and permanence, which is embedded in the habits of a group or the customs of a people'. This definition emphasises the importance of habitual behaviour and regards 'institutions' as imposing form and social coherence upon human activity, partly through the continuing production and reproduction of habits of thought and action (Scapens 1994:306). Although there is no single and universally agreed definition of an 'institution' in the institutional school of thought, a recent definition which clearly demonstrates the construct and characteristics of institutions is provided by Scott (2001:148) who notes that: 'Institutions are social structures that have attained a high degree of resilience… Social structures include norms, values, expectations, procedures, standards and routines' (2001:148).

Social norms and rules have the power to influence the behaviour and decisions of actors in the social field of interest; if violated, legal or moral punishment can be enacted. However, Scott (2001) contends that social norms, rules and values are not the sole component of institutions; rather, it is in human activities that such norms and procedures are produced and reproduced. The process of producing and reproducing common understandings about what is appropriate and, fundamentally, meaningful behaviour, connotes the process of institutionalisation (Zucker 1991). Through institutionalisation, activities that comply with social rules and norms become socially accepted as 'right' or 'proper', or viewed as the only 'conceivable reality' (Oliver 1996:166).

Organisations are social actors and the 'carriers' of social structures (DiMaggio and Powell 1983). Social rules and norms have become something that affect an organisation over time through influencing people in the organisation, the groups it embodies, the vested interests it has created and the way it has adapted to its environments (Selznick 1957). In the process of institutionalisation, organisations are bounded and assessed by powerful ceremonial or institutional criteria, so that they are prone to continue constructing stories about their actions that correspond to socially prescribed dictates about what the organisation should positively pursue and what it should not (Meyer and Rowan 1977). By complying with social norms and values, organisations can be perceived by society as legitimate and can exist and survive by maintaining such legitimacy. As a result, appropriate and accepted rules and norms are diffused and embedded in organisational structures and economic activities (Oliver 1996). These embedded institutional norms and values become taken for granted, so that conformity with them in organisations' everyday life becomes sub-conscious.

However, socially accepted norms and rules can develop and change over time. Certain norms and practices may be formed and institutionalised, while others may become outdated, inapplicable or out of line with changing regulatory standards and social expectations. Norms and practices can thus become de-institutionalised (Scott 2001; Oliver 1992). De-institutionalisation refers to the erosion or discontinuity of an institutionalised organisational activity or practice (Oliver 1992:563). After de-institutionalisation it is likely that a new institution will emerge, accompanied by a 'normal' process of institutionalisation with new beliefs and practices spreading in the organisational field (Scott 1995). Institutionalisation and de-institutionalisation influence each other, reflecting the ongoing process of institutional change.

This paper assumes that business organisations are currently operating in complex institutional contexts within which no stable and central institution of EMA has been formed or overwhelmingly accepted. They have to respond actively, or adapt, to different challenges in the process of institutionalisation whilst confronting perennially changing clusters of circumstances as old values and norms, such as ignoring or avoiding environmental issues and environmental information, become de-institutionalised. In this changing process, four different institutional contexts play their different parts in EMA development, and these are examined in the next section.

12.3 Institutional Contexts and the Development of EMA

Information about legitimate and socially accepted organisational behaviour can be transmitted through different means and mechanisms, such as through imitation or coercion (Meyer and Rowan 1977; Scott 1987). Scott (1995) distinguishes three

Table 12.1 Characteristics of the three institutional pillars (Scott,1995:35)

	Regulatory	Normative	Cognitive
Basis of compliance	Expediency	Social obligation	Taken for granted
Mechanisms	Coercive	Normative	Mimetic
Logic	Instrumentality	Appropriateness	Orthodoxy
Indicators	Rules, laws, sanctions	Certification, accreditation	Prevalence, isomorphism
Basis of legitimacy	Legally sanctioned	Morally governed	Culturally supported, conceptually correct
Line of reasons	What are my interests in this situation?	Given my role in this situation, what is expected of me?	The way we do things around here

analytical pillars or models of institutions: the regulatory, the normative and the cognitive pillars. These three institutional pillars differ in their assumptions about what institutions are and which mechanisms shape organisational behaviour. Table 12.1 summarises the mechanisms, logic, indicators, basis of legitimacy and line of reasons, of these three institutional pillars.

While some research suggests that the three pillars can coincide in explaining organisational behaviour (see e.g. Hoffman 2001), Scott (1995) notes that care should be taken in combining them in explaining social behaviour, as these three institutional settings rest on different assumptions regarding the nature of reality and how to account for behaviour. This study assumes that the three institutional pillars can be distinguished based on their different characteristics and need to be analysed and examined respectively. The following sections discuss each institutional pillar and how they are related to the EMA development.

12.3.1 Regulatory Pillar

The first and the most obvious institutional process works through coercive pressures imposed by the regulatory pillar. The regulatory process concerns the capacity of regulators to establish rules, inspect others' conformity to them and to manipulate sanctions (rewards or punishments) as necessary in an attempt to influence individual organisations (Scott 2001:52). The regulatory pillar provides organisations with a force for compliance as well as rules, schemes and inferential sets which organisations use when selecting and interpreting information for their further development (DiMaggio and Powell 1983). In this regard, the mechanism for conforming to regulation is coercive and laws, rules and sanctions can be seen as the indicators of this pillar.

To an organisation, the underlying logic of regulatory compliance is instrumentality (Scott 1995:35). Instrumentality motivates the organisation to respond to its most immediate audiences, for example the formal and informal pressures exerted by powerful authorities on which the organisation relies (DiMaggio and Powell 1983:150). These institutional pressures from powerful authorities are viewed by the organisation as immediate force, persuasion, or invitations to join in collusion. Conformance to rules, standards and government mandates helps the organisation to survive and grow, whereas failure to comply will result in loss of earnings, a damaged reputation, or even loss of the licence to operate (Oliver 1991).

Regulatory enforcement represents the strongest incentive for environmental actions. Most modern environmental law is less than three decades old (Bates 2002:7). Environmental legislative changes have provided mandated institutional rules that relate to corporate impacts on all environmental media. Under regulatory pressures, organisational change towards the environment can be seen as a direct response to a mandated government environmental requirement (DiMaggio and Powell 1983:150). In many environmental studies (see e.g. Newman and Breeden 1992; William et al. 1993; Baylis et al. 1998), environmental regulatory changes are viewed as the most widespread stimulus for improvements in environmental management. Jennings and Zandbergen (1995) use institutional theory to interpret the concepts and definitions of corporate ecological sustainability and propose that coercive forces—primarily in the form of regulatory changes and enforcement—are the main impetus for the diffusion of sustainable organisations. Milstein et al. (2002) also find that when coercive pressures are strong or increase, organisations are more likely to adopt environmental management strategies and that the variation in environmental strategies is low; in contrast, when coercive pressures are weak, fewer environmental strategies are implemented and environmental practices are often diversified.

While corporate environmental management does not of necessity require EMA to provide information for management purposes, there is a strong though unconfirmed presumption that EMA is a necessary foundation and support for quality environmental management, as it provides the basis for adaptive behaviour in the face of changing circumstances (see the analogous situation with financial accounting in Chambers 1986:66). The main users of EMA are the many types of managers working in organisations. The close relationships between EMA and environmental management and thus between EMA and environmental performance improvement, lend support to the argument that the regulatory institution has a potential to impose pressures on, and provide incentives for, corporations to develop EMA. That is why governments have been keen to promote the voluntary introduction of EMA where they can see a clear advantage for business and the environment (Schaltegger et al. 2002).

There is however a disjunction between legislated requirements to reduce or clean up pollution, for example and the introduction of an EMA system to support corporate compliance with legislative requirements. EMA is predominantly a voluntary part of management activity and is introduced only when managers expect that the benefits of EMA information will outweigh the costs of implementation. In most countries there has not been any mandatory introduction of EMA so that while it is clear that changes and developments in the regulatory pillar could have the strongest potential for EMA development, in practice EMA remains under the control of management. An argument here is therefore that environmental regulatory pressures provide an *indirect* incentive to the current development of EMA, rather than a *direct* incentive and that this constrains the effectiveness of these incentives. It seems likely that the regulatory pillar may have been of lesser importance than the normative and the cognitive pillars in the institutionalisation of the current development of EMA in corporations.

12.3.2 Normative Pillar

While the regulatory pillar is easily understood, interpretable, observable and often formalised in laws and regulations, normative obligations and influences are tacit and less identifiable. The normative pillar refers to shared social beliefs and values between organisations (Scott 1995:40). Scott (1995) argues that organisations and their members do not conform to normative rules and values because of their individual interests (as is the case with the regulatory pillar); instead, they conform because they feel obliged to do so. The logic on which the normative pillar is grounded is appropriateness—the matching of a situation to the demands of a position; that is, given the position or situation of the focal individuals or organisations, what they would be expected to do.

Social norms and values generally emanate from the cultural expectations or changes in society within which organisations function and from the professional developments through which social norms are embedded into professional activities (DiMaggio and Powell 1983). Therefore, in relation to the development of EMA, the normative pillar is discussed here from the perspective of social environmental movements (Section 3.2.1) as well as from the perspective of professional structure and inter-professional communication (Section 3.2.2).

12.3.2.1 Social Environmental Movements

Society bestows upon the organisation a license to exist and operate. Socially responsible, ethical or good 'environmental' behaviour can be explained by social changes and movements in the sense that new 'external norms or practices obtain the status of social fact', to which organisations respond when the norms or practices become 'obvious or proper' (Oliver 1992:148). This is why, intentionally or unintentionally, public opinions and community expectations can be seen embedded in organisations' environmental actions including the development of EMA.

Boons et al. (2000) apply the concept of institutionalisation to explain corporate ecological change and establish a conceptual framework illustrating how sustainable norms and values infiltrate into a given company. They highlight the relationship between ecological pressures from society and organisations' environmental changes, and propose that ecological pressures from the socially constructed 'image' of the natural environment in which normative institution is created will lead to the greening of organisations. Associated with this greening is the need for accounting such as

EMA which provides information for management about greening. Ball (2005) conducted a comparative study of the development of EA (mainly referring to EMA) in a Canadian city council and a UK local council. One of her observations was that when society has been successful in galvanizing by a wider sense of environmental protection, as in the Canadian case, EMA is pressed into use to promote such change. In the UK case, environmental problems are defined at a micro-local level, there being little evidence of a wider social movement with which the council has to engage. In these circumstances, EMA is ignored or marginalised.

Hence, it can be seen that if society and the community have become more enlightened and involved in environmental development, organisations' decision-makers are more likely to take environmental actions so that proactive environmental measures such as EMA will be observed. Social environmental movements may also help EMA to contribute to the process of the de-institutionalisation of conventional accounting (Ball 2005). The instrumental value of conventional accounting is questioned in the face of environmental crisis (Maunders and Burritt 1991; Schaltegger and Burritt 2000) and from a social normative perspective, EMA should be developed in order to open the eyes of both inside (management) and outside parties (Ball 2005:369).

In comparison with regulatory rules, normative rules are not imposed on organisations but are internalised by them (Scott 1995). From the social normative perspective, organisations may adopt EMA on a 'taken for granted' basis. In this regard, there is a greater likelihood that EMA, as a voluntary notion, will be affected by social environmental movements more than by regulatory pressures. However, pressures from social environmental movements do not have the strength of sanction of regulatory enforcement, because they are governed by voluntary and moral considerations. This implies that social environmental changes and movements have to be *gradual* rather than rapid and the process of the institutionalisation of corporate EMA through these social environmental movements has to be slow and long. In short, social environmental movements provide a *greater* but a much *slower* pressure on the development of EMA than do regulatory pressures.

12.3.2.2 Professional Structure and Inter-Professional Communication

The normative pillar also recognises how professions diffuse shared orientations and organisational practices (DiMaggio and Powell 1983). Education and the creation of professional networks form the basis of values and routines within specific occupational fields. A common understanding and development of norms and routines among professionals is institutionalised over the period of education and professional development. This institutionalisation process (in this case, professionalisation) connotes the collective struggle of members of an occupation to define the conditions and methods of their work in order to establish a cognitive base and some legitimisation for their occupational autonomy (DiMaggio and Powell 1983:152). As a result of professionalisation, professionally trained employees create a powerful set of voices to influence and legitimise the routines and activities in the organisations where they work (Boons and Strannegard 2000). Since what you learn determines what you can do, professionalisation is considered to be of great importance in the development of EMA.

Normative modes and rules of professional behaviour can be propagated through two channels (DiMaggio and Powell 1983:152). One channel is through formal education and the other is the growth and elaboration of professional networks that span organisations and across which new models can rapidly be diffused.

Universities and professional training institutions are conventional education centres for building up occupational and management norms (DiMaggio and Powell 1983). As professionals with academic credentials have undergone a socialisation process through university programs before they undertake work and their professional career tracks are closely guarded throughout their career progression, they are more likely than others to have internalised reigning norms and dominant organisational models (DiMaggio and Powell 1983:152–153). Professional work in organisations is therefore subject to pressures to conform to a set of norms and rules developed by universities and professional groups.

However, professional education and training mainly deliver specialised knowledge and stabilised norms and values in a specific profession. These stabilised or institutionalised norms are easily transmitted to newcomers, maintained over a long period of time and highly resistant to change (Zucker 1987:446). There is no doubt that the development of EMA needs interdisciplinary knowledge and approaches in order to deal with interdisciplinary issues. The implementation of EMA needs inputs from multiple sources, such as environmental management systems and financial information systems. Many previous studies reveal that highly specialised professionals such as financial accountants have not recognised the importance of EMA and the full involvement of accounting professionals in EMA is rarely observed (Gray et al. 1995; Parker 2000).

Parker (2000) argues that environmental managers are more competent than accountants in managing more recently understood environmental impacts, control systems and regulations. In contrast, Bartolomeo et al. (2000) find that environmental professionals have not sufficiently drawn attention to, or considered, financial accounting information in making environmental decisions. Environmental professionals, who come mainly from the disciplines of environmental science, environmental management and engineering, have not fully realised the benefits that accounting information and techniques can provide for their environmental decision-making. This may constrain their attitudes towards financial literacy and the role of accounting information in environmental management. For example, Wycherley (1997) conducted an interview with thirty UK environmental managers and revealed that the majority of environmental managers welcome the financial measurement of environmental expenditures, but insist that environmental performance can be improved without the need for detailed accounting information. The results also revealed that many environmental managers lack the necessary knowledge to assess the potential benefits of their environmental improvements. Bowerman and Hutchinson (1998) conducted case studies in three UK local authorities and found that although systems for collecting environment-related data have been developed by environmental engineers, environmental information that could be obtained from accounting systems to enhance decision-making is insufficient.

The above analysis implies that the array of established professional and occupational disciplines explains the existence, functioning and jurisdiction of a given profession and how and why a given profession lacks or denies alternatives in other professions. As the implementation of EMA needs a multidisciplinary team of scientists, engineers and accountants who possess a mixture of technical, management and environmental skills (FEE 1995), conventional professional values, norms and practices are an obstacle to the development of EMA. To overcome this obstacle, stabilised and institutionalised professional structure has to be changed and prevailing thought styles in the existing professional structure have to be altered. If individual professionals can extend existing practices and professional knowledge to broader areas in order to overcome the limitations in their own working discipline, a larger number of professionals and experts in different disciplines will be involved in environmental decision-making and the development of EMA will take place at a faster rate.

Comprehensive EMA models, approaches or systems need experts in all relevant disciplines to get involved, which emphasises the importance of bringing together those who work in different disciplines and of enhancing inter-disciplinary communications between different professionals. The more expansive such multidisciplinary networks and communication are, the more likely is the development and diffusion of EMA across professionals and their work. Hence, it is argued that this inter-professional communication is the most *direct* and *effective* way to promote the development of EMA.

12.3.3 Cognitive Pillar

Cognitive dimensions of human existence place emphasis on a collection of internalised symbolic representations of the world as mediating between the external world of stimuli and the response of the individual organism (Scott 1995:40). When a certain social behaviour or relationship is collectively accepted and internalised in an organisational field, member organisations tend to behave in such acceptable ways in order not to stand out or be noticed by other members as being different. Cognitive behaviour is based more on orthodoxy, i.e. ‘the way we do things around here’, than on instrumentality (regulatory) or appropriateness (normative) (Scott 1995:45).

The mechanism that captures the cognitive dimension is imitation—mimetic processes that underscore the effects generated by the networks of social behaviour and relationship (Meyer and Rowan 1977:341). Such networks constitute a recognised field where organisations involved ‘partake of a common meaning system’ and ‘interact more frequently and fatefully with one another than with actors outside the field’ (Scott 1995:56). The recognised organisational field forms a centre for dialogue and discussion between participants in its field and meaning is made regarding issues arising in the field (DiMaggio and Powell 1983). As a result of such discussion and discourse, the patterns of interaction between organisations become defined by shared systems of meaning, and these meaning systems establish the boundaries of each 'set' or 'community' of organisations, defining its membership and the appropriate ways of behaving (Scott 1994). Once sufficient actors in the organisational field do things in a certain way, that particular course of action becomes institutionalised and thereafter other actors would choose 'mimicry' as a 'safe' and effective strategy (DiMaggio and Powell 1983; Scott 1995, 2001).

Values and rules diffused and institutionalised in an organisational field can have an *immediate* effect on environmental actions in member organisations. When the concepts and approaches of sustainable development and environmental protection such as cleaner production have emerged and been developed in recent years, companies are more likely to notice and receive information about the diffusion of these concepts and approaches. If a member organisation perceives that similar member organisations in the organisational field in which they operate are practicing sustainable innovations, it will be under a cognitive pressure and thus environmental mimicry is a 'safe' choice.

As organisations are likely to imitate the behaviour of other organisations that are closely or increasingly tied to them (DiMaggio and Powell 1983; Covaleski and Dirsmith 1988), they tend to work with or to be monitored by those organisations having a similar size, type, industry category or geographical location. Jennings and Zandbergen (1995) find that large organisations, where sustainable values and standards have been recognised and accepted, are more willing to adopt a wider range of sustainable practices than are small organisations, where decision-makers have not been informed of such sustainable changes.

Likewise, if certain EMA concepts or approaches are perceived as spreading across a specific organisational field, organisations operating in this field are more likely to mimic peer organisations in order to adopt these concepts or approaches. For example, Bouma and van der Veen (2002) indicate that the acknowledgement and allocation of environmental costs as a parameter for organisational decision-making is influenced by the 'organisational field that creates a concept for capturing environmental costs in the mindset of management' (Bouma and van der Veen 2002:286). In Powell's (2000) study of the potential of using life cycle inventory analysis for local authority waste management, he finds that one of the major impetuses for the use of life-cycle inventory information in waste management decision-making is the use of life-cycle methods and information in other similar local councils. Although most environmental managers interviewed in Powell's study were not clear about what life-cycle methods really brought to their councils, they used these methods as they wished to be seen as a 'member' of the leading competitor group, and as 'doing good things' instead of being the 'worst' performer, or a laggard.

The development of EMA can therefore be encouraged by environmental mimicry. Once the adoption of the concepts and approaches of EMA becomes a central issue and is considered legitimate in an organisational field, they are easily institutionalised in that field, since simply following and mimicking other legitimate members without question is a 'safest' strategy. These mimicry pressures are *direct* on each member organisation in the organisational field.

12.4 Discussion and Suggestions

From the institutional theory perspective, this paper analyses the different effects of institutional pillars on the development of EMA. It is argued that current corporate EMA is developed through four institutional relationships, involving environmental regulatory pressures, social environmental movements, inter-professional communication and environmental mimicry. Based on the discussion of each institutional context in Section three, this paper argues that inter-professional communication is the first and the most important step for the development of EMA. Current divisions between professions are an obstacle for the development of EMA. Without the necessary knowledge and broader values being inculcated in professionals who may need to implement EMA, its importance will not be recognised in the first place. Social environmental movements and environmental mimicry both have a direct effect on the development of EMA, but social environmental movements take longer and their effects are slower. The diffusion of EMA will be much quicker in a specific organisational field than in society generally. The regulatory institution provides the lowest direct pressure on the development of EMA, because EMA is one of the internal management processes which regulatory authorities do not directly govern. Based on these arguments, some suggestions follow.

To promote the development of EMA, inter-professional communication is needed. EMA needs multidisciplinary knowledge, information and skills. This interdisciplinary or inter-professional communication may involve three aspects. First, Edwards et al. (2002) emphasise the usefulness of bringing the knowledge of accounting developments to those who work in the environmental discipline. The recent emergence and development of EA and EMA suggests that accountants and accounting information can play a greater part in environmental decision-making, reporting and auditing than is conventionally expected (Maunders and Burritt 1991; Gray et al. 1995; Birkin et al. 1997; Birkin 2000; Smith and Lambell 1997). It is suggested that EMA is more likely to be adopted and developed if environmental mangers are prepared to increase their accounting knowledge and enhance communication with accounting professionals.

Second, professional networks and associations are vehicles that promulgate normative rules about organisational and professional behaviour (DiMaggio and Powell 1983:152). Communication between professionals in the same area or different areas may be more frequent in professional networks than inside organisations, because in organisations, different professionals with their professional rules are normally placed in separate functional areas, making professional communication and developments difficult. A latent function of professional networks is to put people into committees, panels, conferences and study groups in which members can discuss and negotiate about dominant problems and their solutions. Based on their background characteristics alone, these people might not otherwise communicate with each another.

Through formal and informal network contacts between professionals, their accepted modes and rules of behaviour can be formed, developed and changed.

Inter-professional networks such as the Environmental Management Accounting Network (EMAN) create such a communication platform for different professionals whose work may relate to the development and promotion of EMA. It is expected that such network contacts can influence the knowledge base, values and practices of professionals. Members from various professions in the networks can, for example, transmit the message of the desirability of pursuing improved eco-efficiency in an organisation. When new ideas and norms of EMA are initiated by member professionals, old institutional rules are de-institutionalised and instead, changes and innovations will be instigated and diffused throughout the professional community.

Third, although environmental protection, for example through cleaner production, has come to the forefront of business management in some companies, there remains a lack of professionals and experts in this new interdisciplinary area. In Bouma and van der Veen's (2002) case study of theoretical explanations for the development of EMA, it was found that the concept of environmental costs is highly influenced by external institutions such as banks and research institutes. For example, the technique for attaching a monetary value to the environmental impacts of the firm studied is designed by an external research institute. Consulting with, learning from and communicating with external experts and researchers will have a positive effect on organisations' EMA development. As environmental management consulting organisations and researchers are often active in advising governments to adopt new environmental management and accounting approaches, it is assumed that EMA is more likely to be implemented if a larger number of external EA and EMA experts are involved.

The second important institutional influence is environmental mimicry. As previously stated, the more that the adoption of environmental management and accounting practices is noticed by the focal company in a specific organisational field, the greater is the possibility that it will imitate its peers' activities and implement similar practices. In previous studies, company image and size have often been considered important factors in affecting decisions to implement environmental management and accounting systems (see Halkos and Evangelinos 2002; Morrow and Rondinelli 2002; United Nations 2001). This implies that when an individual company operates in its recognised organisational field, it tends to adopt certain actions on a taken-for-granted basis corresponding to its reputation, image or profile. In this regard, increasing the information flows between member companies in the organisational field can be a means of generating and institutionalising EMA knowledge and ideas, for example by increasing publicity for the effective implementation of EMA among large-sized companies, or setting up a number of examples of successful EMA implementation among medium and small-sized companies.

Social environmental movements, as suggested in this paper, have a positive effect on the development of EMA over time via a long and gradual process. How to accelerate this process is another issue to address. Public education is regarded as an important factor contributing to the increase of environmental awareness throughout society. Through education and awareness-raising, the economic, political and social importance of environmental degradation will become a concern for voters, politicians and governments. Society's keen awareness of the value of sound environmental management solutions such as cleaner production technologies, to reduce emissions of carbon as advised by EMA systems, will encourage both environmental regulatory development as well as environmental management actions by businesses.

Regulatory pressures, as indicated in this paper, are at present indirect and inadequate to support the development of EMA, hence the pressure from the UNDSD (Schaltegger et al. 2002) for governments to promote a voluntary approach to EMA. For example, reward or rebate can be used to promote improvement in corporate environmental performance and EMA. Although it is rare to mandate internal environmental management processes, increasing the regulatory requirements for corporate environmental performance would be an indirect but effective way to promote EMA development.

The institutional arguments and suggestions discussed in this paper may contribute to the understanding of current EMA issues and provide implications to facilitate future EMA development. This paper is offered as a starting point for researchers interested in studying the change towards EMA from conventional accounting. Further studies are needed to test, extend and refine the arguments and propositions developed in such settings as those generated by concern over cleaner production.

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Chapter 13
Does Corporate Environmental Accounting Make Business Sense?

Seakle K.B. Godschalk

Abstract Businesses do not operate in a vacuum. They are subject to legal requirements and industry practices; they require resources to manufacture products and/or render services; they operate in an environment from which they draw their resources and which may be affected by their activities; and they operate in a community from which they draw their work force and which may also be impacted by their activities. Corporate environmental accounting is one of the tools that can be used by businesses to address these challenges. For an organisation to apply environmental accounting it must make business sense. Implementing environmental accounting may require resources. Therefore, a business must weigh up the benefits and costs thereof.

This paper discusses the four elements of corporate environmental accounting, i.e. environmental management accounting, environmental financial accounting, environmental reporting and environmental financial auditing. The potential benefits that can be derived from each of these elements are discussed. Many benefits can be reaped from implementing different elements of corporate environmental accounting. Some benefits enhance internal efficiency and competitive advantage, whilst others enhance legitimisation and stakeholder relations.

This paper also argues that for the full benefits of corporate environmental accounting to be reaped the elements of environmental accounting should be integrated with each other and in the day-to-day business of an organisation. The linkages and interactions among the elements of corporate environmental accounting as well as the linkages between corporate environmental accounting and the broader business processes of the company are discussed based on a diagrammatic model.

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13.1 Introduction

Businesses do not operate in a vacuum. They are subject to legal requirements and industry practices; they require resources to manufacture products and/or render services; they operate in an environment from which they draw their resources and which may be affected by their activities; and they operate in a community from which they draw their work force and which may also be impacted by their activities. In order to do all this, businesses need a "license to operate", not only from the authorities but also from all their stakeholders. This comprehensive approach to business was the basis for the *Triple Bottom Line* (TBL) concept (Elkington 1994) or sustainable business.

Corporate environmental accounting is one of the tools that can be used by businesses to address these challenges. Although the term *Environmental Accounting g* is sometimes used at different levels and for different components, for the purposes of this chapter corporate environmental accounting is meant to comprise four main elements, i.e. environmental management accounting, environmental financial accounting, environmental reporting and environmental financial auditing. The relationship between these elements is shown in Fig. 13.1, and will be discussed in more detail in Section 13.7.

For an organisation to apply environmental accounting to its fullest extent it must make business sense. Implementing environmental accounting may require resources, particularly in the initial stages. Therefore, a business must weigh up the benefits and costs thereof. However, caution should be exercised in such cost-benefit assessment, as many environmental and other factors may not easily lend themselves for quantification. One must also be careful not to focus on financial benefits only. One can even ask the question: should we at all try to rationalise implementation of environmental management measures by pointing out business benefits? Should business not implement these measures because they are socially obliged or expected to do so in terms of a normative approach (Bebbington 1997)? Whether one would only want to follow the normative approach or not, identifying business benefits from environmental accounting might help to persuade business people, who tend to think mostly in bottom-line terms, to consider the implementation thereof.

Corporate environmental accounting is an element of corporate environmental management. Therefore, benefits derived from corporate environmental accounting

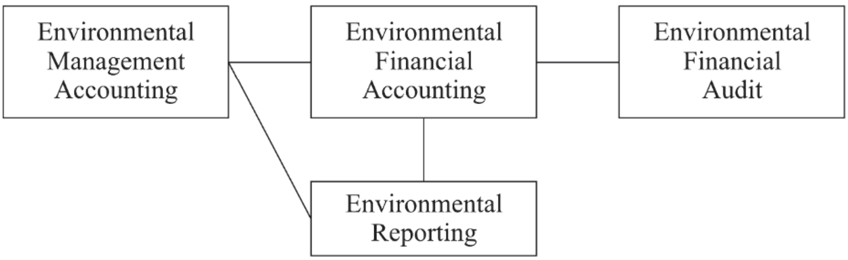

Fig. 13.1 The elements of corporate environmental accounting

are closely related to benefits derived from corporate environmental management. Reaping benefits from corporate environmental accounting is a dynamic concept. Some elements of environmental accounting may have more prominent benefits than others. Benefits derived from environmental accounting can be internally [e.g. efficiency and competitive advantage] or externally [e.g. stakeholder] orientated (Hart 1995). All benefits identified may not necessarily be available for all role players. However, the benefits discussed below have all been identified in some situations and may be available for companies depending on circumstances. The availability of benefits may also change over time or depend on the phase of implementation of corporate environmental accounting. Madsen and Ulhøi (2003) found that Danish companies that had implemented environmental measures in an early stage, had exhausted the 'low-hanging fruit'. They now had to focus on more substantive and expensive changes or technologies that would require longer pay-back time.

This paper will first briefly discuss some theoretical perspectives, followed by a detailed discussion of the various elements of corporate environmental accounting and the benefits that each one may provide. Finally it will be discussed how these elements can be linked into an integrated approach to corporate environmental accounting in support of sustainable business.

13.2 Some Theoretical Perspectives

Without going into a detailed theoretical discourse it is necessary to identify some of the more pertinent theoretical frameworks that are relevant for the discussion of benefits derived from corporate environmental accounting. These include *Legitimacy Theory, Stakeholder Theory and Porter's Hypothesis*. These various theoretical perspectives are not necessarily mutually exclusive, but could be considered supplementary to each other (Gray et al. 1995).

13.2.1 Legitimacy Theory

Early developers of the concept of legitimacy theory were Shocker and Sethi (1974, cited by Patten 1992) and Preston and Post (1975, cited by Patten 1992). Lindblom (1993, cited by Buhr 2002) was the first to apply the concept of legitimacy theory to environmental reporting. The basic tenet of legitimacy theory is that companies cannot continue to exist and thrive if their beliefs and methods are contrary to those of the society in which they operate. This implies that there is some form of 'social contract' between the company and its society. If an organisation cannot justify its continued operation, then in a sense the community may revoke its 'contract' to continue its operations. It then looses its '*licence to operate*'. In order to ensure that society continues to view the company's activities as congruent to its own, the company should disclose its activities.

13.2.2 Stakeholder Theory

Freeman (1984) made a persuasive case that systematic managerial attention to stakeholder interests is critical to firm success. Donaldson and Preston (1995) made important conceptual contributions to this concept, which form the basis of current research in the field. Berman et al. (1999) developed two models on stakeholder management, namely:

- The *Strategic Stakeholder Management* model. The nature and extent of managerial concern for a stakeholder group is viewed as determined solely by the perceived ability of such concern to improve financial performance.
- The *Intrinsic Stakeholder Commitment* model. Firms are viewed as having a normative [moral] commitment to treating stakeholders in a positive way, and this commitment is, in turn, seen as shaping their strategy and impacting their financial performance.

Berman et al.'s (1999) research did indicate support for the first model but failed to find support for the second model.

13.2.3 Porter's Hypothesis

Traditionally, responding to environmental challenges has been seen as a no-win proposition for business, with the related expenditure seen as a net cost. However, in 1991 Porter posited that stricter environmental regulation would lead to innovative approaches that would enhance competitiveness (Porter 1991 cited in Porter and Van der Linde 1995)—Porter's hypothesis. Porter's view was critiqued by various authors (Walley and Whitehead 1994; Palmer et al. 1995; Maxwell 1996) as being too simplistic. Wagner et al. (2001) moderated Porter's hypothesis and developed a model in which the traditionalist view and Porter's hypothesis were combined. The moderated Porter hypothesis forms the key concept for this paper, i.e. that companies implementing corporate environmental accounting will perceive at least some benefits from doing so.

13.3 Environmental Management Accounting

Environmental management accounting (EMA) can be broadly defined as the identification, collection, analysis and use of two types of information for internal conventional and environmental decision making:

- physical information on the use, flows and destinies of energy, water and materials (including wastes); and
- monetary information on environment-related costs, earnings and savings (UNDSD 2001: 4).

It is critically important that both physical and monetary information is tracked, as both provide a basis for decision-making. The physical information should preferably be measured per unit production to eliminate any effects of changes in production volumes. Although the monetary information is important to assess the financial impact, it is subject to price fluctuations, which could neutralise underlying changes in physical units. The actual use of physical units is also a strong indication of the impacts of the activities on the environment. The application of EMA is strongly linked to the concepts of cleaner production and eco-efficiency (Schaltegger and Sturm 1990; cited in Schaltegger and Wagner 2006).

Many environmental costs are hidden away in overhead accounts and line managers are often not even aware of them. Studies such as those undertaken by the *World Resources Institute* (WRI) have shown that these costs can be substantial. The six case studies presented in the WRI study show that for certain products and facilities, environmental costs can account for 20% of total costs (Ditz et al. 1995). As overheads are allocated to the various cost centres on a basis that normally bears no relation to actual environmental causal relationships, these environmental costs may be incorrectly allocated. This might result in wrong product line and pricing decisions, as well as inappropriate investment decisions that affect the profitability of the business. Getting these environmental costs out of the magical box of overheads and into the cost centres where they belong, the company will be able to make better product and pricing decisions, enhancing its profitability. A typical example is that of *Spectrum Glass*. Hazardous waste generated by one particular product, ruby red glass, was responsible for the bulk of hazardous waste generated by the company. Because waste management costs were allocated across the board, ruby red glass was cross-subsidised by the other products and appeared to make a profit. In fact, it was making a loss (Ditz et al. 1995).

EMA focuses on identifying the major environmental cost drivers. This can include raw materials used, environmental resources such as water and energy used, waste that is generated or pollution that is caused. By focusing on these cost drivers and their underlying processes, a company may be able to effect substantial cost savings whilst optimising its business processes. Following a robust process re-engineering project in which environmental management accounting was used as one of the tools, Girsa, a chemical company in Mexico, tripled production, reduced CO_2 emissions from 3.9 to 0.65 t per ton of output, waste-water from 13.7 to 1.5 m^3 per ton of production, and solid waste from 69.8 to 5.3 lb. An investment of US$20 million in environmental efficiency improvements yielded US$30 million in savings. From a major source of controversy the plant has turned into a model of corporate citizenship that the local community is proud of (Thorpe and Prakash-Mani 2003).

EMA is also linked to *Life Cycle Analysis*. The planning for the largest portion of overhead costs is done during the product's design phase (Julian and Nel 2003: 22). Therefore, by following a life cycle approach and changing designs and processes at an early stage, substantial cost reductions during the operating and disposal phases may be effected. Hart (1995) found that the return on pollution-prevention projects averaged better than 60% whereas it was estimated that end-of-pipe pollution-control projects lost on average 16% for every dollar spent.

EMA aims at minimizing wastage of resources used. In this way, a more sustainable use of environmental resources is affected, ensuring the continued access to and use of these environmental resources and the environment from which they are drawn. Procurement costs of wasted resources and waste management costs are reduced. It also prevents overloading of waste management infrastructure. Muraurer Bier in Austria, over the period 1995–2000 was able to effect a 19% reduction of fresh water use, a 30% reduction of fuel oil use and a 32% reduction in wastewater generated per unit product, for a total saving of US$186,000 (International Federation of Accountants 2005: 68). Raytheon, an electronics and aerospace company located in the USA, has used EMA to support a supply chain initiative with both financial and environmental benefits. This initiative resulted in a 92% reduction in scrap costs, a reduction of inventory turnover time from 3–4 months to 1 week, and a reduction of the purchase order cycle time from 3–7 days to 2 days (International Federation of Accountants 2005: 63).

Compliance with environmental legislation is enhanced as the costs of non-compliance are clearly identified. In addition, clean-up costs and liabilities for clean-up of pollution and claims for other environmental damage caused are reduced. EMA will also reduce compliance costs as authorizations will be more readily granted to environmentally well-managed companies than to environmentally negligent companies. Environmentally related fees, taxes and fines will similarly be reduced. As a result of introducing a 'green accounting system' the *UK Environment Agency* achieved a 53% reduction in carbon dioxide emissions between 1998/99 and 2002/03 (International Federation of Accountants 2005: 59). The INCO nickel refinery in Wales achieved a 65% reduction in effluent charges (Benn and Probert 2006).

Currently, external costs caused by the organisation and that are born by society, are often ignored. Such external costs can, of course, by the stroke of a pen be internalised by means of stricter regulation and taxes (Howes 2004). Companies should therefore, benefit by timely identification of such external costs and managing the reduction thereof before they might be forced to back-engineer solutions by future external pressure or legislation. In the long run a preventive approach is much cheaper than a reactive approach. In a survey of 614 US companies King and Lenox (2002) found that the prevention of waste did lead to financial gain but end-of-pipe treatment did not.

Implementing environmental management accounting may result in a variety of benefits, including but not restricted to reduced use of input materials and reduced generation of output waste and pollution, increased efficiency, enhanced compliance, more effective product and price decisions and even improved stakeholder relations. Overall this may lead to increased competitive advantage.

13.4 Environmental Financial Accounting

Environmental Financial Accounting (EFA) aims at ensuring that environmental revenue and costs, assets and liabilities are clearly reflected in the financial statements of the company in accordance with applicable legislation and accounting standards. This component of environmental accounting is primarily driven by international accounting standards. The main users of the financial statements are the shareholders of the company, investors and regulating authorities. Other users include the multitude of other stakeholders such as employees, creditors, customers, suppliers, neighbouring communities and environmental interest groups (*International Accounting Standards Board* 2004).

EFA can assist in the identification of environmentally related revenue, costs, assets and liabilities thereby enhancing compliance with legislation, *Generally Accepted Accounting Practices* (GAAP) and the *International Financial Reporting Standards* (IFRSs). The Sarbanes-Oxley Act of 2002, promulgated following several serious accounting and corporate governance scandals, is a typical example of such legislation in the USA, and has a profound effect on environmental corporate governance. Several *International Accounting Standards* (IASs) explicitly refer to environmental costs, assets or liabilities. These include IAS 37 on *Provisions, contingent liabilities and contingent assets*, IAS 16 on *Property, plant and equipment*, IAS 38 on *Intangible assets* and IAS 2 on *Inventory*. Of particular importance is IAS 37 that deals with the accounting for provisions and contingent liabilities for repair of environmental damage, environmental rehabilitation and clean-up and other closure costs. The implications of other IASs on environmental accounting must be deduced by applying the underling principles. Several *International Financial Reporting Interpretations* specifically address environmental issues: IFRIC 1 on *Changes in existing decommissioning, restoration and similar liabilities*, IFRIC 5 on *Rights to interests arising from decommissioning, restoration and environmental rehabilitation funds*, and IFRIC 6 on *Liabilities arising from participating in a specific market—waste electrical and electronic equipment*. Aspects that currently receive attention in terms of formulating environmentally related accounting standards, interpretations or guidance are the *Accounting for Heritage Assets under the Accrual Basis of Accounting* (a discussion paper issued by the *International Public Sector Accounting Standards Board* on 28 February 2006), as well as *Emission Rights Trading* (IFRIC 3 on *Emission Rights* released by IFRIC in December 2004 but withdrawn by the *International Accounting Standards Board* in June 2005 to allow a wider assessment of the issues at stake).

Changes in these standards can have profound impacts on the bottom line of companies. In-depth knowledge of these standards and requirements and pre-active management of the issues addressed by these standards will reduce the impact thereof (Carpentier et al. 2003; Repetto et al. 2002). The issuing of the *US Financial Accounting Standards Board Interpretation* No 47 (FIN 47) on *Accounting for Conditional Asset Retirement Obligations* that became effective on

1 January 2006 has caused a flurry of reactions, even recalling Enron sized implications (Rogers 2006). Where US companies were previously not obliged to disclose liabilities for environmental disposal and clean-up obligations if it was improbable that such obligations would be enforced or would result in litigation against the company, this has changed with FIN 47. This could result in disclosures amounting to billions of dollars of environmental liabilities previously undisclosed. Li and McConomy (1999) found that Canadian companies with strong environmental commitment were able to adopt new environmental accounting standards quicker than companies with less environmental commitment, thereby enhancing credibility and reducing litigation risk.

Making adequate provisions for environmental liabilities also prevents the company from going bust or suddenly developing a serious cash flow problem. Timely identification of and planning for these events enables the company to incorporate these issues in its strategic planning. Evidence in support of a view that environmental disclosures as such enhance market valuation of a company seems to be inconclusive (Cormier and Magnan 1997). However, it could be argued that companies that consistently report on environmental matters in their financial statements, be it good or bad news, create confidence in investors and creditors. This may lead to improved market ratings and enable access to capital on easier terms. Freedman and Stagliano (1991) found that companies with better environmental disclosure track records experienced fewer declines in market valuation following the introduction of more stringent environmental legislation, than companies with poorer disclosure practices.

Proper EFA results in a better reflection of the financial performance and situation of an organisation, which enhances the quality of decision-making by those stakeholders who base their decisions on the financial statements of an organisation.

13.5 Environmental Reporting

Environmental reporting in this context refers to reporting on environmental issues in addition to prescribed disclosures in the financial statements. Environmental reporting has been the subject of extensive development over the past decades and is affected by many factors. Proper environmental reporting enhances compliance with legislative requirements for disclosure of environmental information. Countries such as Denmark, Norway, The Netherlands, Australia and Sweden (Monaghan 2004), Canada and the USA (Repetto et al. 2002) require by legislation disclosure of certain environmental information. The EU *Modernisation Directive* (2003/51/EC) and the *Integrated P ollution Prevention and Control Directive* (96/16/EC) require the disclosure of certain environmental issues by listed or larger organisations, while non-EU countries such as Australia and Japan also have regulatory requirements in this regard (KPMG 2005). It is expected that the recommendations in the King II report (*Institute of Directors* 2002), that contains extensive guidance on environmental reporting, will be incorporated in company legislation in South Africa in the years to come. Reports on corporate governance invariably include sustainability or triple-bottom-line [environmental, social and economic] reporting. Environmental reporting also enhances compliance with GAAP and the IFRSs.

Several stock exchanges have introduced voluntary systems for environmental reporting based on which socially responsible investment indices have been developed. These include amongst others the FTSE4Good indices, the *Dow Jones Sustainability Index* (DJSI) (Howes 2004), and the *Johannesburg Stock Exchange Socially Responsible Investment Index* (Newton-King 2004). "*Increasingly, the quality of a company's environmental management is being seen as an indicator to the outside world of the overall quality of its management*" (Howes 2004: 107). Therefore, to be incorporated in any of these sustainability indices enhances the rating of a company in the eyes of investors and, therefore, its share price. On the other side, the UK government has instituted a policy of 'naming and shaming' those companies that do not yet report on environmental, ethical and social issues (Howes 2004).

The most widely accepted best practice for environmental reporting are the *Global Reporting Initiative* (GRI) guidelines (Cerin 2002; Edwards et al. 2002; KPMG 2005). The 3rd version of the GRI guidelines was launched in Amsterdam in October 2006 (*Global Reporting Initiative* 2006). Companies who voluntarily produce reports in reference to or in accordance with the GRI guidelines are seen as well managed companies.

It is important that environmental reports should primarily report on environmental performance rather than on environmental management systems and processes as such. Research has shown that companies with formalised environmental management systems, in general, did not perform significantly better than those without (Monaghan 2004). Over-emphasising process rather than performance is a real risk that detracts from the value of environmental reports and can often fail to reach the real objectives (Doane 2004).

Proper environmental reporting builds confidence among shareholders and other stakeholders. The public image of companies with effective environmental reporting will probably have the advantage over the image of companies that either neglect environmental reporting altogether or make it a formality rather than honest and open reporting. The *Co-operative Bank* in the UK is proof that one has not to be big to produce good environmental reports. Its *Partnership Report* has received numerous commendations over the past few years, including best sustainability report in the UK and best environmental report in the UK and best social report in the UK. The effect of its philosophy of open and honest environmental reporting is evident in a much lower than average staff turnover. Since launching the Co-op's partnership approach in 1997, the number of customer accounts has increased by over 30% and the bank's profitability has doubled. An international survey by *Echo Research* has found that the Co-operative Bank is one of the five most trusted companies worldwide (Monaghan 2004).

Several other benefits of environmental reporting have been mentioned in literature, including legitimising activities, distracting attention from other areas, boosting corporate image, preventing the promulgation of mandatory reporting regimes, building up expertise in advance of regulation, enhancing share price, political benefits, risk reduction, competitive advantage, enhancing accountability, informing the public, forestalling disclosure by others and building reputation (Clarke and Gibson-Sweet 1999; De Villiers 1998; Gray et al. 1993). Environmental reporting also offers the opportunity for extensive stakeholder involvement in the identification and monitoring of environmental performance indicators, thereby enhancing transparency, accountability and stakeholder relations. The positive role of environmental reporting in internal motivation and acting as a catalyst has also been mentioned (Hedberg and Von Malmborg 2003).

13.6 Environmental Financial Auditing

Environmental financial auditing focuses on the environmental aspects in the financial statements and should not be confused with environmental management systems audits, that are also often called environmental audits. *International Audit Practice Statement* (IAPS) 1010 *The consideration of environmental matters in the audit of financial statements* (IAASB 1998) provides guidance in this regard. The verification/assurance of environmental reports might be undertaken by auditors but is not part of the mandatory financial audit. It is an integral part of the environmental reporting process and is as such not included in the discussion in this section.

Environmental financial auditing checks the financial statements for legal compliance, compliance with generally accepted accounting practices as well as compliance with best practices on environmental corporate governance. The *Sarbanes-Oxley 2002 Act* specifically requires independent financial auditors to verify that public companies have sufficient controls and procedures to identify, assess, measure and report conditional asset retirement obligations (section 404).

A major contribution of environmental financial auditing could be to identify potential environmental risk areas that could jeopardise the continued existence of an organisation as an ongoing business, either by government sanctions, irreparable reputational damage or excessive cost (Cormier and Magnan 1997). If no or insufficient provision has been made for environmental liabilities, companies have been known to go bankrupt, of which Enron is but one of the most visible examples. This function of the environmental financial audit could prevent companies from going bust by timely identification of such liabilities and the insistence on proper provision for these liabilities.

There appears to be some evidence that stakeholders attribute more credibility to environmental information if it is presented in the financial statements (Tilt 1994). This is most likely due to the fact that the financial statements are subject to regulatory audits.

The main benefits of environmental financial auditing lie in ensuring compliance, identifying risks and lending credibility.

13.7 Integrated Environmental Accounting for Sustainable Business

Sustainable business can only be maintained if resources are used efficiently and sustainably, operations are carried out within the confines of compliance and the impact of its activities on the social and physical environment is considered in an integrated way. This will ensure that the "licence to operate" will remain in place. After having realised that it had lost its "licence to operate" due to severe community disturbances in its area of operations in Nigeria, Shell had to put a considerable amount of money into community development activities in order to regain its "licence to operate" (Shah 2004). Environmental accounting in all its facets contributes considerably to the above-mentioned factors supporting sustainable business.

However, to realise the full potential benefit from environmental accounting a company should implement all its components in an integrated way. It should become an integral part of their doing business. 'Experience suggests that the best way to ensure that a given corporation fully addresses the TBL agenda [and thereby reaps its full benefits, SG] is to build the relevant requirements into its corporate DNA from the very outset. The centre of gravity of the sustainable business debate is in the process of shifting from public relations to competitive advantage and corporate governance—and in the process, from the factory fence to the boardroom', says the founder of the TBL concept (Elkington 2004: 6).

Lee and Ball (2006) found that those companies in the Korean chemical industry that displayed the highest commitment by top management to environmental issues, that realised the strategic importance of such issues and achieved the best operational performance from implementing green strategies were considered leading companies in the industry, not only in terms of environmental management but in respect of management and performance in general as well. Managing these issues at the strategic level as an integral part of the business clearly gave those companies a competitive advantage.

Ernst Winter & Sohn, a manufacturer of diamond tools, as early as 1972 declared environmental protection as one of its corporate aims. It implemented the so-called Integrated System of Environmentalist Business Management (the Winter Model), addressing a comprehensive range of environmental measures. Although not mentioning environmental accounting as such, their model contained several elements of environmental accounting, particularly regarding environmental management accounting and environmental reporting. This successful approach was adopted by many companies in Germany and abroad. Winter already recognised financial benefits from these activities, including direct cost savings and reduced liabilities (Winter 1988).

Being aware of their environmental costs (and benefits) can assist the company's management in its forward strategic planning and consequently, help to reduce the company's exposure to future environmental risks and liabilities. Without adequate and appropriate systems to identify and account for such costs, it is unlikely that companies will be able to meet the future expectations of their customers, shareholders and the requirements of a more stringent regulatory environment and environmentally aware society. 'First movers' will clearly have an advantage (Howes 2004; Nehrt 1996, 1998).

The intangible benefits of environmental accounting in terms of brand value and confidence among shareholders and other stakeholders, are not always easy to quantify. As a result some companies inadequately recognise the long-term value of intangible benefits of environmental accounting. This leads them to ignoring the benefits altogether as not material enough to bother with. In the process companies deny themselves the opportunity of realising the real benefits of environmental accounting to the full extent. 'More work clearly needs to be done on demonstrating the linkage between the intangible benefits of operating more sustainably and competitive advantage, this being the 'missing link' that is most likely to make analysts engage more systematically' (Porritt 2004: 61).

The four components of environmental accounting are closely linked. As a matter of fact, there should be a golden thread linking these components and the business processes of the company. Berry and Rondinelli (1998) made a strong case for proactive corporate environmental management [which includes corporate environmental accounting, SG] and suggested ways in which integration could be promoted. The linkages and integrative aspects are illustrated in Fig 13.2.

During the environmental management accounting process all the major environmental issues will be identified and analysed. Inputs into operational processes, risk

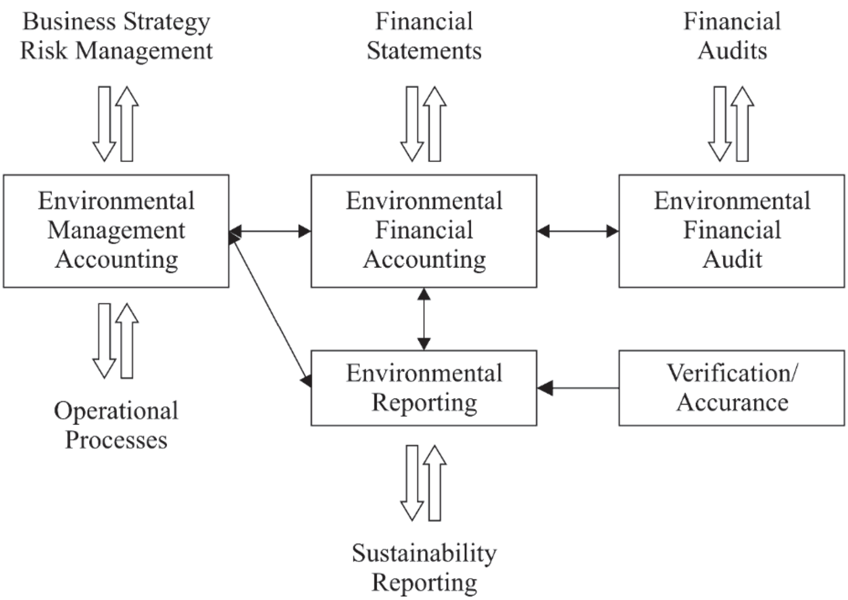

Fig. 13.2 Integrative linkages between elements of corporate environmental accounting and between corporate environmental accounting and business processes. [Internal linkages are shown by single arrows, linkages between environmental accounting and other business processes are shown by block arrows

management and business strategy will be given. Inputs will also be received from these processes for consideration of environmental implications. Specific environmental objectives and targets will be formulated and action plans will be implemented and integrated in the business plans. This will include any aspects that have to be addressed, in order to comply with legislation and accounting standards, in the financial statements. The EMA phase will form the basis of the company's environmental program.

During the environmental financial accounting process those aspects for which disclosure is required by regulation or accounting standards, will be identified and their inclusion in the EMA process will be ensured. Those aspects will be accounted for according to the relevant standards, and will be incorporated in the company's financial statements.

The bulk of environmental information, which might not be required by regulation or accounting standards, will be incorporated in the company's environmental report. The environmental report will in many cases form an integral part of the sustainability report. The process of compiling the environmental report will in itself also serve as a monitoring mechanism for the relevance of and progress with environmental programs under the EMA process. Third party verification of environmental reports might take place in this phase.

However, a major challenge remains the bridging between financial and physical/environmental data, as we are speaking of two different language systems here. This is even recognised by the GRI guidelines: 'Despite the growing overlap between sustainability and financial reporting, the greatest challenge in bridging financial and sustainability reporting lies in translating economic, environmental and social performance indicators into measures of financial value. … New methodologies are required to link performance in the economic, environmental and social dimensions to financial performance' (*Global Reporting Initiative* 2002: 71).

During environmental financial auditing environmental accounting compliance is checked and potential risks identified. This is included in the mandatory audit report. Feedback from this phase is used to upgrade environmental financial accounting. It is also used to feedback into the EMA phase and for addressing issues in the business' risk management process.

If the various elements of environmental accounting are not linked, it will lead to disjointed actions that address the environmental challenges in a piecemeal manner. Proper integration in business strategies will also be hampered and environmental management will be considered a fringe activity for 'greenies'. The involvement of stakeholders in the various components of environmental accounting may act as catalyst to enhance integration.

13.8 Conclusion

The above discussion of the benefits that can be derived from implementing various elements of corporate environmental accounting seems to corroborate the various theoretical posits discussed in Section 13.2. The legitimacy of a company can be enhanced if it identifies and addresses environmental issues that affect the interests of various stakeholders, and if it by reports on these actions. In doing so the company ensures that its activities are in congruence with societal norms. Non-congruence has placed the future viability of some companies in jeopardy (*Legitimacy theory*).

Stakeholder involvement and feedback has proven to be of much value to many companies. Companies that were controversial scapegoats could be turned around to become models of corporate citizenship by cooperating with their various stakeholders. The impact of proper environmental management on the image of companies has been confirmed in many cases. Environmental accounting is an integral part of proper environmental management. Stakeholder relations can be improved by either reducing impacts on them (e.g. surrounding communities) or enhancing the benefits they receive from improved performance (e.g. shareholders (*Stakeholder theory*)).

The many benefits that have been identified and experienced by a wide variety of companies under widely varying circumstances confirm that at least in its moderated manner Porter's hypothesis holds true. EMA definitely improves efficiency and compliance and can lead to cost reductions and improved decision-making. The overall effect of these impacts would be to improve competitiveness, by enhancing cost-efficiency or the company's image and customer relations. Further studies might prove that &backslash;porter was closer to the truth than his critics would concede (Porter's hypothesis)

It is clear that each element of corporate environmental accounting can generate its own benefits for a company. The benefits of some elements are more internally orientated and enhance efficiency and competitive advantage [e.g. environmental management accounting]. Others such as environmental reporting are more externally orientated and enhance legitimacy and stakeholder relations. Of course, not all companies will reap all these benefits. Circumstances and predetermined enabling conditions differ from company to company. However, companies interested in implementing or improving corporate environmental accounting will find at least some of these benefits coming their way.

It is also clear that environmental management accounting and environmental reporting offer more visibly prominent benefits than environmental financial accounting and auditing. However, for a company to reap the most benefits from corporate environmental accounting it should use the powers of synergy and develop a system of integrated environmental accounting. This is the best way to ensure the proper integration of corporate environmental accounting in all its components in the company's business processes.

It is possible that environmental accounting may become standard practice as a result of future regulation. Companies that have already implemented a system of integrated corporate environmental accounting will then clearly have a first mover advantage.

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Chapter 14
An Environmental Accounting Model for a Natural Reserve

Francesco Marangon, Maurizio Spoto, and Francesca Visintin

Abstract The implementation of environmental accounting in a Natural Reserve produced some significant results in terms of restrictions. First, environmental accounting introduced a limitation in scale which was inapplicable on a micro-scale. A second restriction concerned the use of a physical unit of measure was instead of a monetary unit. A third limitation was because environmental accounting only takes costs into account, not environmental benefits. These three limitations led us to develop an environmental accounting model that considered resources in the Natural Reserve, both consumed and produced. The model aimed to supplement monetary accounting (based on cost and revenue) with environmental accounting which reflects not only environmental costs but also environmental revenues, i.e. environmental benefits. The difference between costs and benefits, both economic and environmental, represented the value produced or consumed by the Natural Reserve.

14.1 Introduction

Since 2004 the University of Udine (Italy) and the Italian branch of the World Wildlife Fund have worked together to establish an environmental accounting model for the Miramare Natural Marine Reserve (Trieste, Italy) (MNMR).

At the end of the 1990s the United Nations, the European Commission, the International Monetary Fund, the Organisation for Economic Co-operation and

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Development, and the World Bank undertook a review of the System of National Accounts (SNA) to integrate environmental accounting into economic accounting. As explained in the introduction to the System for Integrated Environmental and Economic Accounting (commonly referred to as SEEA) (UN et al. 2003), integrating economic and environmental information in a common framework permits a consistent analysis of the contribution of the environment to the economy and of the impact of the economy on the environment. It is intended to meet the needs of policy-makers by providing indicators and descriptive statistics to monitor the interaction between the economy and the environment, as well as, serving as a tool for strategic planning and policy analysis to identify more sustainable development paths. The revision of the SNA is intended to move it in this direction, as the SNA standard is too restricted with respect to environmental research questions. In fact, environmental functions are available in many cases without direct monetary costs being incurred by their users whereas monetary accounting usually will not reflect the social cost of depleting or deteriorating natural resources (Pedersen and de Haan 2006).

The previous issues are relevant at not only a national but also a local scale which is the context of individual protected areas. Policy-makers and decision-makers, stakeholders, and funding bodies are likely to seek information that can be used to improve resource allocation. Increased emphasis is in part due to changes in society, especially the increased demand for accountability, transparency, and demonstrable 'value for money' (Hockings et al. 2006).

The research on which this paper reports investigated what value, and how much, the MNMR was able to create from the money received from government and funding bodies. The method refers to environmental accounting models, making some differences to adapt the macro to the micro scale.

The macro scale refers to the SEEA, a 'satellite' system of the SNA that comprises four categories of accounts. The first considers physical data which relates to flows of materials and energy, and manages these according to the accounting structure of the SNA. The accounts in this category show how data flow in physical and monetary terms can be combined to produce so-called hybrid flow accounts (for example, emissions accounts for greenhouse gases). The second category of accounts takes those elements of the existing SNA relevant to the environment and shows how the environment-related transactions can be made more explicit (for example, an account of expenditures made by businesses, governments, and households — to protect the environment). The third category comprises accounts for environmental assets measured in physical and monetary terms (for example, timber-stock accounts showing opening and closing balances and the related changes over the course of an accounting period). The final category considers how the existing SNA might take into account the impact of the economy on the environment, considering three adjustments: depletion, defensive expenditures, and degradation (UN et al. 2003).

The present research focused on the third SEEA category, which takes into account natural capital three broad categories: natural resources, land- and ecosystems. In particular, eco-systems are defined as groups of organisms and the physical environment that they inhabit (Ricklefs 1990). They provide indirect use benefits for humans in the form of a variety of services. Three types of eco-system assets are recognised in the SEEA, among them aquatic.

The implementation of environmental accounting at a micro scale found some limits in the application. Firstly, environmental accounting introduced a limitation in scale. The SEEA models are national accounting systems and are, therefore, effective on a macro scale but not on a micro scale, which is the case in protected areas. Natural resource accounting overcomes this limitation but introduces a second restriction: the implementation of a physical unit of measure instead of a monetary unit. Finally, a third limitation is the accounting for environmental costs but not environmental benefits. If environmental benefits are ignored, the environmental accounting system will take into account the effects of only the resources consumed but not the resources produced by eco-systems.

To overcome these limitations, we developed an accounting framework for a local protected area by adapting the national framework and taking into account both economic and environmental costs and benefits.

In Section 2, the method is outlined and the environmental accounting model is given. In Section 3, there is a brief description of the Miramare Reserve and an illustration of how the model was adjusted to the specific case. Section 4 provides an analysis of the results, and Section 5 concludes.

14.2 Methods

The three limitations mentioned above (scale, unit of measure, and cost but not benefit) led us to develop an environmental accounting model that considered resources in the MNMR, both consumed and produced. The model aimed to supplement monetary accounting (based on cost and revenue) with environmental accounting that reflects not only environmental cost but also "environmental revenue", i.e. environmental benefit. The difference between economic and environmental costs and benefits represents the value produced or consumed by the MNMR.

As the method used, the model adapted and applied the economic asset account. We can see that the environmental accounting structure for the MNMR is the same as that of the natural resources asset account and includes a natural capital dimension (natural-stock account) and a flow dimension (natural-flow account) (Table 14.1).

Natural-stock accounts should be set up based on a long time series. Data should refer to natural resource quality, i.e. species, quantity, density. Nevertheless, in the

Table 14.1 Environmental accounting model for the MNMR

Asset accounts		
Natural-stock account	Natural-flow account	
Natural stock:	Costs:	Benefits:
Quantity	Monetary (Park overheads)	Monetary (Park revenues)
Quality	Environmental (Environmental costs)	Environmental (Environmental benefits)

case of aquatic resources, it is difficult to establish precisely the total stock of fish of various species so various indirect measurement techniques must be used to estimate the physical stocks of fish by species. It has been noted that such measurements may have to be extended to species which are not used by humans but which are vital to the ecological chain to which the species of interest belong. Physical data on stocks are usually compiled by biologists who use different methods to estimate the size of these stocks (UN et al. 2003).

A natural-flow account assesses physical flows between the bio-sphere and techno-sphere (Fig. 14.1) (Nebbia 1996) and is indicated as “Natural resources asset account” (OECD 2004; UN et al. 2003). The techno-sphere is defined as that part of the bio-sphere which is influenced and changed by human activity. In the techno-sphere humans, defined as “special” animals, are the makers and the users of resources. The matrix defines four flows. The first concerns a closed biological cycle, namely, materials flows among the sectors of the bio-sphere (for example, carbon and nitrogen cycles). The second describes the materials flows provided by the bio-sphere to the techno-sphere. The techno-sphere takes resources from the bio-sphere and after transforming them into goods, returns residuals to the bio-sphere, degrading the quality thereby of resources. This process describes the third flow, namely, the waste flows going from the techno-sphere to the bio-sphere. Water, air, and soil are modified and polluted. The last flow describes what passes

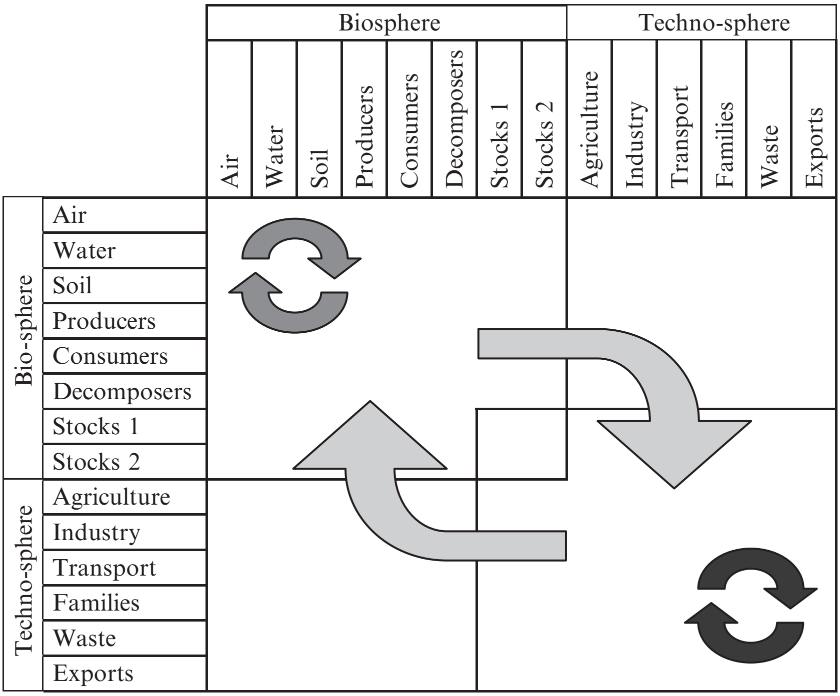

Fig. 14.1 Bio-sphere techno-sphere flow matrix

between economic sectors, also known as an input/output matrix (Nebbia 1996). The environmental accounting in this project analysed two of the four flows: the bio-sphere to techno-sphere flow, which assessed environmental benefits and economic revenue; and the techno-sphere to bio-sphere flow, which assessed environmental and monetary costs.

Results—a Ministry of Environment decree established the Miramare Natural Marine Reserve in 1986 and management was assigned to the Italian branch of the World Wildlife Fund. The MNMR is located in the Gulf of Trieste in the northern part of the Adriatic Sea. The land surface covers 30 ha with a surrounding sea area is 90 ha. The environment is marine and coastal and the land is rocky along the coast. Information regarding the MNMR has been disseminated in the surrounding area by means of scientific research, environmental education projects, and local and national media exposure. Projects have also been set up relating to local tourist management and fishing regulation.

14.2.1 Natural Stock Account

Natural-stock account assessment means assigning a monetary value to the Reserve's natural resources (water, flora, fauna, and soil). However, at this stage we have not yet reached an adequate monetary estimate. To do so would require an accurate census of the fish population and clearly, in the cases of fish and fauna there is a wide margin for error. To overcome the lack of a monetary estimate a qualitative (species variety) and quantitative (density) accounting method was adopted as a measure of natural capital. The qualitative aspect is based on the Initial Environmental Analysis (IEA) carried out during the implementation stage of the Environmental Management System (EMS) (Zuppa et al. 2004). During the analysis, care was taken to indicate sensitive species, whether of community or priority interest. As regards the quantitative aspect, reference was made to the results of a visual census. A visual census is a non-invasive technique used to monitor fish species by means of observers provided with boards or underwater cameras.

14.2.2 Natural Flow Account

To construct a natural-flow account for the MNMR flows of materials and energy from the techno-sphere to the bio-sphere and vice versa needed to be traced. Moreover, input/output matrices were required to reconstruct these movements (Gustavson et al. 2002; PNALM 2003). To allocate monetary values to natural-flows a cost-benefit approach was adopted.

In this case, costs are:

- Monetary (costs contained in the profit and loss account)
- Environmental (flows between techno-sphere and bio-sphere)

- And benefits are:
  - Monetary (revenues contained in the profit and loss account)
  - Environmental (flows between the bio-sphere and the techno-sphere)

Two conditions are required to complete the framework:

1. The same unit of measure must be used in all the accounts, namely a monetary unit.
2. The cost and revenue items must also be the same for both the income statement and the environmental account, as is the case for the input/output matrix used in the national environmental account.

14.2.2.1 Techno-Sphere Bio-sphere Flows

Environmental Costs

The method used to classify environmental costs derives from Nebbia's analysis of the input/output matrix (Nebbia 1996). He found that national accounting breaks down human activity into techno-sphere sectors (agriculture, industry, transport, families, waste, imports, and exports). Environmental accounting for a protected area also divides human activity into sectors according to management goals. It is by means of these goals that the administrative body achieves the Reserve's objectives. At the micro scale, the techno-sphere sectors of Nebbia's input/output matrix represent a total of six management goals (see Fig. 14.2) (Zuppa et al. 2004):

- A: Protection of the environment and exploitation of natural resources
- B: Promotion and dissemination of marine environment knowledge
- C: Environmental education
- D: Scientific research
- E: Promotion of sustainable development;
- F: Financing overheads and one-off costs

Each of these goals benefits from a flow of materials and energy from the bio-sphere. The IEA was used to identify the flows (Zuppa et al. 2004). Indeed EC Regulation n. 761/2001 (EMAS 2) says the IEA's objective is to identify significant environmental interaction and evaluate the environmental impact. The impact is related to the following factors:

- Anthropic presence (knowledge regarding the marine environment and its management and promotion of environmentally-friendly business activity)
- Raw material use (upkeep residuals, urban waste)
- Consumption of fuel for motor vehicles
- Consumption of heating fuel
- Consumption of electricity
- Water consumption
- Administration expenses

Environmental impacts are linked to the consumption of materials and energy or the return of used resources. To transform these impacts into environmental costs the

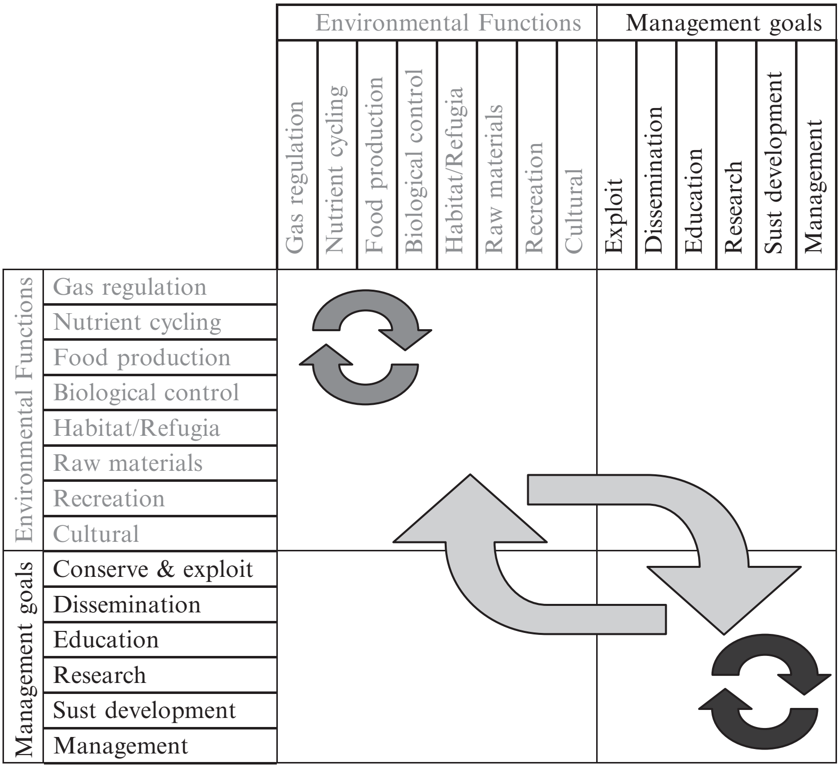

Fig. 14.2 Natural flows account for the MNMR

IEA consumption accounting method was used (Zuppa et al. 2004). An estimate of the environmental cost for various consumption items is achieved using equivalent tonnes of CO_2 as the unit of measurement and estimating the external cost per kilogram of CO_2 to obtain a monetary value. The next step is to apply the environmental costs, which were measured in monetary terms, to the six goals that make up the MNMR techno-sphere.

Monetary Costs

After classifying environmental costs we moved to the reclassification of costs taken from the income statement for the period ended 31/12/2004. To do this we used the Long Term Financial Plan (LTFP) approach (CFA 2002). The LTFP was presented by the Conservation Finance Alliance together with the Nature Conservancy at the 5th World Parks Congress in Durban (South Africa) in September 2003. The LTFP is a long-term model for finance-plan management regarding parks and protected areas. The cost items are recorded for management-plans and sub-plans and cost-centres. This meant that all the cost items on the Reserve's income statement were re-classified according to the six Ministry of Environment goals.

14.2.2.2 Biosphere-Technosphere Flows

Environmental Benefits

The input/output matrix which describes the relationship between the bio-sphere and the techno-sphere divides the former between natural in-organic entities (air, water, and soil) and types of living organisms (producers, consumers, and decomposers). Nevertheless, the approach based on entities and organisms was developed for macro-scale models such as national accounting systems. At the micro scale, since the Reserve covers an area of only 121 ha, this sub-division might not have suited the research aims, so it was decided to substitute it with an eco-system approach based on sub-divisions according to eco-system function.

In the last few decades there has been an increasing interest in the valuation of eco-system functions and environmental goods and services (Bishop and Romano 1998; Costanza et al. 1997; Daily 1997; Daily et al. 2000; De Groot 1992, 1994; De Groot et al. 2002; Mitchell and Carson 1989; Pearce 1993; Turner 1993). De Groot's specification (De Groot 1992) regarding eco-system functions, which was taken up by Costanza et al. (Costanza et al. 1997), should be interpreted as the ability of natural processes and components to provide goods and services that meet human needs, directly and indirectly.

The continental shelf is the main feature of the MNMR's marine eco-system and is the basis for the functions that Costanza et al. (1997) identified (See Table 14.2). The following functions were identified: nutrient cycling, biological control, food production, recreation, and culture (the value of scientific and educational capital). Some of these functions were proposed by MNMR biologists. However, due to insufficient data, this initial analysis has not considered the functions of Gas regulation and Habitat/Refugia. Moreover, given the small surface area, it was not considered appropriate to estimate raw material production.

In this manner, the bio-sphere categories of Nebbia's input/output matrix are represented at the micro scale by a total of eight environmental functions (Fig. 14.2).

Monetary Benefits

Having defined techno-sphere sectors and bio-sphere categories, it is now possible to construct the bio-sphere techno-sphere input/output matrix for the MNMR as illustrated

Table 14.2 Estimate functions

Suggested by Costanza et al.	Suggested by MNMR biologists
Gas regulation	
Nutrient cycling	
Food production	
Biological control	
	Habitat/Refugia
Raw materials	
	Recreation
Cultural	

in Fig. 14.2. The matrix summarises the model's structure and the approach outlined in the previous sections and encapsulated in the following points:

- The monetary values of bio-sphere/techno-sphere flows are estimated by means of:
  - An estimate of the monetary value of the Reserve's functions
  - A re-classification of income
- The monetary values of techno-sphere/bio-sphere flows are estimated by means of:
  - An estimate of the monetary value of the Reserve's environmental impact (based on the IEA)
  - A re-classification of costs on the basis of the LTFP model

By using a single unit of measurement (monetary) and a sole classification we were able to combine three separate instruments: the IEA, the LTFP, and the environmental accounting.

14.3 Analysis

14.3.1 Estimate of Environmental and Monetary Benefits for the MNMR

The functions provided by the environment yield a benefit to the economy. The benefits recognised in the SEEA can be grouped into two broad categories, use benefits and non-use benefits. Use benefits include both direct benefits (the use of environmental assets as sources of materials, energy, or space for input into human activities) and indirect benefits (non-consumptive use, for example, the amenity benefit of landscape). Use benefits also include option benefits (derived from the continued existence of resources that may one day provide benefits for those currently living) and bequest benefits (derived from the continued existence of elements of the environment because they may one day provide benefits for those yet to be born). In addition, an environmental resource may simply have an existence benefit (even without any prospect of being used now, or in the future, it is still desirable to maintain the existence of the entity).

Based on the different kinds of value provided by environmental functions the literature suggests the need to implement different methods: direct market valuation (for example, market prices) in the case of the food and recreation function; indirect market valuation (for example, replacement cost) in the case of nutrient cycling and biological control; and the contingent valuation method in the case of the cultural and recreational function (De Groot et al. 2002; UN et al. 2003).

The Gas regulation function carried out by the MNMR eco-systems was not estimated in monetary terms because the data were not available, as this was the first application of our accounting model. From a methodological point of view, the estimate should have measured the carbon content stored during the formation of marine sediment due to the work of bivalves, as well as, the regulation function carried out by the seaweed strata.

The nutrient cycling function considers the average concentrations of phosphorous and nitrogen. Replacement cost is used to estimate the value of this function, i.e. the cost of mechanically removing phosphorous and nitrogen. In the last 15 years there was an increase in the concentration of these elements in the MNMR. This supports the hypothesis that marine eco-systems store production residuals which derive from outside the area. Replacement costs for continental shelves vary between \$752/ha, and \$2,110/ha per year (Costanza et al. 1997). By taking a precautionary stance (and therefore taking the lowest figure), and applying suitable inflation and exchange rates a value of €774/ha per year was reached. Since the MNMR covers an area of 121 ha the annual value of its contribution to nutrient cycling can be estimated at €93,637.

Food production takes both fishing and angling into consideration. It was estimated that professional fishermen catch 630,000 kg of fish per year from within the vicinity of the MNMR (Odorico and Costantini 2002; Zuppa et al. 2004). By multiplying the total weight of the fish by their market value we obtain an estimate of the monetary value of the food production function. The value of red-meat fish (sardines, mackerel, etc.) is not included because these species are present in the area only because of sea currents. Moreover, as it is difficult to accurately locate the positions of fishing boats only 50% of the catch is allocated to the Reserve. In contrast, so far as anglers who fish close to the Reserve are concerned, their total catch is allocated to the area. An overall estimate of the food production function amounts to €84,026.

As far as the biological control function is concerned, Costanza et al. (1997) assume that control exerted by the high trophic levels is at least 30% of the fish catch value. Consequently, taking the food production estimate, above results in a figure of €25,208 for the biological control function.

As regards the Habitat/Refugia function, the widespread presence inside the Reserve of 13 fish/fauna species was monitored (out of 116 recorded in the Adriatic and Mediterranean Seas) (Castellarin et al. 2001), as well as, three species found in confined areas (Pleuronectidae, Syngnathidae, and Blenniidae). Most probably, the Reserve acts as a recruitment area since a large quantity of small creatures can be found just after the breeding period. To produce a monetary value for the Habitat/Refugia function it would be necessary to calculate the reproduction rate, or the annual increase, in the most commercially valuable fish species. In this way, a corresponding value can be given to a portion of the food production function. However, it was not possible to estimate reproduction rates inside the MNMR.

Because of the Reserve's size and characteristics an estimate of the raw materials function is not feasible.

Tourism in the MNMR was divided into two categories: recreation and culture. The former regards free-time activities while the latter is more closely related to learning and education and refers to the cultural function mentioned by Costanza et al. (1997). Three categories of consumers of recreational activity were analysed: visitors to the visitors' centre and people taking part in underwater activities: scuba divers, and snorkelers. Contingent valuation methods were used to assign a monetary value to the benefits which derive from each of the recreational activities. This results in estimating the recreational demand function from which the so-called consumer surplus can be derived i.e. the value that the consumer assigns to the services offered by the Reserve in excess of the price of the entrance fee. An estimate of this surplus is obtained from the demand function. This can be achieved by linking the number of visitors (quantity) to a variable dimension of tickets (price). The overall benefit is obtained by adding surplus and price. A surplus figure of €22,250 was estimated for the visitors' centre and figures between €760 and €6,203 were reached for each of the underwater activities. The price, which derives from total entrance income, was €29,849 (10,301 visitors) for the Visitors' centre, €19,256 (899 divers) for Scuba diving, and €15,593 (1,583 enthusiasts) for Snorkelling.

Moreover, the economic effects of tourism can be defined as direct, indirect, or induced. Direct effects derive from spending by tourists (added value) whereas indirect and induced effects are the contribution of tourism to the creation of income. They are estimated by multiplying the added value by a Leontiev multiplier of 1.54 (Manente 2004). It is, therefore, necessary to estimate daily tourist spending according to spending type and flow categories (accommodation, catering, and publications). The following data were gathered through questionnaires: Accommodation spending €4,066; Catering €103,300; Merchandising and Publications €5,180. By applying an income activation parameter an overall figure of €173,320 was obtained for revenues produced directly and indirectly in the MNMR. By adding the benefit (incomes plus surplus) the function's value reaches a figure of €267,231. In the natural-flow account, which includes income and expenditure from the income statement, revenues were subtracted to leave a final amount of €202,533.

The cultural function was divided into two macro areas: science and education. The former regards the Reserve as a kind of field labouratory. A quantitative and qualitative analysis of the function can be achieved by using the following indicators: Number of researchers based on man-days (from which a monetary value can be calculated), Research projects (project budget), Agreements with Universities and Scientific Institutes for research and conferences. However, these data were not available and estimates were based on data derived from the literature (Costanza et al. 1997). In this case, the average value per hectare per year is €29.84 giving a total of €3,610. The second macro area includes educational activity that took place in 2004 when 215 schools organised visits to the MNMR for a total of 4,300 pupils. From accounting data it was calculated that educational activity produced revenues of €30,584 in 2004. The overall cultural function value therefore amounts to €34,194 (Table 14.3).

Two main figures emerge from the LTFP: revenues amount to €105,067 (including entrance fees: €64,698) and public funding amounts to €735,348. Table 14.3 also gives the grand total of €1,280,013 for monetary and environmental benefits.

14.3.2 Estimate of the Environmental and Monetary Costs for the MNMR

First, the anthropic impact on the MNMR was considered. Tourism generates several consumer externalities, among which are the use of motor vehicles to reach the area, and the use of complementary and accessory materials for carrying out

Table 14.3 Environmental benefits per function and monetary benefits

Benefits	Functions	Benefits €
Environmental benefits	Gas regulation	Not available
	Nutrient cycling	93,637
	Food production	84,026
	Biological control	25,208
	Habitat/Refugia	Not available
	Raw materials	Not estimated
	Recreational	202,533
	Cultural	34,194
Monetary benefits	Revenues	105,067
	Public funding	735,348
	Total benefits	1,280,013

recreational activities. Factors related to anthropic presence (transport, consumer durables, consumer non-durables, etc.) contribute to the production of CO_2. Although the unit of measure is different the logic behind the transformation of human presence into CO_2 emissions is the same as the logic and method behind the approach used to calculate the ecological footprint (Chambers et al. 2000; Wackernagel and Rees 1996). Indeed, whereas in the case of the ecological footprint total consumption is converted into equivalent surface area measured in hectares, here, the equivalent unit of measure is kilograms of CO_2.

As regards the allocation of CO_2 production to the six goals, anthropic presence was weighted for each of environmental education through educational activities and submarine visits (C) and for promotion of sustainable development by means of fishing-tourism (E).

By using a CO_2 production co-efficient of 17.55 mean kilograms per Italian inhabitant per day (MEF 2005) and considering that on average a trip to the MNMR will last a half-day we can calculate that 17,083 visits will translate into 8,541 inhabitant-equivalent days giving a total of 149,888 kg of CO_2. As the cost per kilogram of CO_2 emitted is 3.099 eurocents an estimated value of €4,645 can be allocated to the consumer externalities produced by visitors to the Reserve (C). For fishing tourism (E) 1,255 inhabitant-equivalent days translates into environmental costs of €683.

Monetary valuation allows us to measure the environmental and social impact of energy production, although the estimates are still inaccurate as the highly complex methodology considers only a limited number of impacts related to energy production. These initial estimates are based on a method devised for the ExternE EU project (Apat 2004).

For raw material use data supplied by the Reserve for paper consumption in 2004 were converted into equivalent CO_2 quantities which amounted to €14. Despite the fact that paper consumption is common to all the goals the figure was so low that it was allocated exclusively to the overheads goal (F). The fuel consumed in the MNMR was used for both motor vehicles and heating. Consumption for 2004 converted into equivalent CO_2 emissions translated into an environmental cost of €216. Since the consumption of fuel for motor vehicles is common to all the goals (as stated in the IEA) the total was shared equally among all goals (€36). Liquefied petroleum gas (LPG) is used in the Reserve for heating and this emits CO_2 during combustion. From Apat (Italian Environmental Protection Agency) we deduced that a kilogram of LPG will produce an equivalent of 3.02 kg of CO_2 (Apat 2003). However, by adding together emissions of methane and nitrous oxide, total CO_2 amounts to 3.16 kg of CO_2 equivalent/kg of fuel. Therefore, CO_2 consumption for 2004 translated into emissions equals €388. Given that, according to the IEA, the consumption of heating fuel falls entirely within goal F the full amount can be allocated to the Reserve's overheads.

Electricity consumption was 54.42 kWh and which translated into an environmental cost of €1. The IEA states that this figure should be shared equally among all the goals but the figure was so low that it was allocated solely to goal F.

Annual water consumption amounted to 273.39 m^3 which was equivalent to an environmental cost of €3. Again, despite the fact that according to the IEA this figure should be shared equally among goals B, C, and F it was so low that it was assigned solely to goal F.

Table 14.4 illustrates environmental costs for all the six MNMR management goals. To conclude the cost analysis, the income statement costs have to be added to the environmental costs. The 2004 income statement was re-classified according to the LTFP model. In this way, the totals could be allocated to the MNMR management goals (Table 14.5).

Table 14.4 Environmental costs allocated to management goals €

Goals	Anthropic presence	Raw materials	Motor vehicle fuel	Heating fuel	Electricity	Water	Total
A			36				36
B			36				36
C	4,645		36				4,681
D			36				36
E	683		36				719
F		14	36	388	1	3	442
Costs	5,328	14	216	388	1	3	5,950

Table 14.5 Monetary costs allocated to management goals

Goals	Sums allocated €
A Protection and exploitation	10,680
B Promotion and dissemination	65,715
C Environmental education	214,166
D Scientific research	23,621
E Sustainable development	203,646
F One-off costs	81,853
G Overheads	219,526
Total amount allocated	819,207

Adding environmental and economic costs amounts to €825,157. It is now possible to obtain a figure for the net benefit in 2004 limited to flows from the bio-sphere to the techno-sphere and vice versa. By subtracting costs from benefits both monetary and environmental (the difference between the total in Table 14.3 and the sum of totals in Tables 14.4 and 14.5) we see that the MNMR produced an annual net benefit of €454,856.

14.4 Discussion

Considering the three limitations mentioned earlier (scale, physical measure of unit, and environmental costs) an accounting model was proposed that would 1) take into account how much the Reserve produced and 2) be capable of co-ordinating and amalgamating various instruments: LTFP (through the re-classification of costs and income), IEA (monetary valuation of environmental costs), and Costanza's model for eco-system valuation (monetary valuation of environmental benefits).

From a methodological perspective the model takes a few steps forward in the accounting framework. Firstly, by adapting macro to micro scale models it develops an approach that can be applied in all protected areas. This is of particular relevance because protected areas manage a specific kind of capital: natural capital. They should, therefore, account for not only economic but also conservation purposes. The integration of economic and environmental accounting is important because it measures the real effects of management actions—whether management is maintaining the core values for which the protected area was established.

Secondly, the model allows not only environmental costs but also environmental benefits to be assessed. The SEEA takes into account environmental expenditures considering three sorts of adjustments (depletion, defensive expenditures, and degradation) but it is do not include benefits. Analysing natural resources from the perspective of the eco-system function permits the integration at the micro-scale of the environment into the economic accounting system.

From an analytical perspective the environmental balance for the MNMR was positive to the sum of approximately €455,000. How can this result be interpreted? Generally speaking, it can be said that the Reserve's development model is in line with sustainability. If this were not so the balance would be negative. The Reserve's natural capital policies, therefore, fully achieve its objectives regarding sustainable development, protection, and exploitation. If we compare the net benefit figure of €455,000 with the financial analysis contained in the LFTP and with the €735,000 contributed by the Ministry of Environment and the Regional Council we can conclude that 62% of public funding is covered by the net benefits produced by the Reserve. It is as if public bodies contributed a net figure of approximately €280,000.

If we consider the three types of environmental functions distinguished as resource functions (providing goods and services to consumption and production processes), sink functions (receiving residues from consumption and production processes), and service functions (providing habitat for living species including humanity) the main benefit derives from resource function and in particular from recreation. It should be highlighted that the second group are sink functions. The MNMR is playing a relevant role in the nutrient cycling function.

From a policy perspective the model developed for the MNMR provides a framework for the management of both economic and environmental information and provides a consistent analysis of the contribution of the environment (bio-sphere) to the economy (techno-sphere) and of the impact of the economy on the environment. It is intended to meet the needs of policy-makers by providing indicators and descriptive statistics to monitor the interaction between the economy and the environment, as well as, serving as a tool for strategic planning and policy analysis to identify more sustainable development paths.

Finally, we consider that further research is necessary to investigate the difficulties (incomplete assessment procedures and insufficient data) connected with the implementation of the model.

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Chapter 15
Measurement and Recognition of Wildlife in the Financial Statements of Public Sector Entities: A South African Perspective

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Abstract Wildlife is an environmental asset. However, the concept of financial accounting for wildlife in financial statements is questioned and various arguments are used to not account for it. For example, fauna moves from place to place which complicates counting, the cost of counting wildlife is expensive, monitoring, measuring, and managing of accounting values does not add value, and parks manage wildlife for conservation purposes not to generate profits.

The focus of the international accounting standards is shifting more and more towards fair-value accounting. Fair-value accounting relies on one of the main principles of accounting, namely, estimation which involves judgments based on the latest available, reliable information. The same degree of estimation must be exercised to account for wildlife, and uncertainties such as wildlife numbers and values are recognised by the disclosure of their nature and extent and by exercising prudence in the preparation of financial statements.

Financial statements are prepared on an annual basis to indicate the financial position of an entity and to hold management accountable. Meaningful financial accountability requires timely, understandable, reliable and relevant information. This information is ultimately used by management to report to the shareholders or government on the deployment of funds and resources entrusted to them.

Transparent financial reporting is a prerequisite for a well-functioning market economy and financial accountability is an indispensable management tool that provides essential information for the effective monitoring and controlling of

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resources. Managing and safeguarding wildlife forms part of this financial accountability.

The absence of financial accounting of wildlife in the financial statements potentially contributes to a deficiency with respect to the availability and usage of management accounting information on wildlife numbers. The theme of this study is that the quality and usage of management accounting information will only be improved and ultimately used for decision-making if the financial accounting is implemented and audited. Complete and accurate management accounting information will allow environmentalists and accountants to evaluate the effect of changes such as drought, diseases, and poaching of animals and the data can further be used to calculate grazing and carrying capacity.

15.1 Introduction

'Then there is a view that if we put a monetary value on wildlife it will lose its intrinsic value. We should protect wildlife for its intrinsic value alone, because this is morally correct' (Davidson 2005:123).

Over the past two decades the concept of sustainable development gained in acceptance and understanding to the point where it is now a major consideration in government planning and policy-making. Sustainable development reconciles three areas of human activity, namely society, economy and environment. Sustainable development does not treat the environment as an inviolable absolute. Instead, it recognises that there should be a balance between economic and social progress and the environment. Economic development or social progress should not destroy the environment or prevent future generations from using the same resources for their development or enjoyment (Sustainable development: The role of Supreme Audit Institutions). As Gray (2002:373) put it, sustainability involves the needs of both present and future generations and consideration of environmental and social justice.

In South Africa, sustainability can be seen to focus on those non-financial aspects of corporate practices that influence the enterprise's ability to survive and prosper in the communities within which it operates. Further, this sustainability was adopted in a business context to mean the achievement of balanced and integrated economic, social, and environmental performance, now universally referred to as the 'triple-bottom-line' (King Report 2002:91). In the United Kingdom, the Turnbull report on codes of corporate governance ensures that for the first time reputational risk including how companies manage environmental, ethical, and social reputations is on the core agenda of corporate governance (Friedman and Miles 2001:523). As people became more aware of threats to the environment the responsibilities of industry and government to address these threats emerged. People's awareness added impetus to efforts by government and business to incorporate environmental concerns into their planning and policy-making activities (Sustainable development: The role of Supreme Audit Institutions).

The aim of conservation areas (parks) is to protect and ensure the sustainability of the environment. To achieve its purpose, in South Africa, a park must (South African National Parks 2002:8):

- Be of sufficient size to allow the long-term functioning of natural eco-systems and contribute to bio-diversity and ecological processes
- Provide scientific, recreational, and educational opportunities and incorporate the needs of local, national, and international communities
- Reduce occupation and exploitation incompatible with its main purpose

All these functions have financial implications and parks are, in most cases, dependent on government grants and donations for financial sustainability. Without this aid most of the parks will not be able to continue as a going-concern since income from tourism, retail income, concession fees, and the sale of fauna and flora is not always sufficient. The going-concern assumption is a fundamental principle in the preparation of financial statements. Under this assumption an entity is ordinarily viewed to be continuing in business for the foreseeable future with neither the intention nor the necessity of liquidation, ceasing trading, or seeking protection from creditors pursuant to laws or regulations (IAS 1, para. 23–24).

Transparent financial reporting is a prerequisite for a well-functioning market economy and financial accountability is an indispensable management tool providing essential information for the effective monitoring and controlling of resources. Financial accountability is strengthened through independently audited financial statements (*UNDP Partnerships*).

To achieve financial accountability it is necessary to implement effective, efficient, and transparent systems of financial and risk management and internal control. Gray et al., (1996:4) define accountability as ‘the duty to provide an account (by no means necessarily a financial account) or reckoning for those actions for which one is held responsible. The first of the responsibilities is to undertake a certain action whilst the second is to provide an account of those actions. Holland and Foo (2003:4) consider accountability key to increasing transparency which in turn socially reconstructs the corporation and influences behaviour within the corporation and stakeholders due to disclosure and increases in congruence of interest between all parties thence lessening conflict. Risk management and internal controls consist of all the policies and procedures adopted and implemented by management to assist in achieving its objective of ensuring the efficient conduct of business and financial accountability. This includes the safeguarding of assets, prevention and detection of fraud and error, accuracy and completeness of the accounting records, and timely preparation of reliable financial information (SAAS 400, para. 5).

There exists, however, a potential mismatch between accounting information and its application to ecological issues (Maunders and Burritt 1991:11), specifically, the consistency of concept due to lack of continuity in the method of measurement and the variability around the measurement. They further intimate that a certain conditioning can take place where populations and values are believed true in terms of both accountability and decision support when this is in fact false. This dilemma has confronted wildlife managers for decades and has manifested in a shift from neo-classical views in management to so-called adaptive management.

The safeguarding of assets forms part of financial accountability. However, in the past, wildlife, which is generally regarded as an asset has not been measured and recognised (accounted for) in the financial statements.

Environmentalists and accountants have used various arguments not to account for wildlife, for example:

- Fauna moves around which complicates counting
- Counting wildlife is expensive
- The scope of species to be included or excluded
- The accounting value does not add value
- Parks manage wildlife for conservation purposes and not to generate profits

However, a lack of financial accounting also possibly contributed to a lack of management accounting information. This, then, poses some questions regarding financial accounting for wildlife. For example:

- Is wildlife an asset?
- Is accounting for wildlife required by the International Accounting Standards (IAS) or are there legislative aspects to be complied with?
- Are accurate counting techniques available and can fair values be determined?

This study addresses the current reality with respect to financial accounting for wildlife by government entities in South Africa, as well as, the issues listed above.

A current International debate is ongoing regarding the reorganisation of accounting based on the perception that accounting practice has contributed to the global environmental crisis (Wildavsky 1994:469). Gray (1992:399) proposed the inclusion of so-called critical natural capital in accounting—assumed to be non-renewable resources. Animals themselves, in the context of this study, are most certainly a renewable resource with financial value. He considers critical natural capital as irreplaceable whilst managed natural capital, such as wildlife habitats, may have human intervention for commerce or conservation.

In South Africa, wildlife in the form of wild ungulates have an inflated monetary value due to the number of private landowners and corporations that actually control wild animals. These animals change hands and underpin the eco-tourist industry. The gambit of this study focuses on the accounting requirement of public-sector wildlife undertakings to account for these animals as financial value as opposed to environmental auditing governed by a different set of legislation in South Africa. Via this requirement, these animals have entered the fabric of the economic systems.

Industry-led initiatives such as ISO 14000 series, although voluntary, require companies to increasingly attend to environmental issues.

15.2 Current Status–Accounting for Wildlife by Government Entities

15.2.1 Accounting for Wildlife

The annual reports and financial statements of six public-sector entities that own or manage wildlife or parks were reviewed to determine if they measure and recognise wildlife as an asset. The six were City of Tshwane, Department of Defence, Eastern Cape Tourism Board, Limpopo Tourism & Parks Board, North-West Parks & Tourism Board, and South African National Parks (SANParks).

Only two, the Eastern Cape Tourism Board, and North-West Parks & Tourism Board accounted for wildlife although different classifications were used. The Eastern Cape Tourism Board disclosed wildlife as inventory to the value of 21 million Rand while the North-West Parks & Tourism Board disclosed it as a non-current asset to the value of 110 million Rand.

SANParks included information on census conducted at the different parks but did not attach a value. All the entities, except the City of Tshwane, disclosed information in their annual reports relating to the management of the environment. This is an indication that to some degree the management accepts responsibility for properly managing the environment. In general, the information disclosed on wildlife numbers in the annual reports were insufficient and the perception was that the wildlife numbers were not used as management information.

Based on analysis it is evident that there is no consistent approach in measuring and recognising wildlife in the financial statements and as a lack of disclosure on management accounting information on wildlife numbers.

15.2.2 Income Generated

Of interest was the percentage of income generated by the Eastern Cape Tourism Board and North-West Parks & Tourism Board by means of wildlife, venison sales, and hunting income (Table 15.1).

Table 15.1 Breakdown of revenue—% of total income

Category	Eastern Cape Tourism (%)	North-West Parks (%)
Government grants	70	44
Wildlife, venison sales, hunting income	16	23
Other income	11	4
Accommodation, catering, tours	3	29
Total	100	100

In both cases government grants accounted for the highest proportion of the income while income from wildlife sales, venison sales, and hunting accounted for 16% and 23% respectively. This indicates that these entities are, to a large extent, dependent on the government grant for financial sustainability but also that revenue generated by means of hunting and selling wildlife contributed a significant portion of total income.

15.3 Financial and Environmental Legislation and its Impact on Managing Environmental Assets

Legislation governs all government entities in South Africa which means that an entity derives its mandate from one or more acts. For the purpose of this study, legislation relating to environmental matters was identified and reviewed to determine whether wildlife is recognised as a resource and if ‘conservation’, ‘natural resources’, ‘environmental resources’, ‘wildlife’, ‘animals’ or similar terminology is used.

Acts were grouped into two areas, general and environmental legislation.

15.3.1 General

- The Constitution of South Africa, 1996 (Act No. 108 of 1996) (Constitution)
- The Public Finance Management Act, 1999 (Act No. 1 of 1999) (PFMA)

Section 24 of the Constitution specifically states that everyone has the right to have the environment protected through reasonable legislative and other measures that secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The PFMA governs all financial aspects. The term ‘natural resources’ is not used in the PFMA but reference is made to ‘asset’. The term ‘asset’ is not defined in the PFMA but paragraph 49(a) of the Framework for the Preparation and Presentation of Financial Statements defines an asset as ‘a resource controlled by an enterprise as a result of past events and from which future economic benefits are expected to flow to the enterprise’. The Oxford Dictionary defines a resource as ‘a stock or supply of materials or assets’. From this explanation it is concluded that natural resources are included in the definition of an asset.

Various sources, including the PFMA and SAAS 400, prescribe the implementation of risk management policies and internal control to safeguard assets. Thus, it is, evident that natural resources should be appropriately managed and protected. This includes adherence to the financial management aspects which will ensure financial accountability.

15.3.2 Environmental Legislation

- National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA)
- Environment Conservation Act, 1989 (Act No. 73 of 1989) (ECA)
- National Parks Act, 1976 (Act No. 57 of 1976) (NPA)

NEMA's objective is to provide for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment; to provide for the prohibition, restriction, or control of activities likely to have a detrimental effect on the environment; and, to provide for matters connected therewith. NEMA defines the environment as the surroundings within which humans exist and are made of the land, water, and atmosphere of the earth, micro-organisms, plants and animal life, and any part, or combination thereof, and the interrelationships among and between them.

The ECA allows a competent authority, by notice in the Official Gazette concerned, to declare any area a protected natural environment provided such protected natural environment will substantially promote the preservation of specific ecological processes, natural systems, natural beauty, or species in indigenous wildlife, or the preservation of biotic diversity in general.

According to the NPA, the objective of the constitution of a park is the establishment, preservation, and study of, wild animals in such a manner that the area which constitutes the park shall be retained in its natural state.

The link between the terminology used in the ECA, the NEMA, and the NPA is very important. The ECA gives a competent authority, subject to certain conditions, the discretion to declare an area as a protected natural environment. This clearly links to section 24 of the Constitution that says that everyone in South Africa has the right to have the environment protected. However, the ECA does specifically link the protection of the natural environment to the preservation of species in indigenous wildlife which is again a direct indication that the legislature regards wildlife to be part of natural resources. The principle is supported by the objective of the NPA which indicates that the objective of a park is the establishment, preservation, and study of wild animals.

It was proved that the legislature, through different pieces of legislation, requires the conservation and sustainable use of natural resources. Wildlife was also positively linked to the terminology 'assets' and 'resources'. Since wildlife is recognised as a resource and controlled by the entity as a result of legislative requirements the objective of paragraph 3 is to determine whether wildlife meets the measurement and recognition criteria in terms of the IASs.

Furthermore, in the South African scenario a distinct possibility exists that the accounting requirements for wildlife will be extended from the public- to the private-sector at some stage. Both private individuals and the corporate-sector in South Africa manage vast tracts of land where wildlife is either a primary or secondary undertaking. Although a global consensus exists amongst authors that corporate environmental reporting is on the increase (Deegan 2002:763). His studies further show that the initial period of increase in environmental reporting was followed by a decrease more evident in mining than in other top-100 sectors. They (De Villiers and van Staden 2006) further implicate political situations in exacerbating these last mentioned phenomena in developing countries. Organisational legitimacy theory predicts that the corporate sector will undertake what is necessary to preserve the image of legitimate business (De Villiers and van Staden 2006). Environmental reporting is on the increase under the banner of 'information as a major element in organisations to manage the stakeholder to gain support and approval' (Gray et al. 1996:45). This is particularly prevalent in South Africa due to the large foreign stake-holding in the abstractive industry and eco-tourism. This is borne out by Gray et al., (1996).

Historically the drive for counting wildlife in public sector undertakings in South Africa came from biologists and managers who required this information as part of management decision support. However, the legal requirement for accounting from a financial perspective allows the accounting sector to become a primary driver in ecological matters. This paradigm shift has several potential consequences. Biologists and managers have continually been at odds with senior management in the allocation of financial resources for monitoring wildlife within the public sector (Harley 2006:2) and the allocation of these resources are now no longer up for debate. There has been resurgence in research into the efficiency and effectiveness of counting techniques in an effort to increase both accuracy and precision of the method. The paradigm shift has, however, not yet manifested in public sector entities as evidenced in this survey. Jones (1996:284) considers wildlife as neglected by accountants.

15.4 International Accounting Standards

15.4.1 General

Financial statements prepared in accordance with the International Accounting Standards prepared on the accrual basis of accounting. On the accrual basis of accounting, transactions are recorded in the accounting records and reported in the financial statements for the periods to which they relate. Financial statements show the results of management's stewardship and accountability for the resources entrusted to it and provide information about the financial position (balance sheet), performance (income statement) and changes in financial position of an entity relevant to a wide range of users in making economic decisions. The nature and materiality of the information affects relevance. In some cases, the nature of information alone is sufficient to determine relevance while information is material if its omission or misstatement could influence the economic decisions of users taken on the basis of the financial statements. The information in financial statements must be complete within the bounds of materiality and cost and an omission can cause information to be false or misleading and thus unreliable and deficient in terms of its relevance (*Framework for the Preparation and Presentation of Financial Statements*, paras. 24–46).

Recognition is the process of incorporating a monetary amount in the balance sheet or income statement for an item that meets the definition of an element and satisfies the criteria for recognition. An element should be recognised if the item has a cost or value that can be measured with reliability. As a result of the uncertainties inherent in business activities many items in financial statements cannot be measured with precision but can only be estimated (*Framework for the Preparation and Presentation of Financial Statements*, para. 82–86). Estimation involves judgements based on the latest available, reliable information for example:

- The use of mean selling prices for wildlife at recent wildlife auctions to determine the monetary value
- Adjustments to wildlife numbers obtained during a count

A practical problem that impacts on the recognition of wildlife is the measurement of actual numbers used. Information must be reliable to be useful and it is reliable when it is free from material error and bias and can be depended upon to represent faithfully that which it either purports to represent or could reasonably be expected to represent. Information may be relevant but so unreliable in nature or representation that its recognition may be potentially misleading. Such uncertainties are recognised by the disclosure of their nature and extent and by exercising prudence in the preparation of the financial statements. Prudence is the inclusion of a degree of caution in the exercise of the judgments needed in making the estimates required under conditions of uncertainty and this may include the calculation of wildlife numbers. However, the exercise of prudence does not allow, for example, the deliberate understatement of assets such as wildlife because the financial statements would not be neutral and, therefore, not have the quality of reliability. The IAS does, however, state that if a reasonable estimate cannot be made the item is not recognised in the balance sheet or income statement. Management could exclude specific species if these cannot be reasonably estimated. For example, leopards have a unique ability to camouflage themselves and move unhindered over manmade fences and could therefore be excluded (*Framework for the Preparation and Presentation of Financial Statements*, para. 24–46).

The IAS allows preparers of financial statements to include supplementary schedules and information with such statements. These schedules provide additional information not presented in the balance sheet, income statement, statement of changes in equity, or cash-flow statement but relevant to an understanding of any of them. Information relating to wildlife can, thus, be included in the schedules and this information can include aspects such as:

- Numbers counted
- Species included and excluded in the count
- Estimated fair values per species

Two key aspects in the preparation of financial statements are that users must be able to compare the financial statements of an entity over time to identify trends in its financial position and performance while comparing the financial statements of different entities. For example, if an entity discloses wildlife in a financial statements in year 1 it should continue to do so. Similarly, entities should disclose such data in a consistent manner to enable the comparison of the information between entities.

Social and environmental accounting (SEA) will never fulfil its potential if fitted within current accounting orthodoxy (Gray 2002:378). Accountants have the capacity to positively contribute to the ecological debate by reforming accounting and reporting systems to take account of environmental and social externalities (Bebbington and Gray 2001:557).

15.4.2 IAS 41: Agriculture

Various International Accounting Standards cover different types of assets. For the purpose of this study only IAS 41: Agriculture was reviewed. IAS 41 defines a biological asset as a living animal or plant but does not explicitly include or exclude wildlife from its scope. It also defines agricultural activity as 'the management by an entity of the biological transformation of biological assets for sale, into agricultural produce, or into additional biological assets.'

From the definition of agricultural activity arises the question to what extent the management activities performed by parks meet the criteria of the definition of agricultural activity.

- Parks do not manage the transformation of biological assets into assets for sale since income generated through selling animals is based on conservation management policies and does not form part of the normal operations of a park. Management of change includes the facilitation of biological transformation by enhancing, or at least stabilising, conditions necessary for the process to take place, for example, controls of nutrient levels, moisture, temperature, fertility, and light. These are usually absent in a park since human intervention is limited.
- Agricultural produce is the harvested product of the entity's biological assets and once again the objective of a park is not to harvest biological produce.
- The last criterion in the definition is the management of the biological transformation of biological assets into additional biological assets. One of the common and natural features that exist within living animals is to transform biologically as they procreate through a natural process. Biological transformation comprises the processes of growth, degeneration, production, and procreation that cause qualitative or quantitative changes in a biological asset.

It, therefore, appears that to determine whether wildlife falls within the definition of agricultural activity the only remaining aspect that can be analysed in the definition is the word ‘manage’. Management involvement in a park is limited to the extent that there is no intervention in the case of fire, flood, or droughts which are natural processes and animals that have a disease will not be treated unless a gene pool of a species is threatened. However, management of a park stems from a legislative requirement, to protect the environment for present and future generations, promote conservation, secure ecological sustainability (Constitution: section 24), and implement financial controls as required by the PFMA, and exercise its functions as required by the environmental legislation.

Given the limitation in the scope of IAS 41, where wildlife is not explicitly excluded, and, as a result of the legislative requirements, it is, therefore, concluded that wildlife forms part of the definition of agricultural activity, namely, the management exercised by an entity of the biological transformation of biological assets into additional assets. It is, however, proposed to amend the scope of IAS 41 to explicitly include wildlife.

IAS 41 has three other requirements that should be met before recognising wildlife:

- The entity controls the asset as a result of past events—control of a park entails the enactment of legislation, having legal ownership of wildlife, exercising access control, and other general controls in a park.
- It is probable that future economic benefits associated with the asset will flow to the entity—revenue is the gross in-flow of economic benefits during the period arising in the course of the ordinary activities of an entity. Receiving visitors to a park for its scenic beauty is one of the ordinary activities of a park resulting in an increase in revenue. Wildlife sold also increase future economic benefits.
- The fair-value or cost of the asset can be measured reliably if an active market exists for a biological asset and the quoted price in that market is the appropriate basis for determining the fair-value of that asset. If an entity has access to different active markets the entity uses the most relevant one. If an active market does not exist the entity can use the most recent market transaction prices or market prices for similar assets with adjustments to reflect differences as basis to determine the fair-value.

15.5 Counting Techniques Available to Measure Wildlife Numbers

One of the arguments against accounting for wildlife is the complexity and cost involved in counting wildlife and the perception that counting techniques are generally inaccurate. Herbohn (2005:519) alludes to the lack of appropriate measurement techniques constraining full-cost environmental accounting experimentation.

At issue in counting wildlife is accuracy or the relationship between the count result and the population number in reality and precision. The former is a holy grail which can never be attained whilst the second is of great value in showing population change over time and in estimating confidence limits around an estimate for audit purposes.

Each survey is an attempt to completely enumerate the population. Each survey produces a count of the population which is some fraction, hopefully large, of the population. In practice, individual counts differ for a variety of reasons due to systematic and random errors. The extent to which repeated counts differ can be stated in terms of the precision of a count. If precision is high then repeated counts will have similar values. Precision is most commonly stated in terms of a variance or standard deviation or may be scaled and presented in the form of a co-efficient of variation.

When repeated survey counts of a population are made these counts will vary as a result of a variety of factors. It is of interest to us to know on average how much variation we can expect in these counts. The usual way of stating this variation is in terms of its variance or its standard deviation. The standard deviation can be considered as a weighted average of the amount by which any individual observation deviates from the average of all observations.

In essence, the co-efficient of variation is the best minimum estimate of a technique's ability to show change over time. That is, a relative change shown that is larger than the co-efficient of variation is sure taken place, whilst a relative change less than the coefficient of variation may be a random event and not a real population change.

Irrespective of technique, precision can be calculated from repeated counts over a short period (replicates) or estimators calculated from sub-samples (distance sampling) or detection probabilities (maximum likelihood estimators).

Two of the objectives of wildlife management are to preserve and maintain wildlife populations and to monitor populations to determine the following (Haughey 2004):

- What species are present?
- How many animals are there?
- Is the population increasing or decreasing?
- How is the structure of the population changing?

These objectives can only be monitored by counting wildlife on a regular basis. For this purpose different counting techniques have been developed and tested over time.

15.5.1 Remote Sensing

Remote sensing is the acquirisition of information about the earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analysing, and applying that information. The process of remote sensing involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements are involved:

- Energy source or illumination: The first requirement for remote sensing is to have an energy source that illuminates or provides electromagnetic energy to the target of interest.
- Radiation and the atmosphere: As the energy travels from source to target it will come into contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from target to sensor.
- Interaction with the target: As the energy makes its way to the target through the atmosphere it interacts with the target depending on the properties of both target and radiation.
- Recording of energy by sensor: After energy is scattered by, or, emitted from the target it requires a sensor to collect and record the electromagnetic radiation.
- Transmission, reception, and processing: The energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data is processed into an image (hardcopy and/or digital).
- Interpretation and analysis: The processed image is interpreted, visually, digitally, or electronically to extract information about the target.
- Application: The final element of the remote sensing process is achieved when we apply the information extracted from the imagery to better understand it, reveal some new information, or assist in solving a particular problem.

Current applications of remote sensing include agriculture, forestry, geo-science, hydrology, land-cover, mapping, and marine (Canada Centre for Remote Sensing 2004).

With the current satellites available to South Africa a 620×620 mm image can be seen (pixel) but this will be brought down to 250×250 mm with the launch of another satellite. With the new improved version it will be possible to remove up to 30% of the grass and tree-cover making it possible to count animals that range in size from elephants to springbuck. Current research also focuses on writing computer programs, called pixel recognition software to identify the colour intensity of different species automate the counting process. The current cost with this technique is approximately R5/ha which is significantly (30%) cheaper than counting from the air or by foot (Gouws 2004).

One of the benefits of remote sensing is that it is not limited to a specific period, for example, winter months. Wildlife numbers can be determined on, or, close to year-end which will improve the accuracy of the measurement.

15.5.2 Commonly Used Counting Techniques

A number of other counting techniques are also available. These are divided into three groups.

Group 1: Drive counts, road-strip counts, and field-strip counts
Drive counts, road-strip counts and field-strip counts are techniques to determine a precise count rather than a complete count. These have are proven to be inaccurate. Since they are not based on calculating the completeness of the population their use would not suffice when preparing financial statements. This is especially the case in large parks. In a relatively small park or park with sparse vegetation, where it is possible to count all the animals, these techniques may be applied with relative accuracy and could be used as a counting technique (Bothma 2002).

Group 2: Aerial counts (helicopters, fixed-wing aircraft, and micro-lights)
The use of aircraft and particularly helicopters has grown consistently since the 1950s and today is almost universally applied in counting wildlife. It provides information on smaller properties in a short time and is less sensitive to habitat diversity and population sizes. In most bushveld applications visibility from the air is also generally better than from the ground (Bothma 2002). However, this method is often applied by inexperienced staff, unschooled in the underlying statistical principles involved, and the non-standardisation of approaches to counting wildlife lengthens the causal chain of poor precision (Reilly 2000:1).

Studies conducted by Van Hensbergen et al., (1996) and Peel and Bothma (1995) concluded that the aerial count underestimated the number of animals. Of the aerial counting techniques the helicopter counts provided the most accurate estimate followed by the micro-light counts. Fixed-wing aircraft were the least accurate of the aerial counts but did provide precise results.

Group 3: Known group or individual counts and ratio methods
When animals occur in fixed herds an indication of their number can be obtained by regularly recording the number and composition of every herd encountered. Animals with spotted or striped patterns or any other recognisable characteristics are unique with regard to their skin pattern. By regularly photographing these animals and building up a photographic register their population size can be estimated reasonably well over time. Moreover, by taking such photographs of young animals as soon as they have acquired their adult coat a record of the age of each individual can be kept that may be valuable in other age-related aspects of animal use and management (Bothma 2002).

Due to the meticulous recording that is needed to apply the known group or individual counts and ratio methods it is regarded as impractical in a park scenario. It could be applied with relative accuracy in a small park.

15.6 Determining Monetary Values for Wildlife

There are philosophical concerns in assigning monetary value to intrinsic environmental values (Herbohn 2005). The measurement comprises the monetary amounts at which the elements of the financial statements are to be recognised in the financial statements. A number of different measurement bases are employed to different degrees and in varying combinations in financial statements (*Framework for the Preparation and Presentation of Financial Statements*, para. 99–101). These include:

- Historical cost—the amount of cash or cash equivalents paid or the fair-value of the consideration given to acquire assets at the time of acquisition. Normally, parks do not buy wildlife and the historical cost will, therefore, not be a true reflection of the value of the wildlife
- Current cost (fair-value)—the amount of cash or cash equivalents that would have to be paid if the same or an equivalent asset was acquired currently
- Realisable (fair-value) values—the amount of cash or cash equivalents that could currently be obtained by selling the asset in an orderly disposal
- Present value—the present discounted value of the future net cash inflows that the item is expected to generate in the normal course of business. This requires complex calculations and estimates to determine possible future net cash inflows and is not feasible in the measurement and recognition of wildlife owned and managed by parks.

IAS 41 defines agricultural activity as 'the management by an enterprise of the biological transformation of biological assets for sale into agricultural produce or into additional biological assets' (IASC 2001:11). To measure the monetary amount two conditions must be present, namely, an active market has to exist and a fair-value should be calculable. This opposed to the so-called non-market value of environmental resources (Milne 1991:82). IAS 41 defines an active market and fair-value as follows:

An active market is a market where the following conditions exist:

- The items traded within the market are homogeneous
- Willing buyers and sellers can normally be found at any time
- Prices are available to the public

Fair-value is the amount for which an asset could be exchanged between knowledgeable and willing parties in an arm's length transaction. The fair-value is based on its present location and condition. If an active market exist the quoted price in that market is the appropriate basis for determining the fair-value. If an entity has access to different active markets the entity uses the most relevant one.

Elad (2004:634) warns that the inclusion of unrealised gains and losses arising from the measurement of biological assets at fair-value and included in the income statement as proposed in IAS 41 and the Australian AASB 1037 'self generating and regenerating assets' are contentious.

In the South African monthly magazine *Game and Hunt* the results of the previous month's auctions held were published. By analysing the information over a 6-month period (June 2004 to November 2004) market-related prices for 30 commonly found species and another 24 sub-species were determined. The market-related prices were based on the number of animals sold and the auction prices. The analysis included 16,440 animals and the total auction value was 77.4 million rand.

From the analysis it was possible to prove:

- The items traded within the market are homogeneous since similar animal species were sold together, usually in a herd. It was possibly to calculate the mean price for a specific species
- Willing buyers and sellers can be found at any time at these auctions
- Prices are available to the public since these are published in the Game and Hunt magazine

15.7 Conclusion

This study indicated a number of aspects:

- Government entities do not measure and recognise wildlife consistently and this makes the comparison of financial statements between entities impossible
- The South African legislature places an important focus on the sustainable development and use and safeguarding of natural resources
- IAS 41 is vague with respect to wildlife. However, normal accounting principles should apply since wildlife represents a resource from which future economic benefits are expected to flow to the entity
- Various counting techniques are available and the latest research focuses intensively on remote sensing
- Fair-value prices can be determined based on auctions held and these data is easy to obtain and relatively indicative of market value

One of the main principles of accounting is estimation. Estimation involves judgements based on the latest available, reliable information, for example:

- The use of mean selling prices for wildlife at recent wildlife auctions to determine the monetary value
- Estimation of wildlife numbers and adjustments made to wildlife numbers obtained during a count, based on other indicators. Uncertainties, such as wildlife numbers are recognised by the disclosure of their nature and extent and by exercising prudence in the preparation of the financial statements

Accounting for wildlife will create other benefits to the preparers and users of the financial statements including detailed analysis of the changes in animal numbers.

This will provide an additional mechanism to evaluate the impact of environmental changes, for example, the impact of droughts and outbreak of diseases or poaching of animals. Additionally, the motivation for monitoring becomes the drive of the auditor in public-sector entities the internal auditors as opposed to the traditional decision support requirement of the wildlife biologist/manager.

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Chapter 16
Environmental Management Accounting and Environmental Accountability Within Universities: Current Practice and Future Potential

Huei-Chun Chang and Craig Deegan

Abstract The role of management accounting in improving both environmental and financial performance through enhanced accountability is attracting increased recognition. However, universities have typically failed to be the focus of attention, generally, because of a mistaken belief that they generate only insignificant environmental impacts. A case-study of an Australian university demonstrates that there is a general lack of consideration given to the management of environmental costs and related cost-savings, due partly to a perceived lack of appreciation by senior management of the extent of environmental costs being incurred. Further, in the absence of relevant environmental cost information, although environmental sustainability itself is promoted as important, efforts to improve internal environmental accountability from an accounting perspective are lacking. In this study, interviews were conducted to identify barriers which affect the adoption of EMA. The results show that perceived institutional pressures and a low profile of accounting for the environment, and management's attitudes influence the adoption of EMA within universities.

16.1 Introduction

Environmental sustainability has received increasing attention within universities. To date, different environmental management approaches have been undertaken to achieve the goal. However, there is a general lack of consideration given to environmental cost management and related cost-savings within universities. Environmental cost information, if available, tends to be aggregated and a detailed breakdown is sometimes problematic. If relevant environmental costs were unknown

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few actions would be taken and only limited environmental accountability could be discharged.

This study was intended to address the issue from a management accounting perspective. A case study research strategy was taken because service-based organisations in general and universities in particular have typically failed to be the focus of EMA-related studies. Further, the influences of institutional or internal organisational factors on the adoption of EMA have not yet been examined within a university setting and hence are not yet understood. The study is, therefore, both exploratory and descriptive in nature. The purpose is twofold—to understand management accounting for major environmental costs, and, to identify the factors which influence the adoption of EMA within universities.

16.2 Prior Literature

It is argued that conventional accounting, as practiced in most organisations, tends to ignore the extent of environmental costs incurred, and, therefore, does not provide a useful basis for demonstrating accountability for using natural resources which have environmental implications (Deegan 2005). Hence, there have been calls by individuals and governments for organisations to apply some form of environmental accounting which explicitly takes environmental costs into account.

Accountability is defined as "the ability to provide an account of its activities both as an explicit record of them and as an acceptance of responsibility for them" (Gonella et al. 1998:86). Gray et al., (1996:38) explain that the account provided is "by no means necessarily a financial account". Hence, a broadened scope of accountability is required that makes financial and non-financial information, to available internal and external stakeholders. Environmental accountability represents one dimension of accountability which calls for an organisation to take responsibility for environmental management, provide an account of actions taken, and implement enforcement mechanisms to ensure that people are held accountable for actions taken and consequences that follow.

Different environmental management approaches have been adopted as environmental accountability attracts increasing attention within universities especially in North America, Europe and Australasia. For example, a number of universities have embarked on initiatives to increase energy efficiency and reduce wastes (e.g. Bekessy et al. 2002; Forum for the Future 2004; NWF 2004; Uhl and Anderson 2001), conducted environmental audits (e.g. Creighton 1998; Delakowitz and Hoffmann 2000; Uhl et al. 1996), provided sustainability reporting (e.g. HEEPI 2007; Towns and Cocklin 2006), and gone all the way to ISO14001 certification (e.g. Arvidsson 2004; Oelreich 2004; Simkins and Nolan 2004). Guides and best-practices are currently available and documented (for examples, see C2E2 2003; EAUC 2007).

Various environmental management initiatives are undertaken but a gap seems to exist between the commitment and the outcome. It is argued that at universities in both North America and Europe most of the environmental initiatives undertaken are patchy and strategic planning for environmental management is still lacking (Dahle and Neumayer 2001; Herremans and Allwright 2000). A survey conducted by Carpenter and Meehan (2002:19) also points out that "environmental management cannot be considered a mainstream business activity" within Australian universities. Environmental management has found its way into universities as an approach towards sustainability but progress to move universities along the continuum of sustainability seems slow.

Studies show that the majority of university staff who are deeply involved with environmental sustainability issues are from either the natural sciences or environmental engineering disciplines (Filho and Carpenter 2006). Accounting is a less obvious place to start if a university is seeking to move forward along the continuum of sustainability so enforcement mechanisms such as accounting and auditing procedures are less evident. Gray and Bebbington (2001:13) argue that "without a 'greener accounting' many environmental initiatives will simply not get off the ground." Unfortunately, the potential contributions that accounting can make have not gained much attention and accountants are not as widely involved in the environmental agenda as they could and should be within universities.

16.3 Research Method

A case-study was conducted on RMIT University in Australia. The University has a long history of commitments to environmental sustainability and efforts have been undertaken to incorporate environmental education into University curricula, put energy-efficient environmental programs into place, and provide environmental information (e.g. energy usages) in its annual report. In terms of efforts undertaken by Australian universities (see Filho and Carpenter 2006), RMIT University is one of the leaders. Nevertheless, like many service-based organisations there is a general lack of appreciation of the benefits that EMA could provide in terms of reducing consumption and improving financial performance. It is hoped that this case-study can serve as an example to uncover current management accounting practice for managing environmental costs (if any) and to provide suggestions and explore what could prevent the University from adopting EMA as a natural extension of its current environmental and reporting initiatives.

A case-study protocol was developed before collecting data. Related information was collected from the available resources such as the annual reports and strategic plans. The University has a sustainability committee which oversees and coordinates the implementation and further development of its environmental and sustainability policies, projects, and external commitments. By attending the committee meetings reviews of related background documents and records were conducted.

A major source of data was through face-to-face interviews and all key members from whom interviews were requested agreed to participate. Ten interviews were carried out—five with directors/managers who are directly involved in either environmental management or management accounting, one with the Head of an academic school, and four with the Vice-Chancellor's (VC's) executive members. Two of the ten participants asked to remain anonymous but the others agreed to their names and identities being disclosed. A list of participants and interview information is shown in the appendix (p. 382). For the purposes of the quotations provided below the ten participants were labelled alphabetically (A to J) so responses could be distinguished.

Interview times varied from 50 minutes to 1½ hours and were open-ended in nature. A plain language statement which detailed the research purpose, interview themes, and definitions of key terms such as 'environmental cost' and 'EMA' was developed and passed to the participants before the interviews. The information gathered was also used as the basis for further inquiry as further sources of evidence emerged through the interviews.

16.3.1 Scope of the Study

To make the case-study manageable it was necessary to limit the scope of EMA which was to be considered and the extent of the environmental costs to be examined. Available case-studies demonstrate that EMA can, depending upon the accounting system in use or being implemented, provide a broad range of information about financial and non-financial aspects of an organisation's environmental performance (Deegan 2003). Thus, the study adopted an EMA approach that emphasises a balance between financial (monetary) and non-financial (physical) information and an internal management decision support perspective.

The environmental costs examined were restricted to costs related to the use of energy (electricity, gas, and fuel), water, and paper, as well as the generation of solid wastes (general wastes and waste paper). This study did not take into account environmental impacts and costs external to universities (environmental externalities) since using the dichotomy provided in USEPA (1995) only private costs were considered.

Determining the environmental impacts is obviously judgmental but consumption of the above resources and wastes generated were considered to be responsible for the University's major environmental impacts and this would also be common for most other service-based organisations too. This commonality is reflected in the case-studies on AMP Ltd and Methodist Ladies College (Perth) by Deegan (2003). The case-study, therefore, focused particularly on these costs, as well as, on waste management and these were referred to as the major environmental costs for the purpose of this study.

16.3.2 Interview Themes

The interview data were broken into themes. Some were concerned with aspects of management and accounting for major environmental costs and others with the views of key players in that process. These themes are:

- Identification of major environmental impacts and associated environmental costs
- Management and accounting for the major environmental costs identified
- Environmental responsibility and accountability
- Institutional pressures on management accounting for environmental costs
- Perceived benefits and costs of management accounting for environmental costs
- Attitudes to and views on adopting EMA practices

16.4 Description of RMIT University

In 2005 RMIT University was one of the largest universities in Australia with over 57,000 students enrolled and over 3,300 employees. It has major campuses in the Melbourne central business district and regional Victoria.

Having strong commitments to environmental sustainability the University committed to an Environmental Policy in 1994. Since then it has become a signatory to various international environmental commitments such as the Talloires Declaration and the United Nations Global Compact and participated in various national agreements such as Waste Wise Organisation and Greenhouse Challenge Agreement. However, as indicated in the University's 2003 annual report, implementing the commitments was progressing slowly and the University was undertaking actions and adjusting strategies to accelerate its progress.

16.5 Main Results and Discussion

The case-study focused on understanding RMIT's current accounting practice for managing environmental costs and barriers to the University taking on some form of EMA. The results show that the potential use of EMA is neglected and, as such, EMA implementation is not considered a priority. A lack of information on environmental costs also reduces the opportunity to improve environmental accountability which is important in driving behaviour change. As one participant said:

> Without active cultural change agents working within the organisation, people become complacent. They're just blasé about how they treat the facilities and power consumption…. At the end of the day, people have to be responsible for themselves…. If people were aware of all to start off with, the lights wouldn't be left on in the first place. It's something that management really can't control. It's a culture change issue. It's an individual discipline issue (F: General Manager/Facilities Services).

The following discussion comprises three sections: RMIT's current accounting practice, the potential future for applying EMA, and roadblocks on the way towards this potential future.

16.5.1 Current Practice

The major environmental costs were examined to determine how they were managed and treated in the accounting system. Their absolute amount (if available) and relative scale are also discussed.

16.5.1.1 Accounting for Major Environmental Costs

RMIT uses a standard accounting package for the purposes of both financial accounting and management accounting. A review and analysis of the accounting system (general ledger) and processes indicated the following:

- The general ledger allows for the automatic generation of total costs for electricity, gas, fuel, water but uses a combined ‘stationery and printing’ account for paper cost and a ‘service contract’ account to include costs incurred on service contracts that support facilities management and which include costs for waste collection and disposal
- For those environmental costs captured within the accounting system only financial information is provided. Non-financial information on the type or quantity of goods or services procured (e.g. electricity and paper) is not currently available within the system
- Operating costs including electricity, gas, fuel, water, and waste removal are combined as part of the ‘facility expenses’ overhead for the whole University. RMIT once charged this overhead back to schools on the basis of floor space occupied but no longer does this
- Consistent with many organisations “waste costs” are recognised as including only the costs incurred in having waste removed from the organisation. Waste costs are therefore understated (and therefore largely unaccounted for) because there is no explicit consideration given to the costs of bought-in resources that end up in waste
- RMIT pays invoices for paper ordered by schools. Costs for paper purchases are accumulated in a ‘consumable materials’ account and allocated to schools

The current treatment of major environmental costs in RMIT’s accounting system (general ledger) is shown in Fig. 16.1.

16.5.1.2 Lack of Links between Systems for Collecting Financial and Non-Financial Data

The University has no link between the systems for collecting financial and non-financial data. The facilities manager of Property Services monitors and records the usages of energy and water for the whole University but the usage data collected are not captured by or included in the accounting system.

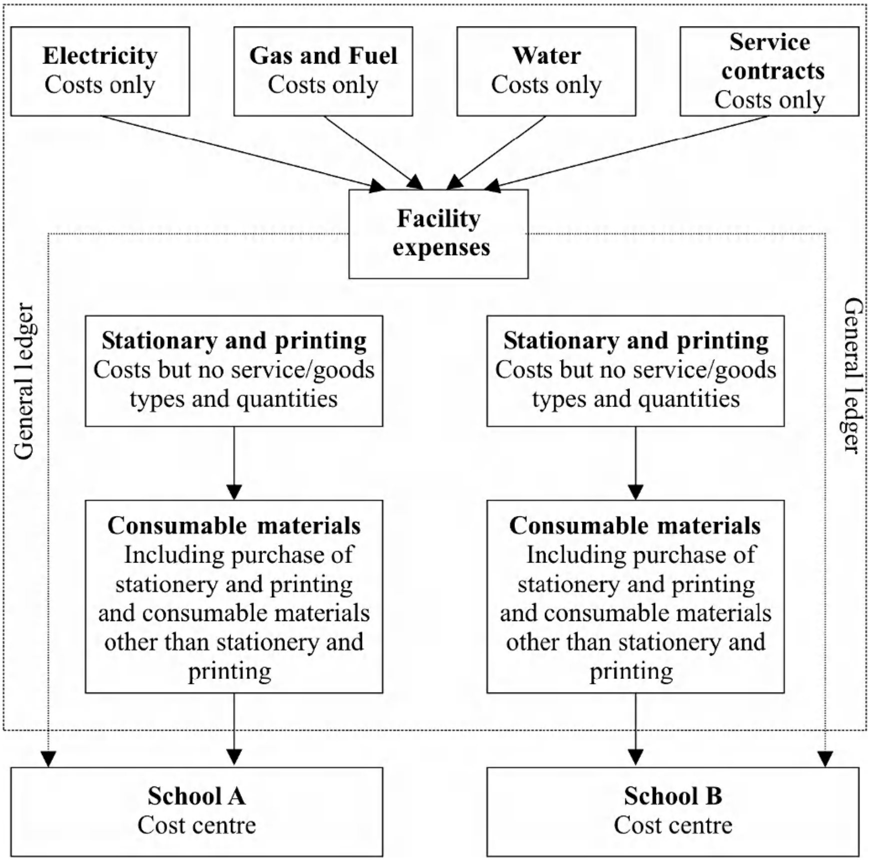

Fig. 16.1 Current treatment of major environmental costs in RMIT's accounting system (general ledger)

As a member of the Australasian Tertiary Education Facilities Management Association (TEFMA) the University must report facilities management-related information (including environmental costs) to the Association each year for benchmarking purposes. The facilities manager is the person who compiles the required environmental information reported. When asked whether there should be a link between the systems for collecting financial and non-financial data and whether accountants could be involved in helping to analyse such information the manager doubted whether accountants are interested:

> I would think that would be valuable, because right now we spend a lot of time with our benchmarking data. We look at the global picture for our particular area of the facilities. I don't think our finance people look at these. They're bottom-line people (F: General Manager/Facilities Services).

16.5.1.3 Management of Major Environmental Costs

A monthly management report was produced by RMIT's Financial Services for reviewing current operations and assessing performance against the budget. The major environmental costs for the University (electricity, paper, water and waste management) are obscured within the accounts, for example, by being included in aggregated accounts titled 'consumable materials' and 'facility expenses'. At the present time there was no further classification or analysis and no form of responsibility-centred budgeting for these aggregated costs. Consider the following statement:

> For the academic areas, they will receive overhead cost for Financial Services and for Property Services…. So they will be able to see, 'Ok, Property Services, it's costing us X.' But it didn't really go down to the level of all the electricity (electricity costing you such and such amount)…. From that perspective, our Property Services, a little bit selfish, have all those electricity costs in their budget. It's up to them to manage, not really up to us (G: Senior Accountant/Property Services).

The main reason for this was that there had been no prior focus on the need for environmental costs information. As one interviewee stated:

> No one has ever come to me and said: 'Tell me the environmental cost of what we do.' So the chart of accounts is not set up to record anything that way…. It's one thing that we've never been requested for, even though it's not a new concept. We've never been requested to provide specific information about it. From what I see, not that I see everything, it maintains a low profile (I: Associate Director/Budget & Financial Performance Management).

Except for the Vice-President of Resources senior management across the University would not know the extent of environmental costs—however, it was not clear that the senior management would actually monitor such information. When asked if environmental costs information could be separately identified and reported the associate director responsible for preparing the monthly management reports said:

> Also we've different accounts. So we think: 'Ok, how can we capture costs properly?' You know, at the end of the day, what are management interested in? They're interested in how much we spend on travel and how much we spend on consumables. So would they ask how much we spend on the environment (environmental cost)? … They never have, or it hasn't come through to me…. They may discuss it at different forums. But it would be very hard to measure. I wouldn't even try to do a chart of accounts. I wouldn't expect to cost it in a ledger, nor then will I be able to give a report to someone, and say: "Here it is exactly and here's an idea of it"…. I don't think we're there (I: Associate Director/Budget & Financial Performance Management).

This has consequently tended to hide various environmental costs, obstruct the management of environmental performance, and reduce further the chances of uncovering potential cost-saving opportunities.

16.5.1.4 Scale of Major Environmental Costs

The study acknowledged that the major environmental costs identified are relatively low compared to other costs incurred by RMIT. For example, energy and water is about 2% of total operating expenditure. However, it is one of the largest items of controllable cost (HEEPI 2005). Further, the actual quantities of resources involved and their associated cost in dollars are quite significant e.g. RMIT spends over AU$6,000,000 a year on energy and water.

Costs for waste collection and disposal, as well as, for paper purchases are not separately identified. Rather, they are included in 'service contracts' and 'stationery & printing' which explain 1% and 1.6% of total operating expenditure respectively.

Unfortunately, as costs tend to be considered on the basis of their relative size the costs relating to the above-mentioned environmental aspects do not attract much attention, in particular, from senior management. Perhaps more attention should be directed at their absolute amount especially in the wider context of growing community concern for universities to minimise environmental impacts and the adverse impacts on reputation and image that not doing so might create.

16.5.1.5 Limited Environmental Accountability

Despite its mission to make a significant contribution to sustainability through teaching and research the University failed to pay much attention to sustainable consumption of resources such as energy or to changing consumption behaviour. That is, it did not appear to practice what it preached. As the senior accountant said:

> I think one of the problems we've got, in terms of facilities type of stuff, is that the University is a teaching organisation and most of the focus goes on teaching students, student welfare, and all that stuff…. Accounting is not our major focus. At the end of the day, most of the things that are discussed are really around the students, the student issues, and education itself. And this sort of issue is secondary. (G: Senior Accountant/Property Services).

Although the focus of universities is on education, they still have to be financially sustainable and are directly accountable to government for their financial performance. From an environmental cost control perspective whether universities are operating in an environmentally sustainable way or people within universities are behaving in an environmentally responsible way should not be a secondary issue. Accountability leads to better performance (Adams 2002) but the University's practice did not mirror an attempt to make people accountable for their environmental performance. The study found that no Heads of academic schools or Deans had any form of environmental targets or budgets imposed within their work plans. As one interviewee said:

> If they had their own budget and their own measures [tied to particular attributes of environmental performance], then they would monitor and control that regularly. It's the nature of the way people are. If they are not being held accountable for it, then they are not really going to worry about it. They might turn the lights off or reduce our energy usage. But they are not really focusing on that. (G: Senior Accountant/Property Services).

At this stage, environmental costs do not seem to be what management is interested in. As the facilities manager said:

> They may believe that they're working at it [environmental responsibility]. But I can tell you that they haven't phoned me up and asked me for what their electricity bill was…. I

> mean, if they knew what that was, they'd get a pretty good idea what it costs the University to make that facility available to them… (F: General Manager/Facilities Services).

Perhaps, due to this limited environmental accountability management seems uninterested in environmental cost control and the savings that could be made, which in turn, has direct implications for the demand to put EMA in place. As one interviewee explained:

> No, it's not their main focus…. It's not monitored, and is not one of their key accountabilities…. But they're not really held accountable for environmental usage. So if that's not in there as one of their key accountabilities, then it's not going to be front of mind in their reactions…. It's not their sort of key focus at the moment (G: Senior Accountant/Property Services).

16.5.2 Future Potential

RMIT's practices were not surprising and were common to most service-based organisations (e.g. Deegan 2003). Fortunately, guides and best practices, although limited in service-based organisations, were available. RMIT had the potential to change its practices.

16.5.2.1 Restructure the Accounting System (General Ledger)

It was identified that one of the key opportunities to link up financial and non-financial information would involve making some changes to the accounting system. An additional field of a non-financial nature could be introduced into the accounting system coding for quantitative information related to the purchase of goods and services such as energy, water, paper and waste management. This information can be used to supplement financial information in dollar terms. It would be particularly useful where costs for goods or services purchased did not directly correlate with quantities used or where they differed between buildings. For example,

> The energy audit that we did last year with the chemical engineering students from Bundoora on Building 223, which is that big line of aged building, that uses in excess of $1,000 electricity per day, a lot of money. I mean your Building 108 uses about the same amount of power as one that runs about 5,000 students. This runs a couple of hundred students (F: General Manager/Facilities Services).

This suggested initiative would enable RMIT to monitor non-financial information on resources used especially electricity and paper. Electricity represents RMIT's highest environmental cost and was separately identified. Paper was recommended partly because universities are big paper consumers generally and as RIMT has a single preferred supplier it is highly possible that a separate ordering and billing system could be set up. Given RMIT's purchasing power the supplier should also be willing to break down invoices into a format that it requests. Water has a lower priority because of its relatively lower cost. Waste management was also an area worth trialing. RMIT conducted an green office project that included waste audits on major buildings. Efforts from the audits for better information will pay off if a robust management mechanism in ensures the information is effectively used. For example:

> You say it's important, but then you think: "Well, what else should we then be doing?" I mean, to what extent are we measuring water cost and energy cost? … What's actually more important is what you then do with that information, which you actually use for management purposes, which I think is an issue for RMIT (A: Pro Vice-Chancellor Business).

The better-informed accounting system would also enable comparisons between buildings or schools and help to identify where the greatest opportunities for costs and environmental savings lie. It could also be a starting point for benchmarking and performance improvement. An immediate benefit to RMIT in general, and Property Services in particular, is that it could be used as an input into environmental reporting such as the TEFMA report if this non-financial information could be generated automatically. The general manager responsible for preparing the report said:

> I think it would help particularly when they see the comparisons and when they think that the place is costing too much…. That would certainly aid in the debate…. It may not gain us more money but we might not suffer a loss (F: General Manager/Facilities Services).

The business advisory manager responded by saying:

> If the organisation was passionate about this, they could design a process so the information was collected as the invoice came to hand…. If we need to report upon it, you can either report upon it as an ad-hoc process or design it as part of an ongoing process. As an ongoing, it's more efficient than ad-hoc (H: Associate Director/Business Advisory).

He also noted that:

> It would be possible to augment the accounting system to have notional general ledger, so non-values. I've got my invoice from AGL. I would input kilo-watt/hour used and the value, so then I could report upon that. If it would be a system change, it wouldn't be a huge system change (H: Associate Director/Business Advisory).

16.5.2.2 Charge-Back

The 'facility expenses' is the overhead for the collective facility service provided (including electricity, water, and waste management). It was once charged back to schools on the basis of occupied floor-space, but no longer. At present, few incentives are provided for schools to reduce resources used and waste generated.

Ideally, schools should be charged a fee based on their actual usages. This point was made previously and activity-based costing (ABC) was introduced as part of the solution at RMIT. However, due to the increasing complexity of the tasks and resources constraint ABC has not been carried through. Consequently, a change to the accounting system to charge schools for their actual costs was deemed to be administratively burdensome and, therefore, not financially feasible at this point:

> Not to say we couldn't get into environmental [costs], because there is something the University, the community, the participants would like to see to make money. We're here to survive financially. But if we could be capturing that and aiming to do better, then yes, we could use ABC for that. We're just not there yet. It's just not a priority right now, which it doesn't mean we're neglecting it or we are not interested in that cost. But they're just managed the way they are managed (I: Associate Director/Budget & Financial Performance Measurement).

Alternatively, energy and water costs could be highlighted as separate items when charged back to schools although these charges would still be based on the floor-space occupied. This could also be done at a building-level rather than at a school-level. Thus, schools (or building occupants) would be able to monitor their environmental impacts and stimulate improved environmental behaviour because their actions certainly influence the overall environmental performance. RMIT could also set reasonable targets and compare different buildings and schools to identify if and where opportunities may exist to reduce energy and water costs and consumption. The point was supported:

> Well I think if we set reasonable targets for all of us to meet and we measure it on a regular basis as part of our monthly management reports, then usually what gets measured, gets managed (B: Vice-President Resources).

16.5.2.3 Create Financial Incentives

At present there is a lack of responsibility-centred budgeting for major environmental costs because, except for Property Services, these are not borne by academic schools and administrative divisions which in turn directly impacts improvement in environmental performance. Consider what the budget control officer said:

> The accountability is hitting the budget on the bar– if we're too far under, that doesn't help anyone; if we're too far over, and obviously it costs the University money. We're just trying to have a soft landing would be the best way to describe it (F: General Manager/Facility Services).

The need to create incentives geared to promote environmental awareness and behaviour change is evident. Two suggestions made by senior management might help:

> I mean you could do it as an environmental accountability or straight out financial. You can say, well you will have certain environmental targets, or you can express those targets financially. Personally I mean however you go about it, if you build it in as a key performance indicator, and then you're going to get action. But you could probably do a lot of it through your financial incentives, even without necessarily introducing the notion of environmental impact. Like we were talking about before, handing back savings on utility costs would be one way, or on other office expenses that have an environmental impact, floor space, heating, paper, all that, hand it all back, any savings that are made (D: Member of the VC's executive team).
>
> But I think you could really increase the performance, the sustainability dimension, by actually putting it in financial categories, which means we got the information and we got the benefit from doing it. It's not that hard (A: Pro Vice-Chancellor Business).

The ideas mentioned could be an effective solution for the excuse of budget constraint and could provide financial incentives to reduce resources used. However,

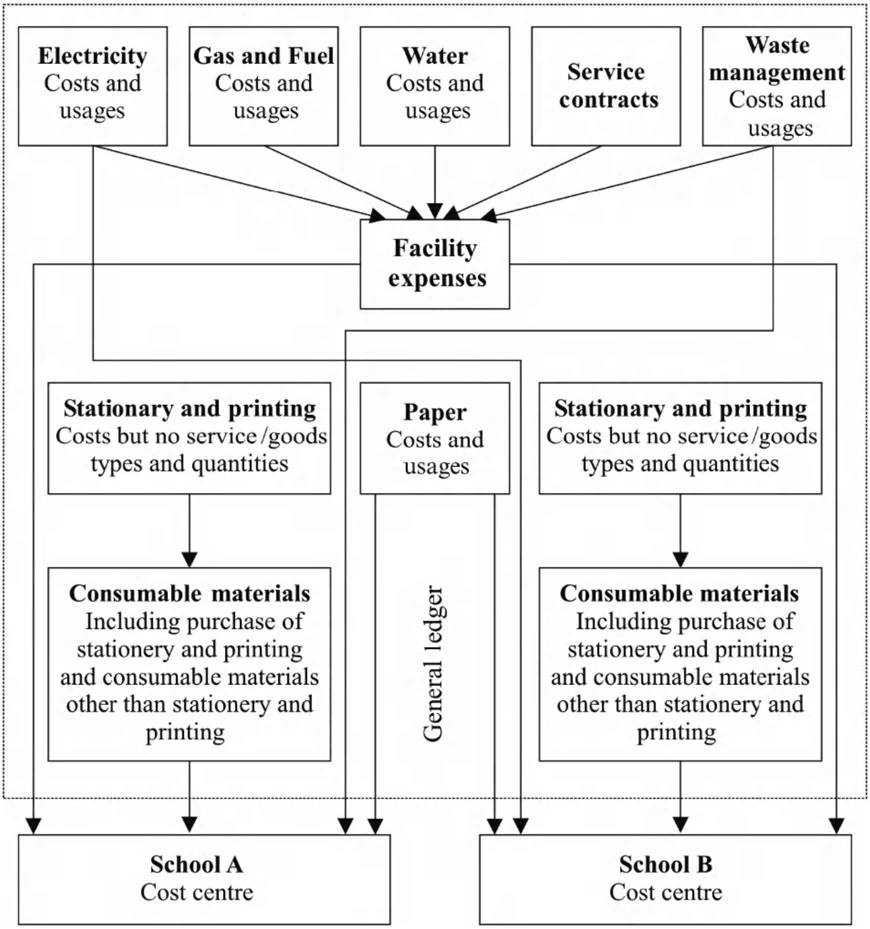

Fig. 16.2 RMIT's suggested treatment of major environmental costs in general ledger

the benefit could be achieved only by providing better information (actual or charged-back costs for resources used) as suggested previously. Suggested changes to the accounting system for achieving the benefits are shown in Fig. 16.2.

16.5.3 Roadblocks to the Future Potential

The potential use of EMA within RMIT has been demonstrated. Similar findings at other service organisations also support its use in such organisations (e.g. Deegan 2003; Jasch 2002). There is evidence that a business-case currently exists as it is clear that accounting for environmental costs can ultimately lead to real cost-savings (and related benefits for the environment) (e.g. Deegan 2003; Harvard Green Campus Initiative 2006). Unfortunately, it appears that University management has not yet been exposed to such literature and information. If they do, what would prevent them adopting EMA? It would be beneficial to the further promotion of EMA especially within a university context if the perceived barriers could be identified. Based on interviews with the key players with different types of management roles within RMIT the following three barriers were highlighted.

16.5.3.1 Absence of Institutional Pressures

Developed from an institutional theoretical perspective three factors were identified that might be related to EMA adoption. They are mimetic pressure, coercive pressure, and normative pressure (for discussions, see DiMaggio and Powell 1983).

When asked what would trigger the University to consider environmental costs as part of future operating costs when making capital decisions an interviewee replied:

> I guess what other universities do. If other universities put more in their reports here and there, if there was some sort of public scrutiny of it, if something gets in the papers … something like that, then that would put a focus on it…. Unless we have environmental issue here, I mean, and that would be around costs, because we are interested in controlling costs anyway…. Unless there was something that went wrong or public pressure on what we are doing, we'd just continue the way we were doing it, I guess (I: Associate Director/Budget & Financial Performance Measurement).

She also agreed that it is becoming general practice for universities to report environmental sustainability information in annual reports because "if corporations do it, then the University ultimately will (I: Associate Director/Budget & Financial Performance Measurement)." External environmental sustainability reporting is becoming a general practice but not EMA for internal decision-making.

Seven of the interviewees indicated that coercive pressure, especially government pressure, plays an important role in promoting environmental initiatives or reporting. For example, the State Government imposed a requirement for universities to purchase at least 10% green power and also requests universities to report back on the environmental initiatives being carried out. RMIT University has fulfilled the 10% requirement. However, "if there isn't any external pressure, it will be a slow process (F: General Manager/Facilities Services)." Government pressure has forced the University to discharge some sort of environmental accountability. Nevertheless, since no external pressure has been imposed on universities for internal environmental accountability it is still an issue that is not in the 'spotlight'. The following quotations highlight the point made:

> If there was some component, for example, of our funding that was contingent upon environmental policies and accounting practices, then we'll do it, but doing it just because Steve and I or Margaret or somebody thinks it's a great, noble thing to do is not going to get us very far (D: Member/the VC's executive team).
>
> Not major enough, no. Because obviously they influence financial reporting, they've influenced what goes into the University's accounts, but not in management accounting.

> They haven't. So if there was a standard, an accounting standard on that [environmental cost], then that would obviously influence… if there was that sort of accountability. I mean, the University's become much more business-like over recent years, because government insisted that they become so. We talk about corporate governance and all of those things that we never used to, so there's a lot of changes, but we just haven't got that far yet. So that would be, if there were external demands upon the University to identify these costs, then what choice do they have? (J: Head of School)

As previously mentioned RMIT is a member of TEFMA which performs a benchmarking exercise for participating universities every year. All the benchmarking information is included in a handbook for making environmental performance comparisons. To ensure compliance, three or four staff members within Property Services are in charge of collecting the data and making sure it is compiled in a manner consistent with previous years. Although normative pressure has encouraged environmental reporting in the University the pressure is placed on environmental management personnel rather than on management accountants. At senior management levels the environment was not really seen as having much to do with accounting. If accountants could be involved and were willing to be involved current reporting practice could serve as a good starting point to enhance environmental performance through the link between financial and non-financial data within the accounting system.

16.5.3.2 A Low Profile of Accounting for Environmental Costs

Despite increasing attention being paid to more sustainable consumption of resources and to changing consumption behaviour EMA has typically failed to be the focus of universities. RMIT has made a significant contribution to environmental sustainability through teaching and research but fails to lead the way in this area. Accounting for environmental costs remains a low profile due partly to universities being universities. For example:

> They [environmental issues] are aspirational issues… But our primary focus must be the delivery of high quality of education and research, because that's what we are as a University. We're a centre for those two products (H: Associate Director/Business Advisory).
>
> Well, clearly the governments think they are key stakeholders, but in my view the most important stakeholders are the students and the researchers and we need to be driven to some extent by what they think are the key priorities. We do regular surveys on the top 10 issues in the minds of our staff and students…. They're [environmental issues] not on the top of the top 10… and I have to listen to it…. We're here because people want to buy our services, they're willing to pay a price, whether to the federal government as loans for higher education or as fee-paying students, and they're the people who drive what we do. The market demands certain things and we have to deliver. No doubt about that (B: Vice-President Resources).

There is no doubt about universities being universities but neglected is that universities produce graduates. From a business point-of-view they should produce as many quality graduates as possible at the least operating cost of which environmental costs should be a part. Universities do not appear to look at their business in that way. For example:

I mean clearly they've got a bottom line effect, and things like energy costs can run out of control and in other ways just have unnecessary costs which probably could be better expensed on something else… but to be honest with you, I don't see that's particularly high profile at this time, either within the University or external to the University. It's not something that everybody is watching, to be honest with you (A: Pro Vice-Chancellor Business).

Nothing comes down from the top to say: 'be careful to watch what you spend on electricity.' The University has come through a difficult financial period over the last couple of years…. During the time of the difficult financial situation, we all tightened our belts, some more than others…. But we didn't tighten them to that extent. There just wasn't the incentive…. We looked at all sorts of other things and carefully contained notes, but not the gas and electricity or whatever charge. Interesting, isn't it (J: Head of School)?

Stakeholders also do not seem interested in how universities manage their environmental costs. Nor do they appear to expect universities to practice EMA. The following quotations support this argument:

I don't think there's any reason to stop doing it, but at the moment, it's just not seen as an imperative, it can't be done. That's my personal view (A: Pro Vice-Chancellor Business).

Barriers are just the people that do it, and whether the information's used or whether people want this information. It's a good thing, but people will lose interest in that. So getting people to input quantities at the same time as they're ordering something, it's just something we haven't explored, and there are other things to focus on right now. It could be useful. One day we probably will do that, but we're just not at that place right now (I: Associate Director/Budget & Financial Performance Measurement).

Because you can produce all the reports you like but if no one opens them then they won't have any impact (B: Vice-President Resources).

Well, again it goes back to competing priorities—what needs to be done and what is most urgent. And you would understand that the most urgent, even if it's not the most important, usually gets attended to first (C: Pro Vice-Chancellor Students).

From the views expressed above it seems reasonable to conclude that managing environmental costs is still not regarded as a priority; they are, therefore, treated the way they were always treated.

16.5.3.3 Attitudes and Views of Key Players

Whether or not to adopt EMA is an issue with both accounting and environmental dimensions. Interdisciplinary collaboration is required to achieve the benefits EMA can deliver. The attitudes and views of key players in the implementation process all have an influence on whether EMA could be successfully delivered. The following quotations highlight the differing attitudes and views:

The major problem is having a robust data set at the start, agreeing on a methodology… and providing accurate reporting. So, the accurate reporting is pretty easy. The technical solution is: 'Can the ledger break it down to that level of detail, and then do we have a methodology to take the inputs… and then allocate it to the ledger that is meaningful and useful to the end user? So, again, it comes back to a cost-benefit analysis…. So all that work, is that going to deliver a benefit to the organisation? And that's the challenge (H: Associate Director/Business Advisory).

From our financial management point of view, it's concerned that charging back environmental costs is just like internally allocating them the expenditure without a lot of return. It's certainly true if the key factors are transparent to the people, then some are going to affect their behaviour. It's very difficult for us, but it's not really [that hard]…. It comes down the question—we expect to spend the resources to get the best results. So I think for the University it's better for us to look at the overall cost of the electricity and then look at ways to reduce it and do the culture change programming (E: Executive Director/Property Services).

I guess it's because we haven't captured the hearts and minds at the senior level to the actually useful and valuable to do it. Now, why am I not doing? Partly we never take time to do it. Secondly, we probably have other things on mind from time to time. Those were probably the main reasons. But this sort of issue would have been identified and go to the senior executive members of the University, maybe two, three, four times a year, so that's contained in the documents. How much discussion do they have? Three, four minutes a year maximum, where we probably just recorded "that's very interesting" and then moved on, because it doesn't seem to be imperative…. So that's a heart and mind issue at the end of the day. There's no compulsion to do this (A: Pro Vice-Chancellor Business).

It was previously acknowledged that the amounts that major environmental costs represent might not be significant enough to influence decision-making from a financial point-of-view. Nevertheless, it was also pointed out that views and attitudes might be changed if the implications of these costs are placed in the wider context of growing community environmental concern. The above quotations show that the benefits that EMA can deliver are still not well understood and as such EMA is not really an issue that captures the hearts and minds of either senior and middle management.

16.6 Conclusions

There is no doubt that universities as educators should provide environmental education. However, do they practice what they preach? The case-study demonstrated the potential for what is achievable at RMIT but found that management accounting for environmental costs tends to be ignored especially when associated financial benefits are not readily visible and achievable in the short-term. This is not a problem unique to the organisation investigated in this study and unfortunately appears common to many service-based organisations. Other pressures or drivers would be required to assist in the debate for EMA as a means of managing environmental costs.

Three barriers to the adoption of EMA within universities were identified institutional pressures, a low profile of accounting for the environment, and management's attitudes. Senior managers are not held personally accountable or responsible for environmental performance, which, as a result, discourages the discharge of environmental accountability. Although some institutional pressures are present they are limited and placed on people involved in the environmental function rather than those involved in the management accounting function. However, without accountants being involved in the process EMA is less likely to be adopted.

The majority of Australian universities are directly funded by the government and accountable to government for their financial performance (in particular, that they do not incur large operating deficits). Unfortunately, the Australian Government does not require much accountability for universities' environmental performances. This lack of accountability at the top-level flows through the various accounting systems within Australian universities. Arguably, it is incumbent on government to address this issue.

While some tentative conclusions can be drawn from this study it should be borne in mind that this is only a single case-study which limits how far generalisations can be made. Whilst the results are perhaps somewhat critical of RMIT anecdotal evidence suggests that other Australian universities are also lacking in terms of establishing systems to manage their environmental costs and hence criticisms of RMIT could equally be levelled at those other universities. Indeed, it is somewhat surprising that RMIT, which in many other facets of environmental practice leads the way, has not led the way in this area too. However, key staff are ready to consider the issue, shown by the openness and transparency demonstrated in this research. In concluding, the results of the study highlight the potential use of EMA and its ability to improve environmental sustainability through enhanced accountability within universities. Let us wait and see which university takes the necessary lead!

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Appendix: List of Participants and Interview Information

Participants		Position	Role Type
A	C. Whitaker	Pro Vice-Chancellor Business	Senior Management
B	S. Somogyi	Vice-President Resources	Senior Management
C	J. Kirk	Pro Vice-Chancellor Students	Senior Management
D	Anon. 1[a]	VC's executive member	Senior Management
E	C. White	Executive Director, Property Services	Environmental Management
F	G. Bell	General Manager, Facilities Services	Environmental Management
G	P. Stockwell	Senior Accountant, Property Services	Environmental Management
H	W. Poole	Associate Director, Business Advisory	Management Accounting
I	A. Stewart	Associate Director, Budget & Financial Performance Management	Management Accounting
J	Anon. 2[a]	Head of School	Academic Management

[a] As indicated in the text, these two participants requested to stay anonymous.

Chapter 17
The IFAC International Guidance Document on Environmental Management Accounting

Christine Jasch and Deborah E. Savage

Abstract This paper describes the core elements of the International Guidance Document on Environmental Management Accounting (EMA), recently published by the Board of Directors of the International Federation of Accountants (IFAC) at www.ifac.org.

17.1 Introduction and Context

Environmental issues—along with the related costs, revenues and benefits—are of increasing concern in many countries around the world. But there is a growing consensus that many conventional accounting practices simply do not provide sufficient information for environmental management purposes. To fill in the gap, the field of *Environmental Management Accounting* (EMA) has been receiving increasing attention. In the early 1990s, The US Environmental Protection Agency was the first national agency to set up a formal program to promote the adoption of EMA. More recently, much interest has been spurred by the meetings and publications of the *Expert Working Group on EMA* of the *United Nations Division for Sustainable Development* (UNDSD 2001, 2002). Currently, Organisations in approximately 30-plus countries are promoting and implementing EMA for many different types of environment-related management initiatives (UNDSD 2002).

Many countries and Organisations have already published guidance documents on EMA (USEPA 1995; SMAC 1996; Environment Canada 1997; USDOD 1999; UNDSD 2001; AGE 2001; JME 2002; German Environment Ministry 2003;

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S. Schaltegger et al. (eds.) *Environmental Management Accounting for Cleaner Production*,

Envirowise 2003) Guidance is also available on the related subject of environmental costing for financial accounting and reporting (ICAEW 1996; UNCTD 1999; EU 2001, 2003) and on national statistical accounting and reporting (Eurostat 2001; EU 2003; UNSD 2003). In addition, a number of excellent books on environmental accounting have been published (Gray et al. 1993; Fichter et al. 1997, 1999; Bennett and James 1998; Schaltegger and Burritt 2000; Gray and Bebbington 2001; Bennett et al. 2002, 2003). All of these have contributed greatly to the understanding and practice of EMA.

The existing guidance documents on EMA typically have focused on:

- Guidance for different national audiences, supplemented by national case studies and pilot projects (e.g., Argentina, Australia, Austria, Canada, the Czech Republic, Germany, Japan, the Philippines, Spain, the UK, the USA)
- Specific environmental management initiatives supported by EMA (e.g., solid waste management vs. supply chain management vs. environmental management systems vs. external reporting)
- Differing levels of emphasis on particular EMA methodologies and approaches

It makes sense that different countries and Organisations would adapt general EMA concepts, language and practices to suit their own goals. A certain amount of experimentation and variation is also to be expected. The great number of existing guidance documents has, however, itself contributed to confusion on the exact definition, benefits, and applications of EMA.

In response to the high level of international interest, the *International Federation of Accountants* (IFAC) decided to commission a guidance document on EMA in collaboration with the UNDSD *EMA Working Group*. The broad goal was to reduce some of the international confusion on this important topic by providing a general framework and set of definitions for EMA that is comprehensive and as consistent as possible with other existing, widely used environmental accounting frameworks with which EMA must coexist.

The IFAC guidance document is neither a standard with defined requirements, nor a descriptive practitioner or research report, nor an implementation manual. Instead, it is intended to be a guidance document that falls into the middle ground between regulatory requirements, standards and pure information. It provides context, definitions and examples, but does not provide details on the many different EMA methodologies available around the world or guidance on day-to-day implementation of EMA. It is also important to note that most EMA experience to date has been in the manufacturing sector. The guidance document reflects that fact.

The chapters in this journal article parallel the chapters in the IFAC document and thus provide an overview of its main contents (IFAC 2005).

First, the IFAC document briefly reviews why Organisations and accountants should care about environmental issues. Environmental performance and disclosure pressures from the supply chain, finance providers, regulatory agencies, and other stakeholders result in ever-increasing environment-related costs for Organisations, but there is also an increasing recognition of the potential monetary benefits of improved environmental performance. There is also growing consensus that traditional accounting practices do not adequately provide the information required for environmental management and the strategic decisions related to it.

Because the world's accountants operate with different accounting practices and languages, the guidance document briefly outlines the general accounting concepts and language used in the document itself. The main point is to distinguish between management accounting (MA), which focuses on internal decision making, and financial accounting (FA), which aims to provide information to external stakeholders.

Next, *Environmental Accounting* (EA) context, concepts and language are reviewed. EA is a broad term found in a number of different accounting contexts: financial accounting and reporting; management accounting; externalities estimation (such as full cost accounting); natural resource accounting, national accounting and reporting, and sustainability accounting. At the *Organisation level*, EA takes place in the context of both management accounting (e.g., assessment of an Organisation's expenditures on pollution control equipment; revenues from recycled materials; annual monetary savings from new energy-efficient equipment) and financial accounting (e.g., evaluation and reporting of the Organisation's current environment-related liabilities).

At the geographic and geopolitical levels, EA information is collected, typically by government, to assess the health of a particular ecosystem (such as a watershed), a particular political entity (such as a nation) or even the entire world. This type of *National Environmental Accounting* can include not only aggregated information from individual Organisations (e.g., the total annual expenditures on environmental remediation by industry and government within a country) and possibly externalities information, but also information provided by *Natural Resource Accounting* (NRA). NRA provides information on the stocks and flows, actual and potential uses and potential value of natural resources such as forestland, clean water and mineral deposits. For example, forestland might be valued for purposes such as helping provide a source of clean water to nearby communities and/or identifying the potential value of the timber on the market. The management accounting of some Organisations that own large amounts of property (timber companies, oil companies, mining operations, and agricultural operations) may actually be a type of natural resource accounting, e.g., a timber company keeping track of its timber stock. However, the IFAC guidance document does not cover this type of EMA.

The term environmental accounting is sometimes also used for the estimation of external environmental impacts and costs, often referred to as Full Cost Accounting (FCA) (Canadian Institute of Chartered Accountants 1997; Bebbington et al. 2001; Howes 2002). In the broader context of sustainability accounting, information on employee health and safety, labour practices, and other social issues are considered as well as environment-related physical and monetary information. The IFAC guidance document does not cover externalities or social issues either.

17.2 EMA Definitions, Uses, Benefits and Challenges

Because EMA has no universally accepted definition the IFAC guidance document offers two complementary definitions which highlight the broad types of information typically considered under EMA, as well as, some common EMA data analysis techniques and uses.

According to IFAC's Statement *Management Accounting Concepts* (IFAC 1998) EMA is 'the management of environmental and economic performance through the development and implementation of appropriate environment-related accounting systems and practices. While this may include reporting and auditing in some companies, environmental management accounting typically involves life-cycle costing, full-cost accounting, benefits assessment, and strategic planning for environmental management.'

A complementary definition is given by the United Nations Expert Working Group on EMA (UNDSD 2001) which more distinctively highlights both the physical and monetary sides of EMA. This definition was developed by international consensus of the group members representing more than 30 nations. According to the UN group:

EMA is broadly defined to be the identification, collection, analysis, and use of two types of information for internal decision-making:

- Physical information on the use, flows, and destination of energy, water, and materials (including wastes)
- Monetary information on environment-related costs, earnings, and savings

EMA places particular emphasis on physical information because (1) the use of energy, water, and materials, as well as, the generation of waste and emissions are directly related to many of the environmental impacts of organisational operations, and (2) material purchase costs are major cost drivers in many organisations. Monetary information under EMA can include various types of environment-related costs such as material purchase costs, environmental protection expenditures, and others as will be discussed later in more detail.

The many potential uses and benefits of EMA information may be categorised into three broad areas:

- Compliance—cost-effective compliance with environmental regulation and self-imposed environmental policies
- Eco-efficiency—simultaneous reduction of costs and environmental impacts via more efficient use of energy, water, and materials in internal operations and final products
- Strategic position—evaluation and implementation of effective and environmentally sensitive programs for ensuring an organisation's long-term competitiveness

It should be noted that there is no strict dividing-line between these three categories. For example, a manufacturing firm that reduces water-use and, thus, wastewater generation via eco-efficient projects might also reduce the load to, and costs of, an in-house waste-water treatment plant installed primarily for compliance purposes.

Prominent uses of EMA-type data for business management purposes include:

- Investment appraisal—A core management accounting technique that informs both routine and strategic investment decisions of organisations
- Life-cycle assessment—Life-Cycle Assessment (LCA) and Life-cycle costing: the analysis of environmental impacts and related costs for a particular material or product line
- Supply-chain environmental management: The management of environmental issues and related costs along several organisations within the same supply-chain, e.g., a large customer and its suppliers.
- Development of Environmental Performance Indicators (EPIs)—EPIs can support decision-making at many different levels (ISO 14031 2000).

Examples of the use of EMA approaches for initiatives of this type are found in Chapter 5 of the IFAC guidance document.

Although management accounting traditionally supports internal decision-making as the primary goal EMA also is viewed by many practitioners as a support tool for *external reporting* to the many stakeholders interested in organisation-level environmental performance. For example, many business firms report EMA-type physical information in voluntary corporate environmental performance reports and some firms also report related monetary information. Chapter 6 of the IFAC guidance document gives examples of the use of EMA information for external reporting purposes.

EMA provides many potential benefits but EMA implementation must overcome some challenges including limitations of conventional management accounting systems and practices with respect to environmental management. Indeed, recognition of these limitations leads to interest in the development of EMA as a field in the first place, examples include: inadequate communication/links between accounting and other departments; unintentional hiding of environment-related cost information in overhead accounts; inadequate tracking of information on materials use, flows, and costs; absence of some types of environment-related information in the accounting records; and, investment decision procedures that rely on incomplete environment-related information.

17.3 Physical Information: Flow of Energy, Water, Materials and Wastes

The tracking of physical information on the flow of energy, water, materials, and wastes is important under EMA because such information allows an organisation to assess and manage (and report) the important materials-related aspects of its environmental performance. In addition, material purchase costs are key cost drivers in many organisations. Unfortunately, much of the required physical accounting information is not easily available to accounting personnel as it is not systematically recorded in the accounting records or not recorded in a way that reflects the real-world flow of materials within the organisation. Personnel in other areas, such as production, environmental, or other operations, often have more detailed estimates and measurements of physical flows of materials but this information often is not cross-checked with that of the accounting department. Thus, accountants need to work more closely with personnel from other departments to accurately perform the physical accounting side of EMA (Table 17.1).

Table 17.1 Organisation-level accounting and reporting

Organisation-level accounting	Organisation-level environmental accounting	Associated mandatory external reporting	Other external reporting links
Financial accounting (FA): An organisation's development of standardised financial information for reporting to external parties (e.g., investors, tax authorities, creditors)	**Environmental issues in financial accounting:** The inclusion in financial reports of environment-related information such as earnings and expenses of environment-related investments, environmental liability and other significant expenses related to the organisation's environmental performance	Financial reporting to external parties is regulated by national laws and international standards, which specify how different financial items should be treated. The financial reports issued by organisations increasingly include information related to their environmental and social performance. Some countries require such content in financial reports, while some organisations include such information voluntarily	In addition, organisations use some of the environment-related information gathered for financial reporting purposes for environmental regulatory reporting, national reporting or voluntary corporate environmental and sustainability reporting
Management accounting (MA): An organisation's development of both non-monetary and monetary information to support both routine and strategic decision-making by internal managers	***Environmental* management accounting (EMA):** The management of environmental and economic performance via management accounting systems and practices that focus on both physical information on the flow of energy, water, materials, and wastes, as well as monetary information on related costs, earnings and savings	There are generally no external reporting requirements specifically associated with MA or EMA	However, organisations use some of the information gathered under EMA for environmental regulatory reporting, national reporting or voluntary corporate environmental and sustainability reporting

Using physical accounting an organisation should try to track all physical inputs and outputs and ensure no significant amounts of energy, water, or other materials are unaccounted. Table 17.2 lists basic types of physical information relevant under EMA. The physical categories shown are in-line with the standard practice of mass balancing and the general structure of ISO 14031 for Environmental Performance Indicators for operational systems. These physical categories may be adjusted to suit specific sectors or individual Organisations.

Materials inputs are any energy, water, or other materials that enter an organisation. Outputs are any products, wastes, or other materials that leave an organisation. Any output that is not a product output is by definition a *Non-Product Output* (NPO). In organisations that use energy and materials but do not manufacture physical products, such as transport or other service sector companies all energy, water, and other materials used will eventually leave as Non-Product Output. The IFAC guidance document uses the term NPO synonymously with the term 'Waste and Emissions'.

As used here, the terms inputs and outputs do not include capital items such as equipment, buildings, land, etc. Some of these items become waste eventually but are not normally monitored via material balances or material flow accounting as they do not enter or exit the organisation with the same frequency or volume as other physical materials and are not typically tracked in the same information systems. Organisations that consider the physical materials embedded in capital items to be significant with respect to environmental impacts at some point in the item's life-cycle (e.g., during final disposal of equipment after its useful life has ended) may wish to track those capital items for environmental management purposes separately from other physical materials. The environment-related costs associated with the purchase of equipment and other capital items are covered in the monetary accounting side of EMA via the inclusion of annual depreciation costs in the appropriate cost categories.

Accounting for all energy, water, materials, and wastes flowing into and out of an organisation is called a 'materials balance', sometimes also referred to as 'input-output balance', a 'mass balance', or an 'eco-balance' (UNEP 1991; German Environment Ministry 1995; Pojasek 1997a, b; EPA 1999; WSDE 2004). As this terminology implies, the underlying assumption is that all physical inputs must eventually become outputs—either physical products or waste and emis-

Table 17.2 Physical materials accounting: Input and output types

Materials inputs	Product outputs
Raw and auxiliary materials	Products (including packaging)
Packaging materials	By-products (including packaging)
Merchandise	**Non-product outputs (waste and emissions)**
Operating materials	Solid waste
Water	Hazardous waste
Energy	Wastewater
	Air emissions

sions—thus the inputs and outputs must balance. The level of precision of a materials balance can vary depending on the specific purposes of the information collection and the availability and quality of the data. Many organisations perform energy and water balances separately from other materials. Material balances are a very valuable tool for the manufacturing sector and less common in the service industry.

Material balances can take place at many different levels. The physical information can be collected for the entire organisation, or for particular sites, input materials, waste streams, process or equipment lines, product or service lines, etc.,—depending on the intended use of the information. Ideally, material balances done on more detailed levels would aggregate to match a materials balance done for a site or organisation as a whole. In practice, however, material balances at different levels are not often cross-checked and, therefore, are not consistent.

For a complete and integrated picture of material use, the details of material flows must be traced through all the different material management steps within an organisation, such as material procurement, delivery, inventory, internal distribution, use and product shipping, as well as waste collection, recycling, treatment and disposal. This type of accounting can be referred to as 'materials flow accounting' (Strobel 2001).

Some organisations may wish to extend the system boundaries beyond their own operations to include physical information from suppliers, customers, and other elements of the supply-chain, with Supply-Chain Environmental Management, or product/service life-cycle or Life-cycle Assessment in mind.

Once the physical accounting data have been collected they can be used both to support the cost accounting side of EMA and to create environmental performance indicators (EPIs) that help an organisation assess and report the material-related aspects of environmental performance (ISO 14031 2000). Even organisations that may not have the expertise or resources to perform comprehensive material balances or material flow accounting, such as some smaller and medium-sized enterprises, can benefit greatly from the estimation of key EPIs (Loew et al. 2003).

From an environmental impact point-of-view the absolute data collected are the most important as these absolute indicators illustrate the consumption of natural resources and the generation of waste and emissions, such as:

- The total amount of fresh water consumed each year
- The total amount of wastewater generated each year

Relative (normalised) indicators represent an organisation's environmental performance in terms of size, production output, or number of employees. These are important indicators since company size, product, or service output can vary from year to year. Thus, these indicators allow an organisation to distinguish between changes in environmental performance as a result of changes in these factors and changes in performance as a result of environmental management efforts. Examples of relative indicators include:

- Amount of fresh water consumed per unit product manufactured or service provided
- Amount of waste-water generated per unit product manufactured or service provided

Relative indicators may also tie physical and monetary terms together such as the waste-water treatment costs per unit product each year.

17.4 Monetary Information: Environment-Related Costs and Earnings

Organisations tend to define environment-related costs differently depending on the intended uses of the cost information, the organisation's view of what is 'environmental,' the organisation's economic and environmental goals, and other reasons. However, cost schemes used by organisations around the world tend to include the following four types of cost categories:

- Categories reflecting the type of environmental activity (e.g., waste control vs. prevention)
- Categories more representative of traditional accounting (e.g., materials vs. labour)
- Environmental domain categories (e.g., water vs. air vs. land)
- Categories reflecting data visibility in the accounting records (e.g., obvious costs vs. hidden costs)

For the IFAC guidance document environmental cost guidelines from around the world were reviewed and a set of cost categories was developed that represents international practice to the best extent possible given the wide range of international language and practice. Although these cost categories are not meant to be prescriptive they are relatively comprehensive and should provide a common language for future discussion. The major cost categories described in the IFAC guidance document are listed in Table 17.3.

Most of these cost categories have sub-categories more representative of traditional accounting such as equipment depreciation, raw & auxiliary materials, operating materials, personnel, etc. The sub-categories are discussed in more detail in the guidance document.

Most of the environmental cost schemes developed internationally, some developed for EMA purposes, others developed for company financial reporting and national statistical reporting include the types of costs that are clearly driven by efforts to control or prevent waste and emissions that can damage environmental or human health. Examples include costs incurred to prevent the generation of waste/emissions; costs to control or treat waste once generated; and costs for remediation of polluted sites. These types of costs are often referred to as environmental protection expenditures or EPEs.

Table 17.3 Environment-related cost categories

1. Materials costs of product outputs includes the purchase costs of natural resources such as raw, auxiliary, and packaging materials and the percentage of water converted into products, by-products, and packaging
2. Materials costs of non-product outputs includes the purchase (and sometimes processing) costs of raw, auxiliary, packaging, and operating materials, energy, and water that become Non-Product Output
3. Waste and emission 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. The sub-categories are equipment depreciation, related operating materials including water and energy, internal personnel and external services, fees, taxes and permits, fines, insurance, remediation and compensation
4. Prevention and other environmental management costs includes the costs of preventive environmental 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. The subcategories are equipment depreciation, related operating materials including water and energy, internal personnel and external services, and other prevention and general environmental management costs e.g. for the publication of an environmental report
5. Research and development costs includes the costs for Research and Development 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 externalities

However, environment-related costs under EMA include not only EPEs but also other important monetary information needed to cost-effectively manage environmental performance. One important example is the purchase cost of materials that eventually become waste or emissions rather than product. Another recent development in the area of EMA is a push to view the purchase costs of all natural resources (energy, water, materials) as environment-related. In a manufacturing setting where most of the purchased materials are converted into physical products this would allow more cost-effective management of the materials-related environmental impacts of those products. Recognition of all resource purchase costs as environment-related is also warranted by the fact that the extraction of all natural resources from the environment results in some type of environmental impact (e.g., via mining activities). The physical accounting side of EMA provides the needed information on the amounts and flows of energy, water, materials, and wastes to assess these purchase costs.

Some organisations may prefer to focus their EMA activities on the narrower range of costs encompassed under environmental protection expenditures (EPEs). Others will take a broader and more strategic view of both environmental management and environment-related costs and, thus, may be comfortable with defining a broader range of costs as environment-related even if some of those costs are viewed as quality-related and efficiency-related at the same time. In the IFAC guidance document the broader range of environment-related costs is used because that is what is needed to cost-effectively manage potentially significant aspects of environmental performance.

Today the majority of EMA initiatives typically do not include ‘external’ costs, the environment-related costs to individuals, business partners, society or the planet for which an organisation is not legally held responsible. However, some organisations do consider external costs and the boundary between internal and external costs related to environment is ever-changing due to both changing environmental regulations and a growing emphasis on corporate social responsibility. Therefore, the guidance document discusses external costs in a little more detail under the cost category of Less Tangibles Costs.

The IFAC document also discusses environment-related earnings, savings and distribution of costs by environmental domain. Environment-related earnings are derived from sales of scrap or waste (for reuse by another organisation), subsidies, sales of excess capacity of waste treatment facilities, revenues from insurance reimbursements from environment-related claims, higher profit margins due to environmentally benign products, etc.

In contrast, environment-related savings are realised only when a defined system changes in some way. For example, if efficiency improvements reduce material-use and waste-generation the monetary savings due to the improvement can be calculated by comparing the reduced costs to the previous higher costs. These types of savings tend to occur when preventive environmental management activities are implemented such as on-site recycling, cleaner production, green research and design, green purchasing, supply-chain environmental management, extended producer responsibility, etc. Savings can also result from improvements in areas such as environmental planning and systems (e.g., via the implementation of EMA).

17.5 Selected Examples of EMA Applications for Internal Management

Chapter 5 of the IFAC guidance document gives examples of EMA applications for internal management at three different levels:

- EMA for a site or organisation as a whole
- EMA for a particular material or class of materials used or produced
- EMA for a particular project

These examples cover a range of issues such as the use of EMA approaches for supply chain management, logistics management, investment appraisal, development of environmental/economic performance indicators, and tracking annual environment-related costs by environmental domain. They illustrate the efficiency benefits of EMA for both business and government. They also illustrate the links between physical and monetary information in ‘Materials Flow Cost-Accounting.’ The examples given come from Argentina, Austria, Germany, Japan, the Netherlands, the UK, and the USA. Table 17.4 provides an overview.

Table 17.4 Selected examples of EMA applications for internal management

Examples	Brief description
EMA at the site & organisation level	
SCA Graphic Laakirchen AG, Austria	EMA for estimation and distribution of total environment related costs
UK Environment Agency	EMA for government efficiency
Verbund Group, Austria	Extracting EMA data from enterprise resource planning
EMA at the materials level	
Ciba Specialty Chemicals, Germany	Materials flow cost accounting
Canon, Japan	Materials flow cost accounting
Raytheon, US	EMA for chemicals management via the supply-chain
Xerox, UK and the Netherlands	EMA for logistics management
Fujitsu Group, Japan	'Cost Green Index'
Murauer Bier, Austria	EMA and environmental performance indicators
EMA at the project level	
Fine paper mill, US	EMA for investment in process efficiency
Sawmill in Misiones, Argentina	EMA for new product development
Polychlorobiphenyl (PCB) Phaseout in a manufacturing firm, US	EMA and less tangible liability costs

17.6 Selected Examples of EMA Applications and Links Related to Other Types of Accounting and External Reporting Initiatives

The final chapter of the IFAC guidance document gives examples of links between EMA and

- National accounting and reporting
- Financial accounting and reporting
- Environmental performance reporting

These examples from Australia, Denmark, Japan, the European Commission and the United Nations illustrate the similarities among and differences between the types of information collected under these accounting and reporting schemes compared to EMA and show the potential for EMA to provide information for these schemes, and vice-versa. Table 17.5 provides an overview.

17.7 Outlook

This article basically followed the outline of the chapters in the IFAC guidance document itself. Several companies assessed their environmental costs using the described approaches. The main documents used are the list of accounts

Table 17.5 Selected examples of EMA applications and links related to other types of accounting and external reporting initiatives

Examples	Brief description
EMA links to national accounting and reporting	
United Nations Statistics Division	The UN system of integrated environmental and economic accounting (SEEA)
Australian Bureau of Statistics	Mining statistical data for internal management purposes
EMA links to financial accounting and reporting	
European Commission	The EC recommendation and the EU directive on environmental issues in company annual accounts and reports
EMA links to corporate environmental performance reporting	
Japan Ministry of Environment and Ricoh, Japan	Valuing and reporting environmental activities
Green Accounts Act, Denmark	Green accounting and reporting

and the cost-center reports. In addition, statistics from the personell, quality, production, and other departments were necessary.

Traditional Management Accounting (MA) has always focused on both monetary and non-monetary information (e.g., cost drivers such as labour hours and quantities of raw materials purchased) to inform management decisions and activities such as planning and budgeting, efficient use of resources, performance measurement, and the formulation of business policy and strategy, the collective goal of which is to create, protect, and increase value for the organisation's stakeholders. Thus, MA activities include data collection as well as routine and more strategic analysis of the data via a number of techniques (e.g., capital investment appraisal) designed to address specific management needs.

The IFAC Statement on *Management Accounting Concepts* (IFAC 1998) outlines how the field of MA has evolved over time in four recognizable stages with a different focus in each stage:

- Stage 1 (prior to 1950)—focus on cost determination and financial control
- Stage 2 (by 1965)—focus on provision of information for management planning and control
- Stage 3 (by 1985)—focus on the reduction of waste in resources used in business processes
- Stage 4 (by 1995)—focus on generation or creation of value through effective use of resources

Thus, according to the IFAC analysis the leading-edge practice of MA has shifted beyond information provision to focus on the reduction of waste (the reduction of resource loss) and the generation of value (i.e., the effective use of resources). In other words, leading-edge MA centers around the use of resources which are defined as 'monetary and physical' resources, as well as, information itself along with the other resources created and used by an organisation e.g., 'work processes and systems, trained personnel, innovative capacities, morale, flexible cultures, and even committed customers.' In organisations where actual MA practices have kept pace with these trends the role of management accountants has evolved accordingly—from information tracking to more strategic roles in policy and planning.

Although EMA is a comparatively new tool it has been used for all of the MA goals listed in the four stages shown above. A clear parallel exists between stages 3 and 4, which focus on resource productivity, and EMA's focus on accounting for the flows of natural resources and accounting for the costs associated with the generation of pollution and waste which partly result from the inefficient use of materials in production or products themselves. It should be noted, however, that for many organisations EMA still has a strong focus on the Stage 1 and 2 goals of cost determination, financial control, and information provision. Nevertheless, EMA information and practices are continuing to evolve in the same direction as conventional MA—towards the resource productivity and value-creation activities for which EMA data are so well suited.

In principle, EMA should be an integral part of MA and not a parallel system. In the real world EMA ranges from simple adjustments of existing accounting systems to more integrated EMA practices that link conventional physical and monetary information systems. But, regardless of structure and format it is clear that both MA and EMA share many common goals. Therefore it is to be hoped that EMA approaches eventually will support the IFAC proposals in *Management Accounting Concepts* that in leading-edge MA 'inattention to environmental or social concerns are likely to be judged ineffective,' and that 'resource use is judged effective if it optimises value generation over the long run, with due regards to the externalities associated with an organisation's activities'.

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Part V
International EMA Developments and Surveys

Chapter 18
Environmental Performance Indicators—Key Features of Some Recent Proposals

Robert Langford

Abstract The paper identifies some key features of the thinking in the United Nations Conference on Trade and Development document "A Manual for Preparers and Users of Eco-efficiency Indicators" (2004). The UN approach is compared with that of the Global Reporting Initiative (GRI) in the third generation of its Sustainability Reporting Guidelines issued October 2006 (GRI 2006) and with that set out in "Environmental Key Performance Indicators—Reporting Guidelines for UK Business" (DEFRA and Trucost 2006). Reference is also made to some of the performance indicators given as examples in the international standard on management evaluation of environmental performance issued in 1999 by the International Organisation for Standardization (ISO 14031).

The paper is intended to provide an overview rather than a detailed analysis. It looks at the extent to which the proposals under review are based on a conceptual framework, the principal impacts addressed, and the guidance provided as regards definition and compilation of the performance indicators.

The differing approaches adopted in the proposals give rise to a number of questions:

1. Is there a prospect of convergence amongst "standard setters" on the key environmental performance indicators?
2. In the meantime, do any of the proposals assist organisations in identifying key environmental performance indicators and the information to be reported?

The paper seeks to address some of the issues that arise in relation to these questions.

18.1 Conceptual Underpinning

The United Nations 'Manual for the Preparers and Users of Eco-Efficiency Indicators' (UNCTAD 2004) sets out a range of eco-efficiency indicators defined as the ratio between an environmental and a financial variable. The aim of environmentally

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sound management is to increase eco-efficiency by reducing the environmental impact while increasing the value of an enterprise (Schaltegger and Sturm 1989). Accounting principles in the UN Manual are based on the IASB Framework for the Preparation and Presentation of Financial Statements particularly the characteristics of understandability, relevance, reliability and comparability. For each eco-efficiency indicator the accounting policy adopted is disclosed. The Manual notes the importance of aligning conceptual frameworks for ecological and financial accounting if the resulting figures are to be combined to produce eco-efficiency indicators and the need to ensure that in defining the reporting entity for environmental items the same criteria are used as in financial reporting i.e. related eco-efficiency indicators would be distorted if upstream and downstream environmental impacts were included.

The GRI Guidelines (GRI 2006) include principles regarding report content and the quality of reported information about an organisation's environmental, social, and economic performance. Report content is governed by the principles of materiality, stakeholder inclusiveness, sustainability context, and completeness. Associated guidance is provided on setting the report boundary, addressed in more detail in a technical protocol. GRI recognises that the boundary of a sustainability report should include entities over which the reporting organisation exercises control or significant influence but the reporting requirement differs depending on the degree of influence. Quality of reported information is seen as being determined by such principles as balance, comparability, accuracy, timeliness, clarity, and reliability. There is no specific reference to the IASB Framework or to any other conceptual framework nor is there any attempt to link the environmental indicators with financial performance. Each category of indicators is expected to be accompanied by a disclosure on the Management Approach in which matters such as overall policy, responsibility, and performance, are described together with additional contextual information.

The UK Reporting Guidelines (DEFRA and Trucost 2006) are intended to apply to large businesses and state that: "where possible, the Government has sought to ensure that the Guidelines are consistent with other standards and reporting guidance". Reference is made to the GRI framework as well as to the Guidelines on Environmental Management Accounting issued by the International Federation of Accountants (IFAC 2005) and the Corporate Accounting and Reporting Standard issued by the World Business Council for Sustainable Development and the World Resources Institute (WBCSD and WRI 2004). The UK Guidelines identify three general reporting principles: transparency (including the definition of boundaries and explanation of processes to manage risk), accountability (including stakeholder engagement and third party assurance), and credibility (including the use of an environmental management system and policy for supply-chain management).

ISO 14031 (ISO 1999) is designed to provide management with information to assist in evaluating environmental performance. It is not essentially an external reporting standard although it accepts that management may wish to make the resulting indicators available to interested parties. Nor does it establish minimum levels of performance or identify core indicators amongst the 146 examples listed in an "informative" annex supplementing the standard. The guidance provided in

ISO 14031 is intended to support existing ISO standards on environmental management systems and makes no reference to other international frameworks such as those of the IASB or the GRI. Two types of performance indicators are identified: *management performance indicators* which measure management efforts to influence environmental performance and *operational performance indicators* which measure the environmental performance of an organisation's operations. Both of these are distinguished from *environmental condition indicators* which provide context by measuring the condition of the external environment and are not directly concerned with a particular organisation's impacts. ISO 14031 suggests a number of possible bases for selecting performance indicators. The standard provides high-level guidance without attempting to explain how any of the environmental performance indicators given as examples should be calculated. In addition to the groups of indicators discussed in Section III below ISO 14031 includes a number of examples of management performance indicators dealing with conformance to requirements and the implementation of policies and programmes.

The various proposals differ substantially as regards their conceptual basis and the principles on which information about performance indicators should be prepared and presented. Only the UN Manual states specifically that the accounting principles are based on the IASB Framework for the Preparation and Presentation of Financial Statements. This promotes consistency. A conceptual framework covering the financial reporting area is reasonably well-established and a paper issued by the Federation des Experts Comptables Europeens (FEE 2000) showed that such a framework is clearly relevant to environmental issues. However, it should not be implied that a link to financial performance is essential to the management of environmental performance. It is sensible to build on an existing framework even though the IASB Framework does not address the concept of "net value added" on which indicators in the UN Manual are based. No other conceptual frameworks are cited by the proposals although there are specific references to documents such as the WBCSD Accounting and Reporting Standard and the IFAC Guidelines on Environmental Management Accounting. Surprisingly, the UN Manual makes no reference to the 2002 version of the GRI Guidelines that were available at the time it was issued.

There is also considerable variation between the principles adopted for preparing and presenting performance indicators. ISO 14031 does not identify any such principles. Amongst the other three proposals the only common principle is reliability (or credibility). Comparability, and clarity (or understandability) appear in both the UN Manual and the GRI Guidelines but not in the UK Reporting Guidelines. Relevance is cited only in the UN Manual although the GRI took the view that it is covered by the principle of materiality (though strictly, the two are not identical as an item may be relevant but not material). The UK Reporting Guidelines include the principles of accountability and transparency, neither of which are specifically listed in the UN Manual or the GRI Guidelines, although it might be argued that such qualities are collectively covered by the GRI principles: shareholder inclusiveness, sustainability context, completeness, balance, accuracy, and timeliness.

Clearly, the concepts and principles underlying the proposals are different in several important respects and further work in this area will be necessary in developing satisfactory guidance for preparers and users. Whilst there may be some merit in considering different approaches this is unlikely to encourage adoption on a broad scale.

18.2 Key Features of Environmental Indicators

In addition to the conceptual divergence there is substantial variation between the different proposals as regards the range of environmental indicators advocated and the impacts covered. In this paper, it is convenient to discuss the way in which indicators address:

- Emissions to air and contribution to global warming
- Water-use and discharge
- Waste and emissions to land
- Energy use
- Materials, use of resources, and recycling

This grouping of environmental issues is similar to that adopted in the GRI Guidelines except that the GRI aspect covering Emissions, Effluents and Waste (involving ten indicators) was divided between Emissions to Air and, as a separate group, Waste and Emissions to Land (including spills). For the purpose of this overview aspects relating to Bio-diversity, Environmental Protection Expenditure, and the Impacts of Products, Services and Transport which are covered in the GRI Guidelines are not examined. Some of the other proposals do not put forward any indicators in these areas and such omissions will need to be addressed if convergence is to be achieved.

18.2.1 Emissions to Air and Contribution to Global Warming

Greenhouse gases are the main cause of climate change and various mechanisms are used to achieve a reduction in their emission. Several indicators are therefore designed to measure emissions and to demonstrate the effectiveness of an organisation's initiatives to combat climate change including the impacts of products and services.

The UN Manual is concerned with the emissions of energy users rather than with the global warming contribution of energy-producing companies, the agricultural sector, or forestry. Global warming gases are defined as the six gases listed under the Kyoto Protocol. An enterprise's global warming contribution over a 100-year timeframe is expressed in kilograms or tonnes of carbon-dioxide equivalent per year. Renewable energy is assumed to have no global warming contribution and "for the time being" other global warming gases (e.g. methane) from the use of energy and transport services are not considered (UNCTAD 2004, paragraphs 200, 201). The eco-efficiency indicator "global warming contribution per unit of net value added" is disclosed with the contributions for each category of global warming gas and management policy on energy use, objectives, and measures to achieve targets.

The UN Manual has a section concerned with ozone-depleting substances that may exist either as part of a "use system", i.e. goods and equipment (such as refrigerators and fire extinguishers) or as a substance sold in pure or blended form. Ozone-depleting substances "added by the reporting entity" through its operations should be reported by weight and ozone depletion potential together with disclosure of the "dependency per net value added", the total amount of ozone-depleting substances recognised during the period, and the management policy.

GRI has five indicators that concern emissions to air and contributions to global warming:

- EN 16 Total direct and indirect greenhouse gas emissions by weight
- EN 17 Other relevant indirect greenhouse gas emissions by weight
- EN 18 Initiatives to reduce greenhouse gas emissions and reductions achieved
- EN 19 Emission of ozone-depleting substances by weight
- EN 20 NO, SO and other significant air emissions by type and weight

EN 16 calls for the total greenhouse gas emissions in tonnes of carbon dioxide equivalent for the six gases listed under the Kyoto Protocol. The supporting guidance refers to different conversion methodologies and compilation guidance. For example, the Corporate Accounting and Reporting Standard issued by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) provides guidance on emissions data that should be provided as standard, as well as, additional optional information. The standard disclosure requires separate emissions data for each of the six greenhouse gases, as well as, carbon-dioxide emissions from biologically sequestered carbon e.g. burning bio-fuels. This is rather more demanding than EN 16. No reference is made to the UN Manual. The indicator includes direct emissions and indirect emissions resulting from the generation of purchased electricity, heat, or steam.

EN 17 deals with other relevant indirect greenhouse gas emissions. Organisations are expected to disclose the total weight of emissions in tonnes of carbon-dioxide equivalent including those arising from the organisation's activities such as employee commuting and business travel. Emissions resulting from imported electricity, heat, or steam are excluded.

As well as calling for the identification of any initiatives to reduce greenhouse gas emissions EN 18 requires the reductions achieved to be quantified in tonnes of carbon-dioxide equivalent. EN 19 calls for disclosure of the emissions of ozone-depleting substances in tonnes excluding emissions from products during their use or disposal. Other significant regulated air emissions are addressed by EN 20 which requires their identification and quantification including disclosure of the measurement method used.

The UK Guidelines include five indicators that concern emissions to air and contributions to global warming:

- KPI 1 Greenhouse gases
- KPI 2 Acid rain and smog precursors
- KPI 3 Dust and particles

- KPI 4 Ozone-depleting substances
- KPI 5 Volatile organic compounds
- KPI 6 Metal emissions to air

Three of these taken together (KPI 1, KPI 2 and KPI 5) cover similar ground to the corresponding indicators in the UN Manual and the GRI Guidelines although differences in scope and classification will hinder comparisons with data prepared on another basis. The UK Guidelines emphasise that indirect greenhouse gas emissions should be reported separately from direct emissions. It is also noted that "companies may decide to report on impacts that occur outside their normal financial reporting boundaries and this is common practice in the case of greenhouse gas emissions." Reference is made to the UK and European Trading Schemes although there is no suggestion that key performance indicators should include information about the impacts of emissions trading.

KPI 3 requires that dust and particles emitted should be reported in metric-tonnes per year, and by size of particle. KPI 4 requires ozone-depleting substances to be reported by type in metric-tonnes per annum. Any estimation method used should be stated. The indicator is expected to be disclosed mainly by businesses that use air conditioning, refrigerators, and certain types of fire extinguishers. The use of ozone-depleting substances is being phased out internationally as a result of the Montreal Protocol 1987. KPI 6 calls for metal emissions to air to be reported in metric-tonnes per year with a discussion of the type of metal, the mass emitted, particle size, and whether emitted from a point or dispersed source.

ISO 14031 suggests the use of indicators covering the quantity of specific emissions per year and per unit of output, the quantity of waste energy released to air, and the quantity of air emissions having ozone-depletion potential or global climate change potential.

It seems unsatisfactory to exclude the emissions of energy-producing companies (as in the UN Manual). There is no agreement as to whether emissions should be reported on an absolute basis or per unit of output (as in ISO 14031) or per unit of net value added (as in the UN Manual). This is an important question that will need to be resolved in developing a standard approach. As regards providing separate emissions data for each of the six greenhouse gases listed in the Kyoto Protocol, as required by the WBCSD Standard, this is clearly dependent on the nature of the reporting organisation and its emissions. Some of the indicators proposed in the UK Guidelines, such as the emissions to air of dust, particles and metal, would be relevant to only a small number of reporting organisations but their measurement in such cases may be a problem. Only the GRI Guidelines focus on initiatives to reduce harmful emissions, thereby, providing an opportunity to focus on the positive aspects and to demonstrate improvement.

18.2.2 Water Use and Discharge

The scarcity of water supplies particularly in certain regions and the potential ecological impacts of water discharge are matters of increasing concern. Efficient use of water and control of discharges is critical to operational performance and the avoidance of reputation risk. Measurements of water withdrawal, recycling or reuse, discharge, and consequent impacts on habitats are therefore of importance to a wide range of stakeholders.

The UN Manual specifically excludes water suppliers and distinguishes between off-stream use (most commercial, industrial, agricultural, and domestic applications) and in-stream water use such as power generation. Water consumption is the difference between water received and off-stream return flow, e.g. release of cooling water. The eco-efficiency derived is "water consumption per unit of net value added" and associated disclosures cover the amounts of water received from each source, return flow, waste-water treatment, and management policy.

The GRI Guidelines include indicators:

- EN 8 Total water withdrawal by source
- EN 9 Water sources significantly affected by withdrawal of water
- EN 10 Percentage and total volume of water recycled and reused
- EN 21 Total water discharge by quality and destination
- EN 25 Identity, size, protected status, and bio-diversity value of water bodies and related habitats significantly affected by the reporting organisation's discharges of water and runoff

EN 8 requires the total water withdrawal from all sources during the reporting period to be stated in cubic metres per year. Water suppliers are not specifically excluded nor are any adjustment proposed for cooling water returned to a water source. EN 9 is concerned with impacts on the eco-system caused by lowering the water-table due to significant water withdrawal. The information to be provided includes the size of water source or sources, whether designated as a protected area, and the bio-diversity value. Where an external supplier is involved the original water source should be reported. EN 10 calls for the total volume of water recycled and reused both per year and as a percentage of the total water withdrawal reported under EN 8.

EN 21 deals with water discharge and quality excluding collected rainwater and domestic waste-water. The total volume of planned and unplanned water discharges is reported in cubic metres per year by destination, treatment method, and whether it is reused by another organisation. Quality is determined according to national regulators of standard effluent parameters. Under EN 25 information is provided about any water bodies that are significantly affected by the reporting organisation's discharges including the volume of the receiving water body its biodiversity value and whether or not it is a protected area.

The UK Guidelines deal separately with water abstractions and emissions to water:

- KPI 14 Water use and abstraction
- KPI 7 Emissions of nutrients and organic pollutants
- KPI 8 Metal emissions to water

KPI 14 is concerned with water abstraction for public water-supply and for direct use by industrial or agricultural processes rather than supplied water which is reported as a supply-chain impact. Reuse or recycling is expected to be discussed but not quantified. KPI 7 addresses emissions to water that can cause pollution and disruption to habitats. Guidance is provided on measurement procedures resulting in disclosure of the volume and content of effluent discharged and the number and volume of any spills that have contributed to water pollution. In the case of metal emissions to water KPI 8 identifies a number of sectors and processes that may give rise to pollutants and requires disclosure of the emissions in kilograms per year together with details of the sampling and monitoring technique used.

ISO 14031 proposes the use of indicators quantifying the water used per unit of product, the quantity of water reused, specific materials discharged to water per unit of product, and the quantity of waste energy released to water.

The exclusion of water suppliers (as in the UN Manual and in ISO 14031) is a marked contrast with the focus of the UK Guidelines which are only concerned with public water-supply and suggest reporting water-use impacts separately as a supply-chain impact. The release of cooling water, treated as a deduction from water received in the UN Manual, but not giving rise to any adjustment in the GRI Guidelines, is another area of difference that needs to be borne in mind when making comparisons between performance indicators based on different proposals. Emissions of metals, nutrients, and organic pollutants, as proposed in the UK Guidelines, are likely to be relevant to only a small number of reporting organisations.

18.2.3 Waste and Emissions to Land

The disposal of waste, particularly hazardous waste and accidental spills, can have a significant impact on the environment and is increasingly the subject of regulation, fines, and penalties. On a more positive note, in addition to shrinking the environmental footprint, reducing waste usually has several financial benefits for an organisation through improved process efficiency and reduced transport costs. Indicators are, therefore, designed to measure the effectiveness of related policies and controls.

The UN Manual identifies waste as a non-product output with a negative or zero market-value, distinguishing between mineral and non-mineral waste. Disclosure comprises the weight or volume of waste generated per unit of net value added and includes waste treatment by incineration, land-fill and temporary on-site storage. The management policy is disclosed together with information about any schemes for energy recovery from the conversion of waste.

The GRI Guidelines include indicators:

- EN 22 Total weight of waste by type and disposal method
- EN 23 Total number and volume of significant spills
- EN 24 Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention and percentage of transported waste shipped internationally

EN 22 distinguishes between hazardous and non-hazardous waste and requires the total weight of waste to be classified by type and disposal method (as between recovery, reuse, recycling, incineration, land-fill, on-site storage, composting, or deep-well injection) with a statement as to how the disposal method was selected. EN 23 requires an organisation to state the total number and volume of recorded spills irrespective of whether these affect soil, water, air, bio-diversity or human health. For those spills that result in a liability included in the organisation's financial statements information about the location, volume, and material involved should be provided. Hazardous waste is addressed by EN 24 which requires the total weight of transported, imported, exported or treated hazardous waste to be identified and separately disclosed.

The UK Guidelines include:

- KPI 9 Pesticides and fertilisers
- KPI 10 Metal emissions to land
- KPI 11 Acids and organic pollutant emissions to land
- KPI 12 Waste (Recycling, recovery and land-fill)
- KPI 13 Radioactive waste

KPI 12 deals with non-hazardous waste whereas the other KPIs concern hazardous waste.

A distinction is made between land-fill, recovery (including waste incineration as a source of renewable energy), recycling, and reuse. Disclosures include the total amount in metric tonnes per year, the proportion disposed of in each way, and whether an estimation method has been used. In the case of pesticides and fertilisers (KPI 9), in addition to the total weight applied the total area treated should be reported. Metal emissions to land arising from industrial activities are reported in metric tonnes per year and whether an estimation method has been used. KPI 11 deals with spills and methods of estimation. The number of spills should be reported with the volume of any significant spills and whether an estimation method was used. Radioactive waste (KPI 13) is classified at three levels. Guidance is provided on measurement procedures and the reporting practice in each case.

ISO 14031 suggests the use of a number of possible indicators regarding waste and emissions to land. These include the total quantity of waste for disposal per year and per unit of product, the quantity of material sent to landfill per unit of product, the quantity of hazardous, recyclable or reusable waste produced per year, and the amount or type of wastes generated by contracted service providers. Other indicators could be the quantities of waste stored on site, waste controlled by permits, waste converted to reusable material per year, and the quantity of hazardous waste eliminated due to material substitution. Further examples deal with the quantity of effluent discharged per year and the quantity of effluent per service or per customer.

Disclosure of separate performance information relating to hazardous waste not proposed in the UN Manual is likely to be considered important by some stakeholders. Instead, the UN Manual distinguishes between mineral and non-mineral waste, which seems less significant and may cause difficulty in compiling the data. Accidental spills, which are specifically addressed in the GRI Guidelines and would be covered by the UK Manual (as KPI 11 in the case of spills to land and by KPI 7 in the case of water pollution) are not dealt with in the UN Manual or in ISO 14031.

Where such accidents occur, they are normally an important aspect of performance to report.

18.2.4 Energy Use

Organisations normally use energy direct from such sources as coal, natural gas or diesel, and/or indirectly from the purchase of electricity or other forms of imported energy. Efficient use of energy and the minimisation of environmental impacts can be monitored using information about consumption of energy from different energy sources and reductions achieved. Any initiatives to provide energy-efficient products and services offer a competitive advantage and the impact of such initiatives may be a relevant indicator.

The UN Manual is concerned with energy-users rather than energy-producers. The impacts of energy-use are dealt with in the context of greenhouse gases and contribution to global warming. A number of different forms and sources of energy are considered and tables of calorific values for a wide range of fuels in different countries (based on OECD figures) are provided. For the purpose of eco-efficiency reporting, energy is valued by its capacity to perform work, and the resulting indicator, after application of a factor to convert to thermal energy, measures the energy requirement per unit of net value added. This is disclosed, with the total energy requirement for the period and the amounts for each energy source, together with the related management policy.

The GRI Guidelines include:

- EN 3 Direct energy consumption by primary energy source
- EN 4 Indirect energy consumption by primary source
- EN 5 Energy saved due to conservation and efficiency improvements
- EN 6 Initiatives to provide energy-efficient or renewable energy-based products and services and reductions in energy requirements as a result of these initiatives
- EN 7 Initiatives to reduce indirect energy consumption and reductions achieved

Under EN 3, primary sources include direct non-renewable sources such as coal, natural gas, and fuel distilled from crude oil, whereas direct renewable sources include bio-mass, solar, wind, geo-thermal, and hydro-energy. Total energy consumed is derived from direct primary energy purchased plus direct primary energy produced less direct primary energy sold. Total energy consumption is stated in joules by primary source and a table is provided to convert volumes of primary energy sources to Giga-joules. EN 4 concerns indirect energy consumption i.e. energy used indirectly through the purchase of electricity, heat (or cooling), distilled fuel (e.g. diesel, LPG), steam, or other forms of imported energy. Using data from providers, an organisation is required to estimate the amount of primary fuels used to produce intermediate energy i.e. for most organisations, electricity and the corresponding primary energy consumed in its production, together with the total amount of indirect energy used, analysed by renewable and non-renewable sources.

EN 5 identifies the total energy saved through conservation and efficiency improvements. A single figure measured in joules is disclosed for the total amount of energy saved. Energy saved as a result of reduced production capacity or outsourcing should not be included. EN 6 deals with initiatives to provide energy-efficient or renewable energy-based products and services. As well as describing the initiatives an organisation is expected to quantify reductions in the energy requirements achieved during the period. Where normalised data is provided, assumptions are stated or industry standards used. EN 7 calls for a description of initiatives to reduce indirect energy consumption, with an estimate of the extent to which indirect energy use was reduced in four different areas and a statement of assumptions and methodologies.

As previously explained, the UK Guidelines deal with resource-use, including extraction from energy sources such as natural gas, oil, and coal but do not propose any specific disclosures from the viewpoint of energy consumption or conservation.

ISO 14031 suggests the use of indicators covering the total quantity of energy used per year or per unit of output, the quantity of each type of energy used, the quantity of energy used per service or customer, and, the quantity of energy units saved due to energy conservation programmes. For producers, the key indicators would be the quantity of energy generated by products or process streams and the land-area used to produce a unit of energy. For organisations with a vehicle fleet, examples also include the average fuel consumption.

Of the proposals examined only ISO 14031 extends the application of energy-use indicators to the energy generated by producers. This is likely to be useful information in monitoring total energy demand and trends although transmission from one region to another may distort the analysis. In the case of the UK Guidelines, energy-use is measured only from the viewpoint of consumption of resources such as natural gas, oil, and coal by volume or weight and there is no requirement to convert to energy units such as Giga-joules. This is a relatively complex area in view of the different conversion factors involved but the resulting performance indicators can be informative in saving energy and minimising environmental damage. Only the GRI Guidelines specify performance indicators that focus on the positive aspects such as savings in an organisation's energy consumption and initiatives to provide energy-efficient or renewable energy-based products and services.

18.2.5 Materials, Use of Resources, and Recycling

Conservation of the world's resources through reduced raw materials consumption and the use of recycled materials are widely regarded as a prerequisite for sustainable development and may also contribute to lower operating costs. As consumption increases, particularly in developing countries, restraint over resource-use becomes critical. Indicators are, therefore, designed to assist in monitoring the efficiency of material flows and the ability to use recycled inputs.

The UN Manual does not include specific eco-efficiency indicators dealing with materials use and recycling.

The GRI Guidelines include:

- EN 1 Materials used by weight or volume
- EN 2 Percentage of recycled input materials

EN 1 is concerned with conservation of global resources and calls for disclosure of the total weight or volume of materials used including materials purchased from external suppliers and those obtained from internal sources. The total may include raw materials that are part of the final product, semi-manufactured goods or components, and materials used in processing or packaging. The total weights or volume of non-renewable materials used (such as minerals, metals, oil, gas, and coal) and of direct materials used are reported separately. EN 2 requires disclosure of the percentage of recycled input materials as a proportion of the total materials used.

The UK Guidelines cover the use of resources:

- KPI 15 Natural gas
- KPI 16 Oil
- KPI 17 Metals
- KPI 18 Coal
- KPI 19 Minerals
- KPI 20 Aggregates
- KPI 21 Forestry
- KPI 22 Agricultural produce

KPI 15 and KPI 16 require the quantities of natural gas and oil extracted to be reported in cubic metres or barrels of oil equivalent per annum. KPI 17 requires metals extracted in metric tonnes extracted per annum broken down by type of metal. Under KPI 18, coal extracted is stated in metric tonnes per year by type of coal and method of extraction (deep mine or opencast). KPI 19 and KPI 20 require minerals and aggregates extracted to be reported in metric tonnes per annum by type of mineral or aggregate. Under KPI 21, organisations involved in forestry and logging are expected to report the volume of harvested timbers and other wood products in cubic metres per annum by type of wood (prior to any drying process), the area from which the wood was sourced, and any evidence as to whether legal or sustainably managed forests were used. KPI 22 requires extracted or sold agricultural resources including foodstuffs such as meat and fish, tobacco, rubber and other crops, to be reported in metric tonnes per annum by type of resource or species (prior to any drying process).

ISO 14031 includes a range of examples of performance indicators covering materials, the use of resources, and recycling. Amongst the management performance indicators listed are the number of products designed for disassembly, recycling or reuse, and financial savings through reductions in resource use, prevention of pollution, or waste recycling. Operational performance indicators include the quantity of materials used per unit of product, the quantity of processed, recycled or reused materials used, the quantity of packaging materials discarded or reused per unit of product, the quantity of auxiliary materials recycled or reused, and the quantities of raw materials and hazardous materials used in the production process.

Other indicators deal with the use of materials by contracted service providers such as the amount of hazardous materials and the amount of recyclable and reusable materials. ISO 14031 also suggests measuring the quantity of materials used during after-sales servicing of products.

Whether it is meaningful or practicable to disclose the total weight of direct materials used, as required by the GRI Guidelines, is somewhat doubtful. The UK Guidelines propose separate indicators by weight or volume for the use of non-renewable materials such as natural gas, oil, metals, coal, and minerals whereas the GRI Guidelines require this information as a single figure. Aggregates, forestry, and agricultural produce, which are covered by the UK Guidelines, are not mentioned in the GRI Guidelines. For certain organisations separate data for the use of these resources may be relevant. For all the indicators on material used there may be uncertainty as regards whether measurement should take account of materials inventories at the beginning and end of the reporting period. (This problem may also apply to other performance indicators although it is perhaps more significant in the case of material). Recycling and reuse of materials is addressed in the GRI Guidelines and ISO 14031 but the related data may be helpful in monitoring the use of resources.

18.3 Conclusions

Comparison of the proposals reviewed in this paper reveals a marked divergence and some overriding conclusions:

- Standardisation of environmental performance indicators in the foreseeable future is unlikely in view of the different approaches adopted by "standard-setting" parties.
- The GRI Guidelines incorporate a comprehensive set of performance indicators for most environmental aspects and offer a reasonable prospect of global acceptance in the medium-term.
- Coverage of the impact groups varies significantly between the different proposals, revealing gaps in some areas and substantial detail in others.
- Convergence on the underlying concepts and principles and on some key environmental performance indicators will be difficult to achieve without an increased degree of coordination and cooperation.
- Key performance indicators are identified (as core indicators) in the GRI Guidelines, whereas other proposals do not offer any equivalent differentiation. The GRI distinction between core indicators and additional indicators may be helpful to organisations in identifying key performance indicators.
- The needs of different groups of users, both internal and external users, are likely to differ significantly but are unlikely to be served in either case by information that is not reliable.
- It is important to support quantitative information about environmental performance with appropriate narrative explanation. The GRI requirement for disclosure

of an organisation's management approach is particularly helpful in this regard.

- A large number of detailed issues, such as the treatment of environmental performance by water and energy suppliers (excluded in the UN Manual), adjustment for opening and closing inventories in measuring materials usage, and the use of absolute numbers rather than ratios, will need to be resolved if convergence is to be achieved.

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Chapter 19
The Need for Standardised Disclosure on Climate-Risk in Financial Reports: Implications of the JICPA Reports

Takeshi Mizuguchi

Abstract Climate-change poses various risks to the sustainability of society and has a substantial impact on corporate value in the form of regulation and reputation risks, etc. Correspondingly, many investors are beginning to show an interest in information from companies regarding greenhouse gas (GHG) emissions. However, disclosures concerning climate-risk in both environmental and financial reports are not really adequate for investment decision-making. Although many companies are disclosing GHG emission data in their environmental reports the scope of the emissions covered varies from company to company which makes the information less useful. In relation to this issue the *Japanese Institute of Certified Public Accountants* (JICPA) published two research reports which examined disclosure practices concerning information on climate-risk in the environmental and financial reports of 26 companies. This study reviews these JICPA reports and discusses a possible direction for climate-risk disclosure.

19.1 Introduction

The *International Federation of Accountants* (IFAC) guidance document on environmental management accounting (EMA) described it as having both a monetary as well as a physical accounting dimension (IFAC 2005). It has also stated that EMA-type information is used for external reporting purposes and internal decision-making.

In this regard, environmental accounting practices in Japan were led by two major governmental initiatives; one by the *Ministry of the Environment* (MOE) and the other by the *Ministry of Economy, Trade and Industry* (METI) (Kokubu and Kurasaka 2002; Kokubu et al. 2003; Kokubu and Nashioka 2005). The MOE initiative focused on disclosing environmental protection costs and the corresponding environmental effects in environmental reports while METI dedicated itself to the

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internal use of EMA. Kokubu and Nashioka (2005) said that EMA is becoming widespread in Japanese companies although environmental accounting practices continue to be strongly influenced by the MOE guidelines. Recently, the METI conduct several projects for promoting material-flow cost-accounting (MFCA) as an effective tool of EMA (Kokubu and Nakajima 2004).

On the other hand, the Japanese government has not undertaken initiatives concerning environmental information disclosure in financial reports which are the main vehicles of information for investors. Therefore, the discussions and practices in this area LAG those in European countries. However, regarding this issue the *Japanese Institute of Certified Public Accountants* (JICPA) published research which reviewed current disclosure practices on climate-risk and suggested a direction for the improvement of disclosure (JICPA 2006, 2007).

The reports focused on the gap between the increasing needs of investors and the current status of disclosure regarding climate-risks. Although these reports are the results of studies by the *Environmental Accounting Technical Committee* within JICPA they do not mean that JICPA as a whole will actively promote the direction suggested by the reports to the government in the near future. However, the reports do include significant implications for the future possibility of environmental accounting and reporting.

The aim of this study is to discuss the necessity of standardised disclosure on greenhouse gas (GHG) emissions in financial reports with reference to the JICPA studies. First, it describes trends among investors concerning the social and environmental aspects of companies. Then it reviews the current status of social and environmental disclosure, focusing on climate risks in both environmental and financial reports. Finally, it discusses the suggestions contained in the JICPA reports and a possible direction for climate risk disclosure.

19.2 Trends Among Investors Concerning the Social and Environmental Aspects of Companies

There is a growing need among investors for information relating to the environment and society. These needs arise from socially responsible investment (SRI), as well as, traditional mainstream investors.

In 2005 SRI assets in the United States reached \$2.29 trillion which is 9.4% of the \$24.4 trillion in total assets under professional management (SIF 2006). In Europe in 2005, SRI assets reached €1.033 trillion (Eurosif 2006). These figures seem to show that SRI is increasingly spreading among common institutional investors and financial institutions. This implies that the need for environmental and social information for investment decision-making is now more widespread than ever.

Apart from traditional SRI the United Nations announced the *Principles for Responsible Investment* (PRI) on 27 April, 2006. These principles, which require institutional investors to incorporate environmental, social, and corporate governance (ESG) mechanism into the investment decision-making processes, were signed by 33 institutional investors that manage a total of \$2 trillion. Now, the aggregate amount of invested assets among these institutions has reached $10 trillion. These efforts represent an intention among mainstream investors as well as the traditional SRI community to attract attention towards ESG issues.

Concerning the Japanese market, Saotome (2007) estimated that fund-managed SRI assets amounted to 400 billion. Only the institutions that signed the PRI, as asset owners in Japan *Kikkoman Corporation Pension Fund* and *Taiyo Life*. These figures show that ESG Japanese institutional investors are still at an earlier stage of development than those in the US and Europe. However, Adachi (2007) stated that, from the viewpoint of an SRI researcher in Japan, the influence of the corporate value of social and environmental issues such as climate-risks will become pronounced and institutional investors will have to consider these issues even if they are not involved in SRI.

Indeed, initiatives requesting disclosure of information regarding climate change receive widespread support from investors. The *Carbon Disclosure Project* (CDP) is an on-going initiative supported by institutional investors from the UK and several other countries. In 2006, CDP, signed by 225 institutional investors with assets of $31.5 trillion, sent questionnaires to more than 2,100 companies around the world asking about their management policies on climate-risk and greenhouse gas emissions.

As another initiative, a network of institutional investors called the *Investor Network on Climate Risk* (INCR) for promoting corporate management and information disclosure with climate change consciousness was established in the US. The network includes more than 50 institutional investors that, as of 2007, collectively manage over $4 trillion in assets. It called on the U.S. *Securities and Exchange Commission* (SEC) to make it mandatory for publicly traded companies to disclose the financial risks of global warming in their securities filings during 2006 in cooperation with another investor network called the *Coalition for Environmentally Responsible Economies* (CERES). In 2007 they called on the SEC again to provide guidance on what kind of climate change related information should be included by companies in their financial reports. Moreover, the *Climate Risk Disclosure Initiative* (CRDI), a collective of investor groups including CERES, INCR, CDP and others, released a new statement entitled the *Global Framework for Climate Risk Disclosure*, in which they demonstrated the expected disclosure framework (CERES 2006).

19.3 Current Status of Disclosure Relating to Climate Risk

19.3.1 Disclosure in Environmental and CSR Reports

The question in this section concerns how companies respond to investors' needs for information on social and environmental matters such as climate-risks in Japan. Companies can provide this information in environmental or CSR reports, which are voluntary disclosures and in financial reports which are regulated by law.

There are many pioneering and respectable initiatives on social and environmental information disclosure. For example, in 2006 the *Global Reporting Initiative* (GRI) issued the third revision of the guidelines on sustainability reporting. These guidelines contain principles and standard disclosures that outline a disclosure framework that organisations can voluntarily, flexibly, and incrementally adopt. More and more companies have come to refer to these guidelines while preparing their CSR reports. Moreover, the MOE has also provided *Environmental Reporting Guidelines* since 1997. Although there is no legal obligation for the issuance of environmental or CSR reports in Japan, (MOE 2006) the number of companies that voluntarily issue these was greater than 900.

However, since this is a voluntary disclosure it is exercised by only a particular set of companies. Under these circumstances investors might not be able to obtain the necessary information about a company, even when their performance and actions on environmental issues have a material effect on business performance. Moreover, as voluntary disclosure is not subject to specific standards each company applies different environmental performance measurements, thus making it difficult to compare information. Indeed, Nashioka (2005) found that although all 483 companies disclosed some form of information on GHG emissions in their environmental or CSR reports, it was difficult to evaluate them using this information due to a lack of uniformity.

In relation to this, JICPA (2007) conducted a more detailed study on disclosure practices concerning information relating to climate-risks and revealed their diversity. It reviewed the environmental and financial reports of 26 major companies in the power, steel, and automobile industries which are the most important industries in Japan in terms of economic power and GHG emission.

According to JICPA (2007) all the companies in the study voluntarily disclosed their total GHG emissions. However, it pointed out that the scope of the data varied considerably. While the study includes a wide range of analysis the following tables clearly show the current situation concerning the disclosure practices on environmental information. Table 19.1 shows operations for which emissions data was reported. Many companies presented emissions resulting from production operations while others also reported emissions resulting from their administrative or transport operations. However, most companies did not clearly state the scope of their operations.

Table 19.2 shows the scope of those business facilities for which emissions data was reported. The study revealed that the scope varied considerably from company to company. Moreover, even when emissions by consolidated subsidiaries were reported, the data often did not cover all the subsidiaries.

These variations in the scope of GHG emission data obviously make the information less useful. For example, it is difficult to make appropriate calculations of eco-efficiency using this data because the reported GHG emission does not correspond to the sales or other financial data of a nother company or corporate group. As a result, it is impossible to make meaningful comparisons between companies in the same industry despite the existence of data from all the companies.

The fundamental reason for this is that there are no uniform standards on where to draw the boundaries when reporting data on emissions. The important consideration is that this problem was not resolved in spite of GRI and MOE guidelines.

Table 19.1 Operations for which GHG data was provided (JICPA 2007)

Operations	Power	Steel	Automobiles	Total
Only production operations	–	1	6	7
Production and transport operations presented separately	2	1	3	6
Production, administrative and transport operations presented separately	2	–	2	4
Production, transport and other operations. Whether administrative operations are included was not clear stated	2	–	–	2
Not stated or not clear stated	4	2	1	7
Total	10	4	12	26

Table 19.2 Business facilities/offices for which GHG data was provided (JICPA 2007)

Business facilities/offices	Power	Steel	Automobiles	Total
Only facilities/offices owned by the parent company	5	–	4	9
Facilities/offices owned by the parent company and *some* domestic consolidated subsidiaries	3	4	2	9
Facilities/offices owned by the parent company and *all* domestic consolidated subsidiaries	1	–	1	2
Facilities/offices owned by the parent company and *some domestic and overseas* consolidated subsidiaries	–	–	3	3
Facilities/offices owned by the parent company and *all domestic and overseas* consolidated subsidiaries	–	–	1	1
Not clear stated whether the data related to facilities/ offices owned by *all or some* consolidated subsidiaries	1	–	–	1
Not clear stated whether facilities/offices owned by subsidiaries are included	–	–	1	1
Total	10	4	12	26

19.3.2 Disclosure in Financial Reports

Financial reporting is usually regulated by laws and international standards. Financial reports provided by companies increasingly include information related to environmental and social issues.

The EU amended its directive on annual and consolidated accounting to apply international accounting standards. The amended directive requires both annual reports and consolidated annual reports to include an analysis of the development and performance of the company's business, and also requires that the analysis shall include both financial and, where appropriate, non-financial key performance indicators including information relating to environmental and employee matters to the extent necessary for understanding the company's development, performance or position.

This directive had a huge impact because it is enforceable on member countries. The respective countries created provisions for the disclosure of social and environmental information in annual reports. However, there will be no uniform disclosure practice across companies in the near future on any specific topic such as risks associated with climate change because the directive is not detailed enough to prescribe this.

In Japan, the financial reports which listed companies are legally required to issue under the *Financial Commodities Exchange Law* (formerly the *Securities Exchange Law*) are called securities reports. Environmental information may possibly be included in securities reports under the sections entitled *Issues to be Addressed, Risks to Business Analysis of Financial Condition and Performance* and *Research and Development Activities*, and under provisions, impairment accounting, or footnotes on contingent liability in financial statements.

Regarding *Risks to Business*, it is prescribed that a specific, easy-to-understand and concise statement shall be given collectively about those matters which might have a significant impact on an investor's decision. Although no direct reference to environmental issues is made, a statement would have to be given if there were any matter connected to an environmental issue 'that might have a significant impact on an investor's decision'.

How, then, are actual disclosure practices undertaken? On this subject, Kozuma (2006) conducted an empirical study of 339 companies that prepare environmental or CSR reports and issue securities reports. According to him, all 339 companies disclosed social information and 258 disclosed environmental information. However, many companies disclosed nothing more than a general statement of their environmentally conscious attitude under *Issues to be Addressed*. Most statements given under *Risks to Business* were broad comments such as 'a strengthened regulation would become a risk factor to business performance' etc. Furthermore, there were no cases of quantitative information disclosure except for one company that stated numerical data concerning actual and target CO_2 emissions and recycled wastes.

JICPA (2007) also pointed out that securities reports by 26 companies that descriptions concerning climate risk in securities reports are usually limited to just one or a few lines acknowledging global warming as one of their *Issues to be Addressed* or *Risks to Business*, while there are some cases providing concrete and detailed descriptions of their activities regarding global warming. None of the companies covered by the JICPA (2007) study provided actual data on GHG emissions in their securities reports.

These studies show that despite many companies disclosing statements on environmental issues the information is limited and there is no uniform disclosure practice across companies. It is natural that securities reports contain less information about climate change than do environmental or CSR reports since they are designed to provide information of a financial nature. However, this suggests that under the current rules it may be impossible to respond to the new issue of climate-risk which is expected to become important in the future. While under the current disclosure rules each company is free to choose the contents of its securities reports on environmental issues, creating more specific disclosure rules and unified standards for topics deemed have an important common effect might lead useful information.

19.4 Necessity for and Possibility of Standardised Disclosure on GHG Emission

Most important is that investors clearly declare that they require information on climate-risk. At the same time, most companies that issue environmental or CSR reports have provided data on their actual GHG emissions. Nevertheless, despite the efforts of GRI and MOE in issuing and promoting guidelines the information on GHG emission disclosed by each company is less useful for investors due to the lack of uniformity. On the other hand, while all listed companies are required by the *Financial Commodities Exchange Law* to issue securities reports there is no detailed rule or guideline for environmental information even in the case that a particular environmental issue is vital to corporate value. This suggests that for quantitative information, tightly defined standards would serve better than voluntary guidelines in ensuring the usefulness of such information.

Of course, voluntary disclosure has its own advantages. Since each company operates a different business under different circumstances and organisational structures and puts varying importance on different environmental issues disclosing information voluntarily and flexibly according to the specific characteristics of the company can result in a more appropriate disclosure. In this respect, it makes sense that environmental and CSR reports have developed as a voluntary action on the part of companies. However, while standardization and comparability of information are not always necessary, certain types of information which are quantitative and material for most companies are better standardised, as shown in Table 19.3.

On view of this, JICPA (2006) proposed a standardised disclosure system for investors using the data from the new reporting framework on GHG emissions established by the Japanese government. In Japan, a mandatory reporting system for GHG emissions was introduced under the *Law Concerning the Promotion of the Measures to Cope with Global Warming* (hereafter referred to as the *Anti-Global Warming Measures Law*). This law requires certain companies to calculate and report their GHG emissions to the national government. It also requires that the

Table 19.3 Types of issues and types of Information

	Types of issues	
Types of information	Specific issues for particular companies	Common issues for most companies
Qualitative information	Stakeholder engagement Voluntary disclosure	Guidelines Voluntary disclosure
Quantitative information	Stakeholder engagement Voluntary disclosure	Standardised disclosure

national government summarise the reported information and make it publicly available. Entities subject to the reporting obligation are specified emitters set out by the law. They submit a report in a prescribed form as shown in Fig. 19.1 by the 30th June of every fiscal year. The public can, obtain the information on GHG emissions on a site-by-site basis.

JICPA (2006) stated that as GHG emissions reported under this system are calculated in accordance with the law the emissions have a clear basis for calculation and can, therefore, be presumed to be highly comparable. The range of entities subject to the obligatory reporting is extensive enough to cover sites with high emissions. Accordingly, emissions reported in accordance with the law are probably fit to be used as fundamental data for information to be disclosed to investors, as far as GHG emissions in Japan are concerned.

JICPA (2006) also pointed out that using the information for the purpose of disclosure to investors would not result in additional effort or cost for companies. Moreover, keeping in mind that such information will be released to the public it is unlikely that companies have reason to avoid disclosing it. On the other hand, if investors were to individually make use of information, they would have to make a request for disclosure. For this reason, investors could benefit from the incorporation of such information into the system of disclosure.

JICPA (2006) also showed an example of a disclosure form for GHG emissions and information relating to disclosure in securities reports to provide sufficient information to investors, (Fig. 19.2). According to JICPA (2006) this disclosure form is designed for incorporation into securities reports with the boundaries for organisations to be covered within the scope of consolidation in financial reporting. In reality, the line-up of consolidated companies may change every year as a result of buying or selling a subsidiary. Under the proposal, details of any change that has a material impact on GHG emissions should be noted together with the emissions concerning that subsidiary.

JICPA (2006) intends to use the information regarding domestic emissions based on what is reported under the *Anti-Global Warming Measures Law*. However, overseas emissions also should serve as important information for investors. Information on emissions at overseas sites, by country, or by region is included in the disclosure form although it is difficult to calculate overseas emissions as accurately as domestic ones. JICPA (2006) recognises that there are several issues to be discussed such as the treatment of volumes of GHG credits acquired from, as well as those sold to, external parties through emissions trading

Report year: FY (year)

<table>
<tr><td>Specified emitter code</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">*</td></tr>
<tr><td>Prefecture code</td><td></td><td></td><td colspan="8">Business code</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Whether or not the reporter is a Type I designated energy management factory etc. under the Law Concerning the Rationalization of Energy Use (if yes, enter the applicable number and the designation number under the said law)</td><td colspan="13">1. Type I designated energy management factory
2. Type II designated energy management factory</td><td></td></tr>
<tr><td colspan="4">Designated energy management factory designation number</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Notes:

1) In the columns for ‘Specified emitter code’, ‘Prefecture code’ and ‘Business code’, enter the codes assigned, respectively, to the specified emitter, its prefecture and business as set out by the Ministry of the Environment and the Ministry of Economy, Trade and Industry.
2) Do not fill out the columns marked with *.

Table I: Calculated greenhouse gas emissions (Part 1)

Classification of substance with a greenhouse effect	Calculated greenhouse gas emission
1) Carbon dioxide generated as a result of energy use	t-CO_2
2) Carbon dioxide other than carbon dioxide generated as a result of energy use	t-CO_2
3) Methane	t-CO_2
4) Dinitrogen monoxide	t-CO_2
5) Hydrofluorocarbons	t-CO_2
6) Perfluorocarbons	t-CO_2
7) Sulfur hexafluoride	t-CO_2

Notes:

1) In the column for ‘Calculated greenhouse gas emission’ of ‘Carbon dioxide generated as a result of energy use,’ enter the total volume of the following (excluding those related to supply of electricity or heat to someone else): (1) Emission of carbon dioxide generated as a result of fuel use; (2) Emission of carbon dioxide generated as a result of electricity use; (3) Emission of carbon dioxide generated as a result of heat use
2) If the site for which this report is submitted is a power station used for the purpose of electricity service business conducted as a main business, or is a site on which a heat supply system used for the purpose of heat supply service business conducted as a main business is installed, enter necessary information in Table 2, in addition to this Table.
3) If the site for which this Report is submitted is a Type I designated energy management factory or a Type II designated energy management factory under the Law Concerning the Rationalization of Energy Use, it is not necessary to fill out the column for ‘Calculated greenhouse gas emission’ of ‘Carbon dioxide generated as a result of energy use’. (The remainder has been omitted)

Fig. 19.1 Report form under the anti-global warming measures Law (excerpts)

1) Action policies of a company on the global warming issue
2) Management structure
3) Risk information
4) Greenhouse gas emission targets, analysis and evaluation
5) Specific measures
6) Future plans

4) **Greenhouse gas emissions (actual record) (in tons of CO_2)**

[Current Business Year]		**Business A**	**Business B**	**Common**	**Total**
Domestic	Carbon dioxide in production				
	Other greenhouse gases in production				
	Sales and management etc.				
	Transportation and distribution				
	Volume grandfathered by Anti-Global Warming Measures Law				
	Subtotal				
US					
EU					
China					
Other					
Total					
Volume of emission credits acquired from (sold to) external sources					

Greenhouse gas emissions at the stage of product or service use

[Current Business Year]	**Total**
Business A	
Business B	

Fig. 19.2 Sample disclosure form (JICPA (2006))

and CDM (a method of estimation and treatment of life cycle emissions at the stage of product use), the approach to the treatment of GHG emissions by a non-100% subsidiary, and so on.

The proposal described above will be a good starting point for discussion in Japan although it is unlikely that the Japanese government will establish a standard for the disclosure of GHG emission data in securities reports in the near future because the *Ministry of Finance*, which governs the *Financial Commodities Exchange Law*, does not seem interested in the matter. Moreover, since neither corporate activities nor climate risks are limited to any country international efforts in pursuit of common global standards for calculating and disclosing GHG emissions would be desirable.

19.5 Conclusion

Certain kinds of environmental issues are directly reflected in actual costs, such as, inefficient use of materials. For tackling these issues, EMA tools that capture the monetary impacts on companies would be useful. On the other hand, there are issues not directly reflected in actual costs but that influence corporate value such as climate change. These impacts are not directly reflected in the current financial information of most companies. However, investors are increasingly demonstrating their need for such information; therefore, companies need to manage them directly using physical data even though they are not easily converted into monetary data. In this sense, improving the physical accounting aspect of EMA, especially for GHG emissions, including discussion about standardised disclosure would be important for the further development of EMA.

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Chapter 20
Environmental Management Accounting Practices in Japanese Manufacturing Sites

Katsuhiko Kokubu and Eriko Nashioka

Abstract Previous questionnaire surveys on environmental management accounting (EMA) practices in Japan have targeted managers in environmental departments in corporate headquarters as being representative of the company perspective. By conducting a questionnaire survey in manufacturing sites this paper attempts to clarify Japanese corporate EMA practices at the operational level. Since environmental departments in headquarters are presumed to have considerable influence on the introduction and performance of environmental accounting at sites this study analyses the relationship between manufacturing sites and headquarters. As a result, the following points were identified. First, the main purpose of environmental accounting at manufacturing sites is to send data to headquarters. Second, approximately half of the sites in the sample used environmental accounting for internal management and environmental accounting was felt to be more useful at these sites than at those which did not use it for internal management. Third, an effective headquarters advises sites about the introduction of environmental accounting for internal management.

20.1 Introduction

In Japan, environmental accounting practices were developing rapidly. The turning point was the publication of the Environmental Accounting Guidelines by the Ministry of the Environment in 2000. The guidelines were revised twice, in 2002 and in 2005 (MOE 2005). The main purpose of Environmental Accounting Guidelines is to show a relationship between environmental conservation costs and environmental

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conservation effects, and, to emphasise environmental accounting information disclosure in voluntarily published corporate environmental reports. In practice, therefore, environmental accounting in Japan developed as a medium for external disclosure (Kokubu and Kurasaka 2002, Kokubu et al. 2003). This is in marked contrast to the situation in Europe and the US (see, for example, Bennett and James, 1999) where the focus was on environmental management accounting (EMA) is oriented towards internal management.

In relation to EMA, the Ministry of Economy, Trade and Industry (METI) published an Environmental Management Accounting Technique Workbook in 2002 (METI 2002). Previous surveys found a gradual but steady spread of EMA in Japanese corporate practice (Kokubu and Nashioka, 2005). Manufacturing sites such as factories measure environmental accounting information and make use of it for internal management. While the environmental departments in headquarters aggregate and disclose corporate environmental accounting information they are only indirectly concerned with those activities that cause environmental costs and effects. Nevertheless, previous questionnaire-type surveys almost exclusively targeted environmental departments based in the headquarters of Japanese companies and virtually none targeted the manufacturing sites where environmental accounting is carried out. At an international level, major studies based on a questionnaire survey (for example, Burritt et al. 2003; Collison et al. 2003) also targeted environmental departments or financial directors at headquarters.

The purpose of this paper is to clarify Japanese corporate EMA practices at the operational level by conducting a questionnaire survey at the manufacturing sites where environmental accounting is actually implemented. In this sense, strategic use of environmental accounting at headquarters is located outside the paper. However, since environmental departments in headquarters are presumed to have considerable influence on the introduction and performance of environmental accounting at sites the relationships between environmental departments and manufacturing sites were also examined. As mentioned, in Japanese environmental accounting practices, at the level of headquarters, the external disclosure purpose is more dominant, so examining this point at site level is the main research focuses in this paper.

20.2 Research Purpose and Sample Selection

To analyse environmental accounting practices in Japanese manufacturing sites our questionnaire targeted companies that publish environmental reports and are listed in four business categories on the First Section of the Tokyo Stock Exchange: Chemicals, Electrical appliances, Pharmaceuticals, and Transport machinery. Manufacturing sites disclosed in these companies' environmental reports were then selected. The reason for targeting these four industry sectors was that they are at the forefront of environmental accounting initiatives and it seemed likely that EMA would be well-developed at their sites.

Electrical appliances and transport machinery are two industry sectors in Japan with a good environmental management record and a considerable number of companies in these sectors have achieved a sophisticated level of environmental accounting information disclosure. The pharmaceutical industry includes some companies which are interested in materials flow cost-accounting which is one of the leading EMA techniques (Kokubu and Nakajima 2003). In 2003, the Japan Chemical Industry Association published environmental accounting guidelines for chemical companies and tried to promote environmental accounting in the sector. Consequently, environmental accounting practices of these sectors are relatively advanced among Japanese companies and the survey results should be understood as reflecting this trend.

The survey targeted a total of 136 companies in the four industries. Each of these companies had its own headquarters and 1,148 manufacturing sites which were disclosed in the environmental reports. Questionnaires were sent to all these headquarters and manufacturing sites. Responses were received from 75 headquarters (55.1%) and 255 sites (19.6%). The number of headquarters from each industry sector that responded was: Chemicals 26 (55 questionnaires sent); Pharmaceuticals 9 (12 questionnaires sent); Electrical appliances 33 (57 questionnaires sent); and Transportation machinery 7 (12 questionnaires sent). The number of sites that responded was: Chemicals 75 (353 questionnaires sent); Pharmaceuticals 13 (55 questionnaires sent); Electrical appliances 157 (667 questionnaires sent); and Transportation machinery 10 (73 questionnaires sent). The survey period was from 1 to 31 March 2004.

The main objective of the survey was to reveal how environmental accounting practices were carried out at manufacturing sites. In this study, the research focus is on whether the purpose of environmental accounting was only to collect data for inclusion in published environmental reports or whether it was also for use in internal management. By analysing environmental accounting techniques and their effects we explored what type of environmental accounting at manufacturing sites should be useful. Moreover, since it is generally considered that headquarters environmental departments would play a large part in environmental accounting practices at their manufacturing sites the influence of the headquarters' policies and advice on environmental accounting practices at their manufacturing sites was also examined.

20.3 General Trends of Environmental Accounting Practices at Manufacturing Sites in Japan

The first question was whether environmental accounting had been introduced at the sites. The results are shown in Table 20.1: 228 sites (89.4%) had introduced environmental accounting, and 27 sites (10.6%) had not. At the level of headquarters, 72 companies (96.0%) had introduced environmental accounting while 3 (4.0%) had not. It is clear that environmental accounting has been fairly widespread at manufacturing sites. For the following questions 228 sites and 72 headquarters are taken as the denominators to calculate ratios.

The next question examined the reason for introducing environmental accounting and the results are shown in Table 20.2. 215 sites (94.3%) replied that this was on the advice of headquarters, while 22 (9.6%) replied that they had taken the decision independently (since several methods of environmental accounting exist this was a multiple answer question). It is clear that few sites replied that they had introduced environmental accounting on their own initiative and that when introducing environmental accounting advice from headquarters played an important role.

Most of the activities at a site are based on the production plans at headquarters and on environmental conservation which places restrictions on manufacturing activities — the site generally follows the advice headquarters. While the introduction of environmental accounting is considered useful for manufacturing sites because it improves production efficiency it seems that without advice from headquarters the sites may not take this step.

Environmental accounting has the twofold purpose of external information disclosure and internal management. For sites, however, there is an additional purpose of sending data to their headquarters. Table 20.3 shows the results of answers relating to these three purposes.

It is to be expected that most companies have "to send data to headquarters" as one purpose since their headquarters need to aggregate environmental accounting information at a company-wide level. However, only about 50% of sites responded with either of the independent site-oriented purposes i.e. "to be used for internal management" or "to include environmental accounting information in site reports". The purposes of environmental accounting at headquarters are shown in Table 20.4.

Table 20.1 Manufacturing sites which have introduced environmental accounting (N = 255)

Have introduced	228 (89.4%)
Have not introduced	27 (10.6%)
No answer	0 (0.0%)

Table 20.2 Reasons for introducing environmental accounting at sites (N = 228, multiple answers allowed)

Advice from headquarters	215 (94.3%)
Site's independent decision	22 (9.6%)
No answer	2 (0.8%)

Table 20.3 Purpose of environmental accounting at sites (N = 228, multiple answers allowed)

To send data to headquarters	213 (93.4%)
To be used for internal management	126 (55.3%)
To disclose environmental accounting information in site reports	107 (46.9%)

Table 20. 4 Purposes of environmental accounting at headquarters (N = 72)

Internal management significantly more important than external information disclosure	5 (6.9%)
Internal management slightly more important than external information disclosure	13 (18.1%)
External information disclosure slightly more important than internal management	37 (51.4%)
External information disclosure significantly more important than internal management	17 (23.6%)
No answer	0 (0.0%)

Clear those companies that emphasise external information disclosure purposes outnumber those that emphasise internal management. These results are consistent with the results of the previous survey by Kokubu and Nashioka (2005).

Table 20.4 shows that from the perspective of headquarters 18 companies (25%) regard internal management as more important than external information disclosure as the purpose of environmental accounting, but on the other hand 75% of companies perceive external information disclosure to be more important. It is to be expected that the emphasis at headquarters affects the view of sites on this issue.

20.4 Environmental Accounting for Internal Management in Manufacturing Sites

While external information disclosure, including data from sites to headquarters, was viewed as the major purpose for introducing environmental accounting both at headquarters and sites is environmental accounting actually used at sites for internal management? Over half the companies introducing environmental accounting intended to use environmental accounting for internal management (Table 20.3—55.3%) and about 53.5% of sites actually did (Table 20.5). However, the remaining sites (45.6%) did not use environmental accounting for internal management.

Table 20.6 shows the aspects for which sites use environmental accounting information in internal management accounting. The values in parentheses refer to percentages calculated using the number of sites employing environmental accounting for internal management (122) as the denominator. These results show that using environmental accounting for improving production processes and waste management is the most popular while many companies also use environmental accounting for budget compilation and investment appraisal. The fact that fewer sites use environmental accounting for product design and development is linked to the observation that this is not a function of manufacturing sites.

The effectiveness of EMA depends on the techniques applied. Appropriate techniques should be used for appropriate decision purposes and so the next question

Table 20.5 Use of environmental accounting for internal management at sites (N = 228)

Using environmental accounting for internal management	122 (53.5%)
Not using environmental accounting for internal management	104 (45.6%)
No answer	2 (0.9%)

Table 20.6 For which aspect of internal management is environmental accounting used at sites? (N = 122)

Improving production processes and waste management	94 (77.0%)
Investment appraisal	76 (62.3%)
Budget compilation	71 (58.2%)
Designing and developing products	51 (41.8%)

Table 20.7 Types of environmental accounting used at sites (multiple answers allowed)

	Use of environmental accounting intended for external disclosure	Use of environmental accounting intended for internal management
Budget compilation for environmental protection (N = 71)	67 (94.4%)	6 (8.5%)
Product design and development (N = 51)	48 (94.1%)	4 (7.8%)
Investment appraisal (N = 76)	69 (90.8%)	10 (13.2%)
Improving production processes and waste management (N = 94)	77 (81.9%)	23 (24.5%)

is what sort of environmental accounting do sites use for these purposes? Table 20.7 shows the results in relation to the categories of different types of use of environmental accounting intended for external disclosure and for internal management respectively. Since both types of environmental accounting were used in some cases multiple answers were permitted. The percentages in parentheses were calculated using as the population the number of sites which used environmental accounting for each category of purpose shown in Table 20.6.

As Table 20.7 makes clear, most sites employed environmental accounting originally intended for external disclosure for various internal management purposes such as budget compilation for environmental protection. Only a very few companies used environmental accounting specifically intended for internal management. As discussed by Kokubu and Kurasaka (2001) and Kokubu et al., (2003) environmental accounting for external disclosure in Japanese companies basically depends on the MOE environmental accounting guidelines. However, because the guidelines define 'environmental cost' as environmental protection cost excluding materials and energy costs its usefulness for internal management is limited (Kokubu and Nashioka 2005). Therefore, Japanese manufacturing sites need to introduce other

EMA to fulfil internal management purposes. However, a relatively large number of sites (23) used environmental accounting for improving production processes and waste management. Eight sites mentioned that materials flow cost-accounting is used for this purpose. Since flow cost-accounting is seen as an effective method for several Japanese manufacturing companies (Kokubu and Nakajima 2003) this trend seems likely to spread in the future.

20.5 Effectiveness of Environmental Accounting at Manufacturing Sites

The introduction of environmental accounting into internal management is not synonymous with an increase in its usefulness. Since no objective index exists to measure the usefulness of environmental accounting the questionnaire offered respondents four options to generate a subjective assessment of awareness. The results are shown in Table 20.8.

From Table 20.8 it can be seen that whilst about 65% of sites recognised that environmental accounting was either very useful or effective to a certain extent 35% considered that it was either “not particularly useful” or “virtually not at all useful.” A site’s perception of the effectiveness of environmental accounting depends on how it uses environmental accounting information for its activities. If it is only a matter of collecting data and sending it back to headquarters, it is less likely that the importance of environmental accounting will be recognised in those sites. It is only when environmental accounting is applied for internal management purposes at sites that its effectiveness will be perceived. As Table 20.5 showed, 45.6% of sites did not use environmental accounting for internal management and this may be a major reason why it is difficult to be aware of its usefulness at the site level.

The above point is examined further by comparing the usefulness of environmental accounting between the two groups of companies distinguished in Table 20.5: those that use environmental accounting for internal management, and those that do not. For the answers in Table 20.8 about the usefulness of environmental accounting 4 points were given for “very useful”, 3 for “useful to some extent,” 2 for “not particularly useful,” and 1 for “virtually not at all useful.” The average

Table 20.8 Awareness of the usefulness of environmental accounting (N = 228)

Very useful	13 (5.7%)
Useful to some extent	135 (59.2%)
Not particularly useful	62 (27.2%)
Virtually not at all useful	17 (7.5%)
No answer	1 (0.4%)

score for each group was then calculated and the difference examined using the t-test. The results are shown in Table 20.9. As is apparent from this table, the score indicating the usefulness of environmental accounting was 2.94 for the group that used environmental accounting for internal management and was considerably higher than the average of 2.27 for the group that did not. The result of the t-test shows that this difference is statistically significant at the 1% level.

For the four categories shown in Table 20.7 when the same method was used to test the difference in the usefulness of environmental accounting between those companies that used it for internal management and those that did not it was found that the former had a significantly higher score at the 5% level in terms of usefulness for budget compilation and at the 1% level for the other categories. These results are shown in Tables 20.10–20.13 which exclude those sites that do not employ the particular internal management tool. For example, the sites that do not compile a budget for environmental protection are excluded from of Table 20.10.

These results demonstrate that sites that make use of environmental accounting for internal management have a higher awareness of its usefulness than those that do not. This indicates that environmental accounting does have a noticeable effect on sites' internal management and suggests that to enhance the awareness of environmental accounting's usefulness it is important to promote its use not only for sending data to headquarters but for internal management too.

Table 20.9 Comparison of the usefulness of environmental accounting for internal management (N = 226, $t = 7.90$, $p = 0.000$)

	Effectiveness of environmental accounting
Group using environmental accounting for internal management	2.94 (N = 122)
Group not using environmental accounting for internal management	2.27 (N = 104)

Table 20.10 Comparison of usefulness of environmental accounting for budget compilation for environmental protection (N = 111, $t = 2.18$, $p = 0.031$)

	Effectiveness of environmental accounting
Group using environmental accounting for budget compilation	3.06 (N = 71)
Group not using environmental accounting for budget compilation	2.83 (N = 40)

Table 20.11 Comparison of usefulness of environmental accounting for investment appraisal (N = 119, $t = 3.48$, $p = 0.000$)

	Effectiveness of environmental accounting
Group using environmental accounting for investment appraisal	3.07 (N= 76)
Group not using environmental accounting for investment appraisal	2.72 (N= 43)

Table 20.12 Comparison of usefulness of environmental accounting for improving production processes and waste management (N = 122, $t = 3.49$, $p = 0.000$)

	Effectiveness of environmental accounting
Group using environmental accounting for improving production processes and waste management	3.03 (N = 94)
Group not using environmental accounting for improving production processes and waste management	2.64 (N = 28)

Table 20.13 Comparison of usefulness of environmental accounting for product design and development (N = 99, $t = 3.48$, $p = 0.000$)

	Effectiveness of environmental accounting
Group using environmental accounting for product design and development	3.12 (N = 51)
Group not using environmental accounting for product design and development	2.73 (N = 44)

20.6 Relationship Between Headquarters and Manufacturing Sites for Environmental Accounting Practices

As shown in Table 20.2 when sites decide to introduce environmental accounting, advice from their headquarters plays a key role. This is considered to be applicable for introducing environmental accounting intended for internal management purposes. Table 20.14 shows how many headquarters provide any advice on introducing this type of environmental accounting. (The population consists of 72 of the 75 companies that responded omitting the 3 companies that had not introduced environmental accounting).

Table 20.14 Does the headquarters advise sites on introducing EMA techniques intended for internal management? (N = 72)

Advice given	14 (19.4%)
No advice given	58 (80.6%)
No answer	0 (0.0%)

Table 20.15 Relationship between advice from headquarters (HQ) about the introduction of EMA and its use at sites (N = 155, $\chi^2 = 11.58$, $p = 0.000$)

	Advice from HQ	No advice from HQ	Total
Sites using environmental accounting for internal management	50	35	85
Sites not using environmental accounting for internal management	22	48	70
Total	72	83	155

These results show the small number of headquarters that advise sites to introduce EMA techniques intended for internal management—fewer than 20%. It is clear that such advice is not common as a business practice. However, when the 14 companies that did give advice were asked what sort of techniques they advised, materials flow cost-accounting was mentioned by 10 companies and came top of the list. Although this number is small it suggests that for manufacturing sites, materials flow cost-accounting is quite popular compared to other EMA techniques.

Did these sites actually follow the advice given by their headquarters? The relationship between the advice of headquarters and the actual use of environmental accounting for internal management is examined in Table 20.15. It reveals that based on the results of the Chi-square test and significant at the 1% level a higher proportion of sites advised by headquarters about the introduction of environmental accounting used this method for internal management than sites that were not, confirming that advice from headquarters actually does influence decisions at the site level.

Table 20.16 sets out a comparison of the perceived usefulness of environmental accounting, distinguishing between sites advised by their headquarters about the introduction of environmental accounting (N = 72), and those that were not (N = 83). The usefulness score was calculated by the same technique as in the previous section, based on the results of Table 20.8.

It is clear from Table 20.16 that sites that received advice from headquarters about the introduction of EMA had a higher awareness of the usefulness of environmental accounting than those that received no such advice (based on t-test results, significant at the 1% level). Since, predictably, a higher proportion of sites that were advised by their headquarters this is evidence of the importance of advice from headquarters to sites about introducing EMA techniques.

Table 20.16 Advice from headquarters about EMA and perceived usefulness of environmental accounting (N = 155, $t = 2.79$, $p = 0.00$)

	Perceived usefulness of environmental accounting
Sites which were advised by headquarters about the introduction of EMA	2.85 (N = 72)
Sites which were not advised by headquarters about the introduction of EMA	2.54 (N = 83)

20.7 Conclusion

The authors carried out an analysis based on the results of a questionnaire survey of trends in environmental accounting practice at sites and in the corporate headquarters of four industry sectors: Electrical appliances, Chemicals, Pharmaceuticals and Transport machinery. As a result, the following points were identified:

- The main purpose of environmental accounting at sites is to send data to headquarters
- Approximately half of the sites responding used environmental accounting for internal management and environmental accounting was felt to be more useful at these sites than at those that did not use it for internal management
- It is effective for headquarters to advise sites about the introduction of environmental accounting for internal management. At these sites there is an increased awareness of the usefulness of environmental accounting

Most of the manufacturing sites whose headquarters adopted environmental accounting are obliged to collect environmental accounting data. This is mainly because Japanese companies employ environmental accounting to follow MOE guidelines which focus on external disclosure. However, the fact that almost 50% of sites did not use environmental accounting for internal management is the main reason why awareness of the usefulness of environmental accounting remains low at many sites.

Environmental accounting can be used effectively at an operational level only if it is used at sites where actual business activity takes place. Whilst strategic use of environmental accounting is outside the scope of this paper these findings would have also some implications for headquarters for the construction of environmental accounting systems in the company. It has been shown that the important thing is not simply to send data to headquarters but to make use of environmental accounting information internally. For this to happen, advice from headquarters is important. Sites which actually use environmental accounting for internal management tend to rate the usefulness of environmental accounting more highly than those which do not. This also suggests the importance of promoting the use of environmental accounting for internal management.

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Part VI
Case Studies in EMA

Chapter 21
Waste Reduction Program Based on IFAC'S EMA Guideline in Danisco A/S

Lars Munkøe and Christine Jasch

Abstract In 2005 and 2006, *Danisco A/S* carried out a corporate pilot program, *Global Waste Initiative*, for testing the adequateness of International Federation of Accountants guidance document on environmental management accounting (EMA) as a tool for production sites in the global bio-tech and food ingredients industrial sector. The chosen pilot sites were diverse from a geographical and production process point-of-view demonstrate differences and similarities. The objectives of the assessments were (1) to investigate EMA as a strategic cost assessment tool for subsequent identification and evaluation of environmental saving initiatives; (2) comparison of EMA results versus annual, reported environmental costs for production sites; (3) to evaluate EMA as a benchmarking tool; and (4) to evaluate required resources for future EMA assessments. The main conclusions of the three pilot assessments were that the overall environment-related costs are considerably higher than the perception of the individual sites and their management. Additionally, the assessments demonstrated a need for strengthening the relation between the environmental and accounting functions of a manufacturing facility to make use of EMA for improvement of environmental efficiency.

21.1 Introduction

21.1.1 Danisco

Danisco is a global business-to-business supplier of enzymes and food ingredients and supplies customers from more than 70 manufacturing facilities throughout the world and more than 10,000 employees world-wide.

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Headquarters are located in Copenhagen, Denmark and the company has worked with sustainability for several years and reports on its performance according to the *Global Reporting Initiative* on an annual basis. *Danisco* is a member of the *Dow Jones Sustainability Index* and the *FTSE4Good Index* and subscribes to the United Nations' *Global Compact* principles.

Danisco's department for Sustainable Development is responsible for key environmental and social areas such as energy, waste, health, safety and the supply-chain, and manages the *Global Waste Initiative*.

21.1.2 Waste Reduction Program at Danisco

A global program for *Danisco* was launched in 2005 focusing on waste and waste-water reducing initiatives. Pilot assessments using environmental management accounting (EMA) were conducted at three of the manufacturing facilities in Finland, France, and United States of America. The intention was to illustrate EMA as a strategic cost assessment tool for identification of environmental saving initiatives.

21.2 Objectives

To illustrate the adequateness of EMA in relation to the waste reduction program three independent pilot assessments were conducted and evaluated. The objectives of these assessments were:

- Investigate EMA as a strategic cost assessment tool for subsequent identification and evaluation of environmental saving initiatives
- Comparison of EMA results with annual reported environmental costs
- Evaluate EMA as a benchmarking tool for each production site between production sites
- Evaluate required resources for EMA assessments

All assessments were based on Jasch (n.d.) and Savage and Jasch (2005). Environmental costs as defined by the International Federation of Accountants (IFAC) guidance document comprise costs for emission control and prevention which are also subject to reporting to national authorities. In addition, the costs for material purchase were assessed and the so-called non-product outputs of material inputs were included in the total environmental costs scheme. This included costs for energy, water input, and operating materials (as by definition they are not part of the product) and losses of raw and auxiliary materials. That way, waste and emissions were evaluated not only by their disposal and treatment costs but also by the material purchase price.

In addition to the costs, which were visible to the waste management department, the assessment revealed several costs, which had been posted to other accounts – and therefore got lost when trying to come up with the total environmental costs e.g. for external disclosure purposes. Direct costs are costs that are posted to a production cost-centre or product and can be traced comparatively easy once the related cost-centre or product has been identified as environmentally relevant. Indirect costs are posted to general overhead accounts and are very difficult to be traced later onwards as the accounts often do not contain remarks on the separate bookings but simply invoice numbers. The environmental costs revealed by the EMA methodology may have been posted to several cost-centres and accounts but are often lost during aggregation as the information flow between the different departments is not non-functioning.

21.3 Pilot Sites

Three production sites at *Danisco* were chosen to participate in the EMA assessments. They are substantially different with regard to products, production processes, utility systems, legal requirements and geography. The intentions were to reveal differences and similarities of the environment-related cost structure across technologies, cultures, and countries.

21.3.1 Danisco Sweeteners OY, Kotka, Finland

The facility is located on the southern coast of Finland. The main product of the facility is *Xylitol* a sweetener used chewing gum and toothpaste. The site has a pre-treatment system for waste water and purchases both power and thermal energy from a bio-mass-based combined heat and power plant close to the facility. As the site is adjacent to the sea the production uses seawater cooling as an alternative to ground water. The site has 170 employees and is certified according to *ISO 9001* and *ISO 14001*.

21.3.2 Danisco USA Inc., Kansas, USA

The facility is a stand-alone facility in an industrial area near Kansas City. The main product is emulsifiers based on vegetable oils. The site purchases power and natural gas for steam production. Waste-water is processed in a pre-treatment system before being discharged to a public treatment facility.

The site has 120 employees and is certified according to *ISO 9001, ISO 14001,* and *OHSAS 18001*.

21.3.3 Danisco SAS, Melle, France

The facility is located in the south-west of France. The main product is *xanthan gum*, a texturing ingredient used in various industrial products. The production facility purchases various utilities and services from an industrial facility nearby and does not, as such, treat waste or waste-water. The plant's energy supply is outsourced. The site has 100 employees and did not have *ISO 14001* or *OHSAS 18001* management systems in place at the time of the assessment.

This EMA assessment was conducted from a local *Danisco* office in Paris with access to the accounting system (SAP) and with the participation of the local accounting manager and a process technician from the Melle production site.

21.4 Conducting EMA Assessments

Based on the three assessments experiences and feedback was collected to evaluate the value added by EMA.

21.4.1 Resources

The experience of the EMA assessments at *Danisco* show that the environmental manager barely has access to the actual cost-accounting documents of the company and only is aware of a fraction of the aggregated environmental costs. In contrast, the controller has most of the information but is unable to separate the environmental part without further guidance. In addition, he or she is limited to thinking within the framework of existing accounts. Also, the two departments, by nature, tend to have different cultures and communicate differently. So, for the EMA assessments, a team was put together consisting of the environmental manager, a production manager, and people working with cost accounting and controlling.

In later years, the time needed for the joint assessment could be limited to a couple of hours, but in principle, the environmental manager knows what to look for but does not know where to find it in the information system while the accounting people know where to find data but do not know what is environmentally relevant.

Each assessment required approximately three people per site for 2 days to complete an EMA assessment and mass balance for a fiscal year. In total, an average of 6 people days is representative of this pilot assessment. The assessment in Melle was conducted in only 1 day but did not include a mass balance for the site. All assessments indicated that future assessments for the sites could be conducted with limited resources compared to this initial assessment. Resources required for the assessment would be an accountant, environmental manager, and the production manager of a facility.

21.4.2 Sources of Information

To conduct an assessment the required information is linked to various sources and information systems. All sites have IT systems covering finance, warehouse management, and environmental performance reporting.

The assessments were based on the previous business year as several accounts were only adjusted annually, e.g. material consumption or provisions for remediation. But as several additional costs had to be estimated, e.g. the time of internal personnel spent on environmental training multiplied by average hourly rates, even though most of the data is taken from bookkeeping accounts, EMA is a cost-accounting tool and cannot be taken solely from financial accounts. Data were also collected from relevant cost centres, to the degree they are available, e.g. for the waste-water treatment plant and other equipment defined as environmentally relevant. Other information sources were stock management and production monitoring systems, which were especially relevant for development of the mass balance and the loss percentages for the different raw and auxiliary materials and for products produced. In spite of this, considerable parts of the assessment were spent on collecting and verifying information to complete the assessment and to ensure consistency of data from various sources.

The assessment started by establishing a mass balance in volumes and recording the related material consumption prices. This often reveals recommendations for stock management regarding the consistent recording of volumes instead of individual figures and other units and regarding the posting of changes in stock to the different specified material categories. Next, the loss percentages for different raw and auxiliary materials were discussed among the accounting department and production which may use average standard estimates and the production and quality managers who have data estimated and records which are based on actual production experiences.

The next step in the assessment was the definition of the different environmentally relevant equipments which are separated in end-of pipe technologies and integrated prevention technologies. The environmental share of this had to be estimated by production and the environmental manager. In addition, equipment producing significant amounts of waste and emissions were defined. For all these types of equipment the accountants traced or estimated the annual depreciation.

For sites operating an environmental management system the environmental manager reported on the projects carried out last year and on any other significant environmentally relevant activities. Tracing the costs related to these activities and the remaining EMA cost categories from the various accounts and previously defined cost-centres was the last step to completing the assessment.

21.4.3 Average Distribution of Environmental Costs

The environment-related costs for the fiscal year 2004–2005 were analysed from two perspectives: cost categories and environmental domains. The average cost distribution of all three sites is shown in Table 21.1. The distinction by environmental domains follows the reporting requirements of European statistical offices for reporting businesses' environmental protection expenditures to Eurostat, the statistical arm of the *European Commission* (Eurostat 2001). The national statistical offices collect the required information directly from businesses. The member countries of the *Organisation for Economic Co-operation and Development* (OECD) also use the *European Commission* domains as does the *System of Integrated Environmental and Economic Accounting* (SEEA) of the *United Nations* (UN 2003).

The assessments were conducted in a spreadsheet where the detailed information was captured and included the source of information. As the costs traced were posted to several accounts and cost-centres for accounting purposes it made sense to collect them separately in a spreadsheet instead of making changes to the accounting system so that e.g. all environmental costs would be included in a separate cost-centre named environmental management. There are, however, recommendations for improving the accounting system to facilitate data assessment; these are recorded in Section 21.5.5. The spreadsheet automatically produces a one-page overview of total costs and a corresponding percentage distribution.

The percentage distribution of the average costs from the *Danisco* sites indicates that the total energy purchase and resulting impact on air and climate accounts for 52% of the total costs by environmental domain. The other important environmental domains impacted are water, waste-water and solid waste with 24% and 23% of total costs. General environmental management accounts for 1% only but several of the columns requested by national statistical reporting of environmental costs are not relevant for this business sector (soil and groundwater protection, noise, dust, vibration, bio-diversity and radiation).

When analysed by cost category, the first category contains the total costs for materials, energy, and water input that also relate to the mass balance (not disclosed here). The mass balance and the corresponding costs for material inputs are also basic information in environmental and sustainability reporting. The environmental statement of the *EMAS Regulations* (EC 2001) requires the disclosure of figures on pollutant emissions, waste generation, consumption of raw material, energy, water, and noise. The data should allow for year-by-year comparison to assess the development of the environmental performance of the organisation. The guidelines on sustainability reporting published by the *Global Reporting Initiative* (GRI 2006) also require the disclosure on the total amounts of material inputs waste. In addition,

Table 21.1 Environmental costs as a percentage of environmental domain and cost categories, average of all three site assessments

	Environmental domain								
Environment-related cost categories	Air and climate	Waste-water	Waste	Soil, surface and groundwater	Noise, dust and vibration	Bio-diversity and landscape	Radiation	Other	Total
1 Material costs of products									
1.1 Raw and auxiliary materials								87	87
1.2 Packaging materials								5	5
1.3 Merchandise									
1.4 Operating materials								2	2
1.5 Water									
1.6 Energy								6	6
Total material costs of products								100	100
2 Material costs non-products outputs	52	15	21						88
2.1 Raw and auxiliary materials	2	7	5						14
2.2 Packaging materials			1						1
2.3 Operating materials	2	5	14						21
2.4 Water		3							3
2.5 Energy	48								48
2.6 Processing costs			2						2
3 Waste an emission control costs	1	8	1					1	11
3.1 Equipment depreciation		1							1
3.2 Operating materials									
3.3 Water and energy		5							5
3.4 Internal personnel		1							1
3.5 External services									
3.6 Fees, taxes and permits		1	1						2
3.7 Fines									
3.8 Insurance									
3.9 Remediation and compensation									
4 Preventive and other environmental management costs								1	1
4.1 Equipment depreciation									
4.2 Operating materials, water, energy									
4.3 Internal personnel								1	1
4.4 External services									
4.5 Other									

(continued)

Table 21.1 (continued)

	Environmental domain								
Environment-related cost categories	Air and climate	Waste water	Waste	Soil, surface and groundwater	Noise, dust and vibration	Bio-diversity and landscape	Radiation	Other	Total
5 Research and development costs									
6 Less tangible costs									
Total environment-related costs (2 + 3 + 4 + 5 + 6)	52	24	23					1	101
7 Environment-related earnings									
7.1 Other earnings			−1						−1
7.2 Subsidies									
Total environment-related earnings			−1						−1
Total environment-related costs and earnings	52	24	23					1	100

indicator *ENVIRONMENT 30* on environmental costs directly references the cost categories 3, 4 and 5 of the IFAC guidance document.

Cost category 1 is not included in the total annual environmental costs as the material costs for products are the core part of production costs. The assessment of total material inputs is a prerequisite for defining the material costs of non-product outputs which are considered the environmentally relevant share aggregated into total annual environmental costs (cost category 2). The cost category for non-product outputs contains information on all material (including water and energy) from cost category 1 which is not sold as a product. For raw materials, auxiliary materials, and packaging materials this implies estimating the loss percentages by material group unless they are already recorded by the quality management department. Operating materials are by definition not included in the product and thus recorded with the total purchase value. In addition, the processing costs of non-conforming or expired products are added. The resulting amount indicates the purchase value of waste.

Materials costs of non-product output accounts for about 88% of the total environment-related costs of the three assessments. This highlights the fact that when comparing the costs of non-product materials with the costs of environmental protection and management the latter is comparatively negligible.

Waste and emission control accounts for 11% of total costs while prevention makes up only 1%. Prevention costs in the assessments mostly consist of costs for internal personnel in the environmental management department plus external consultants dealing with specific projects. Generally speaking, control deals with emissions produced, which is always costly, while prevention starts at an earlier stage and helps to reduce the costs of non-product output (cost category 2) and emission control (category 3). The cost distribution indicates that it could make sense to increase investments in preventive measures to reduce the costs for non-product output and emission control.

Costs for emission control are mostly connected with waste-water treatment and related equipment, water input, energy costs, and personnel that could sometimes be taken directly from the cost-centre for the waste-water treatment plant. Disposal fees, waste-water treatment fees and related permits account for only 2% of total costs.

There are no significant costs for environment-related research and development activities. Also, it has not been attempted to estimate less tangible costs e.g. the risk of costs related to future regulation or estimates for costs related to external impacts of waste and emissions as these estimates contain highly subjective values while all other costs can easily be taken from existing accounting and other records. Lastly, earnings resulting from the sale of materials from recycling and reuse have also been recorded.

21.4.4 Distribution of Environment-Related Costs for the Three Different Sites

The distribution of environment-related costs in the different environmental domains shows a tendency for the three sites (see Fig. 21.1).

Emissions to air make up the largest cost as this area comprises the total energy costs for production. Both Kotka and Melle purchase thermal energy and electricity from a supplier while thermal energy is produced on site in Kansas. As the products for each site are different by nature the energy intensity of the products is not comparable. None of the sites have a waste-water treatment plant on site but the distribution illustrates considerable variances in the relative cost share of waste-water.

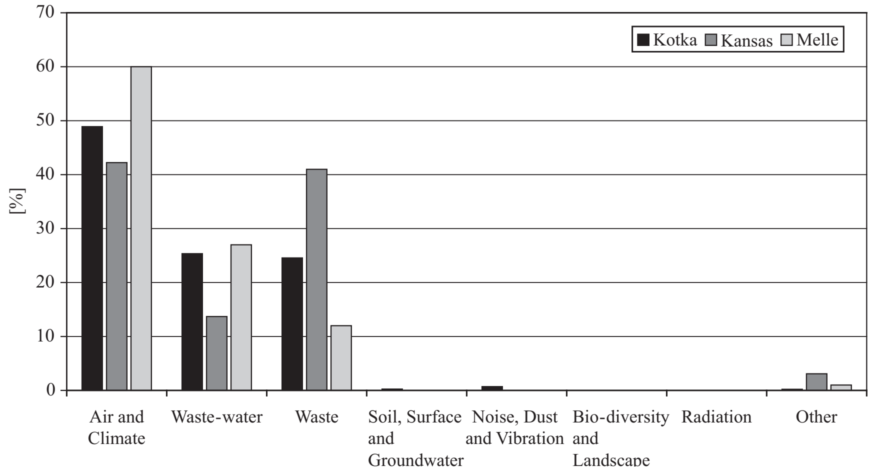

Fig. 21.1 Distribution of environment-related costs in environmental domains

The relative costs for handling waste shows great differences between the sites. In Kansas, more than 40% of the total costs related to waste originating from losses in raw and auxiliary materials. In Melle and Kotka, a considerable part of the raw material losses ends up in the waste-water (see Fig. 21.2).

The distribution of the cost categories clearly indicates material costs for non-products output as the major environment-related cost for the sites. This is not surprising as this category also includes energy consumption for the entire production (see Figs. 21.3 and 21.4).

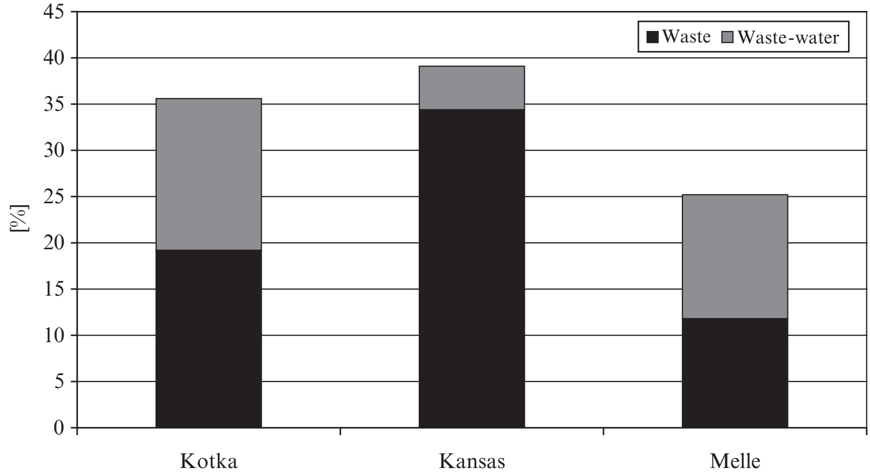

Fig. 21.2 Distribution of relative costs of non-product outputs (operation, raw and auxiliary materials) by environmental domain

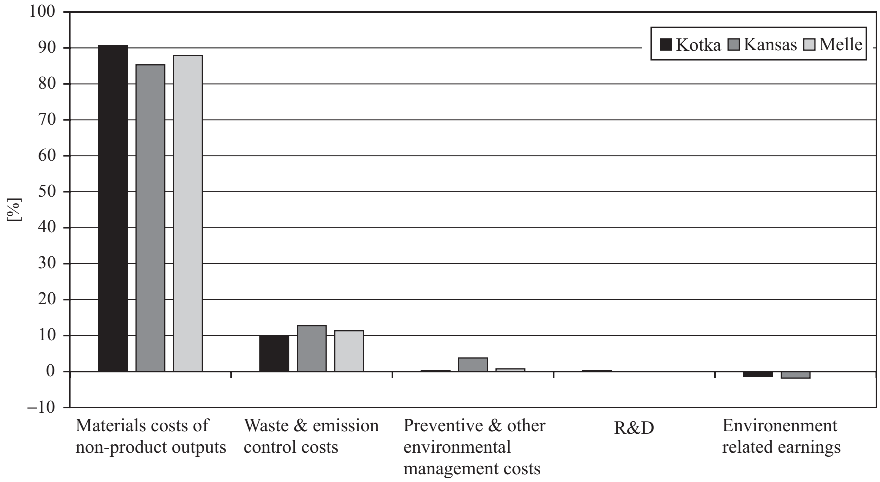

Fig. 21.3 Distribution of environment-related costs in cost categories

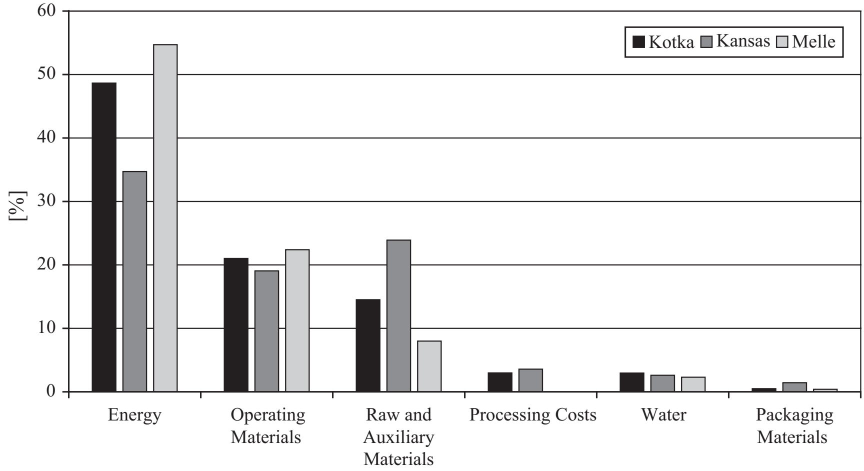

Fig. 21.4 Distribution of materials costs of non-product output in sub categories

Though the costs of non-product outputs is the dominant cost category the composition shows some variation between the sites, see Fig. 21.4.

21.5 Analysis

The assessments and subsequent feedback from the production sites form the basis for an evaluation, reflecting the objectives.

21.5.1 EMA vs. Reported Environmental Costs

The sites collect on an annual basis the costs for waste, waste-water, and energy while the EMA assessment clearly defines the costs in the categories for control and prevention from different perspectives and takes into account the costs of losses. For this reason the EMA environment-related costs differs considerable from the usual way of making up the environmental costs for the sites. Figure 21.5 illustrates the differences which mainly represent the value of the lost materials purchase.

21.5.2 EMA for Benchmarking

Both the local management team and the divisional management at *Danisco* found EMA excellent as a future benchmarking tool. The value added by EMA for the site

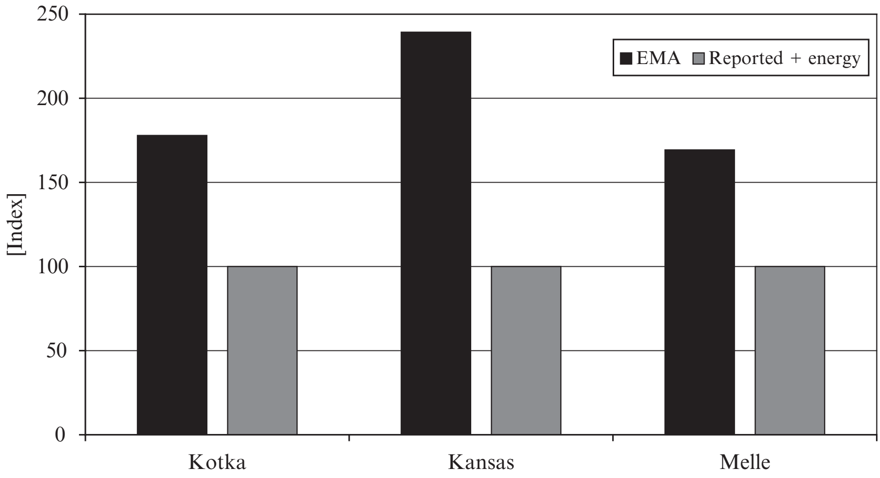

Fig. 21.5 Reported annual environmental expenses including energy vs. EMA environment-related expenses

management is that it is possible to track costs over time for each environmental domain. A detailed picture of each element of the environmental costs enables both the management and the production organisation to improve performance and thus reduce the environmental impact.

21.5.3 Implementation of EMA in Danisco

The implementation plan for *Danisco*'s production sites is still at an early stage but the considerations are described below. For integration purposes with the environmental organisation of the sites the implementation process will be initiated by the corporate organisation, making use of existing structures and tools. When implementing *ISO 14001* and *OHSAS 18001 Danisco* established working groups with representatives of the individual sites responsible for the local implementation. It would seem natural to anchor the implementation of EMA in this organisation as well.

A tool for following up and addressing EMA with the local management would be the current sustainability audit program at *Danisco*. The corporate sustainable development department conducts audits with the purpose of sharing knowledge across the company structure and strengthen the scope of sustainability within the company. As it has been the case with previous corporate initiatives the audit scope could be extended to comprise EMA related topics. This would offer an opportunity to discuss implementation, environmental improvements, and benchmarking related subjects with the local management on a regular basis.

At the end of 2006, *Danisco* faced the need for a new corporate environmental reporting tool for the production sites. The tool used by the production sites for reporting environmental as well as health and safety data was no longer adequate. The data structure of the existing reporting tool did not match the categories defined in Section 21.2 of this contribution but as the tool was replaced *Danisco* revised the data structure in order to facilitate the future use of EMA.

21.5.4 Environmental Saving Initiatives

Though the site management focuses on the main cost categories and elements all three sites identified the EMA assessment as valuable due to the cross-disciplinary nature of the analysis.

The break-down of costs into the environmental domains and the inclusion of the costs of material losses into the analysis were found useful when evaluating environmental performance and continuous improvements. The sites have in place environmental management systems which ensure a focus and commitment of the management to improve the environmental impact from the site. EMA offers in addition the link between the environmental management system and the environment related costs. Benchmarking between the sites and benchmarking the individual sites over time will reveal differences of operation and technology platforms and such inspire for improvements.

Based on the assessment for Melle an energy audit was conducted in late autumn 2006. Of the three assessments the energy share of non-product output accounted for more than 50% in the case of Melle. The audit resulted in considerable energy savings but will not be discussed in details here. The case illustrates EMA as a tool for management. EMA offers the global overview for the local management on which environmental domain, from a cost point of view, could be assessed further. Facing the limitation of budgets and productiveness in manufacturing the managers of the sites approved EMA as a tool for increasing the understanding of the nature of the environment related expenses and a help to improve the environmental performance with the means available.

21.5.5 Resources for Future EMA Assessments

As expected, the initial EMA assessment was rather time-consuming for all sites compared to the time normally invested to report to headquarter on environmental expenditure. Each assessment required approximately three persons per site for 2 days to complete an EMA assessment and mass balance for a fiscal year. In total, an average of 6 person days is representative of this pilot assessment. Nevertheless, all teams stated that future assessments would be uncomplicated as the workflow and information sources have been identified. The three sites estimate that approximately one half day only will be needed for future assessments. In addition, the consistency and comparability of data was improved significantly.

21.5.6 EMA Assessment Recommendations

The assessments produced individual spreadsheets on total environment-related costs and their source of information and a protocol with recommendations to facilitate data collection in the future. Most of them relate to the recording of material purchase and use of the warehouse and accounting system:

- Separate accounts should be established for the different raw, auxiliary, packaging and operating materials. In the list of accounts a distinction should be made between raw and auxiliary materials and packaging which becomes a product with loss percentages. As by definition, operating materials are not included in the product these are considered as waste and emissions
- A procedure for aggregation should be set up by subgroups from the single materials numbers in the stock management system
- The inventory variances should be posted at the end of a fiscal year and separated for each material group and include a separate recording of the price and volume difference this way accurate data on materials inputs and outputs in volume and price could be obtained
- Volumes should be added gradually to the individual figures recorded for the single material numbers in the stock management system. This way, consumption would be aggregated automatically into volumes. Consistent use of units (kg) in the ERP system would ensure that the total sum automatically aggregated does not have to be manually corrected

Other recommendations dealt with the estimation of loss percentages, new accounts for utilities, the recording of sales from recycled materials, and the definition of environmentally relevant equipment:

- Calculation and measuring of loss percentages for the different materials groups should be considered
- Accounts for materials, utilities, and supply versus accounts for services should be clearly distinguished
- Separate accounts for the utilities (energy, water) should be established and defined as direct costs of production
- A clear corporate and sector specific definition of what is environmentally relevant equipment needs to be developed as an internal standard. The current interpretations of the people carrying out the assessment are broad and often contain highly efficient production equipment as well as maintenance expenses. An interpretation of aggregated data on corporate level is thus hampered
- A separate cost-centre for waste-water treatment should be installed where applicable to be able to directly trace the related material and energy input and other related costs

- A classification sign in the list of assets for environmentally relevant equipment should be provided to improve traceability
- Earnings from sales of scrap metals, steam condensate etc., should not be offset directly against the materials purchase account. Instead separate accounts for other earnings from by-products should be established
- Materials and supplies for maintenance from maintenance services could be separated allowing for the total materials input to be calculated

21.6 Conclusion

The conclusions for the pilot sites showed several similarities. In the case of Kotka and Kansas a consistent mass balance should be established covering the fiscal year May 2004–April 2005.

In all cases, the initial assessments could be conducted in 2 days on site with limited resources. For one of the sites (Melle) the assessment could even be conducted in 1 day from a remote location (the headquarters in Paris) with access to the ERP system and with participation of an accountant and a process engineer. It was estimated by the sites that future assessments could be conducted in less than 1 day by local resources.

In spite of the limited resources for conducting future assessments EMA was found suitable as a benchmarking tool between production sites. As future assessments of the individual sites will reveal the development in environment-related costs, new focus areas will be discovered. Benchmarking between sites using a comparable technology platform was also interesting from a management perspective in spite of cultural and regional differences.

As expected, the costs of non-products outputs are considerable in all cases while costs for environmental control are minor. The evaluation also indicated EMA as a suitable tool for benchmarking between sites and useful for identifying cost-flows in production over time.

A subsequent evaluation with the local site management revealed important aspects regarding the interfaces between the administration and management of the sites and the organisations related to production and environmental control. In general, production has a considerable focus on the reduction of material losses and product yield in all cases. In spite of this, the related costs of material losses identified by EMA were not obvious for this part of production in the daily work. Similarly, the focus of the environmental organisation was mainly on environmental control costs and only to a minor extent on the environment-related costs and cost categories.

An important discovery was that EMA offers a strengthened linkage between environmental management systems and business by offering increased integration of information from management, production and the environmental organisation.

The total environment-related costs in each assessment far exceeded the perception of the local organisations. By presenting an alternative and detailed cost structure for the environmental domains and usually increased environment-related costs management is offered a more precise tool for evaluating investments and environmental initiatives. As a consequence, management may improve both environmental and financial performance when prioritising environmental focuses and setting environmental targets.

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Chapter 22
Implementing Material Flow Cost Accounting in a Pharmaceutical Company

Yasushi Onishi, Katsuhiko Kokubu, and Michiyasu Nakajima

Abstract In Japan, several dozen companies are now attempting to introduce material flow cost accounting (MFCA) through a project initiated by the Ministry of Economy, Trade and Industry (METI) and others. Nevertheless, the majority of companies that have introduced MFCA have used it in only a single project for the purpose of cost study and few companies use it continually to conduct improvement activities. In this paper, we present the case of Tanabe Seiyaku Co. Ltd., which has succeeded in the implementation and organisation-wide deployment of MFCA, in order to analyse the primary factors leading to the use of MFCA in continual waste reduction. Our results demonstrate that MFCA data is reflected in the departmental and employee performance evaluation at Tanabe Seiyaku as part of its management control systems and this mechanism is the key to the continual use of MFCA within the company.

22.1 Introduction

Milne (1996) criticised the fact that traditional management accounting potentially provides insufficient information to decision-makers for making informed decisions by failing to include environmental impacts. To integrate these into decision-making, several environmental management accounting (EMA) techniques have been developed. These include life-cycle costing (Kreuze and Newell

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S. Schaltegger et al. (eds.) *Environmental Management Accounting for Cleaner Production*,

1994), full cost accounting (Bailey 1991, USEPA 1996), total cost assessment (USEPA 1992) and the balanced scorecard for sustainability (Epstein and Wisner 2001, Figge et al. 2003).

In Japan, over 13,000 sites are certified according to ISO14001 environmental management systems, and a survey by the Japanese Ministry of the Environment (MOE) shows that more than 700 companies have introduced some kind of environmental accounting technique (MOE 2005). The publication of the environmental accounting guidelines by the MOE in 2000 was the turning point for environmental accounting diffusion in Japan. A survey conducted by Kokubu et al. (2003) showed that the number of Japanese companies adopting the MOE guidelines in order to classify environmental costs was greater than the number of those adopting other guidelines. However, most companies used environmental accounting only for disclosure to external stakeholders, and only a few used it internally. Following the MOE initiative, METI undertook a project to introduce EMA techniques into Japanese companies (Kokubu and Nakajima 2004, see also Burritt and Saka, 2006). The MFCA implementation project in particular achieved remarkable success.

MFCA has been developed in Germany as an EMA technique (Strobel and Redmann 2001, 2002). In Japan, METI launched a project in 1999 to promote EMA using a 3-year plan, in which Japanese companies were urged to introduce MFCA as the principal technique for EMA (see Kokubu et al. 2003). As part of this project, METI experimentally introduced MFCA in four Japanese companies (Nitto Denko Corporation, Tanabe Seiyaku Co. Ltd., Takiron Co. Ltd. and Canon Inc.). The results were presented in the Environmental Management Accounting Technique Workbook published by METI in 2002, and since 2004, METI has been engaged in two projects to promote the use of MFCA. One is a project for large companies, and the other is for small and medium-sized companies. Through these projects, 12 sites at 8 large companies and 15 sites at 15 small and medium-sized companies introduced MFCA in 2004. In addition, other MFCA projects such as that by the Kansai Research Centre, Institute for Global Environmental Strategies (IGES-Kansai) are also underway and about 30 companies have announced the introduction of MFCA.

Most companies that have introduced MFCA use it for a special cost study (Japan Management Association Consulting 2005) without using it continually as a corporate information system. However, by linking MFCA with their corporate information systems, some companies use it continually by incorporating it into their management control systems (i.e. the formal information-based routines and procedures that managers use to maintain or alter patterns in organisational activities) (Simons 1995, see also Anthony 1965 and Otley 1999). In this paper we use Tanabe Seiyaku Co. Ltd. as the prime example of this type of company, with the objective of clarifying through interviews the mechanism that leads to the continual in-house use of MFCA. After reviewing the development of MFCA in the next section, we examine approaches towards introducing and practicing it, and present our research questions. Next, we analyse MFCA practice at Tanabe Seiyaku and provide some implications.

22.2 Development of MFCA

The original form of MFCA was developed in Germany by IMU (Strobel and Redmann 2001, 2002). MFCA is a system that measures materials flows (and stocks) in factories (or processes), in terms of both physical as well as monetary amounts (see Fig. 22.1).

Based on calculations used under the MFCA technique, production costs within a company can be divided into three categories: materials costs, system costs and delivery and disposal costs (Strobel and Redmann, 2002). Materials costs are the purchase costs of raw materials. System costs are for transporting materials within the company, and include labour costs and depreciation of machinery. Delivery and disposal costs refer to costs of transportation out of the company, and include packaging costs, fuel costs of vehicles, and charges for waste disposal. These costs are aggregated based on the physical materials flows of finished products for sale and of non-product outputs (i.e. wastes and emissions) to make a flow chart with data and a flow cost matrix. A flow chart with data is characterised by mapping the materials flow structure in a company and referring to the data on materials, system and delivery and disposal costs. A flow cost matrix is defined as a tabular-form flow cost accounting data in simplified and standardised form at a defined threshold-cut in the flow model (Strobel and Redmann, 2002).Waste and emission costs do not create value for the company. Strobel and Redmann (2002) claimed that material costs account for a considerable percentage of total production costs and that a significant share of these costs arises out of materials losses (see also UNDSD

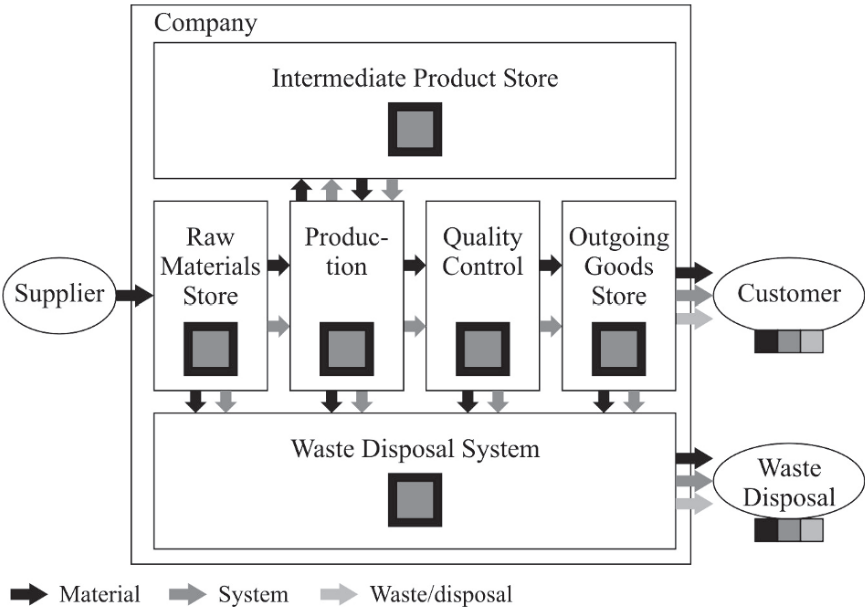

Fig. 22.1 Materials flows within a company (Strobel and Redmann 2002:71)

2001, Gale 2006). A remarkable aspect of the MFCA technique is that waste, which previously had often been measured in terms of weight alone, was now assessed as a cost as well.

In conventional cost accounting methods, the emphasis is on the appropriate estimation of materials input into the factory or process. The physical amount of input materials wasted during manufacture is considered less important. This is because, if the costs of the raw materials that end up as waste were hidden in production costs, the company would not be able to identify the benefits of reducing wastes. In conventional cost accounting methods waste costs therefore tend to be systematically overlooked. Consequently, from the viewpoint of waste reduction, traditional techniques have their limitations. A variety of activities must be conducted if waste is to be reduced. It is unlikely that companies will embark on concrete waste reduction measures unless they know the extent to which this will benefit them. By measuring the cost of waste, something that conventional cost accounting often overlooks, MFCA helps to create concrete action plans for reducing waste and to make proposals for improvement measures. Waste reduction not only lessens the environmental impact but also reduces overall costs, including raw materials, processing and waste disposal costs. These reductions simultaneously result in both environmental conservation and financial benefits. Although MFCA is based on physical materials flow information, environmental impact assessment has not yet been integrated into MFCA so it is not a technique that can at present be used for calculating the full costs of the environmental burden, including social costs for externalities. However, companies can advance their environmental management in order to mitigate environmental impacts by using MFCA to find opportunities to reduce waste and improve resource efficiency. Conventional environmental management systems (EMS) represented by ISO14001 (see ISO 2004; Ammenberg and Sundin 2006) lack a technique for analysing the costs and benefits of environmental protection activities so, for most employees in a company, there are not many incentives to improve environmental performance. However, through MFCA analysis, employees are able to find economic incentives to reduce wastes because it eventually means reducing the costs of input materials.

MFCA is now attracting international attention. It has been introduced as a major environmental management technique in the United Nations Environmental Management Accounting Workbook (UNDSD 2001) and the International Federation of Accountants' Environmental Management Accounting Guidance Document (IFAC 2005). The importance of materials flow-oriented cost accounting, including MFCA and waste cost accounting, has been pointed out by Pojasek and Cali (1991), Rooney (1993), Pojasek (1997), USEPA (1988, 2000, 2001) and Loew (2003), while its future importance has also been discussed (Burritt 2004).

In Japan, the spread of MFCA has been encouraged by METI's Environmental Management Accounting Promotion Project (METI 2002), and in South Korea there has also been a trend towards its development and spread. In Japan and Germany, where the government is promoting the introduction of MFCA, the number of companies introducing it continues to increase. Simultaneously, techniques for using MFCA in operations have also been developed. For example, from the viewpoint of an information system, its integration with enterprise resource planning (ERP) is important and has been discussed by Scheide et al. (2002), Lang et al. (2005) and Wagner and Enzler (2005) among others. In practice, Tanabe Seiyaku integrates MFCA with a SAP R/3, which is a type of ERP system which is used to obtain MFCA data in real time (JEMAI 2004). There are also cases of MFCA being used as a cost management technique (METI 2002; Kokubu and Nakajima 2004). By using MFCA data to measure toxic waste costs accurately, the company was able to improve decision-making on capital investment and to abolish waste incineration (Kawano 2003). In addition, at Canon, it was discovered using MFCA calculations that the reason for the waste of materials input or materials loss lay in the shape of the lenses delivered by a supplier, so it achieved waste reduction by requesting the supplier to change the shape of the lenses (Anjo 2003). Although research on MFCA information systems and cost management techniques is still an emerging field, the number of studies is rising steadily. Furthermore, since MFCA shows that environmental impact mitigation is linked to cost reductions, it is likely to contribute towards an improvement in the quality of management decision-making.

However, it is not always the case that a technique which is capable of contributing to an improvement in the quality of management decision-making can be used immediately in a company's practical business. The development of accounting techniques and the use of such techniques by management are two separate issues. In this paper, we analyse the case of Tanabe Seiyaku, a company where MFCA is more advanced than in any other Japanese company, in order to examine the factors that have made its introduction a success there. In the next section, prior to embarking upon the case study, we discuss the analytical perspective of MFCA practice and propose research questions.

22.3 Analytical Perspective of MFCA: Research Questions

In Japan, MFCA is on the way to being recognised as an effective technique for decision-making in environmental conservation and cost reduction (JEMAI 2004). However, since MFCA is only an information system and does not make any contribution in a company that does not also take substantial actions to reduce wastes, the way in which companies apply MFCA data to their processes is an important issue. In fact, among Japanese companies that have introduced MFCA, some enforce waste reduction activities on a continual basis using MFCA data. On the other hand, there are other companies that use MFCA only to measure the actual materials and energy flows in the manufacturing process, and calculate costs without making any waste reduction activities.

Some literature proposes management systems to improve environmental conservation activities using environmental accounting information. According to USEPA (2000), which advocates the importance of inter-organisational environmental management in order to take waste costs into consideration, several change management practices can help towards improving materials management, including:

(1) use of a cross-functional team that includes members from different divisions; (2) obtaining management support; (3) benchmarking the best practices; and (4) employing total quality management (TQM) tools. USEPA (2001) also proposed a management system for pollution prevention activities using quality control tools and a decision-making framework that identified waste-generating processes using a process map and collected accounting and physical data. This framework involves the following steps: (1) selecting pollution-prevention opportunities using a Pareto diagram; (2) analysing the root causes of pollution using a cause-and-effect diagram; (3) generating alternative solutions using brain-writing; and (4) selecting an alternative for implementation using a criteria matrix or bubble-up/bubble-down approaches and implementation (USEPA 2001:49–66). USEPA (2001) also mentioned that the commitment of top management and the formation of a cross-functional team are the keys in implementing the above process.

However, this argument is not sufficient if EMA, including MFCA is consistently used by a company as a tool for implementing and updating management strategy. This is because managers pursue their goals based on standard costing in cases where their management control systems (such as budgetary control and performance evaluation) have already been designed using information obtained through existing information systems, including standard costing. In such cases, the systematic use of MFCA data would be difficult. To clarify how those companies that continually carry out waste reduction activities using MFCA data incorporate such a system into their management control procedures, we focus on the implementation process of MFCA.

As Bouma and van der Veen (2002:280) point out, it is not unique to EMA that advanced tools are not immediately adopted. In management accounting research there are a number of studies, including Anderson (1995), which analyse the factors which respectively encourage and obstruct the introduction of accounting systems by describing the process of introducing activity-based costing in detail. However, in the fields of EMA and MFCA, there has not yet been enough research into accounting and management control system design. Therefore, the interpretation of individual behaviour in introducing accounting techniques is not so important at present. Rather, at the initial stage of any accounting research, an analysis of the constructed system would be more meaningful. From the above observation, the focus of this study is to reveal (1) what has happened to MFCA implementation during the year and (2) how to continue MFCA practices for waste reduction.

22.4 A Case Study of MFCA: Tanabe Seiyaku

22.4.1 Research Methodology

In this paper, we conduct a single case study of practical business at a company that successfully introduced MFCA. The subject of the survey is Tanabe Seiyaku Co., Ltd. (hereinafter called Tanabe Seiyaku), a Japanese pharmaceutical company. Tanabe

Seiyaku, along with Nitto Denko, Takiron, and Canon, was one of the earliest Japanese companies to introduce MFCA through the METI project mentioned above. Tanabe Seiyaku is at the forefront of the efforts to address waste reduction activity using MFCA because, in practice, it has integrated MFCA with an SAP R/3 ERP system.

The case description is based on qualitative research including semi-structured interviews, direct observation, and documentation. We held interviews with a corporate accounting manager and an environmental manager at the head office and with employees at the factories. The focus of this study is to reveal (1) what happened to MFCA implementation during the year and (2) how to continue MFCA practices for waste reduction. The questionnaire was therefore composed of two questions. The first was regarding how MFCA has been introduced and deployed at Tanabe Seiyaku. The second was about the kind of management control system that they use to support continual waste reduction activity using MFCA. Our analysis is more oriented towards the technological aspects of MFCA, and it is outside the scope of this paper to examine the perceptions of employees concerning MFCA. While we interviewed two employees in different departments, the purpose of the interview was to confirm what was happening rather than what they thought of it. During the research period (from July 2004 to August 2005) six visits were made, during which 20 hours of interviews were conducted and direct observation of the factories was carried out. In addition, preliminary research involving seven visits (27 hours) and based primarily on interviews, was conducted prior to the actual research, from November 2002 onwards.

22.4.2 Introduction and Deployment of MFCA

Tanabe Seiyaku is a pharmaceutical company listed on the Tokyo Stock Exchange with its head office in Osaka. At the end of March 2005 it had consolidated sales worth JPY 171,985 million (equivalent to approximately US$1.6 billion or €1.24 billion) generating a net income of JPY 15,902 million, and a workforce of 4,517 people. Tanabe Seiyaku has three main production factories: the Onoda factory (Tanabe Seiyaku Yamaguchi Co., Ltd.), the Osaka factory, and the Yoshiki factory (Tanabe Seiyaku Yoshiki Factory Co., Ltd.). Tanabe Seiyaku's efforts in environmental conservation stem from the establishment of a committee for pollution control in 1970 and of an environmental management group in 1981. In 1998, the Onoda factory obtained ISO14001 certification. The company began publishing an environmental report in 2000 and disclosing environmental accounting data in 2001.

Tanabe Seiyaku joined the METI project and introduced MFCA in July 2001. A 15-member project team was formed to promote its introduction in practice, consisting of one member from the financial and accounting department, one from the environmental management department, two from the information systems department and eleven from one of the factories. MFCA was initially introduced into a single manufacturing line for one product in pharmaceutical manufacturing at the Onoda factory. A manufacturing cost simulation system (listing actual data on every materials in each process that is used to manufacture 100 kilograms of finished product), the fiscal 2000 costing table, a breakdown master showing theoretical data on each process, and the fiscal 2000 standard costing table, were used to obtain physical and monetary amount data relating to MFCA. Missing data was covered manually. From the data thus collected, the project team drew a flow chart composed of data (see Fig. 22.2) and a flow cost matrix (see Table 22.1).

Figure 22.2 shows materials flows with data on materials costs in the manufacturing line which was the subject of the pilot project when it was used for corporate management, while actual financial data are omitted in this paper. The manufacturing line was composed of six processes including synthesis, purification, bulk drag substances, weighting, preparation, and packaging. Each process was regarded as a quantity centre. Materials costs were apportioned to the costs of finished products and those of materials losses (wastes) by measuring the physical amount of materials flows at each process. While the main materials flew through the manufacturing line from 'synthesis' to 'packaging', the flow chart with data demonstrated that considerable materials costs were thrown away as materials loss (wastes) at each quantity centre. The project team found the most valuable process for improvement from a financial perspective by drawing up the flow chart. The accounting manager mentioned that it was critically important to know the amount of the potential financial benefit from reducing materials losses at each process through implementing MFCA.

Table 22.1 shows total manufacturing costs that are composed of materials costs, system costs, and delivery and disposal costs over the manufacturing line in the pilot project. The pilot project team was informed of the total financial value of materials losses resulting from the flow cost matrix. In Table 22.1, the amount of materials costs included in the materials loss and costs for disposed wastes are considerable (see Kokubu and Nakajima 2004). Although the figures in Table 22.1 are not the raw data from Tanabe Seiyaku, they are close to the real ratio of each cost in the manufacturing line (METI 2002). As a result, it was clear that large waste disposal costs were involved in disposing the chlorinated solvent used for reaction (synthesis) in the pharmaceutical manufacturing procedure, and that substantial materials loss was incurred in this process. The environmental manager evaluated this method because employees in other departments could recognise the effect of waste reduction for economic benefits.

The trial introduction enabled Tanabe Seiyaku to obtain information on possibilities for improvement. On the other hand, the accounting manager found that compiling the experimental MFCA data using the Excel program required a great deal of time and effort. Tanabe Seiyaku concluded that this manual method would never lead to the consistent use of MFCA for improvement. Consequently, the introduction of MFCA at Tanabe Seiyaku advanced to the stage of linking it with an ERP system and the proposal of an improvement scheme. In February 2004, an MFCA system which was linked to and integrated with a SAP R/3 ERP system was introduced throughout the company. An analysis was then made of MFCA data over one year from April 2003 to March 2004. The introduction of MFCA was expanded to include all product lines at all domestic factories, i.e. the Onoda and Osaka factories, as well as at Tanabe Seiyaku Yoshiki Factory Co. Ltd., an affiliate

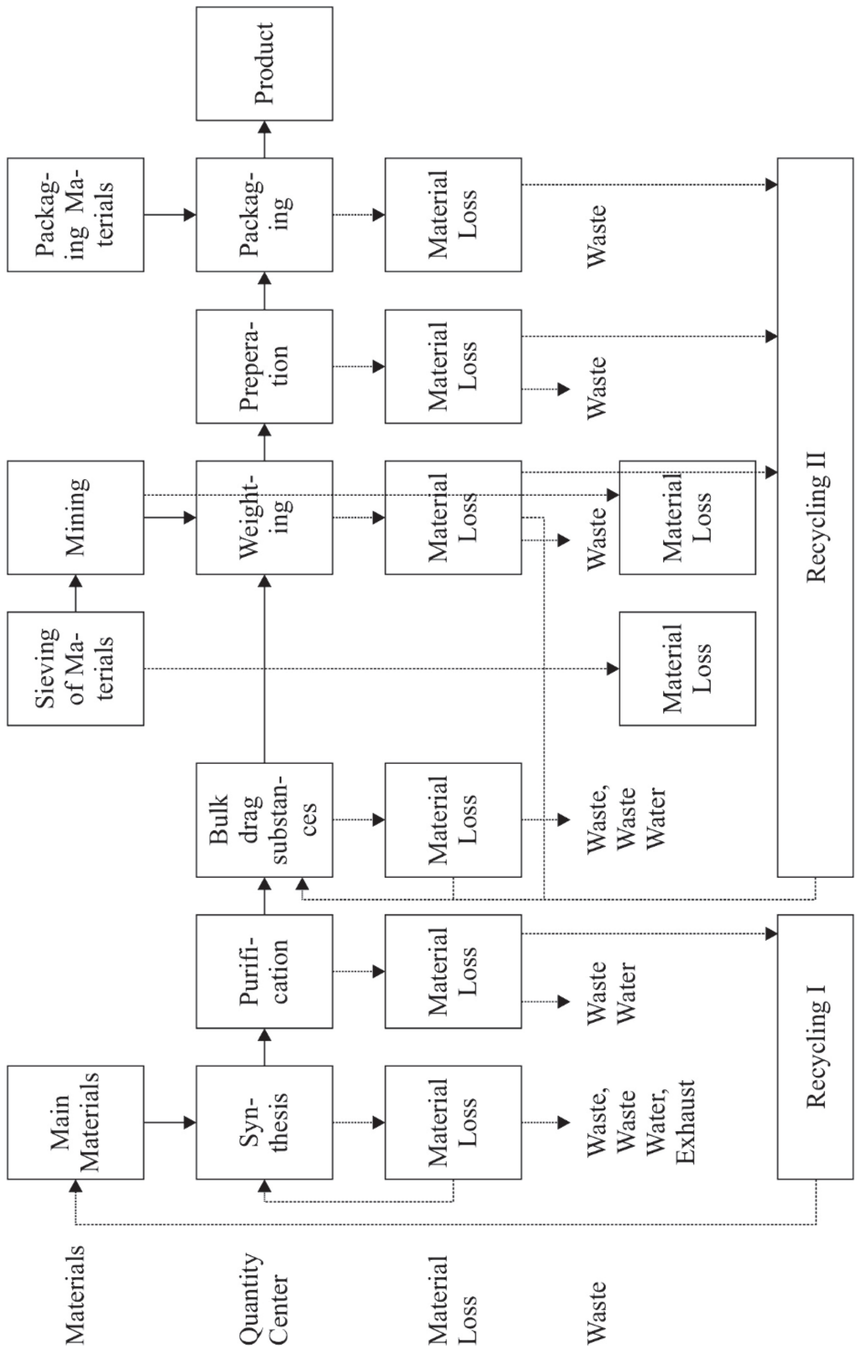

Fig. 22.2 Materials flow chart in Tanabe Seiyaku (METI 2002:117)

Table 22.1 Flow cost matrix in Tanabe Seiyaku (Period: 04/2000–03/2001) (METI 2002:120)

Production costs (JPY thousand)	Materials costs	System costs	Delivery and disposal costs	Total
Product	371,748	1,296,134	0	1,667,883
Materials loss	586,761	628,345	157,836	1,372,942
Disposed wastes in material loss	(346,210)	–	(157,836)	(504,046)
Total	958,509	1,924,480	157,836	3,040,825

that is engaged in packaging. In 2003, new meters were installed at the Onoda factory for energy-loss analysis. These meters measured energy consumption in order to obtain detailed data on this.

Based on the above integrated information system, Tanabe Seiyaku decided to invest in environmental facilities. In May 2003, JPY 66 million were invested in chloroform collection equipment, based on the calculations provided by MFCA (Kawano 2003:23–24). The results of this investment began to show that very month. Apparently, Tanabe Seiyaku had not expected the investment to bear fruit so quickly. Since the company had estimated the annual economic benefits of cost reductions due to the investment in equipment at JPY 60 million, it was possible to recoup the investment within a year. In July 2004, a performance evaluation meeting on MFCA was conducted. This meeting provided various departments with an opportunity to present the results of improvement activities based on MFCA data, and is now held every year. If MFCA becomes a means of continual management control, regular evaluation of activities rather than the ad-hoc use of data would be required, and Tanabe Seiyaku's meetings intend to fulfil this role. The next section provides details of the discussions at the meetings, and their influence on the expansion of MFCA throughout the company.

22.4.3 Management Control Based on MFCA Data

Attention has been drawn towards integrating the MFCA system with the ERP system in practising MFCA at Tanabe Seiyaku (METI 2002; Kokubu and Nakajima 2004). However, Tanabe Seiyaku did not simply maintain an information system for the introduction of MFCA and its expansion throughout the company. It also established an in-house system to assess MFCA initiatives. Such performance management was systematised by holding a regular performance evaluation meeting on MFCA. This meeting, at which the people in charge of improvement activities at factories report to the management on what they have been doing and on financial results, provided an opportunity to confirm factory performances. The accounting manager felt that it was difficult to deploy MFCA throughout the company so he proposed to incorporate MFCA data into performance evaluation. The company then organised a performance evaluation meeting based on MFCA. The accounting department is in charge of MFCA calculations. The first meeting was held in July

2004 and since then this meeting has been held annually, with the second meeting in July 2005 and the third in August 2006.

The manufacturing departments at Tanabe Seiyaku's factories are mainly evaluated based on their cost reductions and the quality of their products. The accounting manager emphasised that Tanabe Seiyaku made it possible to include environmental perspectives in the performance evaluation indicators of the manufacturing departments. In addition, the management-by-objective (MBO) system was adopted for employee performance evaluation. Under this system, employees set their own cost-reduction objectives after talking to their superiors, and their performances are evaluated depending on how well these objectives have been achieved. According to the accounting manager, the process based on MFCA data was as follows.

The accounting department first aggregates MFCA data and provides this to the factories every month. However, factory managers can, if necessary obtain data by accessing the ERP system. Next, staff at the factories in charge of production, environmental issues and logistics analyse the processes in question based on the data provided. From the results of the analysis of the factories materials flow data, improvement plans are developed and implemented in the factories. Factory staff are extensively involved in this. Instead of making a special investment plan for environmental facilities in which investment is required in order to implement an improvement plan, cost-effectiveness is calculated according to MFCA and an investment plan is submitted under the same procedure as that which is used for general investment plans. As a milestone for the improvement process, staff at the factories have to submit their reports to the corporate accounting division twice a year. Finally, the effects of implementation are calculated according to MFCA and reported at the meeting.

An annual performance evaluation meeting enables people throughout the company to confirm the results of improvement activities. At these meetings, factory staff in charge of improvements report to the management on the analysis of their results and the effect of improvement activities based on MFCA, as well as on issues for the future. Several employees said that the most important outcome of reporting at the meeting was to be evaluated formally on their performance by directors of divisions and factory managers. According to the environmental manager, holding the performance evaluation meeting made it possible for employees at the factories to include environmental protection considerations in their decision-making. Management participation in these meetings includes factory heads, staff from the accounting and environmental departments and heads of various other departments. Several board members also participate in these meetings, so the accounting manager mentioned that the meeting is considered important in the company. Since 2005, the manager of the centre responsible for logistics and production planning has also participated and the person responsible produced a report. The head of the R&D department, which has a high degree of autonomy within the company also participated in the 2005 meeting which was important for MFCA deployment in Tanabe Seiyaku because in a pharmaceutical company, the R&D department determines the manufacturing process techniques. In fact, one employee belonging to a factory mentioned that one of the important outcomes of the meeting was that information-sharing on waste reduction with the R&D department was facilitated.

These meetings enable information-sharing on the achievements of factories and departments throughout the entire company. Since several executives take part in these sessions, all personnel within the company can recognise that the amount of cost reduction calculated using MFCA is more important than that calculated using conventional standard costing. Therefore, results reported at the performance evaluation meetings affect the performance evaluation of departments and employees. Moreover, since many participating department heads can understand what is going on in other departments, the sessions function as a forum in which issues can be shared with other departments to encourage cross-functional improvement activities.

22.4.4 Implications

In companies where MFCA is continually practised and expanded into other departments, it is assumed that MFCA data is used in relation to certain kinds of management control systems. Tanabe Seiyaku succeeded in the continual use of MFCA by introducing performance evaluation which is based on it. Under MFCA, the monetary amounts of cost reduction are calculated according to a method that is different from the standard costing which companies normally adopt. Therefore, where performance evaluation is conducted using MFCA data, the difference between cost reduction performances based on existing standard costing and on MFCA comes into question. Tanabe Seiyaku has introduced MFCA into its performance evaluation, which is critically important because linking MFCA data to performance evaluation means that it formally recognised that improvement arising from MFCA data contributed to its organisation. As Epstein (1996:212) pointed out, ‘the integration of improved approaches to decision making … can be accomplished only if employees throughout the Organisation believe that their performance on environmental issues affects the evaluation of their individual performance’; Prior literature has proposed a balanced scorecard approach as a means of incorporating environmental factor into performance evaluation. However, we have shown another example of performance evaluation.

Tanabe Seiyaku holds annual performance evaluation meetings based on the results of MFCA to ensure that all people within the company can confirm these kinds of performance evaluation. At these meetings, the personnel who are involved in environmental conservation at factories report to factory heads and executives, including senior board members, on performance improvement in materials input efficiency due to waste reduction. The executives participating in the meetings mainly belong to the accounting, manufacturing and environmental departments, although the departments responsible for logistics and production planning and for product development and production technology development are also included. Consequently, there is cross-departmental sharing of information about the company’s materials flow and the causes of waste generation.

At Tanabe Seiyaku, departmental performances are assessed mainly in terms of manufacturing cost reduction. Employee performances are assessed using an MBO system which includes cost-reduction objectives. Performance evaluation on waste reduction is systematically confirmed through performance evaluation meetings, depending on whether objectives have been achieved. In this way, cost-reduction performance due to waste reduction is evaluated at the departmental and individual level using MFCA. Tanabe Seiyaku also operates a financial performance evaluation system. However it is noteworthy that, by integrating financial performance evaluation with MFCA data, it has in effect constructed a management control system that enables company-wide environmental conservation-oriented activities to be conducted systematically. As the environmental manager mentioned, they implement environmental activity as a result of cost reduction based on MFCA data.

22.5 Conclusion

This paper has analysed how MFCA, which has attracted attention as the main technique in EMA, has been introduced into a business and maintained. MFCA is a new cost accounting technique with the joint objectives of environmental impact mitigation and cost reduction. Its use among companies is spreading, particularly in Japan and Germany (JEMAI 2004; Strobel and Redmann 2002). It is possible for any company to introduce MFCA, re-calculate manufacturing costs and ascertain waste costs, by properly following the necessary steps. However, advanced management techniques are not always implemented into organisations successfully. In Japan, while some companies implement MFCA as a tool for continual improvement, others implement it as a special cost study without substantial waste reduction.

We looked at Tanabe Seiyaku, one of the companies in Japan in which the introduction of MFCA is most advanced, and clarified the company's mechanism for introducing it using qualitative research in order to reveal the implementation process and the management control system using MFCA. As a result, it was found that by combining MFCA with its ERP system, Tanabe Seiyaku has integrated materials flow cost data into the corporate financial information system and promoted improvement activities that use MFCA. Moreover, these activities are facilitated by the performance evaluation system by integrating MFCA. Especially, organizing performance evaluation meetings concerning MFCA was critically important. Employees at factories are evaluated mainly by reduced manufacturing costs. However, they are evaluated on their environmental performance by the amount of reduced waste cost that is calculated by MFCA.

Since MFCA is a system that provides information, it cannot be used as a stand-alone technique for continual management control. However, if a company hopes to achieve the joint objectives of environmental impact mitigation and greater economic efficiency by introducing EMA, it may be necessary to consider the possibility of a management control technique that uses MFCA. At Tanabe Seiyaku, by combining MFCA with a performance evaluation system, the company has achieved success in terms of these two objectives, i.e. environmental impact mitigation and greater economic efficiency. It is therefore important as a case in which EMA has been successfully introduced.

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Chapter 23
Operational Use of the Environmental Accounting and Information Software TEAMS at Hydro Aluminium Sunndal, Norway

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Abstract This paper presents findings of an intrinsic case study about how Hydro Aluminium Sunndal, Norway (HAS) implemented a environmental management accounting tool (Total Environmental Accounting and Managements System, TEAMS) in 2003. The case study focussed on how TEAMS could be implemented as an effective information and reporting tool at HAS.

HAS is located in Møre and Romsdal, western Norway, and is operated by Norway's largest industrial group, Norsk Hydro ASA (Hydro). Hydro is the third-largest integrated aluminium supplier in the world, with a presence on every continent. Hydro's history and commitment to the United Nations Global Compact principles is the context and perspective of the study of environmental performance on a local scale.

At site-level, a need for more detailed and relevant information on certain emissions, working environment, noise pollution and waste management was identified. The assessment of TEAMS, as a reporting tool, showed that the system is capable of meeting these specific site reporting needs. However, achieving accurate reporting requires that the implementation process is well planned and that sufficient resources are available during the initial phase.

The network of spreadsheets previously in use for environmental management activities, such as accounting and reporting, creates an unnecessarily complex, brittle and vulnerable system. TEAMS will arguably represent a much more resilient and effective information system compared to the present system at HAS. Another important benefit connected to new reporting trends, such as sustainability reporting, is that TEAMS facilitates effective communication with stakeholders.

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23.1 Introduction

Corporate environmental management and implementation of environmental accounting and information systems are recent developments within the past 10 years, and are often driven by the momentum of globalisation. Such reporting for aluminium plants is primarily directed to greenhouse gases and energy use. However, for *Hydro Aluminium Sunndal* (HAS) has been concerned with the environmental welfare of nearby forests, domestic animals (sheep), aquatic organisms in the local river and fjord, and, of course, with the health of local people and workers for decades. The main challenges stem from the emission of hazardous pollutants, such as fluor compounds, polycyclic aromates (PAH) and others (Ongstad et al. 1994). HAS is a so called 'anchor company' at the bottom of a long fjord bordered by high mountains, which creates an intimacy between the aluminium plant, community and nature.

Globalisation of business and growing concern about the future global and regional environment, including threats and changes in the ecosystem's capacity for providing human societies with ecosystem service and goods, has challenged the global community to search for new forms of governance. In recent years, the framework and instruments for assessing the global environmental status on an ecosystem level, and the development of environmental sustainability indicators on the national level have been launched. Among the initiatives challenging the international business community are: the ten principles of the UN *Global Compact* launched in 1999 by Secretary General Kofi Annan (Fussler et al. 2004); *UN Millennium Development Goals, Millennium Ecosystem Assessment* (2005); the *UN Rio-Declaration on Environment and Development* and *UN The Convention on Access to Information; Public Participation in Decision Making and Access to Justice in Environmental Matters—Århus Convention* (Stokke and Thommessen 2003).

Benchmarking in the form of country by country indexes such as the Environmental *Sustainability Index* (Esty et al. 2005) and *Environmental Performance Index* (Esty et al. 2006) has been conducted in collaboration with the *World Economic Forum*. These benchmarks should be regarded as relevant guides for the direction that companies move in order to increase the performance of the host country of a specific company or plant.

Business has responded by developing the concept of corporate social responsibility (CSR) and using the principles of sustainability reporting launched by the *Global Reporting Initiative* (GRI 2002; UNEP 2003).

Effective corporate governance depends on access to relevant high-quality environmental information. The *UN Environment Programme* (UNEP), the *World Business Council for Sustainable Development* (WBCSD) and the *European Union* (EU) have put considerable effort into developing standardised and comprehensive environmental reporting guidelines. These are designed for top-down implementation and express the need for environmental information among decision-makers at an international and national level. As a guideline, actual implementation is left to the individual firms, in this case *Norsk Hydro ASA* (Hydro), to develop a corporate reporting strategy that satisfies stakeholders' requests and demands. However this requires that the need for information at the superior levels (international and national level) is adequately understood at company and site level. High quality environmental and sustainability reporting is expected to be a success factor for corporate and plant management and competitiveness.

23.1.1 Corporate Reporting and Stakeholders

In Hydro the traditional environmental reports are now being supplemented by sustainability reports. This has led to HAS's need for a high quality and flexible environmental information system to satisfy the request for information from upper management. According to the most common framework for sustainability reporting, the *GRI Guidelines* (GRI 2002), this kind of reporting should cover and integrate social, economic and environmental aspects. These three aspects are often referred to as the 'triple bottom line' (Elkington 1998). Besides requiring a broader span of quantitative and qualitative data, new reporting trends have several important characteristics.

There is an evident shift of target group from shareholder to stakeholder, as well as increased focus on engaging the stakeholders in environmental management activities (Elkington 1998). Hydro, as many other corporations, has a well developed and competent unit for following up the communication with media and the public. Elkington (1998:166) stress the importance of stakeholders in driving the sustainability transition force of stakeholders, and to distinguish between the traditional and emerging stakeholders. The first group includes shareholders, lenders, regulators, and government policymakers. Emerging stakeholders include employees, customers and consumers, many kinds of trade, professional and academic organisations, and neighbours and environmental organisations. This means that new forms of communication, e.g. stakeholder conferences and meetings, are needed to supplement the one-way communication represented by the traditional report. Transparency and audit-ability are other important features in the new reporting trends. These principles shall support benchmarking and at the same time ensure uniform assessment criteria when sustainability performance is measured and compared. An indication of the ambitions of Hydro regarding business for sustainable development is presented in a case study by Holliday et al. (2002). For 2004 and 2005 Hydro has designed and edited the annual report both as a financial accounting report and as a CSR report built on *GRI Guidelines* approved by the auditor (Deloitte Statsautoriserte Revisorer AS). The *Dow Jones Sustainability Index* named Hydro a super sector leader in 2006 (DJSI 2006) in the category *Basic Materials*, which include the aluminium sector; Hydro placed second in 2005; and has qualified for the list every year since it was first published in 1996. Performance has been evaluated according to the criteria specific to the aluminium industry (Hydro 2006).

23.1.2 Site Reporting

HAS is currently the largest and most modern primary aluminium plant in Europe. Through an extensive modernisation and expansion project which began in 2000, the plant has been upgraded to meet new productivity standards and strict environmental requirements. Hydro has invested approximately 6 billion NOK in the renewal of HAS. In addition to introducing a far cleaner and more efficient production technology, HAL250, the company has also adjusted and modernised the existing facilities and equipment on site. The renewed plant is now in full operation with a production capacity of 355,000 t primary aluminium per year (Schnell 2004).

Both the technology and the information system at HAS are upgraded to meet new environmental standards and requirements. HAS is focusing on emissions of fluoride, polyaromatic hydrocarbons, dust and suspended matter, sulphur dioxide and some greenhouse gasses (CO_2, CF_4 and C_2F_6). These emissions were selected for special attention after extensive research on environmental effects from primary aluminium production. The most well-known research project is the so-called *effect study* that lasted over 4 years (Ongstad et al. 1994). The most significant emissions were identified during this collaboration between Norwegian aluminium plants and external research institutions.

Today HAS is constantly monitoring their environmental performance, and the plant also discloses environmental information regularly to different stakeholders. Some important external stakeholders are the local community, the *Norwegian Pollution Control Authority*, politicians, customers, suppliers and shareholders. Effective communication with these groups is an important part of HAS' business strategy in order to maintain a green profile and to improve the plant's operating conditions. However, this requires that the plant can provide first-class environmental information at all times. A prerequisite for the external reporting of a presumptive good performance requires good management and operation of the plant, and TEAMS may serves as an environmental accounting management tool for internal work and operations at HAS as discussed by Burritt (2005).

The procurement of TEAMS is an essential part of the ongoing modernisation process. As far as the study group is aware, no other software system to support the environmental accounting was considered. The reason is probably the strong product position TEAMS has in Norway. From 1992, when the first version was launched, TEAMS has been developed in cooperation with oil companies such as *Statoil* and Hydro to become a standard reporting tool for the Norwegian offshore sector, and gradually become important for other sectors as well, including the *Norwegian Armed Forces*. The complex interface between environmental data and the availability of high quality information for decision making and environmental communication requires an effective computerised system. Lang et al. (2005) outlines the connection between software systems and environmental accounting. Hydro also operates a reporting system called *Synergi* at all its plants and sites that maintains data on all health aspects, safety and environmental incidents, accidents, and potentially dangerous events.

Voluntary and mandatory environmental reports are a central part of communication with internal and external stakeholders. In addition to a regular environmental review directed towards society in general, there are also customised reports directed towards the corporation, the authorities and the aluminium industry on an annual basis. Specified environmental information is disclosed to industry organisations such as the *European Aluminium Association* (EAA) and the *International Aluminium Institute* (IAI). In addition, HAS must satisfy internal requests for environmental information. Simplified reports are currently distributed every fortnight for process control. This kind of operational use of environmental reports must be taken into account when the introduction of a new environmental information system is being planned.

23.1.3 Problem Definition

The underlying data collection for all environmental reports is provided by the environmental laboratory at HAS. The laboratory is responsible for sampling, analysis, storage, processing and reporting of environmental information. Most of the data handling is manually taken care of by laboratory personnel. However, many computer systems are used to store both unprocessed and processed data. The large number of individual database applications forms a complex and vulnerable environmental information system. This is the main reason for introducing TEAMS. By gathering all the environmental information into one database the laboratory staff are hoping for a more resilient and effective solution where many operations are automated. This should not only raise the quality of the data itself, but also cut costs and provide a more user-friendly solution for internal and external communication.

On the basis of these premises and expectations the following problem was stated as the purpose and scope of the study: *How can TEAMS support HAS in enhancing the quality of both internal and external environmental information*?

This paper is built on the thesis work of Nertun and Pollestad (2004) and will emphasise how TEAMS can be used to increase the quality of the environmental information that is distributed internally, i.e. the *operational use* of TEAMS. Since corporate reporting follows a bottom-up process, this is a premise for attaining high-quality information also at upper levels of reporting and decision-making.

23.2 Research Methods

A qualitative design was chosen as a framework for the study. Thus, field observations and semi-structured interviews formed a central part of the research process. Depending on position and scope of work of the informants were two different interview guides made. One guide for employees at the environment and raw material laboratory which comprised questions about education, work, user participation,

Table 23.1 List of respondents

User-group	No. of respondents
Environmental laboratory	8
Safety, health and environmental (SHE) department	2
Electrolysis halls	2
Anode production	2
Cleaning plant	1

TEAMS, the taking of samples, measurements and chemical analysis, storage of data and reporting. The other guide was applied in interviews with managers of operations and comprised questions about education, work, information need, reporting, user participation and TEAMS. The total time frame for the study was 20 weeks.

Altogether 15 interviews were conducted with direct and indirect users of TEAMS at HAS. The respondents can be classified into five user groups on the basis of work tasks. The number of respondents from each user group is presented in Table 23.1.

Because of their role in the data handling process, the environmental laboratory is clearly the most important user group of TEAMS. Consequently, more than half of the interviews were carried out there. The rest of the respondents were selected on the basis of today's request for environmental information at HAS. As an example, the laboratory sends emission reports to the Electrolysis Halls every fortnight, which allows the managers to ensure that the processes are under control. In addition to the user groups listed in Table 23.1, the plant also consists of a cast house plus various ancillary facilities, but these facilities are not using environmental information to the same extent.

23.3 Research Findings at HAS

Generally, the study got a certain impression of a more technological focus instead of an end-user focus when environmental information systems are designed and implemented. Thus, the system will often present data that are technically possible to measure instead of data that actually supports decision-making. It is therefore important that the intended use of data is not overlooked in the quality assurance of environmental information systems.

The quality of the HAS environmental information system was examined by decomposing the system into different system parts. These were: sampling, chemical analysis, data storage, data processing, reporting and finally the use of information (Fig. 23.1).

This information chain constitutes the foundation for every environmental report from HAS. Understanding this chain of information was therefore crucial in order to identify how the particular system could be improved. The study group found that HAS faces the situation where the environmental information system maintains

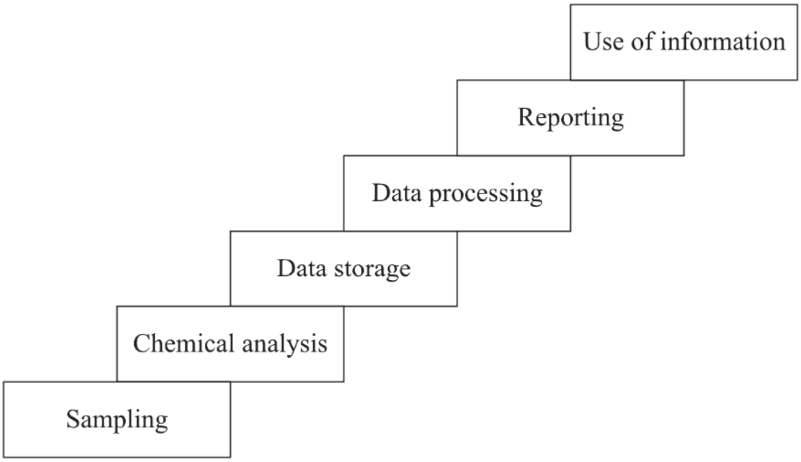

Fig. 23.1 The environmental information chain (Modified after Olsen 1994:45)

high quality when it comes to collection, storage and processing of the data, but that the data presentation sometimes fails to inform the user's decision-making processes. This particular finding was supported by information from the interviews. All respondents saw a large potential for utilising the environmental data in a better way if the presentation could be improved.

Through the interviews with the respondents the study group also received more specific information about how the system could be improved. Based on this information the most common needs were identified and formulated. These needs are presented in a brief outline:

1. *Interactivity*: There is a general need for an interactive solution due to the different requests for information at different levels in the organisations. Not all of these requests are served by the standardised reports prepared by the environmental laboratory. Increased ability to track and examine the underlying data is a common request.
2. Retrieval of additional SHE-information: HAS must reduce complexity and vulnerability by gathering all data on emissions and discharges into one database. This will make it easier to retrieve and present meaningful data for an end-user. Today there seems to be too many SHE-software solutions present at the plant (Safety, Health, and Environment). Ideally it should also be possible to retrieve additional SHE-information from the same database where information on the external environment is retrieved. Noise pollution and working environment are pointed out as important focus areas.
3. Flexible report generator: There is a need for a flexible report generator that can be configured to meet any standard. Some important target groups that require standardised ways of reporting are the corporation, the authorities and the aluminium industry. Clearly there is a potential for saving time if the data is adjusted automatically to meet these standards.

4. Real-time reporting: There is a need for decreasing the time delay between when the event occurs, i.e. the emission, until the event is reported. A shorter gap allows the managers to gain even better control of the processes at the plant. Presentations that present trends are also requested to support process control and general decision-making.
5. Decision support on waste management: Waste management is an important focus area where there is a lack of information today.

When it comes to corporate reporting only a few of the respondents, primarily SHE-staff, are aware that CSR and sustainability reporting are priority areas in Hydro. Consequently the respondents had few thoughts on how the current information system could be upgraded to meet the need for environmental information at a macro-level. However, HAS's environmental manager can confirm that the corporation requires broader and more integrated data from HAS every year, primarily when it comes to relating environmental and economic performance. He also believes that society in general will be more aware of the new reporting trends. Thus one can assume that there will be an increased demand for information on sustainability performance in the immediate future.

23.4 TEAMS as a Reporting Tool at HAS

TEAMS is sometimes referred to as an environmental management system (EMS) for recording, handling, quality assuring and reporting of environmental data. It has been developed to manage the handling of all environmental data in connection with discharge, emissions and waste reported by industry to governmental authorities or for other internal or external reporting purposes. With the increased functionalities and operational use of TEAMS at HAS, TEAMS may also be referred to as an environmental accounting management tool (Burritt 2005, Schaltegger and Burritt 2000) due to the focus on internal users at HAS. The program is based upon four essential components; *the account register, the organisation structure and transaction window, the report module, and factor library* (Fig. 23.2). Together these four parts interact to perform the necessary tasks for keeping track of output and input of chemicals, energy, products and substances for reporting, decision making and operation.

The system is a standard reporting tool for the Norwegian oil and gas sector with a long list of other national and international reference clients. HAS stands out by being the first client that has outsourced the technical operation of the system entirely to the supplier, Emisoft AS. By doing this HAS merely needs to operate the internet version of TEAMS called TEAMSGlobal. This is an end-user product that requires less training since all installation and data configuration are taken care of by Emisoft AS. The challenge for the customer, together with the supplier, is to implement the right combination of tools and functions provided by TEAMS and TEAMSGlobal, in order to realise the full potential of the system.

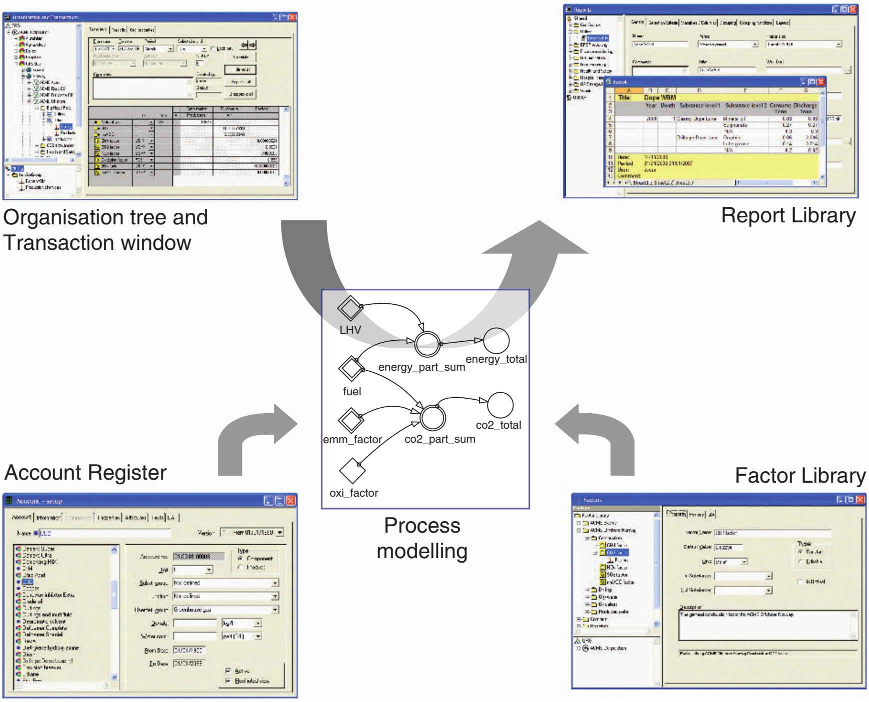

Fig. 23.2 TEAMS program structure (Software from Emisoft, 2006)

23.4.1 Operational Use of TEAMS

After a close examination of TEAMS as a reporting tool the study group found that the standard functions will satisfy most of the needs expressed by the respondents. To serve the request for information at a site-level, the study group recommended that HAS make use of the following functions provided by TEAMS in the first stage:

- Different access levels.
- In TEAMS one can set different access levels and determine the number of licenses. It was recommended that HAS provides access to the five user groups that regularly request environmental information to support interactivity and give the users a unique possibility for closer examination of the data that otherwise was not included in the standardised reports.
- Easy data import.
- The system handles emission data as well as SHE-data, such as information on air quality, sick leave and injuries. Existing data on the external environment, as well as data on safety and working environment, can therefore easily be imported to the TEAMS database. It was suggested that as much SHE-information as possible should be gathered in TEAMS to reduce over all system complexity and vulnerability.

- Predefined reports.
- The report module is powerful and flexible, as requested by the respondents. It was recommended that specified report templates should be made so that data are aggregated and set up according to the custom made specification.
- Traffic Lights.
- This function is available through *TEAMSGlobal*. It is a tool for process control where status indicators, i.e. a green, yellow or a red light, show whether the current emissions are acceptable or not in a highly visible and intuitive manner. It was recommended that HAS used this functionality to support both real-time reporting and process control. TEAMS can also support trend analysis through interfaces with Microsoft Excel.
- The Logistics module.
- This function supports material flow analysis and is especially designed for waste management. It was recommended that HAS considered how this tool can inform the environmental and economic decision-makers in question.

The functional range of the system can be expanded by integrating TEAMS standard functions with other software. TEAMS is designed for easy communication with other systems such as Microsoft Excel, process monitoring equipment and financial management tools. The study group found that integration with a geographical information system was of particular interest to HAS as this integration can give better control over recipients, e.g. fluoride uptake in the local environment, and noise pollution by displaying the geographical distribution of emissions and noise. However, it was recommended that HAS focused on the standard functions from TEAMS in the initial phase.

23.4.2 Corporate Reporting

To enhance the quality of corporate environmental reports the work begins at the site-level. Already at this level it is important to make sure that principles on transparency, stakeholder engagement and audit-ability are attended to. The study group believe that TEAMS can help to ensure the integrity of Hydro's reporting system by providing a complete documentation of the environmental performance at different sites. Still, this requires that TEAMS is introduced as a standard corporate reporting tool. In the TEAMS database all reported data are presented in such a manner that internal or external parties can examine its accuracy and reliability.

Eventually, the TEAMS system will be helpful in developing sustainability performance indicators as the system facilitates data processing as well as import of data from other systems, e.g. financial management tools. It is crucial that both the customer and the supplier of TEAMS is up to date with both national and international reporting trends in order to realise the full potential of TEAMS as a reporting tool. This requires that the particular need for environmental information is satisfied both at a micro and a macro level.

23.5 Conclusions

This study indicates that TEAMS has a considerable potential for improving environmental reports and the general environmental information from industrial companies like HAS. Improving the quality of site reports and environmental accounting management are criteria for enhancing the quality of corporate environmental performance and producing external reports on sustainability. High quality environmental information is increasingly requested among international and national institutions in order to direct industrial activity towards sustainable development.

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Chapter 24
Failure of an Environmental Strategy: Lessons from an Explosion at Petrochina and Subsequent Water Pollution

Xiaomei Guo

Abstract This article discusses the relationship between environmental strategy and performance, based on a case of a famous Chinese company. Though having good management systems and an environmental strategy in place, the company has recently had several serious environmental and safety accidents. By comparing its operating strategy and financial performance with its environmental strategy and performance, the paper aims to show that having an environmental strategy does not necessarily ensure good environmental performance. Integration of the environmental strategy with the operating strategy will help to implement environmental goals and financial goals in the long run. The paper also provides some suggestions on how to integrate both strategies.

24.1 Introduction

On November 13, 2005 an explosion occurred at the petrochemical plant of Jilin Petrochemical Co (JPC), a branch of Petrochina (PTR), killing five people and forcing the evacuation of tens of thousands of others, only 2 years after a well blast at another site had killed 243 people and poisoned more than 10,000. The explosion caused disastrous pollution to the Songhua River, depriving many people of their water supply, and it became the most serious water pollution accident for decades in China. The explosion spilt benzene, a cancer-causing substance, into the Songhua River, causing serious ecological damage to the environment.

Since at first PTR tried to cover up the fact of this pollution, it took more than ten days for people to learn the truth. The news of the water pollution became headlines in major media for several days, and like the Bhopal chemical leak (1984) and the Exxon Valdez oil spill (1989), this accident also received worldwide media attention. As the consequences of the accident were severe, people whose lives and properties were affected took action. Some went to court; some questioned the

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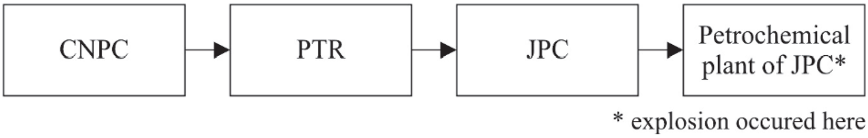

Fig. 24.1 Corporate structure

approval which had been given which had allowed the plant to be set up so close to a major river, and demanded that it be moved away. Soon afterwards PTR removed Yu Li, the manager of the Jilin company, from his position (Xinhua News Agency 2005a), and gave a donation of RMB 5 million Yuan (Euro 1= approximately RMB 10.6 Yuan, US$1 = RMB 7.3 Yuan) to the government of Jilin for remedial work.

JPC of PTR is the first large-scale chemical industry based in China as well as the largest national aniline base. Its parent company, PTR was established in 1993 as part of the restructuring of China National Petroleum Corporation (CNPC) (see Fig. 24.1). It is the largest state-owned company listed abroad on both the New York Stock Exchange (code, PTR) and the Hong Kong Stock Exchange (code, 857), and is the largest producer of crude oil and natural gas in China. In April 2005, it was given an award as the “Best Company in the Asian Oil Industry” and ranked in first place of the “Best Managed Companies in China” by Finance Asia, and was ranked number 57 in the ranking of “Forbes 2000 World’s Leading Companies”, the highest-ranking Chinese company.

According to Xinhua News Agency, the direct cause of the explosion was an operator’s negligence in clearing a blockage in a processing tower (Xinhua News Agency 2005b), but many authors tried to explore the accident further. Wang (2005) found that industrial accidents are not unusual in this plant, a recent major one being a fire in 2001. Yu (2006) suggested that JPC’s management is too superficial, workers worked overtime, and machine maintenance time was cut in order to gain a low-cost advantage. Li (2005) suggested setting up an environmental strategy and enforcing good environmental management.

These articles ascribe the accident to lack of proper management, but a review of the literature before the accident reveals that JPC in fact boasts good management, and PTR has had exceptional financial results for several years. Many stories have been told about its success in turning a huge deficit into profit within a short period. JPC was so successful that PTR, its parent company, had called for every one of its subsidiaries to learn from JPC’s management experience. Zhen (2005) argued that JPC’s success lies in its good management system. On the environmental protection side, PTR has installed an environmental management system (EMS) which is based on the national industry standards and HSE guidelines of the Oil Industry International Exploration and Production (E&P) Forum and includes the main components of ISO 14001, ISO 9000, and OHSAS 8000. PTR and most of its subsidiaries are externally verified against these standards by China Petroleum Health Safety Environment Audit Centre. PTR has set up an environmental strategy and it is one of the first companies in China to release health safety and environmental reports (HSE).

Literature shows that there is a positive relationship between an environmental strategy and both financial and environmental performance (Wagner and Schaltegger 2004; Wagner 2005). Some authors have suggested a framework for an environmental strategy or have highlighted the importance of integration of the environmental strategy into the corporate strategy (Escoubes 1999; Percy 2000; Roy and Vezina 2001). Why did PTR's environmental strategy not protect it from such an environmental accident, and how can it prevent serious environmental accidents from occurring again?

This depends on the level of enforcement of its environmental strategy. Some authors have demonstrated that traditional accounting, and management accounting in particular, concentrates on quantitative measures of economic transactions and has ignored a wide range of non-market activities which are associated with private Organisations and their impact on the bio-physical environment (Bloom and Heymann 1986; Milne 1996). McMahon (1995) suggests that in order to avoid non-compliance, all aspects of a business's operations must be considered and EMSs must be integrated throughout the business, and accountants are becoming an important part of environmental compliance management. Evans (1996) shows that management control systems can provide a framework for an integrated "environment-friendly" systemic approach to deciding on the full costs of running a business, and believes that taking a strategic view which includes both financial and non-financial information could free the decision-maker from reliance on the price mechanism beloved of the economist. Taplin et al. (2006) present a sustainability accounting framework to inform strategic business decisions by fostering greater communication and understanding between different sections of the business, developing new data collection and management processes, and helping to embed sustainable development objectives throughout the Organisation.

This paper will argue that it is not a lack of management that led to the disaster, but a lack of integration of the environmental strategy within the operating strategy. It will demonstrate this idea through a comparison of PTR's operating strategy and its environmental strategy, and an explanation of the conflicts of interest between financial performance and environmental performance, and it will also put forward some suggestions which are designed to ensure the implementation of an appropriate environmental strategy in future.

24.2 PTR'S Strategies

24.2.1 Operating Strategy and Financial Performance of PTR

PTR's operating strategy is "to address the opportunities and challenges … and develop into an efficient, profit-oriented, competitive, integrated oil and gas company. Specifically, the company intends to build upon its strengths to implement its integrated and return-on-capital based strategy" (Petrochina 2005a). To enforce this strategy, PTR "has established explicit financial targets for each business segment focusing on enhancing returns through earnings and cash flow growth and higher capital efficiency to be achieved through more targeted capital expenditures. The company has also put in place an incentive system for management based on achieving these targets. It is in the process of upgrading its management information system to fit its new return-based strategy" (Petrochina 2005a). From these statements, it is clear that PTR is a profit-driven company and its operating strategy is profit-based. This strategy is further developed into explicit financial targets and specific goals and measures. The company also has in place a well-designed management system, including an incentive system and management information system to ensure the fulfilment of its operating strategy.

The return-based strategy and its related management systems have put PTR on the track to high profits. PTR's strategy focuses on reducing cost, and its goal of "improving efficiency and performance in refining and marketing" is to be achieved through "reducing costs of processing, transportation and sales, thereby enhancing profitability." It also aims to increase the profitability of its existing business by "reducing its production and operating costs" (Petrochina 2005a). To achieve these goals, over 3 years the company paid off 30,000 workers and shifted the burden to its various subsidiaries and branches (Chen 2005). For those subsidiaries that were in deficit, the pressure was even stronger. "The Company's chemicals segment is currently experiencing losses as a result of high costs, poor investments and expenditures in uneconomic projects, plants and facilities, and a lack of product focus and effective marketing strategy" (Petrochina 2005a). To undertake a turnaround of this segment, the company plans to "implement cost reduction measures, including reducing processing costs and overhead costs" (Petrochina 2005a).

JPC, a company with a history of more than 50 years, had accumulated a loss of RMB 900 million Yuan and was on the verge of bankruptcy when Yu Li was appointed as the manager. To deal with this huge loss, Yu Li made every effort and successfully reduced the loss in 2002, and from 2003 the plant began to make profit. By the time the explosion occurred, the plant had been earning profits for 3 years (Zhao 2005), and its success was largely attributed to good management. Low costs were established as JPC's strategy, and later this was cascaded into objectives at different levels of working units, and included measures in the responsibility accounting system to account for their respective performances. The plant retained its position as the most profitable company in the chemicals industry, despite the fall in market prices of chemicals products and the rise of crude oil prices (Zhen 2005). The financial performance was remarkable, with profits for JPC of RMB 8 million Yuan in 2003 and RMB 31.9 million Yuan in 2004, and RMB 5 million Yuan for the first 8 months of 2005 (Zhao 2005). No wonder that Yu Li was regarded as a pioneer, and PTR called for every subsidiary to learn from JPC's experience.

PTR also boasted good financial performance. In 2002, 2003, 2004 and 2005, net profits were respectively RMB 46.9 billion Yuan, RMB 69.6 billion Yuan, RMB 102.9 billion Yuan, and RMB 133.4 billion Yuan (Petrochina 2006), and in 2004 it was the most profitable company on the Hong Kong stock exchange. The rate of increase in PTR's net income from 2004 to 2005 was almost six times greater than

Table 24.1 Comparison of major financial results between PTR and Sinopec (in RMB billions) (Petrochina 2005 annual report:8, available from Internet: http//www.petrochina.com.cn/English/tzzgx/2005nb.htm. Sinopec 2005 annual report:28, available from Internet: http//www.sinopec.com.cn/ir/companyreport/index.shtml)

	PTR			Sinopec		
	2004	2005	Change (%)	2004	2005	Change (%)
Turnover	397.354	552.229	38.98	597.197	799.115	33.8
EBIT	151.138	192.171	27.15	63.069	66.814	5.9
Net profits	107.646	139.642	29.72	41.791	43.840	4.9

that of its major competitor in China, China Petroleum and Chemical Corporation (Sinopec Corp), which is also listed abroad (0386 HKEX; SNP NYSE; SNP LSE; 600028) (see Table 24.1 for details).

It is thus evident that PTR has a good operating strategy and management system, and with these has achieved good financial performance.

24.2.2 Environmental Strategy and Performance of PTR

As mentioned before, PTR had installed an EMS system and by the end of 2005, the EMS systems were established and implemented in all its production and business subsidiaries. Instead of an explicitly stated environmental strategy PTR has an HSE policy, which is “People-Oriented and Put Prevention First”. PTR’s goal for HSE is to make itself entirely free from occupational diseases, industrial accidents and damage to the environment, and it considers that “confidence would be won from clients, shareholders and the general public by means of excellent HSE performance and the utmost efforts for attaining sustainable development” (Petrochina 2005b). PTR claims to have business development plans incorporating a series of HSE objectives, and to apply its HSE principles to every business segment. It also claims to have issued a series of rules and regulations concerning HSE management, such as “Rules for Emergency Management of Accidents” applied to the pipeline segment. In the meantime, it emphasises the disclosure of environmental information and has published an annual HSE report since 2000. In fact, PTR is the only listed company in the oil industry that has been successively publishing HSE reports, although since there are no national requirements for environmental disclosure, these reports are voluntary and are not externally verified.

The environmental performance information which is disclosed includes data on emissions of pollutants into water, air and land, as well as investments in environmental protection. For the six years from 2000 to 2005, total environmental investments amounted to RMB 7.772 billion Yuan. In 2004 JPC invested RMB 21.43 million Yuan to reduce nitrous oxide and eliminate nitric acid tail gas from the fertiliser factory, which has polluted Jilin City for five decades (Petrochina 2004). JPC was awarded the title of Environmental Friendly Enterprise by the State Environmental Protection Administration (SEPA). All this seems to show that PTR has done fairly well or even better than many other companies in its industry.

However the occurrence of two major accidents in two years, and especially PTR's response after the explosion, has made people dubious of the integrity of such disclosure. Immediately after the explosion PTR promised to let the public know the truth, but it denied the fact that water was polluted, it claimed that the explosion emitted only carbon dioxide (which is safe for water supplies), and it covered up the fact that benzene had been spilled in the water (Hui 2005; Chu and Ma 2005). When the government confirmed that the Songhua River was polluted, PTR denied any cause and effect relationship between the pollution and the explosion of its plant and admitted that pollution had occurred only after SEPA became involved. It claimed to have made remarkable achievements in the treatment of pollution sources and continued to effectively control the discharge of pollutants (Petrochina 2004), but further investigation showed that polluted water was disposed of into the Songhua River without proper pre-treatment in the on-site water treatment pools at the location of the accident (CCTV 2006). In fact, the pollution of the river could have been avoided.

The explosion caused great damage to the environment, but little was reported in PTR's HSE report. In the section on safety performance, two major accidents are mentioned, one of which is "an explosion of a phenylamine facility, involving eight deaths and causing pollution of Songhua River" (Petrochina 2005b). No more was said in the section on environmental performance. Ironically, the emission of petroleum-related pollutants into wastewater in the chemicals and markets segment of the PTR in 2005 was less than that of 2004. In its annual report, which is compulsory, the disclosure is no better. In the auditor's report, the explosion was mentioned under the section of "environmental liabilities", and "the Company is presumed to bear related liability according to the investigation results". In the management discussion, PTR claimed to have neither probable environmental liabilities nor legal liabilities that would have adverse effects on the company's financial results, and mentioned the explosion only under the heading "others".

This subtle discrepancy indicates PTR's reluctance to face up to the fact of the explosion. PTR claimed to "have learned a lesson from the incident and has strengthened its efforts at ensuring safety in production and environmental protection" (Petrochina 2006), but another gas leakage occurred shortly afterwards, in 2006. AccountAbility, the global think-tank on Organisational and corporate accountability, and CSRnetwork, the leading UK corporate responsibility consultancy, assign social responsibility ratings to the world's largest companies and publish the headline results in Fortune magazine every year. In the AccountAbility rating for 2006, PTR ranked 63, the last-but-one on the list, signalling that it did poorly in accounting for the impact on its stakeholders. The report also shows that the oil sector as a whole slipped to last place, partly due to poor performance from companies including PTR (CSRnetwork 2006).

From the above, it can be concluded that PTR is reluctant to tell the true story about its failings in environmental protection. The facts also show that despite having an environmental strategy, PTR failed to achieve its HSE goals and its environmental performance is not as good as it has claimed. How can it regain public confidence?

24.2.3 The Contradiction Between Financial and Environmental Performance

Why should a well-managed company with excellent financial performance have an environmental accident? One reason is that PTR does not have an incentive to really care about its environmental performance. PTR is in an almost monopolistic position in its industry sector, providing basic raw materials to other sectors. The rapid growth of GDP in China in recent years has spurred huge demand for supplies from the company and the price keeps increasing, yet since the cost of natural resources are not fully reflected in PTR's private cost its profit is extremely high. PTR's good financial performance has covered up its shortcomings in other areas. As the company has become the backbone of the economy, it is difficult for the local government to take action when the company damages the environment. In 2003, after the well blast in PTR's Chongqing branch, the government simply replaced the general manager of PTR at that time and took no further action. So long as the company has huge profits, pays a large tax bill to the government, and GDP rises, it is allowed to continue in operation. However this does not take into account the damage to the environment and the social cost which is borne by the local government.

Moreover, chief executives of extremely large state-owned companies are responsible to the central government, as in the case of the delegation of a governmental official, so that managers are often responsible to the central government rather than to investors or other stakeholders, but the central government is too distant to know the facts at first hand. Even if some local governments try to intervene, this is not easy—since these large state-owned companies are directly responsible to the central government rather than to the local government in their location, the latter cannot have much power in enforcing legal compliance.

As in PTR's case, it had another well blast due to gas leakage in Chongqing municipality in March 2006, shortly after the explosion in JPC. The local governmental official complained about PTR's reluctance to inform the local government, blaming the self-supervision system of these large state-owned companies (Cheng 2006). According to the investigation report submitted to the state council, the blast caused direct economic losses of RMB 69 million Yuan, yet no details of the calculation of the loss were given (State Council 2006). This estimate of losses may be an under-estimate, and does not include the loss to Harbin city. Chen Jinsong, a researcher with the development and research centre of Heilongjiang provincial government, estimated that at present the direct loss brought about by the accident might amount to some RMB 1.5 billion Yuan. The loss included a daily loss in output value of nearly RMB 1 billion Yuan for 51 industrial enterprises in the city that were forced to stop or to reduce production, therefore a total loss of RMB 5 billion Yuan for five days; RMB 5 billion Yuan lost revenues for restaurants and hotels in Harbin; another RMB 5 billion Yuan for the extra administrative cost of the city and province government, who used the governor's fund to control pollution, and allocated funds to purchase activated carbon in order to upgrade water filtration systems and to evaluate the environment after the polluted water had passed. In addition, the pollution had an adverse effect on tourism to Harbin, a famous tourist city which is particularly well-known for its Ice and Snow Festival in winter. The loss of tourism revenue due to the pollution was estimated to be RMB 50 billion Yuan (Liu 2005).

The indirect economic loss is even larger and far-reaching. Due to the pollution, the number of river sturgeon, a species of endangered fish on the list of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), decreased, and the natural resources of Harbin city were badly affected. So on 7 December 2005, three professors and three graduates of Beijing University filed a statement of complaint against PTR to the Supreme Court of Heilongjiang province, asking for compensation of RMB 100 billion Yuan from PTR to set up pollution treatment funds and to protect the rights of river sturgeon to live, the rights of Songhua River and Sun Island to be kept environmentally safe and clean, and the rights of citizens to enjoy the beauty of nature (Gan and Wang 2005). According to Xianhua news agency, Heilongjiang provincial government will invest RMB 500 million Yuan in pollution control and prevention projects at 11 main water sources along the river in order to improve the safety of the drinking water, and some RMB 13.4 billion Yuan (US$1.7 billion) is to be spent on controlling the amount of pollution in Songhua River by 2010 (Li 2007). Nevertheless, Songhua River had already been heavily polluted by various chemical enterprises along its upper stream, and the JPC explosion and the pollution that it caused to the river brought the real picture of the whole situation to the attention of the public.

Although the explosion caused great damage to the environment, costs of rescue work, substitute water supplies, and remedial work to the river's ecology system are borne by society rather than by PTR. In principle it should be PTR who should pay for the costs of rescue and remediation, but in time of emergency it is the local government or other enterprises that pay. In practice, no local government has been able to ask any state-owned companies to refund this later because there is no such legal system in existence, and no matter who pays it is the state that is the ultimate cost-bearer. The above-mentioned complaint by the professors and graduate students of Beijing University against PTR was rejected by the court, for the reason that such cases should be settled by the central government. Fines and penalties are possible, but these are insignificant compared to the cost of pollution prevention.

In fact, after more than a year's investigation, in January 2007 SEPA finally announced its decision to charge JPC a penalty of RMB 1 million Yuan. This amount is only one-fifth of the donation that PTR has made for remedial work, yet it is the highest amount of penalty that is allowed by regulation in China. Ten of PTR's managers received administrative punishment such as warning, demotion, and dismissal, yet none of them had to pay a fine. For PTR, the private cost of industrial disaster is far less than the social cost; it is the financial performance that counts, not the environmental performance. However, if accidents which threaten public lives and properties occur too often, the public blames these oil giants as lacking social responsibility, which is harmful to their reputations. Although PTR made a donation to the local government as a remedy, public hatred against it was not reduced but instead the public actually blamed PTR for this payment, because it looked like a donation rather than paying for its guilt in the form of refund. Indeed, the public were pressing for increased compensation.

Another reason is that PTR is profit-driven. Listed companies are under pressure to achieve financial performance, and the market had little response to the accident. Immediately after the accident, PTR was ranked 7th of the “Top 250 Global Energy Companies for 2005” by the world-famous energy information company Platts. To evaluate the heads of state-owned companies, the State-owned Assets Supervision and Administration Commission of the State Council (SASAC) applies a performance system which uses the external financial reporting as the basis for evaluation and puts too much emphasis on profit or profit-related performance, such as ROI and profit margin. Managers are therefore trained to make decisions in terms of efficiency or profitability, without environmental considerations. To cut down cost, proper training and safety equipment was omitted, experienced workers were released, and temporary workers were used. Water used to extinguish the fire caused by the explosion was polluted, but was then directly emitted to the water supply without treatment, again for the sake of saving costs. To boost profit, the plant put more emphasis on initiatives that contribute directly to the bottom line, paying little attention to regulation and society or to human capital management. Though PTR claimed to have emergency rules for accidents, these were not applied at JPC. It is therefore clear that the environmental policy was not put into action at each level of PTR’s plants, sites and branches.

With the operating strategies explicitly focusing on profit and without proper supervision from outside, the plant put too much emphasis on cutting costs without proper consideration for the company’s long-term benefit. As a result, PTR failed to recognise properly the environmental risks in its strategy and disasters occurred. The consequences of sacrificing environmental performance for financial performance can be serious. PTR suffered loss of lives, disposal of equipment before the end of its useful life and shutdown of production, not to mention the harm to its reputation and a penalty of RMB 1 million Yuan. The state council punished the officials who were responsible for the explosion or pollution. PTR’s vice-president and its parent company, CNPC received an “administrative demerit”, while nine other managers of the PTR group including Yu Li were either sacked, demoted, or received demerits and warnings. Two officials of Jilin province were also punished (State Council 2006). Once proved guilty, the leader of the company may be subject to 3–7 years’ imprisonment and a penalty.

24.3 Mobilising Change

The level of enforcement of PTR’s environmental strategy is low, as is the level of the government’s enforcement of legal compliance. Having operating and environmental strategies which are independent rather than integrated has led PTR into trouble and to avoid recurrences, some steps must be taken. Possible actions are:

24.3.1 Establish Corporate Environmental Governance to Connect the Environmental Strategy with the Operating Strategy

Firstly, according to institutional theory (DiMaggio and Powell 1983) Organisations have two components—the technical component and the institutional component. The technical component is governed by the norms of rationality and efficiency, whilst the institutional component is governed by expectations from the Organisation's external environment, which is composed of the norms and values of stakeholders. Under the current pressure for environmental conservation, organisations should not only set up formal structures that reflect the expectations and values of their various stakeholders but also stress solid measures to ensure the enforcement of their policies. Considering the interest of only one party and neglecting the interests of others will ultimately do harm to the company. As in the case of PTR, the pursuit of short-term benefit to the detriment of the environment has caused serious disaster, damaging the interest and reputation of the company.

In China, the level of legal enforcement varies from time to time. When pursuit of GDP is the local government's top priority, the level of enforcement will be low, but if the consequences of breaking the law are severe and cause great public attention then the level of enforcement will be high. Since PTR's accident has caused great damage and caught worldwide attention, it is not easy for the government to forgive the law-breaking company this time. In fact, ever since 2005 the enforcement of environmental regulations has been emphasised, and several major projects in China were forced to close down because they failed to pass the environmental impact assessment. Following the accident, SEPA has carried out environmental risk assessments on several of PTR's chemical plant sites.

The oil industry has for years received natural resources almost free and earned huge profits, yet it does not preserve the natural environment properly. The state has little return from the oil industry so since March 2006, as public pressure against oil companies has increased, a new special profit tax has been levied on them to compensate for the extremely high profits that they have been able to make from receiving natural resources which are almost free. This is a signal of the government's determination that the resource-users should pay. In SASAC's annual performance evaluation of centrally governed enterprises, PTR was downgraded from A to B because it had had two major accidents in one year (SASAC 2006). This is another signal of the government's determination to make the polluters and resource-users pay. Since June 2006, lawmakers in China have passed two hearings on the draft law on emergency management, aiming to upgrade the country's ability to cope with frequent outbreaks of industrial accidents, natural disasters, health and public security hazards. Officials who fail to take precautionary measures, delay emergency declaration, or try to cover up mistakes, will face tougher penalties. With the government turning to market-based economic instruments and imposing legal liability for environmental damage, operations that have adverse impacts on the environment can carry significant financial implications for business in the future.

Meanwhile, people living downstream of Songhua River have pressed JPC to move away from the area, blaming it for lack of social responsibility. Even after PTR had made a donation as a remedy, the public was still angry. Some analysts called for California Retirement Fund to sell off its investment in PTR. The mission of the aforementioned AccountAbility is to promote accountability for sustainable development, and its disclosure of PTR's poor performance will have an effect on the decisions of international investors.

The explosion of the plant in JPC has also had some far-reaching impacts on the power of citizens as one of the stakeholders of the business. After the accident, the public's awareness of environmental risk from industry was aroused and the middle class has begun to say 'no' to major projects that pose an environmental risk to their neighbourhood (Dyer 2007). In Xiamen, a coastal city in southeast China, a project to build dangerously close to the city centre a toxic chemical plant which will attract investments of RMB 10.8 billion Yuan and may bring a GDP of over RMB 80 million Yuan to the city was forced to be halted temporarily as a result of the actions of scientists, members of the Chinese People's Political Consultative Conference and public opinion generally, even though the project had received approval from the local government. The citizens were afraid of a possible explosion similar to that of JPC, and demanded that the local government should scrap the project altogether and asked for more participation in research into the feasibilities of major projects in the city (Zhu 2007). SEPA finally stepped in and asked Xiamen municipal to rethink the approval that it had given to the project and to carry out an environmental impact assessment of the city's urban planning. Obviously, citizens are having more rights and enterprises cannot neglect their voices.

The environmental pressure at home and abroad poses risks for PTR and will affect the costs and benefits of its operations. For the industry with its oil fields, pipelines and refineries with decades of useful life, a long-term view is very important, and in the long-run environmental performance does matter to the value of PTR. In order to incorporate stakeholder concerns regarding PTR's environmental performance, it might consider setting up corporate environmental governance (CEG) which refers to the values, norms, processes and institutions through which companies attempt to reduce their risk exposure and through which they demonstrate to stakeholders that they operate in a safe and environmentally sustainable manner. It also involves "… setting out the responsibilities of directors and establishing the accountability of the board to all the company's stakeholders, which includes the systems and tools used to achieve the company's environmental objectives and their effectiveness in meeting desired outcomes" (University of Hong Kong 2003). The notion of CEG is a connection of three pillars of sustainability—economic, environmental and social. It is also a policy supported by the UK Environment Agency which covers a full range of its best practice approaches, including environmental values (vision, mission, principles); environmental policy (strategy, objectives, targets); environmental oversight (responsibility, direction, training, communication); environmental processes (management systems, initiative, internal control, monitoring and review, stakeholder dialogue, environmental accounting, reporting and verification); and environmental performance (use of KPIs, benchmarking, eco-efficiency, reputation, compliance, liabilities, business development) (UKEA 2004). Unlike EMS, CEG has a wider coverage of tools and will cover the board of directors as well as the managers responsible for the environment. Based on an extensive literature review and 15 case studies, UKEA has concluded that good CEG can reduce environmental risk and have positive financial consequences. PTR has installed EMS, environmental policy and principles, but it does poorly in other aspects of CEG such as environmental oversight (responsibility), processes (environmental accounting, stakeholder dialogue, internal control), and performance (use of KPIs, benchmarking,, eco-efficiency, reputation, compliance, liabilities), and this is detrimental to its enforcement of its environmental strategy.

Identifying major stakeholders and getting their approval first will make action easier and develop environmental strategy from a potential source of cost to a potential source of market value creation (Escoubes 1999). CEG would help PTR to change its tone at the top, so that the interest of the major stakeholders such as residents, governments, and potential investors, can be considered when setting strategy and formulating corporate policy. It will also help to build up partnerships between the company and its stakeholders, which is vital for implementing objectives. Moreover, CEG will help the management to see the importance of the above aspects of CEG and help to enforce environmental strategy. As environmental risk is reduced, the shareholders can benefit from long-term financial performance.

24.3.2 Cascade the Environmental Strategy to Business Units

As the pressure for environmental protection increases, the needs of the market place and other stakeholders change too. Only those who match their organisations' capabilities to these changes can survive (Otley 1994). A management control system is a system of organisational information-seeking and gathering, accountability and feedback, which is designed to ensure that the enterprise adapts to changes in its substantive environment and that its employees' work behaviour is measured by reference to a set of operational sub-goals which conform to overall objectives, so that any discrepancy between the two can be reconciled and corrected (Lowe 1970, 1971). In today's business, industries that rely heavily on natural resources are exposed to greater environmental risk and ignorance of such risk can lead to disasters. A return-based strategy alone cannot protect the company against such risk, nor can an environmental strategy that is not implemented, so integration of both should be attempted. As the strategies of business change, management control systems should be revised.

In contrast, management control systems including accounting systems can play a proactive role in shaping new strategies (Hopwood 1987; Argyris 1990). The environmental policy and environmental disclosure are simply a commitment to take responsibility for the environment. To put this commitment into reality, a mechanism should be set up to ensure the integrity of the company's values and norms. Defining an environmental strategy is a starting point, but implementation requires further efforts. As a multi-national corporation PTR has various branches and subsidiaries and achieving strategic objectives requires strategy alignment within the company. With the current performance measurement system which places too much weight on profit, environmental performance will not be a top priority of a business unit. As can be seen from the success of PTR's operating strategy, the environmental strategy should be further developed into targets at lower levels of the organisation. Key performance factors should include HSE performance measures as well as financial performance measures. Since most of the environmental performance measures are non-financial measures which directly connect to PTR's environment strategies, this can result in setting goals not only in economic terms but also in environmental terms. In other words, the performance management process should be re-designed to ensure that the corporate and the environmental risks associated with value drivers can be identified and managed and business unit strategies conform.

A balanced scorecard could be developed for PTR (Kaplan and Norton 2001). One of the major strengths of the balanced scorecard is the emphasis that it places on linking performance measures to business unit strategy. A balanced scorecard with its four perspectives (or with environmental issues, perhaps five) can assist the implementation of a strategy by identifying, organizing and managing environmental impacts. In doing so, exposure to the risks associated with environmental damage can be reduced and an advantage can be gained. Otherwise, the conflicting pressure of financial performance and alignment with HSE norms would lead managers at lower levels in a decentralised organisation to be faced with difficult judgments between risk and return.

Another benefit for using a balanced scorecard is improved strategic alignment. With the example of Dow Chemical, Crawford and Scaletta (2005) show that the "balanced scorecard" can help organisations to manage strategically the alignment of cause-and-effect relationships of external market forces and impacts with internal CSR drivers, values and behaviours. This alignment, combined with CSR reporting, can enable enterprises to implement strategies of either broad differentiation or cost leadership. PTR has a low-cost strategy, and it can compete on this strategy with improved technology, effective and efficient use of resources, and re-design of processes, which leads to improved environmental protection, better management of risk, and low costs, a virtuous cycle that helps to improve corporate performance.

24.3.3 Design an Environmental Accounting System to Aid Implementation of the Environmental Strategy

An environmental accounting system can help to implement an environmental strategy. Many writers have suggested that improved business performance requires that information systems be related to the firm's strategy. Companies with different strategic initiatives may require different management information systems to enhance Organisational performance (Miles and Snow 1978; Govindarajan and

Shank 1992). Chow (2003) has shown empirically that the level of strategic application and a proper alignment of an information system with its strategic objectives will improve business performance. A strategy information system application can have an effect on a business's success by shaping the company's strategy and playing an important role in its implementation. Being part of the information system, an accounting system can also have an effect on the strategy application and implementation. Epstein (1996) has suggested 15 steps to implement an environmental strategy, such as integrating environmental information into the financial information and managerial information systems, integrating current and future environmental impacts (costs and benefits) into decision-making and integrating accounting and financial analysis techniques including risk assessment into environmental decision-making. Most of these steps involve accounting. As the environmental strategy is integrated into operating strategy and the corporate strategy is cascaded into business unit strategy objectives, the accounting system should be redesigned to facilitate its alignment with the information system.

However, Brown describes a poor picture of the accounting system that has environmental considerations (Brown 2005): the accounting information rarely provides adequate support for managing or assessing environmental concerns (Gray and Bebbington 2002). Few examples of comprehensive accounting that incorporate environmental information can be found (Schaltegger and Burritt 2000).The actual direct costs of environmental regulation, a small part of the total impact of the environment, were not captured in the accounting system (Joshi et al. 2001). Captured information is highly aggregated, and the systems that capture environmental information are generally kept separate from the systems that are used to manage the business (Epstein 1996; Schaltegger and Burritt 2000). This is exactly the case at PTR.

PTR's information system suits a return-based strategy, not an environmental strategy. Its financial statements say little about its depreciation or operating cost for pollution prevention equipment, nor the cost of installing an EMS system. Losses and damage due to this environmental accident were put under the heading of 'expenses'. Since environmental costs and losses arising from environmental accidents or operating activities are not separately accounted for in its accounting system, this currently does little to inform its environmental strategy.

Moreover, the financial reports evaluate resulting damage *ex post*, not future risk *ex ante*. As a result, the manager will not have insights into the potential sources of environmental cost, so the opportunity to improve environmental performance as well as financial performance is not easily identified. In fact, it is managerial information that will meet the managers' greatest need, not external reports based on economic assumptions of short-term profit. So, in order to prevent environmentally irresponsible decisions from occurring, management accounting systems need to be expanded to include environmental considerations. However, PTR's internal accounting systems held business unit managers responsible for returns-based measures and did not consider environmental measures. As the performance management process is re-designed as suggested, the accounting information system needs to be redesigned to facilitate the enforcement of the corporate strategy.

In fact, various environmental management accounting techniques have been proposed by academics or industry (Schaltegger 1996; EPA 1995; IFAC 2005). Most of these techniques can also be applied in Chinese companies (Guo 2003). An information matrix for identifying alternative management strategies for framing and responding to environmental issues has been developed (Brown et al. 2005). A well-designed accounting information system will not only facilitate the preparation of related environmental information and help managers to be aware of environment-related business opportunities and risks and manage them better, but will also keep a record of the environmental performance of various business units and monitor and evaluate the execution of strategy, which will make the business units more responsible for environmental performance.

24.4 Conclusion

This paper examines the relationship between environmental strategy and environmental performance. Using the case of an industrial accident at PTR that caused severe environmental consequences, it has demonstrated that a well-stated environmental strategy does not necessarily guarantee good environmental performance. Lack of incentives to care about environmental performance, and the profit-based operating strategy, may have caused conflicting financial and environmental performance. To avoid accidents from occurring again, integration of the environmental strategy within the operating strategy will be needed. Under present environmental pressure in the oil industry, PTR should try to set up corporate environmental governance to ensure the interests of major stakeholders in operations, re-design its management control system, use a balanced scorecard to translate its integrated strategy into operating units and redesign its accounting information system to identify the costs of and obtain greater control over its actions.

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Part VII
Success Factors in Implementation

Chapter 25
Evaluating Management Accounting from a User Perspective: A Study of the Environmental Accounting System of the Environment Agency in England and Wales

Martin Bennett

Abstract *The Environment Agency in England and Wales* developed its *Environmental Accounting System* (EAS) with several aims, one of which is to provide a management accounting tool to support managers across the agency. This paper explains the EAS and reports on a study that took a user-oriented approach to evaluate its effectiveness in this. The research found that at the time of this study, the information generated by the EAS was not yet being used for this purpose as anticipated, but that both current and potential future users were able to identify several further potential uses for EAS information and suggest ways in which it might be further developed, with implications for the role of those managing the EAS.

25.1 Introduction

The variety of scope of the papers which have been presented at EMAN conferences and published in previous EMAN books show that, like mainstream management accounting, environmental management accounting (EMA) has been interpreted liberally to include a broad range of different approaches (Bennett et al. 2002, 2003, Rikhardsson et al. 2005, Schaltegger et al. 2006).

As would be expected, a high proportion of these are on methods and systems that are intended to be applied, or have actually been applied, at the level of individual businesses and companies (or other equivalent entities, such as government agencies). These can be distinguished between normative recommendations of systems designed for companies to adopt in order to generate relevant information and reports on initiatives that companies have actually taken. The former group includes for example several prescriptive systems which advocate the collection and reporting of 'environmental costs' on the implicit assumption that this will ipso facto represent added-value information for managers and other users (IFAC 2005, Jasch 2003, Kokubu et al. 2003, JMOE 2002) and similar suggestions of how

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conventional management accounting techniques can be adapted to support environmental management (EPA 1995).

The initiatives that companies have actually taken have often been occasional or one-off projects rather than part of a continuing system and have often arisen from a specific research study or have been promoted and pioneered by individual champions within organisations (Bennett et al. 2006, Bent 2006, Burritt et al. 2002, Ditz et al. 1995, EnviroWise 2002, EPA 1998, Howes 2002, Schaltegger and Wagner 2005, 2006, White et al. 1993). Although there are exceptions such as Baxter International's use of its Environmental Financial Statement as a continuing process (Bennett and James 1998a) and the Augsburg Eko-Effizienz model (Stroebel 2001, Stroebel and Redmann 2002), the risk for many company-based initiatives is that when the research study finishes or the project champion moves on, the initiative may lapse.

This paper reports on a study which aimed to fill a gap by directly researching users within an organisation, to ascertain the uses that they actually make in practice of information generated by a continuing environmental accounting system established as an additional element within their organisation's existing accounting and information systems, on the principle that the benefit of any management information is defined by the value which it adds for the organisation through users' improved management decisions and judgments. This organisation is the *Environment Agency of England and Wales* ('the Agency') which designed and introduced its own *Environmental Accounting System* (EAS) as a continuing information system, with the intention that over time it would become institutionalised and permanently 'embedded' within the organisation and with several aims including the management accounting purpose of providing relevant information for managers.

25.2 The Environment Agency of England and Wales and Its Environmental Accounting System

25.2.1 The Role of the Environment Agency of England and Wales

Like most national environmental protection agencies, the Environment Agency's most visible role is to regulate and enforce national laws and regulations. It also has two further roles which are often less common in other countries. Firstly to promote and publicise good environmental management practice (including through the Agency's website, where further information on the Agency and the EAS is available: http://www.environment-agency.gov.uk/environmentalaccounting) and secondly an operational responsibility for managing water resources, flood defences, fisheries, recreation, conservation and navigation. The scale of these activities means that the Agency is a substantial operation in its own right. With an annual budget of £700 million and 10,500 staff it is comparable in scale to one of the UK's largest 100 companies and its resources (including 215 buildings and depots and a fleet of 6,500 vehicles) inevitably create a significant environmental impact which needs to be managed.

The Agency's operations are geographically spread across England and Wales, with eight Regions (for simplicity and brevity although at the sacrifice of strict accuracy, the term 'Region' is used here to include the principality of Wales as well as the seven regions of England) and three central support functions reporting into a central Head Office and a sub-infrastructure of Areas and facilities.

25.2.2 The Goals of the Environmental Accounting System

As part of its own environmental management the Agency decided in 1997 to adopt its own environmental accounting system (EAS). This was developed and has subsequently been managed by its Environmental Finance department (EF). The EAS's primary aims were to collate data for the Agency to publish externally in its Annual Report and Environmental Report and to support its own environmental management system (EMS) in order to achieve ISO 14001 certification (and subsequently also EMAS) by monitoring the financial savings and environmental benefits which have been achieved since its introduction, which have included reductions in water costs of 44% and in CO_2 emissions of 73%. Having achieved these primary aims, EF has also developed the EAS to provide also a management accounting tool which would support managers across the Agency by tracking relevant information and reporting it to those who might find it useful in their work.

In developing its EAS, the Agency aimed not only to develop a management tool for its own benefit but also to provide a model of good practice which could be made available to other organisations, particularly elsewhere in the public sector. EF has therefore been active in publicising the EAS as it has evolved, through its website and through participation in external activities such as the United Nations Experts Working Group on EMA and presentations and papers (Pearce 2001) (Ward and Dicks 2001), and it has been cited as an example of good EMA practice in the public sector internationally (IFAC 2005, UNDSD 2003).

The EAS collects data on the Agency's 'internal environmentally significant expenditure' such as energy, materials and travel costs incurred on buildings, vehicles and plant, which at the time of this study represented in total some £250 million (36%) of its total annual spending. It combines both financial data (costs) and related non-financial information on the physical quantities which represent the drivers of both costs and environmental impacts, such as distances travelled by Agency vehicles and tonnes of consumables. The operation of the EAS and the quantities derived from it for the Agency's external reporting are regularly reviewed by both the Agency's internal audit function and its external auditors, the National Audit Office, whose report on the System is published annually (NAO 2004, 2005).

The EAS aims not to capture new data but rather to collect into a single system from a variety of sources a range of different data that is already being captured somewhere across the Agency. In principle, therefore this should already be potentially available for use by managers in other parts of the Agency, but since it is dispersed across a number of separate systems it can be difficult in practice for managers to access this directly, particularly under the pressure of time that many decisions demand.

When first introduced, several managers found that the EAS provided a useful additional database, so EF provided information on request to meet this demand. In 2002 they extended this into systematic internal reporting with the introduction of an Environmental Accounting Quarterly Report (EAQR). This reported in a one-page tabular format a selection of key indicators of environmental significance, both financial and non-financial, for example environment-related costs such as energy, water and transport and corresponding physical units such as KWh, cubic metres (of water) and mileage. The quarterly totals of each of these variables were both reported for the Agency in total and analysed between each of its eight Regions and three central functions, so that inter-Region comparisons could be made in order to identify and disseminate good practice and to provide an incentive by recognising and publicising above-average performance.

The EAQR was distributed quarterly to approximately 40 staff identified by EF. These were mainly in the finance and environmental management functions in the Regions—*Regional Finance Managers* and *Chief Accountants*, and *Regional Environmental Management Advisers* (REMAs). REMAs are the Agency's own internal environmental management experts within each Region and are responsible for providing advice and training to colleagues, helping to monitor the Agency's own environmental performance and promoting good practice and to provide a link in chains of collecting and disseminating data on environmental performance. Copies were also distributed to managers in areas such as procurement, and extracts were provided to Directors.

Finance and environmental management staff are not usually in positions to control or significantly influence directly any substantial environmental impacts themselves, but they are in a position to disseminate information and influence those who do, such as operational managers and managers of individual offices and vehicle fleets. EF therefore decided that they would be the most appropriate target audience for the EAQRs as intermediaries, which would also be consistent with normal practice in the Agency in the distribution of information from the centre.

During the period of this study the main source of data for the EAS was the Agency's mainstream accounting system, the Integrated Accounting System (IAS). This was a bespoke system and still included disparate elements which the Agency had inherited from its various predecessor bodies in the mid-1990s. Plans were already in progress to develop a new information management system to be designed by Oracle, derived from its well-developed enterprise resource planning (ERP) system. The new system, One Business One System (1B1S) was in design at the time of this research but was only subsequently implemented in fully operational mode. This study is therefore based on experience under the previous system, from which EF was able to draw in helping to design 1B1S. However the conclusions that can be drawn are still pertinent, both for other organisations interested in considering a similar initiative, and as a study in the design and application of a novel and innovative management accounting system.

25.3 Research Design

This study aimed to assess the EAS's usefulness in practice as a management accounting tool from the perspective of its intended users. It was therefore analogous to a market research study in which the product under research was environmental accounting information and the customers were the recipients of EAS-generated information. The population was therefore defined initially as those persons to whom EF distributed the EAQRs (though excluding the Board and senior managers, for practical reasons of accessibility). This was in the expectation that these interviewees would be close enough to final users such as operational managers to be able to identify those decisions and actions that could reasonably be attributed to EAS-generated information; i.e., that would probably not have occurred without it. A series of semi-structured interviews was therefore conducted with a sample of 12 persons from this population, with the aim of identifying the effects on actual behaviours and actions which could be attributed to EAQR-generated information and any decisions which this had positively informed and influenced.

However these interviews did not produce the results which had originally been anticipated. Although interviewees were unanimously supportive of the concept of an EAS and the principle of using accounting to support environmental management, they were generally unable to identify actual instances where EAS-generated information had positively influenced behaviours or informed decisions. It was therefore decided to revise the research design and introduce a second phase of interviews in which the focus would be on not these intermediaries but on the potential final users themselves.

However this meant that it now became more difficult to define the total population and the nature of the interviews also had to change. Whereas the population which had originally been planned for the study was clearly defined and bounded as those persons to whom EF had decided to distribute the EAQRs, the population of potential final users of EAS-generated information is open-ended and can be defined only as those people who: (1) have opportunities through their positions in the Agency to influence its environmental impacts or environment-related costs and (2) might be better informed with the information that the EAS might generate than without it.

Two principles were adopted to guide the selection of a sample in this second phase and to ensure a reasonable breadth:

1. Those persons with control or significant influence over decisions and activities which could affect the Agency's main environmental impacts (road transport and energy consumed in the use of buildings respectively)
2. A range of different levels of management, defined in terms of the level and time-horizons of decisions over which they had control or influence:

   - Those in a position to control immediate operational performance, such as facilities managers.
   - Those with control or influence over longer-term strategic decisions such as purchases of new vehicles, and the acquisition, design and refurbishment of buildings.

- Those in positions to control or influence decisions which might not have an obvious immediate environmental impact but which could fundamentally affect the Agency's needs for environment-related resources in the very long-term. Examples here included the design of organisational structures which could affect the need for staff transport (for example, through needing to arrange frequent meetings between staff based in different locations) and the design of buildings and their consequent energy demands.

Since the resources and time available for the research were constrained, the number of interviews in this second phase of the project had to be limited and it was accepted that the nature of the study had now to be only exploratory rather than aiming to provide a definitive portrayal of the actual uses of environmental accounting information. A sample of seven persons were interviewed, all being in positions to influence the Agency's environmental impacts in the near or distant future and reflecting each of the three levels of decisions described above.

Although the interviews in both phases of the project followed a semi-structured format, the agenda and nature of the discussion had to be fundamentally adapted in this second phase from a *user wants* (decision makers) approach to a *user needs* (decision models) approach (AAA 1977; Sterling 1970). In the first phase, it had been reasonable to assume that interviewees would both be familiar with the EAS and would also be able to identify and articulate their own perceptions and opinions. This meant that a *user wants* approach was appropriate since the researcher could treat users' decision models as a 'black box' and respond solely to their expressed wants, rather than needing to try to understand these or the situations for which users might find the information relevant and how they might then use it.

However, this assumption could no longer be made in the second phase since it could not now be assumed that interviewees would already be aware of the EAS and what it offered, or even be familiar with the Agency's mainstream accounting systems; or that they would necessarily be able to conceptualise their job requirements in terms of the accounting information which might be relevant. To continue the market research analogy, the product was no longer a well-established one whose consumers understood its nature and capabilities and what they wanted from it, but rather a concept for a new product still in design for whose functionality the potential eventual users might not yet even perceive a need, much less a specific use. The approach therefore had to be changed to one based on *user needs* with the researcher taking responsibility for understanding the customers and their potential needs adequately in order to be able to design a product which could prove valuable in use, even before those customers are themselves aware of their need.

Interviews in the second phase were therefore more open and wide-ranging than in the first phase. The main aim was to ascertain and understand interviewees' job definitions and their main responsibilities for monitoring performance and making decisions and what was required in order to discharge these and in particular their present uses of accounting information, which could be affected by the particular individual's aptitudes and preferences as well as by their job content. Discussions were deliberately kept open and interviewees were encouraged to think speculatively around possibilities. This meant that at times the topics discussed could move beyond a conventional understanding of what accounting systems usually represent. Interviews were recorded and subsequently transcribed and analysed to identify common themes and issues of interest.

25.4 Findings

In both phases of this study interviewees were invariably supportive of the principle of environmental accounting (though it is acknowledged that neither this sample nor the Environment Agency as an organisation can be claimed necessarily to be representative of any wider population, and interviewees may also have been influenced by the ‘halo’ effect of a system developed and promoted from the finance function). However, most found it easier to express general aspirations about the purposes for which they might find useful the broad types of information that an EAS might generate, rather than to be definite on any specific information or explain how this might positively influence performance. Three main potential applications were identified: regular operational performance monitoring, decision support and life cycle costing respectively.

25.4.1 Regular Operational Performance Monitoring

Although in both phases interviewees were supportive of the concept of linking accounting with environmental management and appreciative that the EAS provided valuable contextual background, the study did not provide any evidence that EAS-generated information was as yet having any direct effects on behaviours or decisions. Interviewees in the first phase (intermediaries rather than final users) were generally not close enough to final users to be able to be identify specific decisions or actions and since the final users who were interviewed were not themselves on the distribution list for the EAQRs there had been no opportunity for the EAS to have had a discernible influence on them as yet, although they could often suggest information which they might have found valuable had it in fact been available.

Most interviewees attributed the non-use of EAS-derived information to perceived deficiencies in the data which EF had extracted from the Agency’s existing accounting and operational information systems to provide the inputs into the EAS. It had been hoped for example that the EAS would make it possible to control consumption in more detail than currently by providing information on both costs and physical quantities at the levels of individual facilities. Interviewees generally recognised the potential use and value of this, but explained that despite additional quality assurance checks by EF during the process of extraction and collation they were not yet sufficiently confident of the quality of the information currently reported by the EAS for this to be possible, although several hoped that the planned

1B1S system would eliminate this problem. Information provided through the EAQRs was therefore not used for regularly monitoring operational performance in the manner in which variance analysis reports, for example, would conventionally be used, and most interviewees reported that they found the existing financial reports adequate for this.

Attempting to use the EAS to control consumption in more detail than previously raised major basic problems of data capture. For example it was frequently impossible to match measures of physical quantities of energy and water consumed against the corresponding monetary quantities recorded in the accounting system accurately, mainly due to practical issues of the timing of the capture of physical quantities through meter-readings. For example, reported quantities of energy consumption per employee might be distorted by inconsistencies in timing between the booking of invoices and the actual consumption of the energy. In annual financial reporting these timing differences are not usually a problem since monthly and quarterly lags are largely smoothed out in corporate annual totals, but for managerial control at a micro-level such as in managing individual buildings, information is needed which is not only accurate but which also has financial and physical quantities stated consistently in detail for short time-periods. For example, at the time of this study it was not possible to use EAS-generated information to analyse variances between price and usage, since this would have to be based on an analysis of consumption down to the level of individual facilities if it were provide a practical basis for effective control. This problem is partly attributable to the complexity of the Agency as an organisation, with several hundred facilities being supplied with energy in total, not only its main buildings and depots but also small unstaffed locations such as sensors to monitor local conditions such as river levels where meter-readings cannot always be easily and cost-effectively taken as frequently as would be needed, but it is likely to be repeated to some extent in any organisation with a complex pattern of energy supply.

The Agency also deals with several different energy suppliers which means a variety of different invoicing arrangements, depending on a number of factors including the size of the facility being supplied and a single invoice may cover several different facilities within an area. The periodicity of both individual and composite invoices also varies and is not necessarily for complete calendar months, which would be necessary if it were to be coterminous with the Agency's own accounting system. Suppliers' invoices are frequently complex since a single invoice may include several different tariffs as well as multiple sites. Although the quantities invoiced by suppliers can be checked in total against internal meter-readings, interviewees pointed out that it was not possible to analyse these into accurate and reliable quantities of usage at facility-level due to the complexity and lack of uniformity of the invoices, and since existing information systems were inadequate to capture physical quantities systematically as well as costs.

The existing accounting system did in fact include a capacity to capture physical quantities, but in practice it was difficult to ensure consistent adherence to this since it depended on consistently accurate manual data entry by accounts clerks, so that results could frequently be distorted by errors and omissions. The new 1B1S system was expected to solve this problem for some types of expenditure since it would make it possible to capture physical quantities within the system itself, but even this would be insufficient for energy consumption since charging systems can be complex and invoices often contain high volumes of information, which it was considered unrealistic to expect data input staff to process. To address this, EF was developing a system of ‘electronic billing’ (‘e-billing’) to supplement its main systems. With e-billing, suppliers are contractually required to provide to the Agency not only their usual regular periodic invoices but also more detailed supporting analyses in electronic format. These are sent to EF who then input this additional data directly into the EAS’s supporting systems. EF anticipate that when the e-billing system has been fully implemented, all electricity and gas suppliers will be providing e-bills in addition to their main invoices, which will then make it possible to capture and compare both costs and physical quantities at the level of individual buildings.

Similarly, although all interviewees recognised the potential value of comparing performances between Regions in benchmarking exercises, the quality and limited detail of the present data meant that only superficial comparisons could be made. Attempts at meaningful comparisons were also undermined by obvious structural differences between Regions for which the EAS was unable to allow. For example, some Regions enjoyed a better public transport infrastructure than others so that they could more easily avoid using cars for business travel, and buildings could differ in age and quality with consequent effects on energy and water consumption. It was considered that these factors were as likely to explain differences between the reported performances of Regions as any underlying differences in their performance. However since the quantities reported in the EAQR were at the highly aggregated level of each Region as a whole, the effect of any structural differences such as these was not transparent. To address this satisfactorily would have required that the EAS’s present high-level data also be supported by a database of more detailed operational-level data (for example, of energy efficiency at the level of individual buildings) into which users could ‘drill-down’.

25.4.2 Decision Support

Most interviewees saw the main potential attraction of an EAS as a source of relevant and reliable information to support the decisions that they faced from time to time. Examples included designing the specifications and refurbishments of buildings; the locations of new facilities; the relative costs and benefits of alternative methods of providing and conserving power; policies on vehicle procurement and maintenance, including the choice of fuel; cost-benefit analyses of video-conferencing systems and policies on home-working, hot desking, car parking and the encouragement of car-sharing by staff.

Even for information which already existed somewhere in the Agency, interviewees agreed that it would be valuable to have this available from a single easily accessible source, with adequate assurance of its accuracy and reliability. In a decision-making situation they often found that much potentially valuable information was available only from informal systems, so that they would have to contact the information-holders on each separate occasion to seek their co-operation. Since there is often only limited time available in which decisions have to be taken, these often have to be made under pressure based on only limited information which can be of dubious quality. Systematising these informal processes could, in the expression of one interviewee, transform the process of collecting together decision-relevant information from being ‘person-dependent to system-dependent’.

This implies a role for the EAS as an intermediary between original sources and potential final users. Several interviewees went further and suggested that it should also aim to collate relevant external data and information. This implies a broader and more strategic role for the EAS, to represent not only an extended application of existing internal accounting data but also a proactive scanning of the organisation’s external business environment in order to provide an information-based internal consultancy service to operational managers. To be most effective, EF as the internal owners of the EAS would have not only to be reactive to requests for information but also proactive in identifying potential opportunities for which data could be collected and then to persuade decision-makers of its value.

Even with the improved flow of information to managers that was generally confidently anticipated from 1B1S, there could still leave a supplementary role for an EAS. This would be firstly to collect and report information which 1B1S was not designed to capture in the first place, such as data from external sources and store this so that it could subsequently be easily extracted as needed and combined with information from 1B1S itself. Secondly, complex integrated systems can often be inflexible after implementation so that it may not subsequently be possible to amend them easily and cost-effectively, either for omissions in the original design of the system which may become apparent only with hindsight, or for new demands and types of information which can subsequently arise. This leaves a gap which a supplementary semi-formal system might fill between major re-designs, which would also help to inform the specifications for those re-designs. Even where information is simply transferred from 1B1S into the EAS, this transfer process still provides an opportunity to perform additional quality checks to ensure its reliability.

25.4.3 Life Cycle Costing

Life Cycle Costing (LCC) measures the environmental impacts and costs of an asset over its life as a whole and is particularly relevant for long-life assets such as buildings and vehicles, where most impacts and costs arise only after acquisition when the asset is in use. LCC means that the costs, benefit and impacts associated with the initial investment decision are better integrated with those arising during the asset’s subsequent life and eventual disposal and can help to avoid situations where features of new projects which could reduce costs and environmental impacts in the long-term but which require some extra initial expense might not be adopted, solely in order to stay within capital budgets. Since several of the Agency's assets are long-life, its central procurement function was already working to develop LCC to guide its decisions.

Implementing LCC effectively requires both adequate information to support the initial decision and also adequate systems to be able to track costs and benefits subsequently in sufficient detail to be able to compare outcomes back against those decisions and ensure accountability. Several interviewees suggested that the EAS could help with this, provided that the budgetary control regime could be managed liberally enough to avoid rigid and potentially counter-productive distinctions between capital and revenue spending and rigid annual budgeting cycles which can militate against the integration of spending between different years.

25.5 Conclusions

Although the lack of evidence of actual uses of EAS-generated information to influence decisions and management behaviours appears discouraging, this can best be understood as part of a learning process which has diagnosed the gaps in data and the need to develop further both the EAS and other complementary systems. The initiative to date has also usefully raised the awareness of what might be possible and encouraged several positive suggestions from potential users of what they could usefully derive from such a system.

Section 25.4.2 described a potential decision support role for the EAS as an intermediary between sources of information including the Agency's formal information systems and final users. However since it is not possible to predict all possible future decision situations that may arise which may have some environmental significance, it is not possible to specify precisely in advance the full set of potentially relevant information.

To ensure that EAS-generated information is relevant to the continually changing needs of users will require a more active and dynamic role for EF as its managers, based on a continuing decision needs approach, than is usually needed to run formal information systems. It implies a role as a combination of a proactive researcher and advisor who are aware of users' present and potential future needs and an internal consultant who is able to identify opportunities and help users to devise solutions. Key competences in this role would include not only extensive environmental knowledge and skills in information management, but also an intimate knowledge of the organisation in order to be aware of the opportunities that may be available and of which individuals might be in a position to exploit them and influence policy formulation, whilst at the same time being careful not to appear to supplant users in their ultimate responsibilities for taking and implementing decisions.

This approach is consistent with strategic management accounting literature which encourages the management accountant to play an active role as an integral member of the management team. Much EMA can be understood as the application of modern good management accounting practice to a specific area of managerial concern, such as the development of environmental balanced scorecards (Figge et al. 2003), environment-based risk assessment (Burritt 2005), strategy formulation (Wagner and Schaltegger 2004) and the analysis of environmental initiatives by companies in terms of their potential effect on shareholder value (Rosinski et al. 2006) (Schaltegger and Figge 1998). To link EMA innovations such as the EAS to an organisation's mainstream management accounting in this way could be mutually beneficial by both enhancing the management accounting function's capacity to support the rest of the organisation and also helping to embed EMA into the organisation and ensure its own continuation.

The research provides a reminder of the crucial importance of adequate data and how traditional information systems may be inadequate to achieve improvements in operational management which require non-financial as well as financial data and of the importance of adequate and appropriate detail in designing accounts coding systems. Detailed managerial control of operational performance at those levels of management which are able to take effective practical action requires more detailed and carefully controlled data than is needed for only the broader purpose of overall financial control. The Agency has been fortunate in being able to plan on the basis of the features expected from 1B1S and a solution which requires a complex and expensive ERP system may be viable for only a few large organisations; however the principle of designing accounting and other information systems so that data on both costs and physical quantities can be captured and reconciled in adequate detail is common to all organisations.

The other change which was found necessary to support detailed managerial control was a change in suppliers' billing arrangements and formats. However since not all organisations will be in a strong enough position relative to their suppliers to negotiate this, there may be a role here for legislation and regulation to require suppliers' billing to be simplified and standardised in order to enable energy users to control their consumption.

The experience to date of the EAS also indicates that when seeking to introduce management accounting innovations, it is insufficient merely to make the information available and then leave its use to potential users. The innovators also need to take responsibility for leading those potential users whilst at the same time being careful not to appear to be pre-empting their roles and responsibilities and then from the outset to monitor carefully the actual uses being made and the effects of these on behaviours and the organisation's performance.

EF has continued to develop the EAS subsequent to this study, with the benefit of the features which are now offered following the implementation of 1B1S. It would be valuable in due course to repeat this study based on the uses made of post-1B1S EAS-generated information. This would make it possible to distinguish how far the lack of use of EAS-generated information found in this study mainly reflected simply a temporary problem of data quality and availability, or might indicate more fundamental limitations in this particular model of environmental accounting. It would also help to indicate the type of underlying mainstream accounting systems that are needed to make an EAS of this type feasible: in particular whether this approach is restricted only to organisations with sophisticated information systems such as an ERP, or could be more widely applicable too.

Further research would also be welcome into more advanced applications of environmental accounting information that are now enabled by the improved underpinning main accounting system. These might include for example its use to measure an overall environmental 'footprint' for the Agency as an indicator of its overall performance, either for the Agency as a whole or less ambitiously for evaluating specific policies and programmes such as (say) the overall effect of the Agency's policy of trying to move its people to rail rather than road in their business travel and to enable more detailed environmental performance benchmarking exercises.

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Chapter 26
An Empirical Examination of the Role of Environmental Accounting Information in Environmental Investment Decision-Making

Tapan K. Sarker and Roger L. Burritt

Abstract An experiment is used to investigate two important factors associated with environmental investment decision-making by managers: the regulatory regime in which the firm operates and the nature of environmental information used as a decision aid. Two regulatory regimes are examined, a command and control regulatory regime and a voluntary self-regulatory regime. Two accounting systems are contrasted, environmental management accounting and conventional management accounting, thereby providing a 2 × 2 experimental design for the empirical study. The paper considers environmental investment decision-making by different types of managers working in the Australian offshore petroleum industry. These empirical results indicate that environmental accounting information has a more significant influence on the willingness of managers to incorporate environmental considerations into investment decisions and to avoid future environmental risks, than does the type of regulatory regime.

26.1 Introduction

Most investors have a keen focus on the financial benefits from their investments (Fayers 1999). However, as social values change and environmental awareness grows, investors and corporate managers are beginning to identify the potential role of investment in assisting moves towards ecologically sustainable development (Young 1992). Such moves have lead to the concept of socially responsible investment, also called sustainable investment or ethical or environmental investment, which can be defined as:

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> [T]he process that considers the social and environmental consequences of investments, both positive and negative, within the context of rigorous financial analysis and meets certain baseline standards of corporate social responsibility (O'Rourke 2003).

Burritt (2004:29) points to a gap in the literature and suggests that there remains a need for:

> [A]dditional research studies…that…provide relevant environmental information for practical decisions that involve corporate environmental impacts … and incorporate long-term (strategic) considerations in the corporate decision making, planning and control process.

Investment decisions typify such long run decisions. Previous studies identify a complex range of factors that influence the impact of environmental issues on investment decision-making by business managers. These include: the regulatory climate or environment in which the firm operates (Earnhart 2004; Yishai 1998; Gunningham and Rees 1997), the types of information strategies used to assist in management control and decision-making (Eisner 2004; Schaltegger and Burritt 2000), managerial interpretations of environmental issues (Ness and Mirza 1991) including environmental values, the level of the manager's knowledge (Fryxell and Lo 2003) and management's overall strategy (Al-Tuwaijri et al. 2004; Eisner 2004), the influence of social control (ANZECC 1998), regulatory costs such as pollution charges and mandatory clean-up costs (Thomas 1995; Joshi et al. 2001) and stakeholder opinion including the role of non-government Organisations and industry Organisations as third parties (Gunningham and Rees 1997; Eisner 2004; Scott 1995). From this complex array of variables two have been chosen for detailed analysis—the regulatory regime and the environmental information strategies used and their possible interaction.

Hart (1997) recognises that: "like it or not, the responsibility for ensuring a sustainable world falls largely on the shoulders of the world's enterprises, the economic engine of the future … and more importantly, on their management."

Hence, given the potential importance of enterprises and their management to the environmental impacts of business, the focus here is on enterprises operating in a single industry in Australia—the offshore petroleum and gas industry, an industry with potentially significant environmental impacts. Young (1992) argues that to be sustainable a business should consider the fact that investment is not just about making money. Instead, business needs to search for quality investments that simultaneously improve environmental quality and human living standards. However, deciding upon the projects in which to invest is a difficult process as decision-makers are faced with a complex range of environmental investment variables. In the case of the offshore oil and gas industry these include multiple objectives such as maintaining mangrove and marine biodiversity while increasing the amount of drilling through oil and gas rigs, thereby increasing the discovery and production of oil and gas resources. To further complicate the matter each decision-maker in a team draws on different environmental values, knowledge and cognitive processes to determine the best course of action which affects their willingness to take the environment into account. As success or failure of environmental outcomes rests upon how well investment decisions are made, it is important to understand the investment decision-making process and provide tools to make it easier to achieve goals that can lead to sustainable investment pathways.

Previous studies (Ness and Mirza 1991; Schaefer and Harvey 2000; Schweiger and Latham 1986) also examine the role of managers in acquiring and disseminating environmental information including: the motivational effects of participation and managerial intuition as the basis for decision and action (Schweiger and Latham 1986; Carliss and Clark 1994), the effect of experience on decision-making (Mohammad and Arnold 1987), concern of managers for social values (Blamey and Braithwaite 1997), demographic profile and investment strategies (Tippet and Leung 2001) and the nature and type of environmental regulations that managers take into account when considering investment decisions (Benidickson et al. 1992). Sharma (2000) finds that, in the Canadian oil and gas industry, environmental strategies are associated with management interpretations of environmental issues as either threats or opportunities. The extent to which some companies incorporate environmental concerns into decision-making was heavily dependent on the perception that managers have of these issues as opportunities or threats (Sharma 2000). Ness and Mirza (1991) identify that: "the intention of managers to incorporate environmental issues in their investment decision-making depends on their self-interest related to their specific role within the business".

It is recognised that different managers could have different roles and perceptions and so a range of manager types from across the supply chain in the offshore petroleum industry are included in the study in order to allow for possible variance in their willingness to take environmental considerations and environmental risk mitigation into accounting in investment decision-making.

In summary, there is a perceived need for further empirical study of the relative impact of different factors and their possible interrelationship in environmental investment decision-making. The paper begins to address this issue through the development and implementation of an experiment which is designed to investigate the influence of two of these important factors which are associated with environmental investment decision-making by managers. First, the regulatory climate in which the firm operates is considered and second, attention is given to different types of environmental information and disclosure strategies used to assist environmental investment decision-making. In recognition of the potentially differing roles and perceptions of managers the paper considers environmental investment decision-making by different types of managers working in companies in the Australian offshore petroleum industry.

26.1.1 Aims and Objectives of the Study

Based on the previous gap identified in the literature, the central question investigated in this paper is to examine the role that different types of (i) regulatory regimes and (ii) accounting information strategies, play in influencing environmental investment decision-making.

26.1.2 Research Questions and Hypotheses

Within this context, this study seeks to answer the following three research questions:

1. Does the company's regulatory regime influence the willingness of managers to include environmental considerations in their major investment decisions?
2. Does the company's information and disclosure strategy influence the willingness of managers to avoid future environmental risks in major investment decisions?
3. Is there any link between the company's regulatory regime and information and disclosure strategy which has an effect on the manager's environmental investment decisions?

These research questions lead to the development of the following six hypotheses expressed in the null form:

- H1a: A manager's willingness to incorporate environmental considerations in major investment decisions is not affected by the regulatory regime in which the company operates.
- H1b: A manager's willingness to undertake environmental investments to avoid future environmental risks is not affected by the regulatory regime in which the company operates.
- H2a: A manager's willingness to incorporate environmental considerations in major investment decisions is not affected by the use of an environmental information and disclosure strategy.
- H2b: A manager's willingness to undertake environmental investments to avoid future environmental risks is not affected by the use of an environmental information and disclosure strategy.
- H3a: The nature of the regulatory regime in combination with the environmental information strategy has no effect on the willingness of a manager to include environmental considerations in major investment decisions.
- H3b: The nature of the regulatory regime in combination with the environmental information strategy has no effect on the willingness of a manager to undertake environmental investments to avoid future environmental risks.

26.2 Regulatory Regimes and Environmental Information Strategies

The key independent variables in this study are regulatory regimes and accounting information strategies and their possible interaction. The following sections discuss the two independent variables of this study.

26.2.1 Regulatory Regimes

The term ‘regulation’ carries various meanings ranging from the conscious ordering of activity to formal promulgated provisions. Regulation is usually defined as the imposition of rules by government, backed by the authority of the State and the use of penalties that are intended to change the behaviour or action of individuals or groups. Regulations are aimed at preventing harm or providing benefits for segments of society. ‘Regulation’ as the term is used in this paper refers to environmental regulation which is termed as one of the most important strategies for protecting the environment (Gunningham and Rees 1999). Regulation can be by government fiat, known as ‘command and control’, or through self-control, for example through an industry association. These are explored further below in the context of the Australian offshore petroleum industry.

26.2.2 Information Strategies

Environmental decision-makers today face greater difficulties than ever before (Dale and O’Neill 1999). Some of these difficulties are social and political in nature, they arise partly because of controversial but deeply held views about how decision-making should be conducted and what the outcome should be. However, a main concern is the constraint on resources available for investment decision-making caused by decision-makers who do not have the time or means to analyze in a systematic way the problems they face. Environmental Management Accounting (EMA) information is introduced here as a decision-making tool that may enhance the environmental investment decision-making process for managers.

Environmental issues—along with related costs, revenues and benefits—are of increasing concern to many countries around the world, but there is a growing consensus that conventional accounting practices simply do not provide adequate information for environmental management purposes (IFAC 2000). To fill the gap the emerging field of EMA is receiving increased attention. EMA provides information about environmentally induced financial impacts on a company that is not normally provided by conventional accounting systems (Schaltegger and Burritt 2000). It is primarily designed for internal decision-making, but can assist with internal and external accountability. Thus it can provide key information to guide management behaviour in relation to the environmental efficacy of investment projects. EMA has been identified as a driver of sustainable investment (Reyes 2000) and has become an important tool in the process of building better environmental management systems (Wilmshurst and Frost 2001). It can also provide the data needed for sustainable supply chain management through better identification, allocation and analysis of environmental costs through which the profitability of potential investment projects can be assessed. By using EMA information, managers of resource-based companies are able to recognise and achieve benefits from sustainable investments in two ways: firstly, by reducing costs and lowering product prices and secondly, by reducing liabilities and improving the image of the company.

EMA can support the management investment decision-making process by, for example, providing information about environmental costs associated with future capital investment decisions, including disposal costs, contingent costs such as environmental liabilities, or the costs of potential environmental incidents and their follow-up (Shapiro et al. 2000).

26.2.3 Regulatory Regimes and EMA Information

Environmental costs are often driven by regulations (Shapiro et al. 2000; Gunningham and Johnstone 1999): for example, certain regulations specify that the product must be disposed of in a particular way. In consequence, it is useful to consider the possible interrelationship between regulatory regimes and the accounting strategy designed either to reveal, or not reveal, environmental aspects of corporate activity.

The underlying relationship between the regulatory regimes and accounting information system are illustrated in Fig. 26.1. The figure illustrates that environmental accounting information (i) could influence investment decision-making

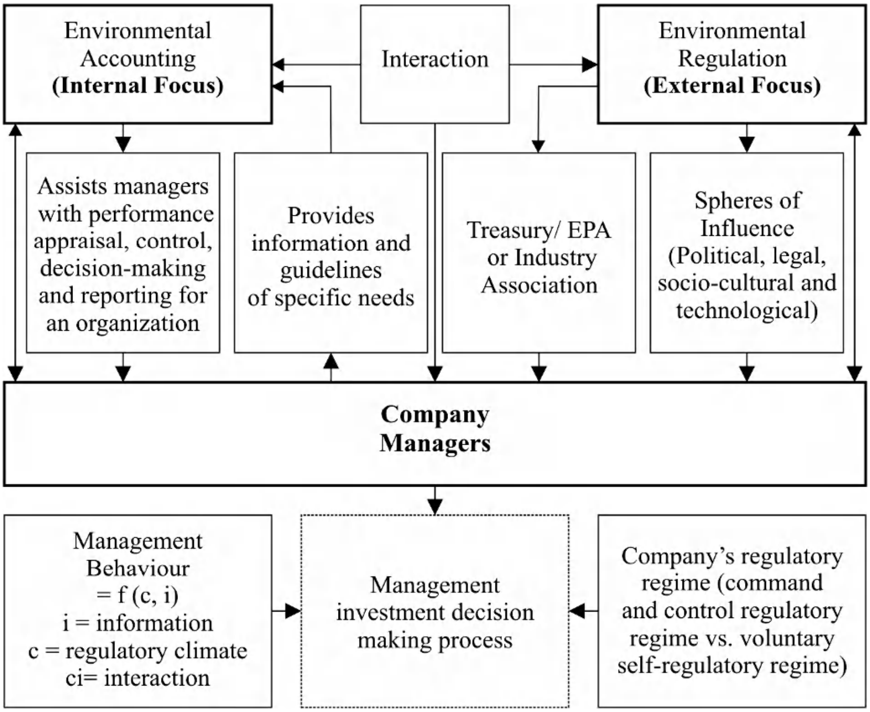

Fig. 26.1 Conceptual framework: Environmental accounting and investment decision-making

differently under different regulatory climates (c). There could also be an interaction effect (ci). In addition, the relationship could depend upon personal characteristics of the different managers involved, so it is important to include a range of managers in any empirical testing.

26.3 The Context: Australian Offshore Petroleum Industry

The focus of this study is the offshore petroleum industry, which covers the exploration and production of oil and gas resources from the sea. It has the potential to cause serious incidents to the marine environment as well as to the occupational health and safety of people engaged in such activities. Examples of such incidents include the Exxon Valdez oil spill in Alaska in 1989, the Piper Alpha disaster or the North Sea oil spill in 1988, the Santa Barbara offshore oil spill in 1968, the sinking of Amoco Cadiz off the coast of Brittany in 1978, and the IXTOC oil spill off Mexico's Caribbean coast in 1979. Such incidents lead to a serious image problem for the oil industry among investors, policy makers and civil society. Concern is summed up by Elkington who argues that people are becoming increasingly aware of the systematic abuse of citizens and nature which is inherent in the production and processing of petroleum and petroleum products (Elkington 1999).

Australia faced serious oil incidents in the past that caused more than 21,000 tonnes of oil spills (AMSA 2005). In addition to offshore oil spills this sector produces more than 17.02 million tonnes per year of greenhouse gases (CO_2_e) (Sarker and Burritt 2005) and frequently causes severe fatalities and injuries to personnel (APPEA 2004).

Australia relies heavily on offshore oil and gas for its energy needs with over 98% of oil and gas being produced offshore (APPEA 2003). Consequently annual investment in offshore exploration is much higher than in onshore exploration, with an average investment of A$700 million p.a. compared with A$200 million p.a. in onshore exploration (APPEA 2004). Hence, because of its relative importance this study investigates the environmental investment decision-making of managers in the Australian offshore petroleum industry.

26.3.1 Regulatory Regimes for the Offshore Petroleum Industry in Australia

The regulatory regimes of the Australian offshore petroleum industry can be broadly categorised into two groups: one that places the emphasis on laws and regulations i.e. coercive "command and control", and the other that prefers to rely on voluntary undertakings by organisations themselves, namely "industry self-regulation". The following section discusses the role of government regulation on environmental investment decision-making.

26.3.2 Government Regulation in the Australian Offshore Petroleum Industry

Environmental regulation has predominantly been informed by command and control (CAC) government regulatory policy. CAC regulation is a compulsory form of government intervention in which government literally commands industry and individual business corporation to meet specific environmental standards, either directly through legislation or indirectly through delegated authority and controls its behaviour through the threat of sanctions. The principal rationale underlying mandatory regulation is the theory of deterrence, under which compliance is treated as a function of the probability of an offender being punished and the severity of the penalty.

Offshore petroleum operations in Australia are governed by Australian Government legislation known as the Petroleum (Submerged Lands) Act 1967. Australian governments require petroleum companies to conduct their activities in a manner that meets a high standard of environmental protection. To gain the necessary approvals to undertake petroleum activity in an offshore area, a project proponent must establish the level of risk involved and the strategies needed to mitigate any potential impacts. The companies operating oil and gas exploration and production in Australia face extensive regulatory requirements in environmental, health, safety and biodiversity conservation. These include seven government Acts and eleven regulations all imposed by the Commonwealth as can be seen in Fig. 26.2.

Acts

1) Petroleum (Submerged Lands) Act 1967
2) Petroleum (Submerged Lands) Fees Act 1994
3) Petroleum (Submerged Lands) (Registration Fees) Act 1967
4) Petroleum (Submerged Lands) (Royalty) Act 1967
5) Petroleum Excise)Prices) Act 1987
6) Petroleum (Timor Sea Treaty) Act 2003
7) Environment Protection and Biodiversity Conservation Act 1999

Regulations

1) Petroleum (Submerged Lands) (Management of Well Operations) Regulations 2004
2) Petroleum (Submerged Lands) (Data Management) Regulations 2004
3) Petroleum (Submerged Lands) (Mgt. of Safety on Offshore Facilities) Regulations 1996
4) Petroleum (Submerged Lands) (Occupational Health and Safety) Regulations 1993
5) Petroleum (Submerged Lands) (Management of Envoronment) Regulations 1999
6) Petroleum (Submerged Lands) (Pipelines) Regulations 2001
7) Petroleum (Submerged Lands) (Registration Fees) Regulations 1990
8) Petroleum (Submerged Lands) Fees Regulations 1994
9) Petroleum (Submerged Lands) (Datum) Regulations 2002
10) Petroleum (Submerged Lands) Regulations 1985
11) Petroleum (Submerged Lands) (Diving Safety) Regulations 2002

Fig. 26.2 Australian Government laws and regulations affecting the offshore petroleum industry

The following section discusses the link between industry self-regulation and environmental investment decision-making.

26.3.3 Industry Self-Regulation in the Offshore Petroleum Industry in Australia

Two key problems are associated with government regulation of the industry. First, regulators have limited capacity to monitor and enforce the environmental and safety standards in Australia's vast offshore areas. Second, the offshore oil and gas companies being regulated face difficulties in dealing with the increasingly complex regulations which often provide little or no incentive to go beyond mere compliance (Gunningham and Johnstone 1999). Industry self-regulation provides an alternative to government regulation. The offshore industry association, operating on behalf of its members, is known as the Australian Petroleum Production & Exploration Association (APPEA). Thus, the effectiveness of industry self-regulatory environmental regulation adopted by APPEA is considered as an alternative to existing government regulation.

APPEA and its member companies have adopted self-regulatory environmental measures which have the objective of operating to the highest safety and environmental standards. Self-regulation is through the formulation and acceptance of codes of practice in key areas of business activity. Previous empirical research for the period 1996 to 2002 (Sarker and Burritt 2005) investigates the effectiveness of industry self-regulatory strategies adopted by APPEA member companies in achieving safety and environmental standards. It concludes that the use of a self-regulatory environmental information and disclosure strategy has a strong role in enhancing industry environmental, health and safety performance. This supports the examination here of the relative usefulness of EMA information to aid environmental investment decision-making by managers.

26.4 Research Method

In Milne and Chan (1999) and Milne and Patten (2002) an experimental investment scenario is used to generate data for analysis. Both of these studies use experimental decision cases in experiments which assess the decision-usefulness of narrative disclosures for investment decision-making. O'Donovan (2002) uses a similar approach to ascertain disclosure choice by managers. In particular he uses vignettes which describe scenarios involving hypothetical environmental issues or events and fictitious corporations.

The advantage of such an approach is the ability to manipulate the variables of interests to measure in a direct way the potential impacts. Tortman (1996) suggests that such an approach is useful for examining the main and interaction effects, as well as for controlling for confounding variables by building a single design. However it has to be recognised that in an experiment participants are not making real-world investment decisions and consequently the external validity of the results can be called into question. Unlike surveys that capture attitudes, decision experiments measure behaviour. The advantage with decision experiments of course is that while they do measure changes in behaviour, they do so under controlled and hypothetical conditions which provide greater internal validity.

The extent to which such behaviour would be repeated in real decision situations is always open to debate and debate over the trade-off between internal and external validity remains ongoing. In short, the level of confidence that can be placed on the experimental results depends to some extent on how well the experimental conditions model the actual decision setting being emulated (Milne and Patten 2002).

26.4.1 Sample Selection

Previous studies (Milne and Chan 1999; Milne and Patten 2002) include only practising accountants and investment analysts as the individuals having a significant degree of experience in understanding accounting processes and the necessary skills to evaluate investments. Top management are often key managers involved in large investment decisions however, a significant number of investment decisions are delegated to field-level managers in the industry (Bromiley 1986; Wheelwright 1986; Baldwin and Clark 1994). In the case of natural resource-based companies, managers at different levels in the production and supply chain indirectly influence the company's overall strategic decision-making, including fundamental investment decisions which shape its future direction (Eisenhardt and Zbaracki 1992). In consequence, a variety of managers engaged in overall company activities are included in the decision experiment, thereby enhancing the internal validity of the study.

Participants in the experiment were managers in the APPEA member companies working in offshore oil and gas exploration and/or production in Australia. The managers included were randomly selected from eight different categories in the supply chain: (1) management/administration (2) exploration/production (3) finance/accounting/taxation (4) occupational health, safety and environment (OHSE) (5) drilling/operations (6) marketing, human resources and external affairs (7) project management/technical consultants and (8) others. Four of the 52 member companies were excluded as their head offices were outside Australia. Managers from 48 companies were available for this study. Four managers were chosen from each of the 48 companies listed in the 'APPEA 2005 Members Directory' and this gave a total of 172 managers available for inclusion in the experiment.

98 surveys were returned by managers, giving a response rate of 57%. There were three incomplete responses, reducing the useable responses to 95, comprising 85 males and 10 females. The average age of respondents was 44.73 (with a standard deviation of 9.28) years. Descriptive data are shown in Table 26.1.

Table 26.1 Demographic data

Gender (n):	
Males	85
Females	10
Average (sd) age in years	44.73 (9.28)
Average (sd) work experience in years	20.76 (9.73)
Environment-related work experience (%)	
Yes	63.2
No	36.8
Investment-related work experience (%)	
Yes	57.9
No	42.1
Location of company (%)	
Western Australia (WA)	71.6
Others	28.4
Company's country of incorporation (%)	
Australia	65.3
Overseas	34.7
Company's area of operation (%)	
Exploration (only)	13.7
Production (only)	2.1
Both exploration & production	75.8
Others	8.4
First language (n):	
English	90
Others	5

26.4.2 Experimental Design

The experiment was based on a 2 × 2 between-subjects full factorial design. It used a within-subject comparison of internal versus external factors that influence management behaviour in relation to the incorporation of environmental considerations into investment decision-making. Participants were randomly allocated to one of four treatment groups, as shown in Fig. 26.3.

The experimental material included a general description of the purpose of the study and provided an assurance of participant confidentiality. The experimental task comprised a vignette that was based on an investment decision at the hypothetical XYZ Company Ltd. After reading the randomly allocated case materials the participants were asked to provide their opinions in statements relating to three broad areas in the questionnaire: (1) managers' views towards a company's investment decisions and environmental concerns (2) managers' views towards government or industry regulations regarding the company's operations and (3) managers' views towards the use or non-use of environmental information and disclosure strategies in the company's operations. For all statements, the participants were asked to respond on a six-point

Investment decision aid	Company's regulatory regime	
	Government regulatory regime	Industry self-regulatory regime
Use of EMA information as an investment decision aid	Cell 1 (X1)	Cell 2 (X2)
No use of EMA information	Cell 4 (X4)	Cell 3 (X3)

Fig. 26.3 Experimental design lay out (Note: The experiment involves a multivariate (2 × 2) design)

Likert scale that was anchored by 'Strongly disagree' (1) and 'Strongly agree' (6). After completing these tasks and before handing in their responses, participants answered questions designed to check for manipulation and demographics as well as signing the letter of consent for this research in line with ethical procedures. Initial results from the survey are outlined in the following section.

26.5 Initial Results

In this section correlation between variables, hypothesis testing and the manipulation checks are examined in turn.

26.5.1 Correlation Analysis

The results of correlation analyses between the dependent variables and the demographic variables are reported in Table 26.2.

The results show that gender and investment-related work experience are significantly correlated to dependent variable 1, '*managers' willingness to incorporate environmental considerations in their major investment decisions*'. Gender, age and work experience are significantly correlated with dependent variable 2, '*managers' willingness to undertake environmental investments to avoid future environmental risks*'. These variables were next included in the ANCOVA model as covariates (see next section).

Investment-related work experience was negatively correlated with dependent variable 1, indicating that the longer the investment-related work experience, the lower the willingness to undertake environmental investments to avoid future environmental risks.

Work experience and age were positively correlated with dependent variable 2, indicating that the longer the work experience and the older the manager, the greater the willingness to undertake environmental investments in order to avoid future environmental risks.

Table 26.2 Correlation analysis

	1	2	3	4	5	6	7	8	9	10
Dependent Variable 1: Managers' willingness to incorporate environmental considerations in major investment decisions	**-.270**[a] (.008)	.184 (.074)	.199 (.054)	.019 (.853)	**-.203**[b] (.048)	0.72 (.487)	.061 (.559)	.021 (.839)	-.077 (.457)	-.077 (.459)
Dependent Variable 2: Managers' willingness to undertake environmental investments to avoid future environmental risks	**-.314**[a] (.002)	**.245**[*] (.017)	**.243**[b] (.018)	-.143 (.166)	-.181 (.079)	-.002 (.986)	-.034 (.742)	-.079 (.444)	.092 (.376)	-.177 (.086)
Gender (1)		**-.220**[b] (.033)	**-.242**[b] (.018)	.094 (.367)	.194 (.060)	-.109 (.295)	.051 (.624)	.031 (.764)	-.117 (.260)	.073 (.483)
Age (2)			**.859**[a] (.000)	**-.274**[a] (.007)	-.172 (.095)	-.131 (.207)	-.073 (.479)	-.104 (.316)	.165 (.111)	**-.283**[a] (.005)
Work experience (3)				**-.242**[b] (.018)	-.089 (.390)	-.086 (.410)	-.029 (.779)	-.107 (.300)	.095 (.358)	**-.296**[a] (.004)
Environment related work experience (4)					**.321**[a] (.002)	-.092 (.374)	-.198 (.055)	.069 (.506)	-.128 (.218)	.015 (.882)
Investment-related work experience (5)						.023 (.829)	-.050 (.628)	.094 (.364)	-.075 (.471)	.085 (.410)
Company's country of incorporation (6)							.071 (.496)	.150 (.148)	-.079 (.449)	.022 (.834)
Company's area of operation (7)								-.039 (.710)	-.188 (.068)	.030 (.774)
Company's size (8)									**-.330**[a] (.001)	.001 (.993)
Company's environmental rating (9)										.110
First language (10)										(.288)

[a]Correlation is significant at the 0.01 level (2-tailed).
[b]Correlation is significant at the 0.05 level (2-tailed).

26.5.2 Hypothesis Testing

To test the six hypotheses, within-subjects ANCOVA was applied for the two dependent variables: (1) managers' willingness to incorporate environmental considerations in their major investment decisions and (2) managers' willingness to undertake environmental investments to avoid future environmental risks. The results can be found in Tables 26.3 and 26.4.

Comments on the results of testing each hypothesis follow.

Results in Table 26.3 Panel A indicate that regulation (via regulatory climate) does not have a statistically significant positive impact on the willingness of managers to incorporate environmental considerations in major investment decisions. The null hypothesis, H1a, cannot be rejected.

Table 26.3 Dependent variable 1: Managers willingness to incorporate environmental considerations in major investment decisions (managers are willing to incorporate environmental considerations in their major investment decisions in your opinion (strongly disagree—1; strongly agree—6))

Panel A: Test of between-subjects effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig
Covariates:					
Gender	6.649	1	6.649	8.944	**.004**
Investment-related work experience	1.652	1	1.652	2.222	.140
Main effects:					
Regulatory climate (1)	.550	1	.550	.740	.392
Environmental information and disclosure strategy (2)	9.254	1	9.254	12.449	**.001**
Interaction effect:					
REGCLM*INFODIS (1*2)	.060	1	.060	.081	.777
Error	66.161	89	.743		
Corrected Total	83.958	94			

R Squared =.212 (Adjusted R Squared =.168)

Panel B: Means (SDs)

	Company's regulatory climate	
Managers' willingness to incorporate environmental considerations in major investment decisions	Government regulatory climate	Industry self-regulatory climate
With EMA information	5.22 (0.751) (n = 27) X1	5.33 (0.485) (n = 18) X2
No EMA information	4.62 (1.299) (n = 26) X4	4.83 (0.816) (n = 24) X3

Table 26.4 Dependent Variable 2: Managers willingness to undertake environmental investments to avoid future environmental risks (The company should undertake the new investments in the exploration site (Strongly disagree—1; Strongly agree—6))

Panel A: Test of between-subjects effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig
Covariates:					
Age	.145	1	.145	.182	.670
Gender	6.941	1	6.941	8.723	**.004**
Total work experience	.018	1	.018	.022	.822
Main effects:					
Regulatory climate (1)	1.380	1	1.380	1.735	.191
Environmental information and disclosure strategy (2)	4.767	1	4.767	5.991	**.016**
Interaction effect:					
REGCLM*INFODIS (1*2)	.008	1	.008	.010	.923
Error	70.016	88	.796		
Corrected Total	82.905	94			

R Squared =.155 (Adjusted R Squared =.098)

Panel B: Means (SDs)

Managers' willingness to incorporate environmental considerations in major investment decisions	Company's regulatory climate	
	Government regulatory climate	Industry self-regulatory climate
With EMA information	5.04 (0.759) (n = 27) X1	5.17 (0.618) (n = 18) X2
No EMA information	4.08 (0.796) (n = 26) X4	4.17 (0.761) (n = 24) X3

Results in Table 26.4 Panel A indicate that regulation (via regulatory climate) does not have a statistically significant positive impact on the willingness of managers to undertake environmental investments to avoid future environmental risks. The null hypothesis, H1b, cannot be rejected.

The conclusion is that there is no impact of regulatory climate on the willingness of this diverse sample of managers, from the offshore petroleum and gas industry in Australia, to address environmental issues in major investment decisions.

Results in Table 26.3 Panel A indicate that environmental information and disclosure strategy does have a statistically significant positive impact on the willingness of managers to incorporate environmental considerations in major investment decisions. H2a is not confirmed.

Results in Table 26.4 Panel A indicate that environmental disclosure strategy does have a statistically significant positive impact on the willingness of managers to undertake environmental investments to avoid future environmental risks. H2b is not confirmed.

Consistent results were obtained for the significant impact of environmental disclosure strategy on the willingness of this diverse sample of managers from the offshore petroleum and gas industry in Australia to address environmental issues in major investment decisions.

Results in Tables 26.3 and 26.4 Panel A indicate that there is no significant interaction effect between regulatory climate and environmental disclosure strategy. The null hypotheses H3a and H3b hold.

The final stage of analysis is to examine the results when two regulatory climates, government regulation and self-regulation and two environmental information strategies, with and without environmental information, are considered. These results appear in Tables 26.3 and 26.4 Panel B.

Panel B in Table 26.3 provides the means (standard deviations) of the scores for managers' willingness to incorporate environmental considerations in major investment decisions. The mean (standard deviation) score for the use of environmental accounting information in a self-regulatory regime is 5.33 (0.485) as compared with 5.22 (0.751) in a government regulatory regime [X2 > X1], but the difference is not statistically significant ($F = 1.847$, $p = .065$). The mean (standard deviation) for the non-use of environmental accounting information in a self-regulatory regime is 4.83 (0.816) as compared with 4.62 (1.299) in a government regulatory regime [X3 > X4], but again the difference is not statistically significant ($F = 1.407$, $p = .071$). This result reveals no difference between the impacts of both regulatory climates on managers' willingness to incorporate environmental considerations in major investment decisions. Similar conclusions can be drawn from Panel B in Table 26.4 in respect of managers' willingness to undertake environmental investments in order to avoid future environmental risks. These results reveal that for both of the environmental accounting strategies, the type of regulatory regime has no differential impact on the willingness of managers to undertake environmental investments in order to avoid future environmental risks [X2 > X1 and X3 > X4].

Panel B in Table 26.3 shows that the mean (standard deviation) score in a government regulatory regime where EMA information is available is 5.22 (0.751) as compared with 4.62 (1.299) where it is not available [X1 > X4]. This difference is statistically significant ($F = 8.562$, $p = .004$). Likewise, the mean (standard deviation) score in a self-regulatory regime where EMA information is available is 5.33 (0.458) as compared with 4.83 (0.816) where it is not available [X2 > X3]. This difference is statistically significant ($F= 3.626$, $p = .030$). This result reveals significant differences between situations where EMA is and is not available. As before, similar conclusions can be drawn from Panel B in Table 26.5 in respect to managers' willingness to undertake environmental investments in order to avoid future environmental risks. These results reveal that for both regulatory regimes the availability of environmental accounting information is linked with a greater willingness of managers to undertake environmental investments to avoid future environmental risks [X1 > X4 and X2 > X3].

26.5.3 Manipulation Checks

To ensure that the different regulatory climates and environmental information strategies were perceived as being different by participants, four items (separate questions) were measured on a six-point Likert scale anchored at strongly disagree (1) and strongly agree (6). The scores of these four items were totalled to form the government/self score (theoretical range 4 to 24). A *t*-test indicated a significant difference between the two treatment groups ($t = 2.57$, $p = .006$; 2-tailed test). The mean (Standard Deviation) for participants in the government regulatory treatment was 15.39 (2.18) and the mean (SD) for participants in the self-regulatory treatment was 13.88 (3.28). A similar procedure was carried out to test the success of manipulation of the availability/non-availability of environmental information and disclosure strategy. The mean (SD) for the availability of environmental information and disclosure strategy was 14.42 (1.54) and for the non-availability of environmental information and disclosure strategy it was 13.72 (1.38). The results were significantly different ($t = 2.32$, $p = 0.011$), demonstrating that both manipulations were successfully differentiated by participants.

26.6 Conclusions

Environmental investment decision-making is an important activity for the future viability of the offshore petroleum and gas industry, as indicated by the high level of resources which are typically committed by organisations to the capital investment process and the importance of the industry's environmental impacts (Swain and Haka 2000). This study investigated the potential role that environmental regulation and environmental accounting information can play in major investment decision-making by managers with diverse functions in the offshore petroleum industry in Australia.

The inherent idea examined in this study is whether the availability of environmental accounting information affects the willingness of managers to take environmental considerations into account in their investment decision-making and whether it affects the willingness of managers to undertake environmental investments in order to avoid future environmental risks. Null hypotheses H1b and H2a were both rejected, confirming that there is a positive relationship between information disclosed and the impact on environmental investment decision-making by managers. Furthermore, the evidence reported here reveals that when environmental accounting information is available to managers at various stages of the value chain in the offshore petroleum industry, they are more willing to take investment decisions that consider the environment and future environmental risk reduction. As gender was found to be negatively correlated with the dependent variables in both cases one issue for further study is the impact of gender and in particular whether there is any significant difference between men and women in the environmental investment decision-making process.

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Chapter 27
Success Factors in Developing EMA—Experiences from Four Follow-Up Case Studies in Finland

Anna Kumpulainen and Tuula Pohjola

Abstract Pressure to include environmental issues in corporate decision-making is increasing. *Environmental Management Accounting* (EMA) is a tool-kit for monitoring environmental loads and costs caused by a company's processes and thus it is essential for effective environmental management. This paper aims to identify the success and failure factors in EMA development, on the basis of four longitudinal case studies conducted in large Finnish companies in the period 1996–2005. In the mid-1990s, pilot EMA systems were designed and implemented in these companies, and in 2005, the current state of their EMA practices was recorded by interviewing corporate representatives and studying corporate reports. This follow-up study showed that only one of the companies had voluntarily and successfully continued developing its pilot EMA system, whereas the others had abandoned their systems as not being value-adding. The motives behind this outcome are important to clarify in order to ensure that further EMA research and development focuses on essential questions.

27.1 Introduction

Environmental issues are of increasing concern to many countries and organisations throughout the world. Environmental impacts are leading to greater financial consequences, alongside increased promotion of environmental awareness by international governments and other bodies, and voluntary acceptance of the need to address environmental issues to maintain corporate legitimacy (Burritt 2004). An organisation's competitiveness is directly and indirectly affected by growing environmental pressure from its different stakeholders (Green and Hunton-Clarke 2003). Examples include supply chain integrity, disclosure, financing, regulatory control, environmental tax, as well as cap and trade (e.g. the *Kyoto Protocol*) pressures (IFAC 2005).

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In order to effectively manage the environmental pressures listed above, with their related costs and benefits, an organisation needs systematic practices for data collection, analysis and reporting. *Environmental Management Accounting* (EMA) is a tool-kit to meet this demand. EMA can be broadly defined as being the identification, collection, analysis, and use of two types of information for internal decision-making: physical information about the use, flow and end-state of energy, water and materials, and financial information about environment-related costs, earnings and savings (UNDSD 2001). In turn, the uses and benefits of EMA divide into three main areas: Compliance benefits arise from cost-effective adaptation to environmental regulation and self-imposed environmental policies. Eco-efficiency benefits are realised with simultaneous reduction of costs and environmental impacts via more efficient use of energy, water, and materials in a company's operations and final products. Finally, strategic positioning benefits are derived by evaluation and implementation of effective and environmentally sensitive programs that ensure a company's long-term competitiveness (FEA 2003).

EMA requires expertise in various areas, including environmental, technical, accounting and finance, marketing and public relations, and general management. Accountants have a special role because of their access to an organisation's monetary information, their ability to improve and verify the quality of such information, and their skill in using this information to help make sound business decisions in areas such as investment appraisal, budgeting, and strategic planning. However, communication between accounting and other departments is often underdeveloped as environment-related cost information is hidden in a company's overhead accounts or not found in accounting records at all. Additionally, materials use, flow, and costs are seldom tracked adequately, and investment decisions are thus made on the basis of incomplete information (IFAC 2005). The importance of environmental management is easily underestimated if its added value is not clearly quantified (Bennett et al. 2003). Identifying and implementing environmental improvements can be facilitated by demonstrating their value, in addition to environmental performance, in short-term business effects. The early adoption of simple improvements can encourage subsequent receptiveness to more ambitious proposals (Bartolomeo and Jan Jaa 2000).

Organisations in over 30 countries have already begun promoting and implementing EMA for many different types of environment related management initiatives, and plentiful case studies have been conducted in different industries (UNDSD 2002). Several organisations have published guidance documents on EMA, and on the related subject of environmental costing for financial accounting and reporting. Different countries and organisations can adapt those EMA concepts and practices that suit their own goals. A certain amount of experimentation and variation is also expected, as EMA is still a relatively young and emerging field in comparison to, for example, conventional management accounting. Nevertheless, the large number of existing guidance documents has led to confusion about the exact definition, benefits and applications of EMA, as well as available approaches and tools (IFAC 2005). In response to this confusion, the *International Federation of Accountants* (IFAC) published the first general guidance document on EMA in 2005. This document is probably the most comprehensive guideline in the field so far.

In Finland, one of the very first attempts to develop EMA systems was Tuula Pohjola's doctoral dissertation research in the mid-1990s. During 1995–1996, a total of ten pilot projects were run in six Finnish companies, and pilot EMA systems were designed for their energy management, transportation, and/or logistics processes. In 2005, four of the same companies participated in a follow-up study, the purpose of which was to record developments in their EMA practices. This long a follow-up period is still rare in the young research field of EMA. Therefore, this paper aims to provide a valuable long-term view on the motives and management practices that cause EMA to succeed or fail within an organisation. This knowledge can then be used, for instance, when designing and implementing EMA systems in other organisations.

The rest of this paper is divided into four sections. Section 27.2 presents the research methodology. Section 27.3 describes the four follow-up case studies and their results. Section 27.4 goes into more detail with the case study of Kesko Food Ltd., the most successful case company as to EMA. Finally, Section 27.5 discusses and concludes the findings of the whole follow-up study.

27.2 Research Methodology

27.2.1 Methodology for the Initial Case Studies in 1995–1996

The starting point for this follow-up study was Tuula Pohjola's (1999) research project, the empirical part of which was conducted during the years 1995–1996. The methodology of Pohjola's research was constructive: a general EMA model was designed, planned and tested in a total of ten case studies in six Finnish companies. According to each of these case companies' choice, separate EMA systems were designed for their energy management, transportation and/or logistics processes.

Pohjola's case studies included four steps: Firstly, the processes of the company were described in detail. Secondly, the environmental impacts of the company were identified and quantified, based on the process descriptions. Thirdly, environmental costs were calculated and finally, the potential improvements in the processes were simulated. Figure 27.1 presents the framework for these case studies.

According to Pohjola, all six case companies were at a comparably similar level as to their EMA know-how and practices after the pilot case studies. Each company then took responsibility for developing their pilot EMA systems further, and integrating these systems into their everyday business operations.

27.2.2 Methodology for the Follow-Up Case Studies in 2005

In the beginning of 2005, a follow-up study of the development of pilot EMA systems was conducted. Four of the initial six companies participated at this time; one company refused because of confidentiality reasons and another mentioned a current lack of interest in EMA.

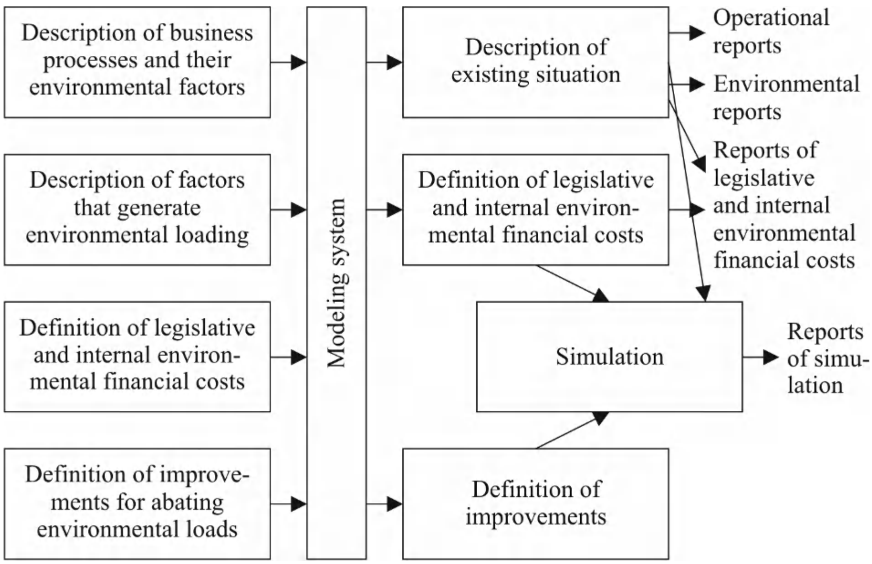

Fig. 27.1 Framework for the EMA case studies in 1995–1996 (Pohjola 1999)

The empirical data for the follow-up study was gathered by visiting the four companies between February and April 2005, and interviewing key personnel responsible for EMA. A few additional individuals recommended by the main interviewees, were also contacted by telephone or email to get detailed information about some specific questions. In addition, if any relevant data about EMA developments after 1996 had been lost due to personnel changes, the former personnel were also contacted and interviewed. Table 27.1 summarises the interviews in the follow-up study.

All of the face-to-face interviews conducted at the beginning of 2005 were semi-structured. They included open questions about environmental management, EMA and environmental reporting. The questionnaires were sent to the interviewees beforehand by email. The interviews lasted for about 1.5 hours, and all were recorded and transcribed. Where additional data was needed, interviewees were contacted again by telephone or email and interviewed briefly using open questions. Telephone interviews were not recorded but notes were made during them. The corresponding author of this paper conducted all of these interviews.

In July 2005, two additional face-to-face interviews were conducted at Kesko Food Ltd. after its superiority in EMA had been recognised. This time, interviews were unstructured and conducted by both of the authors of this paper. These interview situations were less formal because of Tuula Pohjola's acquaintance with the interviewees and so whilst notes were made during these interviews they were not recorded.

Secondary data was also gathered by studying annual and environmental reports and websites of the case companies.

The empirical data was analysed qualitatively, using inductive content analysis methodology. The empirical research data was first categorised in Excel tables.

Table 27.1 Interviews conducted for the follow-up study in 2005

Company (Number of Interviews)	Interviewees	Interview type	Time
Elisa (3)	Environmental manager, 2004–	Face-to-face	Mar 2005
	Environmental manager, 2001–2004 (retired)	Telephone	Apr 2005
	Environmental manager—2001 (retired) (*)	Face-to-face	Apr 2005
Fujitsu Services (4)	Property manager	Face-to-face	Feb 2005
	(1) Quality coordinator, (2) warehouse manager (logistics and configuration centre)	Face-to-face	Mar 2005
	Quality manager	Email	Apr 2005
	Service manager (former quality manager) (*)	Telephone	Apr 2005
Kesko Food (5)	Logistics and environmental manager (*)	Face-to-face	Feb 2005, Jul 2005
	Environmental specialist	Telephone	Apr 2005
	Senior manager, corporate responsibility	Face-to-face	Apr 2005
	Logistics manager (retired) (*)	Face-to-face	Jul 2005
VR (2)	Environmental manager	Face-to-face	Mar 2005
	Depot manager (*)	Telephone	Apr 2005

* The same interviewee had already participated in the pilot case study 1995–1996.

Then, the present state of the case companies' EMA practices was compared to the situation of 1996 and the findings from the literature. Finally, the interviewees were contacted again to check if any significant changes had taken place after the interviews. The interviewees also read the results section of this study, and corrected possible misunderstandings or inaccuracies concerning their companies.

27.3 Results from the Four Follow-Up Studies 1996–2005

This section first introduces the four case companies that participated in the follow-up study. Next, the pilot case studies of 1995–1996 are described. After this, the case companies' developments in EMA are introduced company by company and then summarised.

27.3.1 Introduction to the Case Companies

Elisa Corporation is a provider of telecommunication services and solutions. Since 1996, Elisa has gone through drastic changes: It has expanded from Southern Finland to cover the whole country and added Internet services to its product portfolio.

Table 27.2 Summary of the case companies' turnovers and personnel numbers

	Turnover (M €)		Personnel	
	1996	2005	1996	2005
Elisa	288	1,337	3,400	4,989
Fijutsu Services (*)	317	311	1,784	1,996
Kesko Food	1,871	3,830	6,500 (**)	9,822
VR	894	1,197	14,820	12,800

* The financial year of Fijutsu Services is April–March; ** The personnel of the whole group, no separate figure is available for the foodstuffs division that was not yet a subsidiary in 1996.

Elisa also has international operations in Estonia and worldwide mediator solutions. Organisational changes have recently taken place at Elisa as its subsidiaries have been merged into the parent company and a large number of personnel have been dismissed (Elisa 2006).

Fujitsu Services Oy is part of the global company Fujitsu Limited, the world's third largest IT services provider. Its operations in Finland are part of the group's Services division which is headquartered in London. Fujitsu Services' business in Finland includes integrating software applications into hardware systems, warehousing, delivering systems to business customers and managing the systems' life cycles (Fujitsu Services 2006). In recent years, continuous mergers and incorporation of business units have been typical for the company.

Kesko Food Ltd, is one of the two leading retail grocery providers in Finland. It is part of the large retail corporation, Kesko Group, which also operates in ironmongery, agriculture and the home and speciality goods trade. Kesko Food's turn-over accounts for over 50% of the group's total. Kesko Food has operations in Finland and also in the Baltic countries through a joint venture. After 1996, major changes in Kesko Food's business have been the concentration of trade, centralised warehousing and the increasing proportion of sales accounted for by the company's own brands and hence also imports (Kesko 2006).

Finally, the *VR Group* is a Finnish transport company providing rail transport and supplementary road transport services. The group also offers track construction and maintenance services. VR is a limited liability company entirely owned by the Finnish state (VR 2006). VR's basic business is rail services and this has remained relatively the same since the 1970s when electric trains were taken into use. However, legislative pressure on the environmental impacts of the railway business has grown considerably.

Table 27.2 presents the turnover and personnel of the four case companies in 1996 and 2005.

27.3.2 State of EMA in 1996

During 1995 and 1996, Tuula Pohjola designed pilot EMA systems for six Finnish companies in close conjunction with project teams from these companies. In each case company, the pilot EMA systems covered energy management, transportation or logistics chain activities (purchasing, manufacturing, and storing, packing, delivering and waste management)—or a combination of the three—according to the company's own choice. These pilot EMA projects were effectively the start of systematic environmental management within the case companies. Previously, only some minor initiatives had been taken, such as defining an environmental policy. None of the companies had yet implemented an environmental management system or equivalent (Pohjola 1999).

Table 27.3 summarises the pilot EMA systems designed for the four case companies that participated in the follow-up research in 2005. Tuula Pohjola (1999) also carried out an evaluation of the success of these pilot studies. According to Pohjola, the pilot studies gave the companies comparably similar know-how about EMA, and the responsibility for developing their EMA systems then remained with the companies.

27.3.3 Developments in EMA During 1996–2005

27.3.3.1 Developments at Elisa

At Elisa, three environmental business accounting models were defined in 1995–1996: an energy model was designed for an office building, a road traffic model for the company's own vehicles, leased cars and staff cars and another transport model for the decentralised office work of Elisa's call centre sales team. After these pilot projects, Elisa continued by widening the energy model to include the whole corporation. Extensions to the metrics of the transport model were also planned but not implemented as they did not receive management support. Finally, the model for the decentralised office work was abandoned almost immediately, due to a fear of possible inequality caused by remote work.

Thanks to its experience with EMA, Elisa had a major role in developing environmental accounting for the European Telecommunications Network Operators' Association at the end of the 1990s. Despite this, Elisa's EMA enthusiasm gradually decreased. Management support and budgeted resources for environmental management remained low, and thus a great deal of all environmental work was done in the responsible employee's own time. This individual was eventually changed in 2001, and at the same time, much of the previous EMA work was discarded because the company did not wish to continue EMA development. This happened once again in 2004.

Since 2004, Elisa's environmental metrics have included only energy and water consumption, fuel consumption and waste from the company's domestic operations. Additionally, some Finnish subsidiaries are still excluded because of the rapid changes in Elisa's organisational structure. Some of these EMA metrics remain as estimates because no exact data has yet been gathered. EMA information is only reported internally, though the company aims to improve the accuracy of this information in order to monitor environmental objectives and to be able to use the data in external communication.

Elisa's greatest challenge in regard to EMA is the lack of appreciation of the significance of environmental issues in the telecommunication industry. Elisa's

Table 27.3 Evaluation of the case studies 1995–1996 (Pohjola 1999)

	Process Description	Environmental Loading	Environmental Performance	Internal Environmental Costs	Simulation Module	Computer-aided Model	Comprehen-siveness of the Model (1–3)	Model Realisation
Elisa's Energy Model	Excellent	All	Defined	Defined	Defined	Very good	2	Excellent
Elisa's Transportation Model	Good	All	Defined	Defined	Partial	Good	2	Excellent
Elisa's Distance Work Model (Transportation)	Good	All	Defined	Defined	Partial	Good	2	Good
Fujitsu Services' Energy Model	Good	All	Defined	Defined	Defined	Very good	2	Good
Fujitsu Services' Transportation Model	Average	All	Defined	Defined	Partial	Good	2	Good
Kesko Food's Logistics Chain Model	Excellent	All	Defined	Defined	Partial	Very good	3	Excellent
VR's Transportation Model	Average	All	Defined	Not defined	Partial	Average	3	Average
VR's Logistics Chain Model	Good	All	Defined	Partial	Partial	Good	3	Good

customers and owners have not pressured the company to improve environmental management and corporate management does not budget sufficient resources to do this. Compliance with environmental legislation is regarded as adequate. Elisa does not yet benchmark the other companies' work or guidelines for EMA. Additionally, gaps in internal communication and documentation hinder continuous improvement of environmental management practices.

27.3.3.2 Developments at Fujitsu Services

Two EMA models were defined for Fujitsu Services in 1995–1996: an energy model for an office building a transport model for leased and staff cars in the maintenance department. After these case studies, Fujitsu Services developed EMA practices for its waste management operations and continued monitoring energy consumption. Nevertheless, systematic EMA practices were abandoned some years later because they were not found to be value-adding. Furthermore, Fujitsu Services' transport accounting system was abandoned when the company outsourced transportation operations in 2001.

At present, Fujitsu Services monitors energy and water consumption, as well as waste generation in its real estates. In addition, the logistics and configuration centre—the only Fujitsu unit in Finland currently holding an environmental certificate—monitors the progress of its own annual environmental objectives with the help of two simple metrics. In 2005 these metrics were the percentage value of its electronic documents in proportion to all documents and the proportion of energy waste of all unsorted waste. Some environmental data about deliveries is also collected from Fujitsu Services' transport operators. EMA information is used to monitor operations and for internal reporting. Fujitsu in Finland does not report externally.

The environmental management and accounting practices of Fujitsu Services remain at a minimum level because the company does not consider that its operations cause significant environmental impacts. Corporate co-ordination on environmental issues is missing and each of the business units can adopt their own practices. No stakeholder needs regarding environmental issues are canvassed, nor are guidelines studied.

27.3.3.3 Developments at Kesko Food

In 1995–1996, a logistics accounting model was designed for the main warehouse of Kesko Food. The model included the processes of purchasing, storing, packing, office work, distribution and waste management. Since then the EMA model has been continuously developed. In 1999, the first completed part of the model was applied to waste management and energy consumption and emissions of the groceries' logistics chain were evaluated for the first time. In 2000, regional distribution centres adopted the waste management calculation, which then covered Kesko Food's entire logistics chain. In 2001, Kesko Food started to use the system to monitor transportation (purchasing and distribution transport, truck costs), transportation fleet, return logistics and packaging. The simulation module of the pilot EMA system was, however, considered unreliable and was not taken into use.

Later changes in Kesko Food's IT systems have slowed development. For instance, links between the EMA system and the old IT system have not been successfully transferred to the new IT system adopted in the early part of this decade. Therefore, only the waste management part of the whole EMA system was used in 2005, though this module is very sophisticated. For instance, at Kesko Food's main warehouse waste data is automatically transferred to the system by the waste management operator.

Kesko Food has been the most progressive part of the Kesko Group in regard to EMA, though other units are now also conducting some EMA. In 2005, Kesko Group's externally reported environmental metrics and indicators included energy and water consumption, and the environmental profile of energy, transport and its emissions, waste and recycling rates and packing materials. Additionally, development of the number of eco-labelled stores and products is monitored (Kesko 2006). Site-specific values and those values from Baltic operations that are not accurate enough for verification by an external auditor are only reported internally. Some cost accounting has also been conducted when assessing savings from waste management and real estate investments. Additionally, Kesko follows and reports on the progress of stakeholder relationships and environmental aspects of risk management and office work, though these often cannot be expressed numerically.

According to Kesko's corporate responsibility unit the group has found EMA to be useful, especially to monitor and improve its processes and for external reporting and image management purposes. Kesko aims to enjoy competitive benefits by being the most environmentally responsible company in the Finnish retail business. The group is currently building a unified corporate responsibility accounting system. This new system will integrate existing information systems in order to produce comparable information from Kesko's corporate responsibility reporting in all divisions. Integration of ecological and economic metrics is also planned. In addition, EMA systems for Kesko's foreign operations are under construction. These systems will utilise the same accounting system as in Finland.

Corporate responsibility issues are included in Kesko's corporate strategy and a concordantly large amount of resources is allocated for environmental management. In 2005, Kesko was ranked as the best retail company in the Dow Jones Sustainability Index for the third year in succession (Kesko 2006). Kesko utilises EMA guidelines and anticipates future stakeholder requirements in environmental issues. The biggest challenges related to EMA at Kesko have been the changes in its IT systems, the company's expansion abroad and data availability limitations set by external stakeholders.

27.3.3.4 Developments at VR

Two EMA models were defined for VR in 1995–1996: a transport model for the railway freight services and a logistics model for the maintenance works. VR did not continue the development of these pilot models as they were considered to be too labourious. The company has also had to develop its own EMA procedures due to specific legal obligations. In addition, the group utilises EMA for management decisions and progress monitoring, environmental reporting, as well as to provide emission information and other environmental data for its large business customers (such as Finnish paper companies). VR also uses life-cycle assessments in large equipment purchases.

VR's present environmental metrics and indicators include energy and water consumption, environmental profile of energy, rail transport and its emissions, road transport, waste and recycling rates and packing materials (VR 2006). VR benchmarks some environmental management standards and guidelines but does not strictly follow any specific format. Future requirements, such as the possible inclusion of transportation in the EU emissions trading scheme are anticipated.

27.3.3.5 Summary of the Follow-Up Case Studies

The results from the four follow-up case studies show that Kesko Food has been the only case company to emphasise and utilise EMA voluntarily. Kesko has included corporate responsibility issues in its corporate strategy; EMA has been found to be important for both internal and external corporate purposes.

In the other three case companies—Elisa, Fujitsu Services and VR—EMA work has not been as successful. Their investments in EMA have been mainly limited to compliance with environmental legislation and most of the information about their pilot EMA systems has been lost during the years. At Elisa, no management support is given to environmental issues because of a lack of interest from external stakeholders. Due to this, the resources available for environmental work remain low and no time is allowed for complicated EMA practices. Fujitsu Services lacks corporate co-ordination and its environmental work is very short-term—the environmental impacts are not considered to be significant in that business. VR on the other hand, has been legally obliged to monitor its environmental impacts. Being the only rail transport company in Finland, VR also needs to fulfil the national demand for environmental information about rail transport as well as the information needs of its large business customers. It has been found to be important to have an environmentally friendly image when lobbying for railway services.

The Kesko Food case is discussed in more detail in Section 27.4, in order to better recognise the motives and management practices behind its success in EMA development and implementation.

27.4 EMA Success Factors at Kesko Food

EMA at Kesko Food has its origins in making logistics more effective. In a country like Finland with a large geographical area and a comparatively small population, logistics costs are significant. Up to 10% of the prices of certain goods can be accounted for by transportation costs. Therefore, Kesko Food had already started to benchmark the logistics processes of the industry-leading companies in the early 1990s. The company soon became aware of the possibility of achieving major savings as well as the more effective logistics that could be reached through environmental management. For strategic positioning reasons, Kesko Food also wanted to create a reputation for being a pioneer in environmental issues. Other motivational drivers for building the initial EMA system arose from the desire for ISO 14001 certification and consequently the need to have a comprehensive data collection, analysis and reporting system. The company also anticipated that future environmental reporting requirements would increase for service companies.

Essential for the success of the design and implementation of Kesko Food's pilot EMA system was the large amount of resources allocated to the pilot project in 1995–1996. The project group included ten full-time employees from Kesko and a few part-time computer programmers. Though the exact man-hours are not known this was a major resource investment. The project executive group even included financial accounting personnel, to help to combine financial information and physical environmental metrics. EMA was implemented gradually and firstly in waste management operations where financial savings were comparably easy to achieve. In this way, management support for further actions was quickly secured. Additionally, Kesko Food received financial support for its pioneering EMA work from a Finnish technology fund.

The success of Kesko Food's pilot system was largely due to apposite timing and personnel. The then logistics manager (at that time there were no environmental managers in the retail sector in Finland) had a good rapport with both the corporate managers and retailers who were also a significant owner of the company. He was therefore easily able to get the support required for the pilot EMA project. He also wanted to support the independent initiative of the employees and for them to take responsibility for the environmental management aspects as soon as they had been implemented. In addition, any retreat from environmental activities was rendered less likely by anticipating goal setting and transparent reporting.

Kesko Food also encountered several challenges when implementing EMA. For example, the initial transportation accounting system was too detailed and difficult to use and the changes in Kesko's IT systems caused problems when links between the data collection and analysis systems could not be successfully transferred between the old and new systems. Challenges also arose from the natural tendency towards sub-optimisation, internationalisation of operations and the limitations set by external stakeholders. Yet throughout, with innovative thinking and deliberation these problems were overcome.

Even today, Kesko Food is putting continuous effort into EMA. In its business, the savings from logistics and other environment-related costs are one of the few remaining means to increase profits. The Kesko Group intends to communicate its environmental goals throughout the entire value chain thereby impacting also other environmental aspects than those of its core processes. Kesko follows and implements environmental legislation assiduously and insists that its partners act in the same way. Through Kesko Food's increased market power and its own brands the company can also set stricter environmental requirements for its own suppliers. For instance, it has established several cooperative projects in packaging with large Finnish food companies. Finally, Kesko Food's independent retailers are provided with significant support in environmental issues through the Kesko's environmental store concept, which ensures that they also become involved in EMA work.

27.5 Discussion and Conclusions

The environmental management work of companies and other organisations has been changing rapidly in recent years. Pressure from the European Union has had a significant effect but alongside compliance with environmental regulations and permit conditions, voluntary commitments and measures also have an increasingly important role.

The follow-up study in the four Finnish case companies (1996–2005) showed that only one of these companies had voluntarily continued to develop its pilot EMA system. This company, Kesko Food Ltd., had considered the possible eco-efficiency and strategic positioning benefits of EMA in addition to the compliance gains. The latter viewpoint was clearly prevalent in the other case companies. Of these three 'reactive' companies, VR was the only one that had also considered eco-efficiency (when purchasing costly equipment, for example).

The EMA success factors that can be recognised in these case studies are:

- An innovative attitude and persistent key personnel
- Transparent goal setting, internally and externally
- A gradual EMA development process with early realisation of the first financial savings
- Management support and sufficient resources
- Broad involvement of personnel: accounting, all functions/locations included in the EMA system, cooperation with external partners and stakeholders (and possibly also external support and financing)
- Value-chain and long-term thinking
- Benchmarking of other companies and EMA/environmental management guidelines
- Anticipating future requirements (e.g. legislation, disclosure, needs of the green market)

In contrast, the 'critical failure factors' in EMA are: lack of management support and insufficient resources allocated, too narrow a project group in EMA design and development, unclear or missing quantification of added value and problems with technical implementation. A company's internal resources are not always sufficient and external support usually is costly. The company's field of business provides its own challenges: if the core operations do not have clear environmental impacts, or if the company is not close to the end customers, the environmental aspects may be more easily ignored. Rapid changes in the business environment also are challenging, especially when the EMA development is beginning.

Unquestionably, establishing a smoothly functioning and comprehensive EMA system is challenging and requires much work. But as the follow-up study showed, a motivated and persistent organisation can develop value-adding EMA practices. The scope of the four case studies are too small to generalise the research results, though based on the authors' experience there are only a handful of other Finnish companies that have voluntarily placed an emphasis on EMA and so the situation is not better elsewhere. The underlying reason for this is that environmental issues are not yet considered as being an integral part of core business processes in many companies but rather as a way to placate environmentally-conscious stakeholders. Therefore, the attitude of senior management must be understood before a really effective EMA development project can be started.

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