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Total Cost Assessment

Recent Developments and Industrial Applications

Edited by
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International Institute for Industrial Environmental Economics
at Lunds University

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Invitational Expert Seminar
Nagu, Åbolands Län, Finland
June 15-17, 1997

Edited by Mikael Backman and Rabbe Thun

Arranged by
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PREFACE

This seminar was arranged in the framework of the Working Group on Policies, Strategies, and Instruments to Promote Cleaner Production of the UNEP Cleaner Production Programme. It was planned and organised by the secretariat of the Working Group, i.e. the International Institute for Industrial Environmental Economics (IIIEE) at Lund University, Sweden, in co-operation with VTT, Finland. The seminar was a follow-up to a previous seminar on environmental accounting, held in Opio, France in 1996. Financial support to this seminar was provided by the Finnish national research programme “SIHTI 2” (Energy and Environmental Technology), Neste Corp., Finland, and the Swedish companies Vattenfall, Sydkraft AB and Volvo AB.

36 invited experts took part in the seminar, which was held in Nagu, Finland, on 15-17 June, 1997. This report is a compilation of the written contributions handed over by the lecturers. All views expressed in the papers are those of the respective authors and not necessarily those of UNEP or the Working Group.

Lund, February 1998

Mikael Backman, Mårten Karlsson & Ulrika Wennberg, IIIEE

Rabbe Thun & Virve Tulenheimo, VTT

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INTRODUCTION TO THE SEMINAR

The following proceedings are the result of an invitational expert seminar in the field of Total Cost Assessment (TCA). The seminar was a follow-up of a previous expert meeting on the subject *Challenges and Approaches to Incorporating Environmental Costs into Business Decisions*, held in Opio, Provance, France, 3-5 June 1996. The invited experts represented a large variety of organization from industry, finance, academia, and consultancy, each with explicit knowledge and experience within the field of Total Cost assessment.

The seminar was given the title *Recent Developments and Industrial Applications*, focused on tools for incorporating costs into the decision-making process. Specifically, the concept and methodology Total Cost Assessments was discussed in the context of the development of environmental accounting practices in general with an aim towards greater coordination between various related instruments.

The seminar was divided into an opening session, seminar sessions with presentations covering specific topics, one workshop with a demonstration of different software and tools, and finally, a conclusive and open discussion with participation from all participants of the seminar. Not included by the proceedings is the final discussion at the end of the seminar and the workshop on software and tools. Specific topics, presented by the proceedings under separate headings, were as follows:

- Terms and Concepts of Environmental Cost Accounting
- Environmental Accounting as a Decision Support Tool
- Allocation and Valuation Techniques
- Case Studies of Environmental Cost Accounting
- Environmental Performance Evaluation

In the opening session, reflections were made on the usefulness of TCA and future needs and priorities for the area. Presentations from UNEP Cleaner Production Programme, two Swedish energy producers (Vattenfall and Sydkraft), and VTT Chemical Technology concluded on the need and importance of TCA in the future but also raised the issue on the problems in practical applications of the methodology.

In the next section, *Terms and Concepts of Environmental Cost Accounting*, comprises presentations that give the reader a comprehensive overview of several applicable techniques and methodologies. The third section, *Environmental Accounting as a Decision Support Tool*, provides examples on how TCA and related methodologies can be used to support decision-making. Examples are gathered from industry (Ontario Hydro, ICI, Italiana Petroli SpA, and Volvo). This section also provides the reader with a presentation on a model, *The Stakeholder Value Analysis Toolkit*, suggesting a practical approach to implement environmental considerations in decision-making in order to maximize stakeholder value.

The forth section, *Allocation and Valuation Techniques,* comprises presentations on cases and tools that give detailed and in-depth knowledge on methodological constraints, such as the valuation of environmental impacts and allocation between different products or production systems. This issue can additionally be studied in the fifth section, *Case Studies of Environmental Cost Accounting*. However, the focus of this section is on the presentation of a variety of applications of TCA and related methodologies on a diversity of objects.

The last section, *Environmental Performance Evaluation*, deals with the measurement and communication of environmental performance. The section comprises presentations on both financial investment in eco-efficient companies (Swiss Bank) and the development of environmental performance indicators (Imatran Voima and Ontario Hydro).

The proceedings show a wide variety of cases were TCA, environmental accounting and related methodologies have been implemented successfully in industry and other organizations. The methodologies have been found to be useful tools in a wide diversity of business sectors, by the proceedings emphasized mainly with examples gathered from the energy sector.

It is clear that companies have picked up the signals that something is happening. But it is also clear that the setting of priorities lacks consensus. There are uncertainties on what to be done and whether actions already taken have been correct. Where is the boundary for external and internal costs? Liability?

Are we shooting the breeze and missing the point or are we getting the point but missing the target?

OPENING SESSION

From Opio to Nagu: Reflections on TCA from an Electricity Utility's Perspective
Staffan Görtz, Sydkraft Konsult AB, Sweden

UNEP Cleaner Production Programme and Tools for Environmental Management and Accounting
Kristina Elvebakken, Cleaner Production Programme, UNEP IE, France

Micro and Macro Perspectives of Green Accounting - Background and Steps Towards Integration
Torsti Loikkanen, VTT Chemical Technology, Finland

Environmental Accounting from an Energy Producers Perspective
Karin Annerwall-Parö & Leif Halvorsén, Vattenfall, Sweden

Shooting the breeze and missing the point.

From Opio to Nagu: Reflections on TCA from an Electricity Utility's Perspective

Staffan Görtz
Sydkraft Konsult AB, Sweden

INTRODUCTION

This paper will be presented at the invitational expert seminar on ”Total cost assessment - recent developments and industrial applications” in Nagu, Finland, June 15th -17th, 1997. The speech will be held as an introduction to the seminar with personal reflections on four different topics concerning the use and limitations of TCA from an Electricity Utility's perspective. The presented ideas are not claimed to be scientifically undisputable, but rather serve as a base for further discussions. Therefore, no conclusions will be drawn.

BACKGROUND

In June 3rd -5th, 1996, an invitational expert seminar was held in Opio, France on ”Challenges and approaches to incorporating the environment into business decisions”. The Opio seminar aimed at presenting a state-of-the-art on environmental accounting including general discussions on how to incorporate environmental performance as one out of many parameters as a base for decision making. Some advanced software were presented as well as several case studies. Some of the cases studies were based on extended LCA methodologies.

This follow-up seminar in Nagu will focus more specific on TCA (Total Cost Assessment) models, including terms and concepts, as well as methodology. Many of the presented papers will focus on how to value environmental impacts, and how to internalize and allocate externalities such as environmental costs. Again, different models and case studies will be presented. Finally the role of TCA on environmental management systems will be discussed.

Sydkraft - the largest private owned electricity producer in Sweden - has during the past tried different strategies and methods to integrate environmental protection and awareness in decision making. These strategies have, however, rapidly become inappropriate as the public, market and lawful demands for environmental performance and information have increased. Further, making correct decisions become more complicated as research continuously provide new results and theories about environmental impacts.

As a result of the internal need for decision support models, Sydkraft found it appropriate to sponsor the expert seminar in Opio. It also felt logical to sponsor the follow-up seminar in Nagu, since the influences from the Opio seminar resulted in several spin-off projects within Sydkraft.

ENVIRONMENTAL IMPACT, NATURAL VARIATION OR SUCCESSION

Many people believe that all or most of the environmental impact is caused in modern time and is only recently discovered. Activities generating some kind of impacts have, however, been going on for a very long time - more or less as long as man has been on earth. Many believe for example that acidification was first observed in the 50ies or 60ies. Back then, sulphur was more or less considered to be the only pollutant causing the damage. The nitrogen oxide emissions were said to give a positive effect since the amount of biologically available nitrogen in most places is limiting the primary production in nature. In some places in Northern Scandinavia this is also the fact.

Acidification, we were told back then, was only a problem in small, isolated and poorly buffered lakes. Nowadays we, however, know that acidification is a large problem not only in lakes but also in soil and ground water. We also know that not only the SO_2 and NO_x emissions cause the acidification, but even other pollutants contribute, some in interactive ways. We also know that in many places there is a natural acidification.

The fact is that we should have reacted much earlier. For instance - some 200 years ago, forest damages in England could be related to industrial pollution of sulphur and heavy metals. It was even determined that the damage was related to the increased levels of dissolved trace elements in the soil, and that this was a result of heavy metal and sulphur pollution. These are two of the most important sources of soil acidification.

In the beginning of the 18:th century the Swedish navy cut down the oak forests around Gothenburg on the Swedish west coast, leaving a poorer landscape of naked rocks. This environment is today very attractive, and even considered as one of the most beautiful areas in the region. This is just an example of that environmental degradation is a subjective issue and that our willingness to accept changes in the environment is a function of time. Even further back - some 2000 years ago - the Romans cut down the rich forests around the Mediterranean leading to the growing of the Sahara desert, and also leaving behind them a more naked landscape. Sahara is still growing due to progressive cutting of the forest in the north. Again, this environment - especially the north side of the Mediterranean - is so attractive that it is one of the largest destinations for mass tourism in the world. In Northern Africa the population has learned to live with the changes as time goes by. The change is more or less considered as an on-going succession.

This leads to the question of what kind of impacts or changes are acceptable. Some changes take time for us to accept, other we simply just learn how to live with (even though we have a hard time accepting them). Some changes we even start to love. Cities and buildings are other examples of the latter. Man is just one out of billions of species on earth. We as well as other species change the environment as we live. The only difference is the number and the extent of the changes we cause, the overall impact.

The examples mentioned above are a polarized extreme. The other extreme can be exemplified with some of the catastrophes we know by names as Bhopal, Basel, Exxon Valdez, etc. These are impacts that we probably never will accept or learn to cope with. And there is no doubt that the damage must be restored.

The base for our judgement on what’s acceptable or not is very unstable - the boundaries for our acceptance moves as we take new steps.

ENVIRONMENTAL PERFORMANCE AND COSTS

Good environmental performance is no longer an isolated legislated and forced cost that society has put as a burden on the industry’s shoulders. Most modern western world companies have come to realise that a good environmental performance is not only profitable but also a necessity for sustainable business and even for survival in a long term perspective.

The environmental performance must therefore be taken into account in all decision-making processes within the entire organization. Until now this has mostly been done on an unstructured basis, and has often only included more or less ”hot” environmental issues such as pollution to air, water and ground. Other aspects such as use of natural resources, chemical treatment etc. have been included when considered possible and not involving too much efforts. In many case studies, lots of efforts have been put in, the methodology can, however, be questioned.

Putting internal monetary values on the environmental impact as well as other external costs, is one method for companies to incorporate their environmental performance into the decision-making processes.

Incorporating environmental impacts such as pollution of SO_2, NO_x, particles etc., into decision making has been a natural step to take for many companies since the authorities have enforced the decrease of this pollution. Most countries have a legislation by which these emissions are regulated. Some countries, among them Sweden, have specific taxes and fees on some emissions. The companies have been forced to incorporate these pollution costs into decision making as the society actually has set a monetary value on the environmental impact. We have learned to internalize these costs as the authorities have given them monetary values. The given values do however not have any correlation to the real cost of the impact or the caused damage for the society.

It is most certain that the companies will have to pay for the polluted environment in the future – in one way or the other. How this will end up is still to be determined. The society will sooner or later start to force the companies to clean up and restore contaminated ground, polluted lakes etc. Other more diffuse costs will have to be covered by taxes.

Most companies’ environmental costs are related to activities in the past. Many of the plants or units causing the pollution and even organizations do not exist any more. These costs must be considered as environmental debts. Who’s responsible for these costs can be questioned. The company itself is in part responsible, but even the society has to take its share. The society is not only responsible because of authorizing and permitting the activity, but also by permitting the use of the produced goods and supporting the development. Some examples of the latter are electricity generation and vehicle production. Whether the society has supported all kind of environmental-impacting activities can be questioned, but it is obvious that the society is in part at least indirectly responsible for all impacts. Their share of responsibility varies from case to case.

The environmental debts must probably be taken as overhead costs both by the companies and by the society. The latter has to finance this through taxes and most likely as industrial production taxes. The external costs of today - defined as undefined - are internal costs of tomorrow. The environmental debt is the major part of many facilities' total environmental cost.

It is however important to include the on-going impact into the decision making process. These costs will, as mentioned above, most likely be real internal costs in the future and therefore have an influence on whether a new project, process or product will be profitable or not.

There are many difficulties involved in internalizing and allocating external costs. Most external costs are more or less undefined. Environmental impacts are especially difficult to value and translate into monetary values. When making the decision, marginal costs must be used. The real costs varies on a large scale both in short and long time perspective. The costs do not only include scientific knowledge, but also attitudes among society, customers, consumers, politicians, authorities, etc.

Environmental degradation has been going on for a long time. We also know that the damages that we have caused will remain as a scar in the nature for a long time. Some impacts are reversible, others irreversible.

When making decisions, we add all kind of costs and set up a pay-time limit. Aspects as technical lifetime give us further limitations. All aspects added together give us the economic lifetime for the project, process, plant etc. During this economic lifetime all the costs have to be paid off. The environmental costs as well as other externalities have to be discounted over this time period. The problem is that the environmental impact has been going on before the decision is being made, and will continue after the economic lifetime has ended. That is, after the plant has been de-commissioned or shut down, the product has been taken off the market, etc.

Future costs can be invested in funds in the same way as is done for nuclear wastes in some countries, for instance in Sweden. For every kWh electricity produced, a certain amount of money is placed in a fund. By the end of the calculated economic lifetime, the fund is large enough to cover the costs for safe dismantling and nuclear waste treatment.

ENVIRONMENTAL MANAGEMENT AND DECISION MAKING

The environmental management's and the environmentalists' role in the company organization has been discussed for a long time. Almost every company organization has found its own solution. Like most other company responsibilities, it is the management that has the overall responsibility, both towards the owners and towards the society.

Comparing environmental management systems with the structure of any kind of management system including the financial control system, it clearly shows a high degree of similarity - they are almost identical on a macro level. They are of course different in details.

Since the top management has the overall responsibility for the company's environmental performance as well as the responsibility for results, quality, feasibility etc., it is important to delegate the responsibility to all management levels within the organization. It is therefore inefficient for a company to have an environmental manager with full responsibility for the environmental performance. There are however such examples. An organization with interfering authorities faces a risk of becoming inefficient. An environmental manager, coordinator or controller can only be responsible for supervising and supporting the organization with knowledge, competence, management systems, etc.

In a small company or at a minor site environmental management can be implemented either by informal discussions between the employees or by formal decisions at weekly meetings. A larger organization do however have a need for some kind of structured method on how to work. Quality systems as ISO 9001 and 9002 are such examples. ISO 14001 is an example of an environmental management system.

A management system - for instance an environmental management system - is however nothing but a base for the environmental protection activities. The certificate is only a ”driver’s license”, it doesn’t tell whether the organization is a safe driver. The environmental performance will be a result of how the decision makers take these questions into consideration and deal with them. The environmental performance can be just as good in a company without a formal and certified system as in a company that hasn’t any. On the other hand the small company has nothing to loose on developing a management system.

Many companies form specific management systems for each management objectives. This strategy has its advantages, but also its disadvantages. The larger the company, the more are the disadvantages and the potential conflict areas. To solve this problem, an overall management system has to or can be implemented including all the different objectives.

The advantages of forming just one overall management system are many:

- All management systems (environmental, quality, financial, etc.) are similar by structure and methodology.
- All management levels are responsible for all kinds of performance (environmental, financial, quality, workers’ health, etc.).
- All kinds of different aspects have to be considered when making a decision. There are obvious advantages having decision makers that can compare these aspects themselves.

Even though the decision makers might not have the competence required to get the complete picture of complicated matters, the basic knowledge is vital for being able to ask the right questions and also to understand the answers. So, there will still be a need for professional environmentalists. Some examples:

- Headquarters’ functions - supporting the organization.
- Internal and external consultants - for investigations, analyses etc. (for instance larger TCA-, EIA- and LCA-studies)
- Constructors, consultants, operators etc. - must all have environmental competence in matters that are adequate to their daily work in the future.

The last example given above is tangible to the principle of decision makers’ environmental responsibility. Decision makers are responsible for taking environmental aspects into account when making decisions, constructors etc. are responsible for the same when designing, investigating etc. So in order to make environmental management a useful tool in decision making, the following ingredients are vital:

- Environmental management system - or even better - an overall company management system covering all kinds of aspects. A very small organization can manage without this kind of system.
- Competence, attitudes and experience.
- Available and approved methods to identify and understand the environmental impact, and also to extract adequate information and identify significant environmental aspects.
- Methods to value environmental impacts and to convert them into other units - for instance monetary costs. This is essential for the decision makers to be able to take the environmental performance and protection into consideration.

FUTURE NEEDS FOR TOTAL COST ASSESSMENT

Total Cost Assessment (TCA) has been used in industrial studies. The use has however been limited for a number of reasons. So far, to be able to use the existing models, it has been necessary to let expert competence lead and/or supervise the studies. The models are so far too complicated for the industry to start using them themselves. The industry do however have a big need for TCA models in the future. In order to spread and increase the use of TCA models in the industry, the models have to be further developed. This has to result both in improved and comprehensive models, as well as in very rough and simplified models. Larger studies can bear the burden of using complex, time consuming models. It is, however, even more important to develop simplified models, which can be used for supporting smaller decisions. For daily, operational, and fast decision-making there is neither time nor economic space for model supporting. These decisions have to be based on knowledge or even on feelings. Decision-making on feelings is useful if the feeling is based on competence and sense.

UNEP Cleaner Production Programme and Tools for Environmental Management and Accounting

Kristina Elvebakken
Cleaner Production Programme, UNEP IE, France

INTRODUCTION

Let me start by saying that I will NOT talk about Total Cost Assessment (TCA) in details, nor will I talk specifically about TCA. This is not our task at UNEP. I will rather talk about TCA as one of several ecotools that we at UNEP consider to be very important in our work to promote Cleaner Production (CP), an important step to achieve the goal of Sustainable Development.

The outline of my presentation will be as follows: I will first cover some of the priorities of our CP Programme over the next two years and then, I will move forward to talk about two projects that we are working on at UNEP. The projects are both dealing with TCA and other ecotools and hopefully they will be of interest to you. One project is to review the state of the art of various ecotools including TCA, and the other project is to prepare a booklet on the relationship between the various ecotools, environmental strategies and paths and the environmental goal.

FUTURE PRIORITIES OF THE UNEP CP PROGRAMME

The CP Programme was launched in 1990 and one of our major objectives is to promote CP worldwide. I presume you already know about the programme and our definition of CP.

Every second year since the launch of the programme we have organized a High Level Seminar in order to readjust and target the programme to the actual needs. Last time we had our seminar was in autumn 1996 in Oxford where recommendations were given to our priorities for the coming two years. Thus, some of our major priorities are as follows:

- build CP into procurement and supply chain requirements
- clarify the relationship between CP and various ecotools and strategies
- develop an international CP declaration
- increase emphasis on products and services
- increase demand side for CP.

The two projects that I will talk about are related to the first two mentioned priorities.

PROJECT 1: REVIEW OF ECOTOOLS

Concerning the priority of building CP into procurement and supply chain, TCA together with other ecotools, e.g. Environmental Impact Assessment (EIA) and Life Cycle Assessment (LCA), play an important role in this.

If we are not able to assess and quantify the impacts related to processes, products and services, saying that we don't have any efficient ecotools for assessment and quantification, it will be difficult to effectively build CP into procurement and supply chain. We need efficient ecotools for assessment and quantification in order to be able formulate demands on the manufacturers and suppliers. These demands will in the long term "force" the manufacturers and suppliers into CP.

In the same way, if we don't have ecotools that can help us in determining where in the production processes, the product and supply chains the impacts originate from, it will be difficult to effectively build CP into procurement and supply chain.

The ecotools should be able to assess and quantify the environmental impacts from the:

- Environmental perspective (e.g. EIA, ...)
- Economic perspective (e.g. TCA, ...)
- Societal perspective (??.....)

and throughout the:

- Product and supply chains (e.g.LCA, Life Cycle Costs (LCC), ...)

Therefore, and for many other reasons, there is a need to make more efficient and to further develop such ecotools.

However, when this is said I will like to stress that we can already do a lot in terms of building CP into procurement and supply chain only by using common sense. But we need to proceed both on the pragmatic and the, let me say, theoretical path.

US EPA has taken an initiative to fund a UNEP project dealing with ecotools. One important condition is supplementary funding from other countries and some countries have already shown interest in the project.

- The background of the project can be summarized as follows:
- Numerous ecotools already exist on the market
- Rapid emergence of new ecotools
- No common understanding of when and how to apply the ecotools
- Varied experience in applying ecotools
- Yet no widespread application of ecotools.

Therefore, the objectives of the project are to:

- Review the state of the art in the development and use of ecotools
- Identify potential barriers to the use of the ecotools
- Prepare recommendations on how to overcome potential barriers.

We will start up with two ecotools and then, based on the results, move further on to other ecotools. Eventually with time we hope also to be able to look at how the ecotools fit together with each other. Thus, the ecotools to start up with will be:

- LCA
- Environmental Accounting, and then
- Other ecotools.

I will later on come back to which other ecotools that could be relevant.

Concerning Environmental Accounting, I think this is pertinent to you. In a sense Environmental Accounting is similar to TCA, or at least includes TCA. Thus, the information/conclusions from this expert seminar will be very important when preparing the review of the ecotool of Environmental Accounting. I would also like to say that we look forward to cooperate with you on this project.

The project activities - for each ecotool reviewed - will be:

- Report highlighting the development of the ecotool and of its effective use
- International expert meeting to review the report
- Final synthesis report including recommendations.

We have not come that far in the project, but we are just about to start drafting the initial report.

PROJECT 2: PREPARATION OF A BOOKLET

The other UNEP project I will talk about is closely linked to our priority of clarifying the relationship between CP and the various ecotools, including TCA, environmental strategies and paths, and the goal to achieve. The outcome of this project will be a booklet that describes the just mentioned relationship.

The background of the project is - not surprisingly - very similar to the background of the ecotools project. It can be summarized as follows:

- Numerous ecotools and environmental strategies already exist on the market
- Rapid emergence of new ecotools and strategies
- Need to give a clear message on;
    - how the ecotools fit together; and
    - which direction we want to take in order to achieve the goal of Sustainable Development.

In other words, we believe there is a need for making a common point of understanding or a framework of reference in order to better sell the message of CP, among others. Thus, the booklet is meant to give a clarification of what we want to achieve and what direction and which means we need to get there. For instance, what is the relationship between the strategy of CP and the ecotool of Environmental Management System (EMS) and how do CP and EMS fit together with the goal of Sustainable Development.

Thus, the objectives of the project are to:

- Describe the links between the various ecotools, environmental strategies and paths and the goal to achieve
- Describe the synergy from integration of the various ecotools and strategies.

We have not, yet, come that far in the project because - to be honest - it is also an internal exercise to agree upon how the different ecotools and strategies etc. fit together and how we can present that in a simple way in the booklet (I do not dare to think about how it will be when the booklet undergoes external review!). So far, the idea is to base the whole booklet on a figure, see figure 1.

Let me give you an explanation to the figure. The figure can be divided into two parts: a theoretical part and a practical part.

In the theoretical part we have the goal (Sustainable Development), the path (Cleaner Production and Consumption when dealing with the industrial sector) and the strategies and policies. The goal and the path are fixed, as decided by the politicians etc. in Rio 1992. On the other hand, the strategies and policies are more free to choose and it is here we need to show the right direction saying by selecting e.g. CP instead of end-of-pipe.

In the practical part we have several ecotools including TCA. First, we have the tools like Environmental Management Systems (EMS) and Total Environmental Quality Management (TEQM) which provide the framework, or the toolbox, for the other ecotools. In addition to providing the toolbox these tools can also help in identifying which ecotools that should be included in the toolbox.

The ecotools to be included in the toolbox can be divided into two groups: analytical tools and tools that are more procedural and that need data, typically generated by the analytical tools, in order to be utilized. Let me immediately say that this classification of the various ecotools is not discrete and that it will be individual where one wants to include the various ecotools. Also, we might still change the classification....

The ecotools which might be included under analytical tools are:

- TCA
- LCA
- LCC
- EIA
- Full Cost Accounting (FCA)
- Environmental Performance Indicators (EPI)
- ......

The ecotools which could be included under procedural tools are:

- Environmental Auditing
- Cleaner Production Assessment
- Risk Assessment
- Environmental Reporting
- Ecodesign
- ......

The analytical ecotools can again be divided into tools that are dealing with the environmental impacts from the environmental, economic, or the societal perspective as mentioned earlier.

The just mentioned ecotools are all "candidates" for a status of the art review in a second phase of the previously mentioned project concerning ecotools.

With starting point in figure 1, we will in the booklet especially describe the:

- Links between strategy/policy (the theoretical level) and the ecotools (the practical level)
- Links between the toolbox and ecotools to be included in the box.

The first mentioned links will be explained by using CP and EMS as an example, whereas the links between the toolbox and the ecotools to be included in the box will be illustrated by using EMS and CP Assessment as an example.

If any of you have any comments to this figure or if you know about any other projects which are dealing with something similar to this project, I would be very interested in hearing from you.

CONCLUSION

Let me just briefly conclude on my presentation:

- TCA and other ecotools have an important role in promoting Cleaner Production which is one of several paths to achieve the goal of Sustainable Development
- The CP Programme of UNEP is working on:
  - a project that will produce a state of the art review of various ecotools, starting with LCA and Environmental Accounting
  - a project that will produce a booklet describing the links between the various ecotools, environmental strategies and paths, and the environmental goal to achieve
- UNEP is interested in dialog and cooperation on the two mentioned projects.

<table>
<tr><th colspan="3">Theoretical Level</th></tr>
<tr><td>Ultimate Goal</td><td colspan="2">Sustainable Development</td></tr>
<tr><td>Path</td><td colspan="2">Sustainable Production and Consumption</td></tr>
<tr><td>Strategies</td><td colspan="2">Cleaner Production/Eco-Efficiency/...
Carrying Capacity
Sustainable Harvesting
…</td></tr>
<tr><th colspan="3">Practical Level</th></tr>
<tr><td colspan="3">Ecotools</td></tr>
<tr><td>Ecotools for Framework or Toolbox</td><td colspan="2">Environmental Management System (EMS) or Total Environmental Quality Management (TEQM)</td></tr>
<tr><td rowspan="5">Ecotools to be included in the Toolbox</td><td>Procedural Tools</td><td>Analytical Tools</td></tr>
<tr><td>For instance</td><td>For instance</td></tr>
<tr><td>Env. Auditing</td><td>Total Cost Assessment</td></tr>
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Figure 1: The relationship between various ecotools, environmental strategies, among others CP, and paths, and the goal to achieve.

Micro and Macro Perspectives of Green Accounting - Background and Steps Towards Integration

Torsti Loikkanen
VTT Chemical Technology

INTRODUCTION

The present paper discusses on micro and macro aspects of environmental accounting. The focus is possible benefits of the integration of environmental accounting on the micro and macro levels, and on the exploration whether such an integration would be beneficial for companies, their customers and all stakeholder groups, and which are the main problems in the progress towards such a system.

ENVIRONMENTAL DATA AND DECISION-MAKING

In a democratic society remarkable decisions promoting sustainable development – such as the exploitation of natural resources, the state of the natural or built environment, goal setting in environmental policy, etc. - are being made in a political decision-making process. The final outcome of this process is usually a compromise made between different interests of various social, economic and political parties, interest groups and stakeholders. It is not unusual that some of the stakeholder groups will remain unsatisfied with final decisions.

One necessary condition for a well-balanced decision-making process in environmental issues, as in any important social and economic issue, is that the data basis on which decisions will be made, is comprehensive and sufficient enough, and as reliable as possible. Moreover, it is important that citizens and all stakeholder groups can trust that the data used is as transparent as possible. Shortages of data cause respective uncertainties for decision-making. Nevertheless, imperfect data is not an obstacle for environmental decision-making and assessments of uncertainty of data can be made if needed.

The data on the state and changes of the environment, as well as on related social and economic issues, are produced by a number of authorities studying and monitoring the state of the environment, as well as by research communities and statistical institutes. In order to be applicable to decision-making process, environmental data often have to be polished and visualized into a ”non-scientific” understandable and ”transparent” form. This is important for citizens in order to understand, accept and commit themselves to used data and decisions being made on this data basis. Although research communities and other institutes producing and polishing environmental data are not directly responsible for the final (political) use of the data, they nevertheless play an important role in the scientific interpretation of the data.

These general starting points are exceptionally important in the case of environmental accounting. Environmental accounting consists of physical and socio-economic data on the state of the environment. The basic ideas of EA are (1) to provide an integrated data system for the resource process from natural resource stocks through extraction and processing to end-use and disposal, including recycling, waste management and pollution abatement, and all related environmental effects, (2) to measure resources in physical units and thus be able to provide data on material and/or energy flows and balances, and (3) to connect physical accounts and measurements to economic valuations and aggregates, above all to national accounts and economic statistics and economic forecasting and analytic models (Lone 1992, 240). Where resources and data permit, an annual report and an audit on changes in environmental quality and in the stock of the nation´s environmental resource assets are needed to complement the traditional annual fiscal budget and economic development plans (WCED 1987, 314).

In the case of *economic* environmental accounting, in which the state and changes of ecological data are ”translated” into economic terms, the uncertainty of data is higher than in the case of ecological accounting. Decision-makers often prefer to make valuation not only in physical terms but, in order to make physical effects co-measurable in common monetary units. Although monetary valuation may increase the uncertainty of decision-making, it is desirable, and related methodologies should be further developed.

DEVELOPMENTS OF ENVIRONMENTAL ACCOUNTING

In the environmental management remarkable changes have taken place in the previous decades. Some 20-25 years ago pollution control was primarily based on government policy and actions, with a ”top down” approach, using such instruments as environmental standards, norms and respective regulations aimed at restricting especially emissions of production. Since the recognition of environmental problems in the 1960s and 1970s, the importance of data as a key element for sophisticated planning, formulation and implementation of pollution control policies was recognized by governments.

Consequently the development of environmental accounting was launched by some countries gradually in the 1970s, and on a national level EA has been developed particularly since the early 1980s, the Netherlands, France, Norway and Canada being among the pioneers. Respectively the UNEP, UN’s statistical office and the World Bank took initiatives with regard to the development of environmental accounting. Some of the projects launched were mainly aimed for the needs of developing countries, in order to support the sustainable use of forests, water and other environmental resources.

Right from the beginning, efforts of developing environmental accounting faced some problems, which are familiar in other sectors of the society as well. One of the problems is the complicated integration of ecological and economic data - still one of the key challenges. Another is the compatibility of micro and macro level data. Governments started to create very ambitious environmental indicator and data systems, and recently the micro perspective of these issues is emphasized as well, due largely to new requirements of customers, shareholders, and other stakeholders. Accordingly many companies develop actively environmental accounting systems in order to be aware of their environmental issues and in order to use these data for a sustainable development and improvement activities.

Along the development of quantitative environmental data also the limitations of this quantitative data in the decision-making have been increasingly recognized both in physical and socio-economic issues. Consequently it is realized that quantitative data must be supported by qualitative data in the decision-making. Currently a huge amount of data of the state of the environment is already available, and in the future the emphasis will not only be on the rational use of this data, but also on the development of integrated and interactive environmental micro and macro data systems.

TOWARDS INTEGRATION OF MICRO AND MACRO LEVEL ACCOUNTING

The integration of environmental accounting both on micro and macro levels is ultimately a practical question – why, for whom and for what purpose such data should be produced. Moreover, the same question should be made with respect to the needs of integrating environmental accounting on micro and macro levels - why, for whom and for what purpose?

A current example of the need of integrated environmental micro and macro data is the planning of the mitigation of greenhouse gas emissions. Emission data is produced with a bottom-up approach by emission measurements and explorations by companies, authorities and other institutions, and these data are aggregated into industrial branch data on macro levels. Nevertheless, when considered from the perspective of data needed for concrete mitigation measures, aggregated emission data remains insufficient, and specific plant level emission data must be provided. In other words, available statistical data remains inadequate. Moreover, this problem relates to technological change. Technology is a dynamic and changing issue and in mitigating emissions by new technological solutions their impact on emission reduction as well as related costs ought to be known.

The planning and decision-making both of companies and of governments is normally based on accounts which do not encompass all environmental costs, and may mislead planning, decision-making and behavior. This approach is of importance for technological development as well. As long as accountants do not encompass all environmental costs, technologies using environmental commodities seem more profitable than they actually are, which may mislead technological trajectories towards an unsustainable direction. Therefore in the future indicators and environmental accounting (EA) both on micro and macro levels including all environmental costs should be further developed.

On a company level, EA relates to opening up of “hidden” environment related items of a traditional accounting system (see e.g. Ditz et al, 1995). This “full cost” accounting is an important issue for a proper allocating of company costs according to sources of pollution and also for the application of *the pollution pays principle*. The development of the company level EA is promoted by governments for example by the Environmental Protection Agency (EPA) in the US, encouraging business to understand the full spectrum of their environmental costs and the needs of integrating these into the decision-making.

Which are the future opportunities in the integration of micro and macro perspectives of environmental accounting? Could the vision be a system of similar to that of national accounting, i.e. firms gather versatile environmental data, authorities compile this data and publish it on a branch or national level? Or should the environmental accounting of the future on both micro and macro levels be more transparent than current data systems in order to smooth the path towards sustainable development?

SOURCES

Ditz, D., Ranganathan, J. and Banks, R.D. 1995 Green Ledgers: Case Studies in Corporate Environmental Accounting, A World Resources Institute Book.

Lone, Ö. 1992 Environmental and Resource Accounting, in P. Ekins and M. Max-Neef (Eds), 239-254.

WCED 1987 Our Common Future, the World Commission of Environment and Development, Oxford University Press.

Box 14.1 Directions for the European Union on environmental indicators and green national accounting

As a follow-up to the Fifth Environmental Action Programme (CEC, 1992), the European Commission has proposed a harmonised system of integrated economic and environmental indicators and accounts for the member states of the European Union. The main features of the Commission's proposal (CEC, 1994) are

- establishment of a European System for Integrated Environmental and economic Accounting (ESEA) (which would be closely modelled on the SNA satellite accounts framework);
- establishment of a European System of Environmental Pressure Indices (ESEPI). This will comprise a set of physical indicators and a system of weighting coefficients which may be used to combine indicators into so-called environmental pressure indices – for example, physical measures of emissions of particulates combined to provide a pressure index for air quality;
- combining the more conventional indices of economic performance (growth rates, GDP *per capita*, and so on) with the new indices of environmental pressure, to form a European System of Integrated Economic and Environmental Indices (ESI);
- the development and extension of work on 'greening' the National Accounts, at this stage primarily through the satellite accounts approach, and by improving the methodology and enlarging the scope of monetary valuation of environmental assets and environmental damage.

A useful by-product of this proposaö may be a greater focus on environmental problems and policies of an international or regional dimension, which as noted in Chapter 12 may not be regarded as priorities at a national level.

Comparison of GDP and 'NDP'

		Net Change in Natural Resource Sectors[a]				
YEAR	GDP[b]	Petroleum	Forestry	Soil	Net change	NDP[b]
1971	5,545	1,527	-312	-89	1,126	6,671
1975	7,631	-787	-249	-85	-1,121	6,510
1980	11,169	-1,633	-965	-65	-2,663	8,505
1981	12,055	-1,552	-595	-68	-2,215	9,840
1984	13,520	-1,765	-493	-76	-2,334	11,186
Average Annual Growth	7,1 %					4,0 %

Notes:

a. Positive numbers for resource sectors imply growth in the physical reserves of that resource during the year

b. in Billion Constant 1973 Rupiah

Source: Repetto et al. (1989)

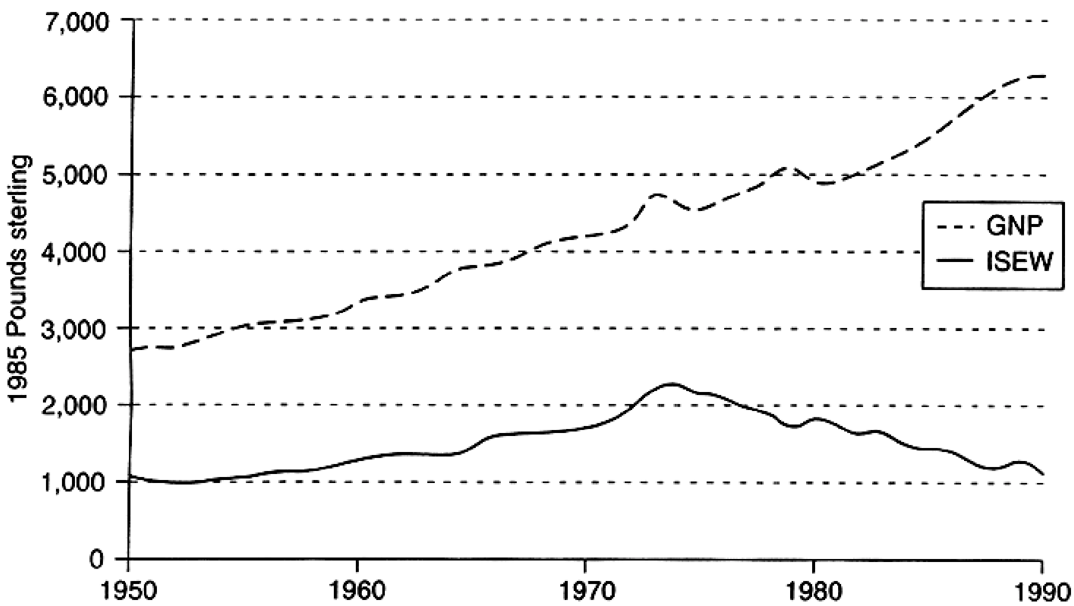


Fig 14.1 Illustrative indicator for the UK: Index of Sustainable Economic Welfare (*source*: Jackson and Marks, 1994).

Environmental Accounting from an Energy Producers Perspective

Karin Annerwall-Parö & Leif Halvorsén
Vattenfall, Sweden

INTRODUCTION

I will start by doing a short presentation of my company, Vattenfall, to make you all understand the framework behind my discussion.

Vattenfall is one of the biggest energy companies in the Nordic countries and supply the area with 20 % of the areas electricity. The electricity is produced half by nuclear power and half by hydro power. We are also working on the heating market, the natural gas market and are doing work in the area of energy efficient solutions. An important part of the business idea is ”with Sweden and the Nordic Region as its domestic market identify and satisfy the customers requierement for efficient and environmentally compatible energy solutions”. For Vattenfall, the Nordic region is an open and common market. The Group´s ambition is to increase its market share in the Nordic countries and to participate in the restructuring of the electricity and heating markets in Sweden, the other Nordic countries and the Baltic region.

Vattenfall´s vision is to be:

- a leading European energy company
- a global energy partner.

Vattenfall has engagements in all countries around the baltic sea.

The environment that we are working in is under dramatic change since some years. Let me first mention what is happening in Europe with the question of deregulation. Great Britain was in the beginning of this decade the first country to do the big step to deregulate the electricity market. Since then several countries has made this step including Sweden that did it in the beginning of 1996. As a result of the deregulation the trend to make the energy question more international has strengthened and the energy companies are now more customer oriented than earlier.

Secondly we are working in the framework of the energy policies that sometimes changes. Last week the Swedish parliament decided to phase out the first nuclear plant next summer and the second one three years thereafter. To make this possible the amount of renewable energy sources in the Swedish power system must increase. One possible renewable energy source is combined heat and power plants with bio mass as a fuel. Other sources are hydro power, wind power, black lye vaporization and solar cells. During this change of the energy system the parliament has given Vattenfall a big responsibility.

The third important change in the surrounding world of Vattenfall is the environment questions. The climate change is probably one of the most important of them. The solution is a renewal of the energy system. It is also important to use both resources and energy in an efficient way. Some of the others environmental questions are air pollution in built-up areas, electrical and magnetic fields, biological diversity and of course radiation and safety.

In this presentation I will go on with doing a presentation of how Vattenfall is working with the environmental questions. A special a study of environmental performance indicators that we are doing follows on that. Finally I will present my expectations for this seminar which I see as a very important event.

VATTENFALL´S ENVIRONMENTAL WORK

The work at Vattenfall with environmental questions is done under the impression of responsibility, openess and a holistic perspective.

As a part of this Vattenfall adopted a new environmental policy last year. It is based on the commitments in ICC´s Business Charter for Sustainable Development and also the demands from EMAS.

The implementation of the environmental policy is based on several steps. The environmental management system is one. But it is also important with education so that the employees understand the environmental questions and know what to do. One tool in the environmental management system is to have some form of environmental performance indicators not to mention the environmental performance report.

The environmental management system is beginning with making the environmental policy and an environmental review. The further steps are to make environmental objectives, to go through an environmental program and making necessary implementations. One of the most important part is to make the feed back through the environmental audit and thereafter if necessary change the policy or objectives. It is important that this is a process that continuously is going through the evaluation and review.

Vattenfall started the introduction of the environmental management system last year and the goal is that it should be fully adapted not later than next year. In year 2000 it should be possible for all units and companies within the Vattenfall group to be ISO 14001 certified or EMAS registred.

The way Vattenfall has choosed to incorporate the environmental question is to make the work a natural part of the daily work. In the different business areas we are having environmental coordinators that have responsibility to the environmental work done in their business area. Together the coordinators form a group that discuss principals of importance for the whole company. We are also having consultants in our company group that are working with environmental questions and we are also doing R&D in the area.

Electricity is used in the manufacture of most products. The increased awareness of environmental impact and the desire for a sustainable society mean that more companies are demanding specific information on environmental impact, including that arising from the electrical energy consumed. If you conduct your own life-cycle assessment, you also need a study from your supplier.

At Vattenfall we just have finalised a life cycle inventory for the production system and we are going to make the same for the distribution system after summer.

In our work with life-cycle studies we have got as far as an inventory of data, but we need to proceed in order to assess the effects on the environment. We also want to broaden our work to include environmental risks. Our industry has a long tradition of describing and calculating risks in connection with nuclear power. These methods can be adapted and used for other industrial processes and other energy chains and to include risks to the environment in a broader perspective.

Some months ago we published our second environmental report. It documents the current status of our environmental work. With the report we hope to encourage a broader discussion of energy issues. In the report is included the environmental accounts for our company.

I have copies with me from both the life-cycle studies and the envrionmental performance report if you are interested to read about it.

ENVIRONMENTAL PERFORMANCE INDICATORS

At Vattenfall we have started the important work with environmental performance indicators. We have just finished a feasability study in the area and are going into an execution phase after the summer. Some of the conclusion that are coming from the feasability study is the following:

- We are following the work that is being done in the standardisation area, ISO 14031. We do think that it is very important to follow this work because it is important to speak the same language between countries and companies. Actually it is the only way to do benchmarking. But, we do not think it is necessary to follow the standards when we are working with the indicators used for internal purpose only.
- We have also studied the Nordic project that has been going on for some years with some big companies involved from both Sweden and Norway. In the first phase that project has developed a model to implement environmental Performance Indicators. In the next phase the project will start the actual work with implementing the indicators and from Vattenfall we are looking on the possibilites to do some form of work together with that project.
- Often people are saying that they are planning to use the environmental indicators as a tool to steer the organisation in environmental matters. From Vattenfall we have another opinion. We are looking at the indicators as a needle instrument that shows what actually is happening and the environmental management system as the tool to steer.
- The environmental indicators is a necessary tool to do comparisons between different companies but also a tool to do comparisons in the future with our own company
- We have discussed the important difference between indicators for the management level and for the more operational level. In the ISO standard they are calling the first ones for Environmental Managent Indicators (EMI) and in the other one they are calling them Environmental Performance Indicators (EPI).

For the moment we are at Vattenfall in the process of the Balanced Score Card concept where the main change from former kinds of steering system is that it should be a balance between different kind of parameters, for instance economy, environment etc. It is obvious that the environmental questions must be one part of the managements tools for the future. It is also very important to develop the EPI´s together with the people that actually are going to use them. That implies that when we are going to discuss indicators for the management level we must have the management people involved in the process.

An interesting form of environmental indicator that we will try in one part of the business area is a form of environmental travelling account. In that it will be possible to see what the travelling in our company will cause in form of environmental emissions. Then it will be possible for everybody to choose a way to travel that will minimize the emissions.

In the coming autumn we will be working with the operational phase of the project. We are going to work actively with the management and the business areas. We are going to start some form of pilot project to test a data system. We are also going to work within the nordic project and will be following the ISO-work in the area.

EXPECTATIONS FOR THE FUTURE

What are then the expactations for the future?

One important thing is that it will be necessary to look at the environmental work as a process. The process is divided into different parts. One important part is the ”Live as the book” - part. That explains the normal work done by our company. But it also necessary to have other parts involved. One of those parts is the one that creates the trademark for our company. Another part is where development of products and services will take place. To make this parts work together the necessary tools are for one to have a clear strategy and for the other to have an organisation that is capable to handle this things.

One vision that I personally have is that the environmental business will be such a natural thing to work with that there will in the future not be a special environmental process but instead environmental objectives in all processes and decisions within the Vattenfall Group.

Let us during this days together discuss the importance of the environmental question. When I decided to let Vattenfall sponsor this UNEP Expert Seminar I did it because I do think it is necessary for Vattenfall as a big energy company to learn from what the discussions are at the academic world. I do also think that we can help to make a practical example for the academics and I do think we have something to show other companies.

I hope that when we are leaving Nagu on tuesday we will have been dicussing and started to find the answers to some of the following questions:

- What kind of theoretical methods are usable dealing with environmental accounting?
- How to define environmental costs?
- Where is the boarder line between internal and external costs?
- How can you use Environmental Performance Indicators in the management system?

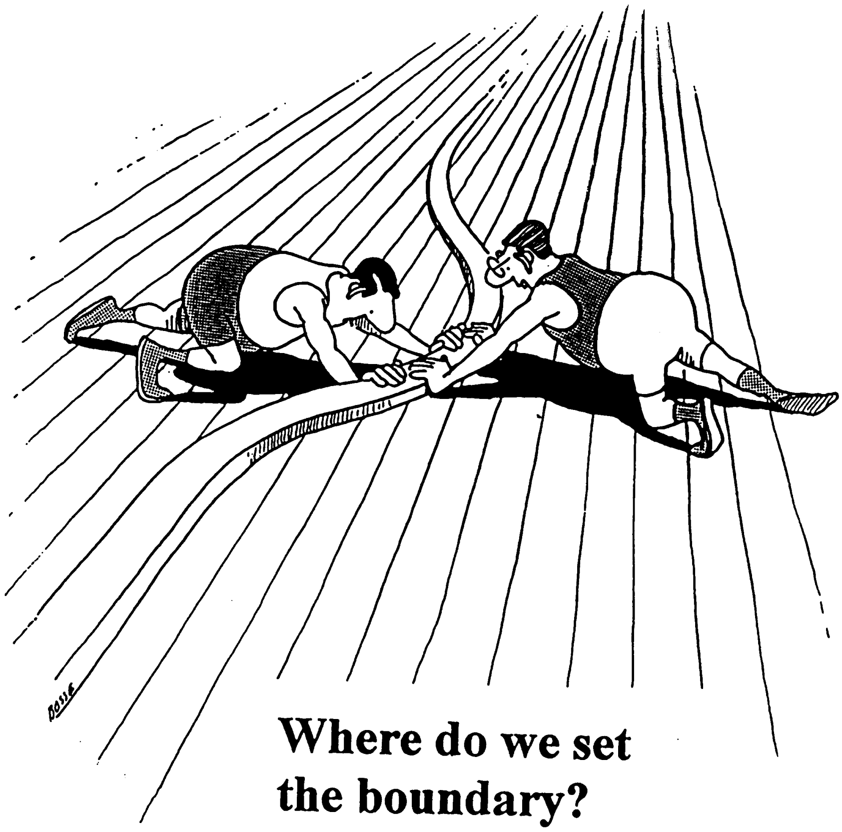
TERMS AND CONCEPTS OF ENVIRONMENTAL COST ACCOUNTING

Environmental Cost Accounting
Allen White, Tellus Institute, USA

Environment-related Management Accounting: Current Practice and Future Trends
M. Bennett, University of Wolverhampton Business School, UK
P. James, Sustainable Business Center, UK

Some Thoughts about Environmental Accounting
Giuseppe Sammarco & Matteo Bartolomeo, FEEM, Italy

What Are We Learning About Total Cost Accounting & Full Cost Accounting?
Christopher H. Stinson, The University of Texas at Austin,USA



Environmental Cost Accounting

Allen White
Tellus Institute, USA

INTRODUCTION

A business's long-term profitability depends on the quality of the product or service it offers, the demand for the product or service, and its ability to produce efficiently. Efficient production means maximizing output for a given level of input, or conversely, minimizing input for a given level of output. Firms that consistently produce efficiently create a sound competitive advantage for their enterprises.

A critical element of efficient production is the accurate and consistent measurement of inputs and outputs. The often repeated axiom "what gets measured gets managed" has never been more true. Without accurate cost information, it is difficult to adequately assess the profitability of a product, a department, or a firm, and even more difficult to know what changes to make in order to improve profitability in today's highly competitive business climate. Management accounting systems can provide the information required to make those decisions.

WHY MEASURE ENVIRONMENTAL COSTS?

Environmental costs are impacts incurred by society, an organization, or an individual resulting from activities that affect environmental quality; these impacts can be expressed in monetary or non-monetary terms. They include any cost, both monetized and less tangible, with short- or long-term financial consequences for the firm. These costs are often not tracked by or are hidden in overhead accounts within traditional management accounting systems, but they can be a significant component of a firm's overall cost structure. The failure to include them in financial analyses has the effect of sending the wrong financial signals to managers making process improvement, product mix, pricing, capital budgeting, and other routine decisions. In an increasingly global economy, where labor, materials, and capital costs are likely to converge over time, environmental cost management and performance may increasingly distinguish corporate winners from the corporate laggards.

Mounting pressures on industry to achieve strong environmental performance have a number of ramifications for the business community. First, some costs of doing business that have traditionally been external to the firm – e.g., health effects of air pollutants – are being shifted to the firm's balance sheet and income statement through regulation. This shift is the result of more stringent rules regarding pollutants already regulated and new rules affecting previously unregulated pollutants.

Second, just as the outcry over questionable and secretive management of corporate finance led to financial disclosure regulations early this century, today's stakeholders are demanding public disclosure of environmental performance information. The result of this trend is that activities with direct or indirect adverse environmental effects are becoming more costly to operations, to capital budgets, and to stock prices[1].

Even absent external pressure, the true costs of environmental impact – including the costs of waste, of liability, of diminished image – though often obscured by biases associated with traditional systems are real and can be significant. Actively managing these costs is therefore an important aspect of maintaining a lean, profitable business. Whether driven by internal motivation or external concerns, a firm can create a sustained competitive advantage by systematically reducing environmental costs. And the first and critical step of cost reduction is improved cost identification and management.

WHAT IS ENVIRONMENTAL ACCOUNTING?

Environmental Accounting (EA) is a broad-based term that refers to the incorporation of environmental costs and information into a variety of accounting practices. Figure 2 below depicts some of the different contexts in which EA is used. At a macroeconomic level, EA is used to account for costs associated with a region's stocks and flows of natural resources. A redefinition of national income that incorporates such environmental accounts into conventional measures such as the Gross Domestic Product is an example of macroeconomic EA.

[1] Feldman, Stanley J., Peter A. Soyka, & Paul Ameer. *Does Improving A Firm's Environmental Management System and Environmental Performance Result in a Higher Stock Price?* ICF Kaiser Working Paper, 1996.

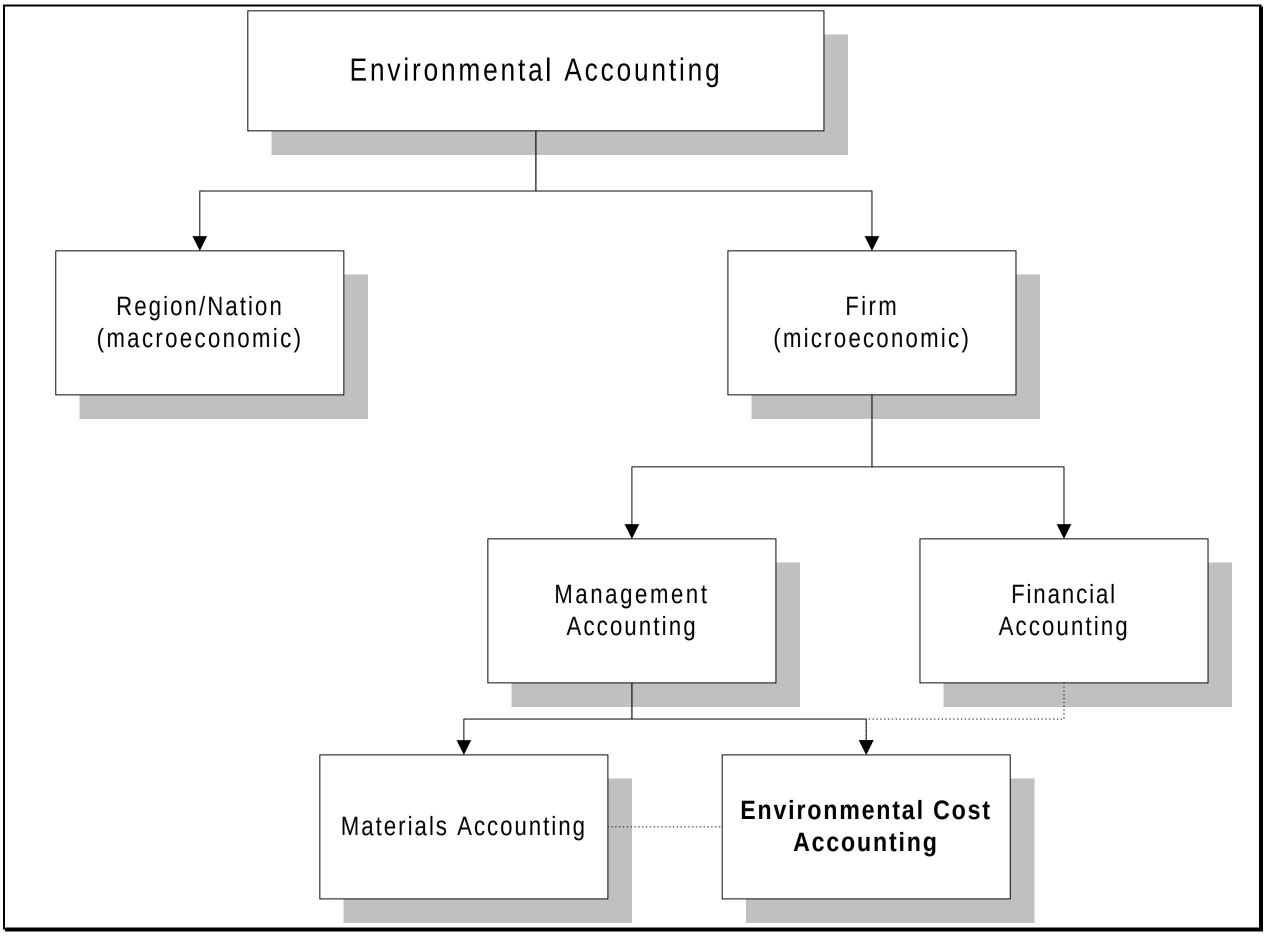


Figure 2. Some Contexts of Environmental Accounting

At the microeconomic or firm level, EA can apply to both financial accounting and management accounting. Financial accounting, whereby a firm reports its economic activity to an external audience, has requirements for disclosure of environmental liabilities and certain environmental costs. This application of EA is governed by the "Generally Accepted Accounting Principles" which are established by the Federal Accounting Standards Board and the US Securities and Exchange Commission.

In terms of management (or internal) accounting, EA is the way that businesses can account for the material use and environmental costs of their operations. Materials accounting is a means of tracking material flows through a facility in order to characterize inputs and outputs for purposes of evaluating both resource efficiency and environmental improvement opportunities. Environmental cost accounting (ECA) is how environmental costs – including those that are often hidden in general overhead accounts – are identified and allocated to the material flows or other physical aspects of a firm's operations (as might be identified via materials accounting). The application of these internal EA concepts provides consistency between an organization's environmental goals and its financial goals, meaning environmental improvement can directly lead to financial improvement. It is this direct link between the financial and the environmental performance that makes robust environmental accounting practices so compelling.

Financial accounting and its environmental requirements have been standardized to provide consistent and comparable information to investors, regulators and other stakeholders, while management accounting practices vary widely from firm to firm. Likewise, the manner in which firms apply EA principles differs. A few firms make efforts to identify their relevant environmental costs and to use this additional information to guide business decisions. Most firms, however, operate without recognizing the magnitude or source of these costs, which can lead them to poorly informed decisions. Correcting this information gap is the primary purpose of EA.

HOW CAN EA SUPPORT BUSINESS DECISION MAKING?

The concepts of EA as they apply to internal management decisions are the focus of this document. In this context, EA concepts can be applied at all levels of an organization to help make sound business decisions such as those in Table 1 below. Accurate, timely information is the critical underpinning of business decision making, and EA practices provide means of exposing information obscured by conventional management accounting practices.

Table 1. Business Decisions Supported by EA[2]

Product Design	Capital Investments
Process Design	Cost Control
Facility Siting	Waste Management
Purchasing	Cost Allocation
Product/Process Costing	Product Retention/Mix
Risk/Liability Management	Product Pricing
Strategic Planning	Performance Evaluations
Supplier Selection	Plant Expansion
Environmental Program Justification	

The cases included in this document touch only a few of these business decisions. While applications relating to capital investments, product/process costing, and strategic planning have been better documented than the rest, a broad range of business decisions can benefit from the adoption of EA principles. As the preceding table and graphic indicate, environmental accounting can play a role in many aspects of business management. To the extent that environmental costs exist in almost every phase of a business' operations, EA practices can support improved decision making in many different applications throughout an organization. Following are descriptions of some of the more common applications.

EA Informs Product/Process Costing

Businesses generally look to the marketplace to gauge the demand for a product and, from that demand, the price the market is willing to pay. They then compare that price to their cost of making the product to determine whether or not there is adequate

[2] Adapted from US EPA's *An Introduction to Environmental Accounting As A Business Management Tool: Key Concepts and Terms* (EPA 742-R-95-001), page 6.

profitability to justify its production. Of course, producers consider other factors – such as market positioning, customer retention, and long-term sector growth – when deciding what and how much to produce, but the costing of the product and the processes that produce it remains fundamental.

When environmental costs are not adequately allocated, cross-subsidization occurs between products. In most cases, different products are made by different processes, and each process tends to have a different environmental cost. For example, consider a facility with two processes, A and B, that use the same number of direct labor hours for a batch of product. Process A, however, uses hazardous chemicals whereas process B does not. The facility incurs environmental costs from the use of the hazardous chemicals in a number of ways: specification and procurement of the chemical which includes evaluation of Material Safety Data Sheets; design of the process to minimize worker exposure; shipping costs associated with transporting hazardous chemicals; monitoring, reporting, and permitting to meet applicable regulations; employee training in handling and emergency response; storage and disposal costs; and liability for the chemical from purchase to grave. In addition, there may be less tangible costs such as tarnished corporate image and inability to meet delivery or quality requirements.

If all of these costs are bundled as 'environmental' overhead and allocated to processes A and B on the basis of direct labor hours (a common practice), products made by process B are in effect subsidizing those made by process A. In other words, a traditional accounting system would show process B to be more costly than it really is and process A to be less costly. Armed only with this information, managers are inclined to overestimate the profitability of products made by process A and correspondingly underestimate the profitability of those made by process B. Eventually, this type of accounting can put the firm at a considerable competitive disadvantage. Conversely, by more accurately allocating these costs, managers can make better decisions about product mix and about where cost-saving opportunities lie, thereby putting their firms ahead of the competition.

EA Informs Capital Investment Decisions

Companies develop and enlarge their businesses by investing in their human and physical capital. Their long-term financial viability hinges on the strength of these investments. Generally, a company's investors demand at minimum a return comparable to that which they can obtain through other investments. This demand places pressure on companies to invest their limited capital funds wisely. Environmental costs are often a significant component of capital and operating costs. There is often, therefore, a considerable financial return available to companies that can reduce these costs. When environmental costs are properly accounted for, investment analyses of environmental performance improvements provide managers with information to determine whether and to what extent the benefits of such investments will exceed the costs. But to achieve these results, managers must first be able to define and measure these environmental costs in a systematic and consistent fashion.

One specific application of EA for capital investment analysis is Total Cost Assessment (TCA); a method by which investments, particularly environmental investments, can be evaluated in a way that more accurately reflects their profitability potential. The four basic elements of TCA that make it more informative than conventional analysis are: (1) a more comprehensive cost inventory that includes less direct, less tangible costs[3]; (2) allocation of costs that are typically assigned to overhead accounts, and either allocated on the basis of an inappropriate cost driver or not allocated at all; (3) evaluation of projects using longer time horizons in order to better capture the full benefit of the investment, a significant portion of which may be realized after the first 2-3 years; and (4) profitability indicators that account for the time value of money, making the results more realistic and reflective of an investment's true cost or benefit.

Evaluating environmental projects using TCA helps put them on equal footing with other projects competing for capital funds. Projects that appear to be financially weak using conventional analyses may look considerably stronger and more competitive once their true return has been identified. For example, an expensive investment in a process change to accommodate a switch to an aqueous solvent may appear to be a poor investment with a long payback if only direct labor and material costs are considered over a three-year time period. However, if the full environmental costs of the existing process – such as solvent disposal costs, regulatory permits, worker health, and liability for accidental spills or leaks – are allocated to the process and included in the analysis, the less visible cost savings associated with the switch, considered over a longer, 7-8 year period, may well yield an impressive rate of return and a shorter-than-expected discounted payback. Of course, TCA does not ensure profitability *a priori*. It does however ensure greater transparency, clarity, and rigor in making capital investment decisions.

EA Informs Strategic Planning

Understanding the nature and magnitude of its costs is vital to the successful, long-term operation of any firm. When planning strategically, businesses look externally at the markets they serve, and internally at the resources they control. They then are in a position to decide where the best profit potential lies and what strategies will be necessary to achieve that potential. Profit potential can be substantially affected by environmental costs and how they are managed. In this way, EA is a critical strategic element of long-term commercial success.

Looking outward, many businesses see customers that are increasingly more demanding in terms of quality, of which environmental performance is an integral component. Many companies that produce consumer products are finding lucrative markets in green goods where customers, who will often pay a premium for a green product, believe they can positively impact environmental quality through their purchasing decisions. Similarly, companies producing raw materials and intermediate goods are finding more stringent customer expectations with regard to environmental performance of both their operations and their products. To many consumers and buyers, good environmental management is indicative of a firm's general management and of its ability to consistently produce reliable, high-quality products. To the extent that the application of EA concepts encourages financially sound investment in the production of products of higher environmental integrity, it can strategically position a business to seize this powerful market opportunity.

[3] See US EPA's *An Introduction to Environmental Accounting As A Business Management Tool: Key Concepts and Terms* pages 7-11 for a discussion of environmental costs.

Customers and other stakeholders, to varying degrees, are calling for increased environmental responsibility on the part of businesses. Concepts of environmental accounting can be applied to the development of environmental management systems, including those consistent with the increasingly prevalent ISO 14000 standards, that enable strategies to answer that call. As firms position themselves to enhance the structure of their systems, EA will be integral to their development and capabilities. These systems coordinate EA-based data to provide managers with information to better understand the impacts of their decisions. This information can be used strategically to drive improved environmental performance.

A strategic vision and corresponding management commitment is necessary to fully integrate environmental costs into a company's business decisions. Viewed over the long term, those firms that properly account for the true environmental costs of their operations will be in a superior position to meet tomorrow's competitive challenges.

For a more complete description of EA concepts, readers are encouraged to see EPA's *An Introduction to Environmental Accounting As A Business Management Tool: Key Concepts and Terms* (EPA 742-R-95-001).

Environment-Related Management Accounting: Current Practice and Future Trends

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ABSTRACT

This paper considers the various purposes in business which can be served by environment-related management accounting and the range of information potentially available to support this, including a review of the main financial report items to assess the relevance for environmental management. It reviews the main current management accounting techniques and considers how these can be adapted to reflect environmental factors and support environmental management, and goes on to propose environmental value analysis to evaluate the relationship between an organisation's economic value added and its environmental impacts. It also develops a conceptual model to position these areas, and the papers within this special issue. It concludes that there are inevitably problems in measuring some of the broader (and probably most significant) effects, but that as the information available is expanded and improved, and as environment becomes a significant cost issue for business, there is an increasing potential for environment-related management accounting to make a substantial contribution to both business success and sustainable development.

INTRODUCTION

Environmental accounting was put "on the map" in the early 1990's by, amongst others, the work of Gray (1993) and collaborators in the UK, by that of the US Environment Protection Agency (1995) and the Tellus Institute in the USA and the Fondazione ENI Enrico Mattei in Italy. There are now a number of variants, one of which is the subject of this special issue - environment-related management accounting. This is a topic of growing interest and a rapidly developing practice and academic literature (for example, Rubinstein, 1994; Ditz et al., 1995; Epstein, 1996; Schaltegger, 1996; Tuppen (ed.), 1996).

Section 1 of this paper defines environment-related management accounting whilst section 2 describes its relevance to business and environmental management. Section 3 explores the main areas of financial and non-financial information which are actually or potentially available as inputs to environmental management accounting. Section 4 discusses the relationship between environment and various management accounting techniques. Section 5 argues that an important goal of environmental management accounting should be assessing the eco-efficiency and/or sustainability of an organisation's activities. The final section provides conclusions and discusses the likely development of the subject in coming years.

Figure 1 also provides a graphical representation of the main areas of discussion. It is divided into four vertical levels to indicate a progression from the foundation of non-financial and financial information through the techniques which process this information into outputs which are useful for managers and stakeholders and to the highest level of assessing the environmental value of an organisation's activities.

WHAT IS ENVIRONMENT-RELATED MANAGEMENT ACCOUNTING ?

The term environmental accounting has been used to cover both national and firm level accounting activities, the processing of both financial and non-financial information and the calculation and use of monetised external damage costs as well as those which are internal to the firm. For clarity, Table 1 distinguishes six different domains of environmental accounting which are relevant to the firm-level, based on their boundaries of attention - an individual organisation, the supply chain of which it forms part and the whole of society - and the extent to which they focus on financial and/or non-financial information. The six domains which emerge can be defined in this way (the two life-cycle definitions are based on EPA, 1995):

Energy and Materials Accounting - the tracking and analysis of all flows of energy and substances into, through and out of an organisation.

Environment-related Financial Management - the generation, analysis and use of monetised information in order to improve corporate environmental and economic performance.

Life-cycle Assessment - a holistic approach to identifying the environmental consequences of a product or service through its entire life cycle and identifying opportunities for achieving environmental improvements.

Life-cycle Cost Assessment - a systematic process for evaluating the life-cycle costs of a product or service by identifying environmental consequences and assigning measures of monetary value to those consequences.

Environmental Impact Assessment - a systematic process for identifying all the environmental consequences of a organisation, site or project's activities.

Environmental Externalities Costing - the generation, analysis and use of monetised estimates of environmental damage (and benefits) created by an organisation, site or project's activities.

Environment-related management accounting - the use of accounting and related information to support internal management - can potentially encompass all of the six domains but in practice is primarily concerned with environment-related financial management and the linkages with energy and materials accounting and other internal and external systems which are necessary to generate financial data. It therefore mirrors general management accounting, which makes similar use of a variety of non-financial information but has a bias (possibly excessive) towards financial information. One reason for this is that for profit-seeking firms the ultimate objective (maximising shareholder value, or profitability) is expressible in monetary form, and information which can be expressed in the same terms is always likely to attract more immediate attention. Secondly, the financial side of management is relevant to all functions, including environmental management. Not only do environmental budgets need to be managed, but proposals for action which can be justified in terms of conventional methods of financial investment appraisal and product costing, for example, are more likely to be successful.

Like management accounting in general, practical environment-related management accounting is also a process which can reate interaction between different individuals and functions within organisations and helps develop new perspectives on problems and opportunities. Hence our working definition of environment-related management accounting is ‘the generation, analysis and use of financial and non-financial information in order to improve corporate environmental and economic performance’. As figure 1 indicates, it is therefore concerned with i) making better use of, or modifying, existing sources of information and generating new ones ii) making better use of or modifying existing management accounting techniques and iii) evaluating the sustainability and/or environmental efficiency of a company’s operations. In practice, it can also be iv) a valuable means of creating linkages between the accounting, environmental and other functions of a company. The techniques and approach to areas such as data verification of environment-related management accounting can be useful, as Gray has pointed out, inputs to environmental management (albeit as a junior partner to environmental managers themselves).

As a specific variant of general management accounting environment-related management accounting is primarily focused on provision of information for managerial decision-making and other purposes (rather than reassuring external stakeholders about the company’s financial and environmental probity which is the focus of financial accounting and environmental reporting respectively). The premise which is driving its development - that currently available information and techniques are inadequate (in this case for successfully understanding and managing the business impacts of environment and improving environmental performance - is also one which researchers such as Johnson and Kaplan (1987) believe applies to almost all areas of management accounting. Hence, many of the points made in following pages and many of the articles in this special issue, have a significance beyond their environmental context.

WHY UNDERTAKE ENVIRONMENT-RELATED MANAGEMENT ACCOUNTING ?

The potential benefits to business of environment-related management accounting can be summarised as:

demonstrating the income statement (or profit & loss account) and/or balance sheet impact of environment-related activities

- identifying cost reduction and other improvement opportunities
- prioritising environmental actions
- guiding product pricing, mix and development decisions
- enhancing customer value
- future-proofing investment and other decisions with long-term consequences.
- assessing the eco-efficiency and/or sustainability of a company’s activities.

Income Statement and Balance Sheet Impact - As we discuss below, there is growing evidence that environment can have significant impacts on expenses, revenues, assets and liabilities and that these impacts are often under-estimated. Pilot studies of 6 US sites by the World Resources Institute, for example, found that, on their definition of environmental costs, they comprised almost 22% of non-feedstock operating costs at Amoco’s Yorktown refinery and 19% of the manufacturing costs of a Du Pont agricultural pesticide (Ditz et al, 1995). Making such financial impacts apparent can make it easier to take, and win support for, further environmental initiatives.

In the US, most attention has focused on the balance sheet issue of environment-related liabilities. This is a consequence of the high levels of damage claims and fines and specific legislation such as that requiring clean-up of contaminated land. It has been estimated that American industry may be under-provided for ‘Superfund’-related clean-up liabilities by up to a trillion dollars (Schoemaker and Schoemaker, 1995). Liabilities are less in the UK and other European countries but significant for some companies. They may become more significant if proposed legislation on the topic comes into force.

Investment in environment-related assets can also be significant - the chemical industry has estimated that up to 20% of its new capital investment in recent years has been to deal with environmental problems. This is financially significant because these assets have to be financed but, to the extent that the need for them is driven by compliance rather than commercial business criteria, they do not create any direct return.

European attention has been more focused more on opportunities to reduce or avoid expenses than liabilities and this topic is rising in importance in the USA. Initiatives are usually done on a one-off basis (see below) but an aggregate measure of savings can be a useful means of demonstrating that environmental management can be a profit contributor rather than merely an additional cost burden on business, and of building bridges between environmental staff and mainstream management. 3M calculates the accumulated first years savings from initiatives carried out under its pollution prevention pays (3P) programme whilst Baxter, as we discuss in the case in this issue, produces an annual environmental financial statement with details of expenses and savings. So far less attention has been paid to the revenue opportunities arising from environmental action but these too may be significant in future.

Cost Reduction and Improvement - a number of corporate programmes, practical demonstration projects and research studies have demonstrated that waste minimisation and similar initiatives can create savings and cost avoidance. In the first phase of the Aire and Calder Valley study (Johnston, 1994) for example, potential improvements worth £2 million p.a. were identified across the 11 industrial sites studied, with more longer-term possibilities in prospect when the project had run longer. 72% of the proposals stimulated by the project had pay-back periods of either zero or less than 12 months. Similarly impressive results have been reported by other waste minimisation and energy efficiency projects - including one at Sulzer as the paper by Schoeder and Winter describes. In addition, these and other initiatives such as product redesign can sometimes increase product quality and therefore sales revenues.

Of course, once the ‘low hanging fruit’ has been gathered there may be a point at which further cost reductions are not available (Walley and Whitehead, 1994). However, if increasing regulatory and social demands continue to increase and to create new potential costs for business, this point may be delayed for some time. Even after many years of waste minimisation initiatives Dow, for example, is expecting to find a large number of waste minimisation and similar projects which can provide annual returns on capital of at least 30-40% over the coming decade.

Prioritise Environmental Actions - If they are fortunate, companies will need to prioritise between a number of win-win improvement opportunities. If not, they may need to prioritise between environmental improvements which do not create any net economic benefit but which may nonetheless have differing rates of (negative) return. Du Pont, for example, calculates the costs of different means of meeting given emission reduction targets as a means of achieving this.

Guide Product Pricing/Mix/Development Decisions - To maximise product profitability, accurate product cost information is vital so that it can be taken into account when setting prices. This information also allows poorly performing products to be changed or dropped from the product range. A study by the World Resources Institute found, at several companies it examined, that although environmental costs were significant they were not being fully identified and allocated to products, so that pricing was not reflective of real costs (Ditz et al., 1995). As previously noted, environment can also influence the lifetime costs of products - for example, by requiring end-of-life disposal routes. Gaining a better understanding of these costs - as with the Philips model for considering end-of-life disposal costs described in the paper by Stevels - allows timely action to be taken to minimise or avoid them through redesign and/or to put more cost-effective disposal routes in place.

Enhance Customer Value - Environmental actions taken within discrete portions of product chains can sometimes be economically and/or environmentally sub-optimal so that co-ordinated action can provide higher returns for all of the chain members involved. One example from our research was a company providing a chemical in a small disposable container. The containers were expensive to buy and incurred waste disposal costs for the customer. Changing to reusable containers reduced procurement costs for the supplier and eliminated the customer's waste costs. Demonstrating a detailed business case for such actions can spur improvement and also provide opportunities for developing closer relationships with customers.

Future Proofing of Decisions - Many investment and product development decisions are determined by levels of costs and benefits arising some years in the future. Unanticipated environmental factors can often affect these costs and benefits, sometimes to the point where returns become negative. As Epstein's paper discusses, environmental scenario planning, based on projections of future environmental costs, can reduce the dangers of this occurring.

Assessing Eco-Efficiency and Sustainability - As section 5 discusses, data such as economic value added can be adjusted to take environmental damage costs into account or related to environmental parameters to measure the efficiency with which environmental resources are being utilised.

Form of Benefits

The financial benefits of environment-related management accounting can arise in several forms, both tangible and intangible. The latter in particular are problematic to identify and measure. The most obvious benefits are any direct cost savings resulting from environment-related actions, as indicated by reductions in the absolute amounts of spending on a cost-item - for example, hazardous waste disposal costs - from one year to the next (see below for definitions of what environmental costs are). However this measure alone may be misleading, since despite real improvements in performance the absolute level of spending could still increase rather than decrease if either business volumes have increased more than proportionately, or the prices charged for the product or service have increased.

The latter is particularly likely with environment-related costs, and is in fact one of the main stimuli for companies to take action. For example, the landfill tax recently introduced in the UK means that waste disposal costs have increased by more than would otherwise have been justified by either general inflation or market-generated price changes. Similarly the costs per kilo of ozone-depleting substances such as CFCs have increased several-fold over recent years since the Montreal Protocol. The real value of the improvements in performance is therefore indicated best by a comparison of actual current spending against not previous years' spending in absolute terms, but against the hypothetical amount of what the cost would have been if that improvement had not taken place, but market prices and business volumes had continued to increase. This is a hypothetical figure and therefore less easy to calculate and justify than an actual figure taken from an accounting ledger, but a more realistic measure of real benefit. This is the basis adopted by Baxter International in its calculations of "cost avoidance" in preparing its Environmental Financial Statement (see Bennett and James' paper).

Benefits such as those arising from enhanced customer perceptions of the company, or improved staff morale, are also real but even more difficult to attempt to measure. In practice it is unlikely to be worthwhile to attempt to quantify the benefits, at least not in monetary form, though this should not mean that their existence is then overlooked. To avoid this, Baxter note at the foot of their EFS, without quantification, "Examples of Undetermined Savings" (and also, for transparency, "Examples of Undetermined Costs").

KEY INFORMATION FOR ENVIRONMENT-RELATED MANAGEMENT ACCOUNTING

This section discusses the existing information sources and systems which can provide inputs to environment-related management accounting, the extent to which they take environment into account (or conceal its importance) at present and possible ways in which they can be modified or supplemented to reflect environmental considerations in future.

Non-Financial Information

Data on flows of energy and materials through an organisation is usually collected in some form by operational process records, material resource planning systems, resource planning, emissions monitoring and other systems. It is a vital resource for environment-related management accounting, not least because the full costs of wasted materials (i.e. including their purchase price and the costs of processing them to the point where they become waste) are often the most significant environmental cost (see below). Except for a special industries such as chemicals and pharmaceuticals which have always been concerned with the yields and detailed characteristics of their processes, few organisations in the UK and USA appear to have a full picture of their energy and material flows - indeed, obtaining such a picture is usually the first step in successful waste minimisation programmes. There are as yet no equivalents (at least in the public domain) of the Germanic 'ecobalancing' approach practised by Kunert and other companies, which builds a picture of all energy and material flows on a periodic basis. One potential task for environment-related management accounting in the Anglo-Saxon world is therefore to apply the ideas and associated techniques in an American, British or other English-speaking country.

There are also many other useful sources of non-financial information. One example is product specifications with standard quantities of materials and labour, which are important in calculating product costs.

Financial Transactions and Reporting Information

Accounting in business (and non-business organisations) must meet the day-to-day operational needs of initiating and recording transactions and managing assets and liabilities such as, respectively, working capital and bank loans. Companies in all advanced economies are also legally obliged to ensure that regular financial reports are made available to shareholders to provide them with reassurance that their assets are being safeguarded and their interests are being met. This is centred on two core reports. The first is the income statement, which aggregates expenses and revenues throughout a given financial period (usually a year). The second is the balance sheet, which summarises a company's assets and liabilities at a particular point in time (usually at the end of the same financial period). These four basic categories of expenses, revenues, assets and liabilities are reflected in figure 1.

Expenses and revenues

The basic accounting systems within organisations (the bookkeeping systems and ledgers) will generally capture and collate expenses in terms of a combination of two parameters:-

- the type of resources being acquired and consumed: materials, labour, services, depreciation, etc.
- the functional area of the business in which the expenses are incurred: production, selling and distribution, general and administrative, etc.

These classifications reflect the sources of the data in the various sub-systems of a normal business accounting system. Labour costs will be available from payroll systems, materials costs from materials management systems which draw their data from invoices and bills of materials, the depreciation charge from a register of fixed assets, etc.

Reclassifying accounting data after its initial entry is sometimes impossible and almost always time-consuming and costly. Hence, the secret of success in all areas of management accounting - including that related to environmental issues - is to capture any information necessary for analysis (such as the purpose of expenses) - when the data is entered. However, modifying existing systems can also be costly. The lowest cost option is to build in environmental considerations when systems are being changed for other reasons, for example, because of a move to activity based costing (ABC - see below). A key task for environment-related management accounting is therefore ensuring that the needs of environmental management are considered when changes are being made. The opportunity is to obtain better quality data but almost equally important is avoiding a deterioration in the quality of existing data. In one company we researched a reengineering exercise resulted in previously separate entry categories for energy purchases - electricity, gas etc. – being collapsed into a single energy category. As a result, it has lost the ability to easily calculate its energy-related carbon dioxide emissions.

Assets

Accountants identify three broad categories of assets - fixed (or long-term) assets, current assets and goodwill (a particular type of long-term asset). Fixed assets are those with a useful life beyond a single accounting year and are (with some exceptions) stated in the balance sheet at their original historic cost, reduced by depreciation provided to date in respect of the portion of their useful life which, to date, has expired. The high cost and long life of assets such as pollution control equipment and landfill sites means that these can be significant fixed assets. Calculations of environmental costs often exclude depreciation but this is a real cost.

An alternative method of valuing fixed assets is at their replacement cost. This is of potential environmental significance because rising environmental standards often mean that the cost of building new environment-related facilities is much higher than those which are replaced (see below). This is the case with landfill at one chemical company we recently interviewed. The company has a long-standing site which is fully depreciated. Hence, only operating expenses are charged back to product and process cost centres. As the site has many years' life this can be practically justified but, at current rates of waste generation, a replacement landfill facility will have to be built at some point. This is likely to be very expensive and will therefore result in an immediate increase in recharged costs as depreciation is included in the figures. However the conventional method of basing these re-charges on historic costs means that managers who take decisions which affect the volume of wastes generated, through process control and product design, are not encouraged by the system to take into account also the opportunity cost which is indirectly incurred as landfill capacity is consumed.

The main current assets for most companies are cash balances, debtors (accounts receivable), and stocks and work in progress. Although environment has some tangential relevance to these - changes in environmental legislation could result in stocks becoming more difficult or impossible to sell - this is not a major area of concern.

Goodwill is an asset with whose treatment the accounting profession has been struggling - with only limited success - for some time. Conventional accounting practice recognises and includes goodwill in company balance sheets only when money is directly outlaid to acquire it, when one company is purchased by another. The goodwill then arising is the amount by which the purchase consideration exceeds the value of the tangible net assets acquired, and represents what the acquirer is prepared to pay for the present value of the amount by which the acquirer's future profits are expected to exceed a normal rate of return. However the true value of goodwill in any company should also include what it has built up within the business as a result of operating over time and building up a reputation amongst customers, even though this is not represented by any specific outlays and is therefore not captured by the accounting system. Several studies have suggested that environment is an important determinant of company reputation although the precise extent of this is difficult to quantify.

Liabilities

Liabilities can be distinguished by type into three broad categories: sources of finance, liabilities arising from normal operations, and provisions.

In most major corporations the raising of finance and the balancing of debt and equity is handled within the finance function by a treasury management function which is separate from the financial controlling activities of then allocating, managing and accounting for this finance within the business. Environmental performance is increasingly significant for treasury management since the extent of risks being borne by a company, including those which are environment-related, can affect access to and the cost of raising new capital. Several studies have shown that the shares of companies with good environmental records have out-performed the market average - thereby lowering the cost of raising equity - and, conversely, that those of companies which have experienced major environmental incidents have been depressed, making new equity more expensive (World Business Council for Sustainable Development, 1997). Kvaerner, for example, has paid slightly lower interest rates on loans because of its good environmental record and consequently greater creditworthiness (WBCSD, 1997). Some analysts and insurers are coming to see evidence of good environmental management by a company as indicative of the quality of its management generally.

Liabilities arising from normal operations include trade and most sundry creditors, corporation tax due, and tax collected but not yet paid over in connection with PAYE and VAT, etc. These may be affected by any events occurring within the business, including environment-related, but are unlikely to be particularly significantly affected by environmental management.

Provisions are amounts allocated to cover any likely (or certain) future liabilities or losses which have arisen but have not yet been settled (provisions included under “liabilities” will exclude any provisions in connection with the impairment in value of assets, such as arising from depreciation or the obsolescence of inventories, which will be reflected in the balance sheet as a reduction in the value of assets). There is considerable concern that significant liabilities could exist, in respect of (for example) remediation or future de-commissioning costs, which are frequently not fully provided for in company financial reports. Until now the emphasis has been on quantifying liabilities arising from past events but, whilst this remains important, Brent Spar and other developments have focused attention on potential future liabilities.

TECHNIQUES

The third tier of the pyramid in figure 1 identifies the main accounting techniques which are used to process the information arising from the financial and non-financial information systems for management’s benefit - performance measurement, operational budgeting and control, costing, pricing, cost projection, demand forecasting, investment appraisal and shareholder value analysis. All of these are actually or potentially relevant to environment. One important distinction is between those which are concerned with current data and those (broadly cost projection, demand forecasting, investment appraisal and shareholder value analysis) which are making projections into the future. Following sections discuss the environmental relevance of each of these techniques.

Performance Measurement

Performance measurement is a growing field in all areas of business. Traditional performance measurement in the UK and USA has focused on meeting financial targets, particularly at higher levels of management. However, over the last decade the quality movement and other drivers have focused attention on the importance of non-financial performance measures and schemes such as the European Quality Award or Robert Kaplan's 'balanced scorecard' now provide templates for this (Kaplan and Norton, 1996). These developments have - together with other factors such as regulatory requirements and demands from external stakeholders - led to the rapid development of environment-related performance measurement (Bennett and James, 1997; Epstein, 1996). As previously noted environment-related management accounting could, in principle, have an important role in this area - although one study found little evidence of this happening in practice (Bennett and James, 1997). Its main environmental implications in the immediate future are likely too be in ensuring that financial performance measures reflect environmental considerations - for example, by ensuring that environmental costs are identified and allocated to budgets.

Operational Budgeting and Control

The setting of budgets is an important means of implementing strategic objectives whilst tracking budgetary outcomes can be a valuable means of tracking how well objectives are being achieved. Budgeting is of relevance to environmental management for three main reasons. Firstly, environmental actions will require resources which need to be specified within budgets. Secondly, budgetary outcomes can be a useful means of checking whether environmental goals are being achieved - for example, over-budget expenditures on energy provide an early warning that energy targets are unlikely to be achieved. Finally, as has been previously noted, identifying and allocating environmental costs to specific budgets provides a powerful incentive for action to be taken.

Costing

Costing is the area of greatest activity within environment-related management accounting and, as we note below, most of the papers in this special issue address it. This section discusses four main issues associated with costing:

- cost definitions
- activity based costing
- quality costing
- product costing.

Cost Definitions

One preliminary question in this area is what constitutes environmental costs? In some countries this term is legally defined for tax and/or statistical purposes and is generally confined to expenditures on labour and equipment which are wholly intended to ameliorate an organisation's environmental impacts. In general, this has also been the approach of companies reporting this information in their financial or environmental reports.

However, for many companies this definition would exclude a substantial element - the full cost of waste. As well as any costs directly associated with disposal (e.g.

landfill charges and tax) this will include also the loss of all costs invested in the product up to the point of loss - the raw materials, and conversion costs incurred up to that point in the process. An expanded definition would therefore comprise:-

- expenditures whose main purpose is ameliorating environmental impacts, including:-
- expenditures on building, depreciating, operating and decommissioning equipment
- expenditures on labour and services related to amelioration of environmental impacts;
- any other expenditures whose main purpose is amelioration of environmental impacts; and also
- expenditures on purchasing, processing and disposing of materials, energy and water which are neither incorporated into nor are essential to produce final products and services.

However this definition also can be criticised as over-restrictive since it is still confined to defensive expenditures which neither add commercial value for the company nor offer the potential to improve future environmental performance. A positive case for business spending on environment is that it can - at least in part - represent an investment which will justify itself through future benefits, through either cost savings or enhanced revenues. Baxter's Environmental Financial Statement (see Bennett and James' paper) reports two separate categories of environmental cost: "Remediation and waste disposal costs", and "Costs of proactive program". The costs of the proactive program, in contrast to those of remediation and waste disposal, are incurred in the expectation that they will generate future benefits: for example, the time spent by staff in re-design of products and their packaging. The total of these costs can then be compared with the resulting benefits to provide an approximate cost-benefit evaluation. Our own, maximal, definition of environmental costs would therefore include the two elements listed above (amelioration, and full cost of waste), and also:-

- costs associated with actions taken to improve the future environmental performance of the business
- costs associated with environment-related actions taken with the intention of improving future business performance.

Activity Based Costing (ABC)

An expanded definition is important because traditional costing techniques have been based on specific direct cost categories such as labour and materials, plus a residual overhead - with the latter frequently either being allocated to products or processes on a more or less arbitrary basis, or written off as a period cost and therefore not tracked through to products or processes at all. In many companies, the main part of environment-related costs such as energy, water, waste disposal and the salaries of environmental staff are likely to be included in overheads (White et al., 1995). This means that, where products or processes have high environmental costs, the figures are hidden from decision-makers. This reduces the motivation to reduce the costs and can also create a bias against pollution prevention projects.

One potential solution to this problem is activity based costing (ABC). This tries to create more meaningful cost information by tracking costs to products and processes on the basis of the underlying 'drivers' which cause those costs to be created in the first place. The amount of cost lost in overheads is thereby greatly reduced. As a result, product prices can be set more accurately and significant cost drivers can be targeted for cost reduction measures. Where environment is a significant cost driver, it will be highlighted naturally by ABC activities. However, there is usually considerable scope for more proactive environmental concern, either by building a more detailed picture of environmental cost drivers and categories where these have already emerged as important or by highlighting them when this is not the case (Kreuze and Newell, 1994). Schaltegger's paper explores this issue in greater detail.

Quality Costing

Another - alternative or complementary - approach is quality costing. The rationale of quality costing is to highlight the costs of non-quality in order to develop motivation to reduce them and prioritise possible actions. Conventional quality costing distinguishes three types of costs

- failure - the costs of putting right or otherwise dealing with defects, whether as a result of internal failure or external failure as when they occur in use by customers
- monitoring - inspection and other costs to ensure that defects are eliminated or detected
- prevention - costs of avoiding defects.

The finding from cost-of-quality studies is frequently that in the long run the costs of prevention are far lower than those of monitoring and failure. However without the studies this might not be apparent, since failure costs include several which are intangible and/or further from the point in the operational process at which the loss in quality occurred.

A Dutch study which used this model to calculate the 'costs of non-environment' found that, on a narrow definition of environment as the costs of dealing with pollution and wastes, they amounted to around 2% of total operating costs (Diependaal and de Walle, 1994). To be valuable in the environmental field, failure costs probably needs to be defined more broadly so that it includes what might be called indirect failure costs or the 'costs of inefficiency', i.e. the costs of purchasing and processing materials and energy which end up as waste. Several studies have found that these costs of inefficiency outweigh other environmental costs, especially in Europe where the liability costs associated with accidents or contamination are less onerous than in the USA. The German textile producer Kunert, for example, has calculated that its costs of inefficiency amounted to around 10% of turnover.

Product Costing

Producers need accurate information about the cost make-up of their products in order to determine price and identify cost reduction opportunities. Users need data about the total costs of products they are buying in order to compare alternatives which have different proportions of acquisition and operating costs. Designers need both types of information in order to create products which have reasonable purchase and running costs. Environmental costs are important in all these cases and there can be detrimental consequences if they are not properly identified and allocated.

As several case studies demonstrate (Ditz, Ranganathan and Banks, 1995), it is not uncommon for a small number of products to generate a large proportion of emissions or wastes. If these costs are not allocated to individual products but treated as a general overhead, then clean products will appear to have higher costs than is actually the case while dirty products will appear to be cheaper to produce than they really are.

Life-cycle costing takes this further by seeking to identify all the costs incurred during the whole life of a particular product (or system). Environmental costs can be a significant element in the total cost of buying, using and disposing of a product. It can therefore be sensible to identify and calculate these at the time of purchase. Two particular areas which a number of organisations have started to examine are the costs of dealing with emissions or wastes from equipment operation or of disposing of products at the end of their lives.

Costing in this Issue

A majority of the papers in this edition focus on costing. Schaltegger provides further detailed discussion of the topic and provides examples of how costing decisions can influence environmental outcomes. Schroeder and Winter examine the process and content of an exercise to understand the full costs of a facility at Sulzer Hydro. Stevels outlines a model of end-of-life product costs developed by Philips and used as an input to their product design activities. Bartolomeo examines issues related to the costs of materials and wastage and of decommissioning end of life oil facilities in Italian chemicals and oil companies.

Burritt provides a more iconoclastic view. He challenges the traditional rationalist assumption that the principal purpose of management accounting is to provide accurate and relevant decision support information. He argues that no information is objective and is always more or less subtly shaped by the context and purpose of its creation. He therefore believes that the purpose of management accounting information, including when used in an environmental context, should be not to aim for accuracy for its own sake but (as in Japanese industry) to influence the behaviour of managers and others, for example by creating internal taxes to penalise poor environmental practices. These taxes would be set more on the basis of sustainable development needs than of actual costs.

Pricing

Pricing requires consideration of customers and competitors as well as costs, so accounting techniques are only one aspect. However adequate cost analysis is an essential part of pricing decisions, which may be distorted by any inaccuracies in costing systems.

Life-cycle costing provides the framework to consider costs not only within the organisation itself, but also along the product chain, by including as well as internal costs also costs incurred upstream (by suppliers) and downstream (by customers and consumers). This can help to identify opportunities where modest extra spending by the company may increase value for the customer disproportionately which can be reflected in an increased selling price and/or increased sales volume. As Bennett and James' paper demonstrates, Baxter International has generated substantial savings in materials costs for itself through packaging re-design. As well as this benefit, reducing the quantity of packaging which the final user has to dispose of is becoming an increasingly significant selling point in countries such as Germany with strict legislative controls.

Cost Projection

Projecting future costs is an important part of investment appraisal and is also valuable for other purposes. Environment can be an important determinant of these future costs. This is highly visible with new legislative or regulatory demands. However, forward-looking companies will also be considering the potential costs of possible future legislation or other environmental action. One indication that this may happen is when costs in one country are much lower than in others. Another is when there are large external damage costs created by environmental impacts which are not yet reflected in the company's internal financial calculations. As Epstein's paper, and other researchers (Tuppen, 1996), note companies making capital investment and other decisions with long-term financial consequences might be wise to at least consider the implications of these. Ontario Hydro is one of the few companies to have done so in practice.

Demand Forecasting

Environmental factors are already shaping many markets and will almost certainly influence more in future. This influence takes two forms - the volume of a product or a service which can be sold and the price it is sold at. Sales volumes of a number of products - for example, CFCs - have already been largely or completely curtailed by law as a result of environmental considerations and the likelihood is that more will be withdrawn from the market or 'sunsetted' in future. Customers may also discriminate against products with poor environmental performance, especially if better performing ones offer similar value. Sunsetting and other environmental developments also create opportunities for new products. Indeed, it may be that the revenue streams from future eco-efficient products - i.e. ones which offer greater customer value and better environmental performance - will have far greater impact than any of the other areas discussed in this chapter. However it is not usually possible to do more than guess at the amounts of potential future revenues from hypothetical new products, and consequently less attention has been paid to this area in the environmental accounting literature than to methods of cost analysis.

Investment Appraisal

Environmental factors can be significant in determining the ultimate returns from new investment. It is therefore important that they are identified and considered during the early stages of investment decision-making. This not only allows major problems to be avoided but also provides an opportunity for remedial action at a stage when the costs of doing so can be relatively low.

Many companies are currently bringing environment into capital budgeting by requiring qualitative assessments of impacts arising from major investments. This can be extended in two main ways. One is by widening the range of costs and benefits which are taken into account. A 1995 Tellus Institute survey of US companies, for example, found that over 60% of respondents are now considering the costs of emissions and waste monitoring, treatment and disposal in project evaluations (White, et. al., 1995).

The second is by adopting appraisal techniques to take account of the long-term benefits of environmental actions and/or the potential risks of investments with serious environmental impacts. This can be done by applying lower or higher discount rates to environmentally significant investments, or for long-life projects by extending the period for which future benefits are considered beyond the usual truncation point.

Epstein's paper discusses these issues in greater detail and suggests a three stage screening process to evaluate the environmental parameters of capital investments.

Shareholder Value Analysis

In recent years there has been an increase in interest in measuring shareholder value. This has been in part in recognition of the principle that in law (and so far as capital markets are concerned) corporations exist primarily for the benefit of equity investors, and in part as a correction for generally perceived deficiencies of conventional measures of accounting profitability as the main indicator of business performance.

The term is often used only loosely, but when used more exactly defines shareholder value as the present value of the company's future cash flows, discounted at an appropriate rate. As environment can affect all of the main parameters in this equation - future expenses, revenues and cost of capital - it is therefore an important element to be considered in any calculations.

OBJECTIVES: ENVIRONMENTAL VALUE ANALYSIS

The highest tier of our pyramid is concerned with what we term environmental value analysis - the relationship between an organisation's economic value added and its environmental impacts. This can be evaluated in two ways. The first is by developing relational measures. The output measure can take a variety of forms - for example, turnover or profits - but as value added is a more direct measure of the net economic contribution made by a company, it is widely considered to be the most appropriate. Calculations can then be made of value added per tonne of emission or unit of environmental impact or, alternatively, tonnes emitted or units of environmental impact per £ of value added. These give a crude measure of how efficiently organisations or, in aggregate, industries are using environmental resources.

However, knowing that an organisation is using resources efficiently says little about whether their use is sustainable. Sustainability implies limited 'eco-capacity', i.e. a finite availability of physical resources such as fossil fuels and biological materials and of environmental 'sinks' such as the atmosphere. The costs of exceeding this eco-capacity can, in principle, be calculated and then disaggregated to firm level via taxes - for example, a carbon tax - or other means. The relationship between these 'costs of unsustainability' and value added can therefore be a crude measure of an enterprise's sustainability.

Of course, in a world where all such costs are internalised through taxes and other measures sustainable value added will be the equivalent of economic value added but this is far from the case at present. Hence, approximations to sustainable added can be produced by taking estimates of damage costs. In the case of environmental damage costs, figures are available for many impacts although there is limited consensus about the best basis of calculation or their accuracy. In the case of social damage costs, few figures are available and this situation seems unlikely to change for the foreseeable future.

Only one organisation has so far made even a crude attempt to calculate its sustainable value added. This is the Dutch computer services company BSO Origin, who in its 1992 environmental report calculated its main environmental impacts and then converted these into financial amounts to represent the imputed costs of those impacts. The data for this was based on calculations of long-term costs of control in the Dutch National Environmental Protection Plan. This gives a net cost of each environmental impact individually, and of all their environmental impacts in aggregate, which can be compared with the value added as calculated through their conventional business accounting processes.

The methodology of this can easily be criticised, both for the bases on which costs per unit of impact are calculated, and on how far upstream and downstream costs should legitimately be included. At the present level of understanding of business (and other) impacts on the environment it is difficult to assess what meaning if any can be attributed to the values generated (BSO recognise this and claim only that their system indicates orders of magnitude rather than precise values). However the BSO exercise is best seen as a first experiment in devising a comprehensive system which recognise and quantifies all of the environmental impacts of a business, irrespective of the quality of current legislation and regulation in the country of operation.

CONCLUSIONS AND FUTURE TRENDS

Sustainability is about far more than economics just as business encompasses many other elements than income statements and balance sheets. Environment-related management accounting is just one component of introducing sustainable development and strengthening environmental management within business and needs to be supplemented by many other measures. However, as the preceding discussion and references demonstrate, it can make a contribution to both business success and sustainable development.

There is now a growing and rich theoretical and practical body of work about the topic. There is also a trend is towards integration of the work and practices being carried out within individual countries. US practice and research is becoming well known in Europe and practitioners and researchers in individual European countries are also interacting to a greater degree. One example of this is the European Union-financed Ecomac (ecological management accounting) project - and a related environmental accounting network - which is studying current practice in Germany, Italy, the Netherlands and UK.[4]

One recent study to which the present authors made a contribution (Tuppen (ed.), 1996) concluded that most actions being taken at present are mainly relatively simple ones such as identifying and allocating energy and waste disposal costs which either

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[4] Details of the research project and accounting network can be obtained from the co-ordinator, Teun Wolters of TNO, at Fax 00 31 555421458 E-mail teuwol@stb.tno.nl

did arise, or could well have arisen from, for non-environmental reasons.[5] However, it noted an emerging consensus that practical environment-related management accounting is closely related to the development of ABC, which is likely to be more widely adopted in coming years. The study also identified eight practical environment-related management accounting options which could be introduced by the report's sponsors, BT, and - by extension - other European compaanies.

One of these options involved calculating environmental externalities (an important issue in assessing the environmental costs and benefits of replacing transport with telecommunications). However the study also concluded that it is doubtful whether many organisations will develop methods in the foreseeable future to account formally for external costs.

An area of equal difficulty and importance is understanding the revenue implications of environmental actions. There are many who believe that opportunities for volume growth and/or higher pricing of eco-efficient products provides much greater opportunities than saving or avoiding expenses by waste minimisation or other measures. However, it is difficult to devise satisfactory techniques to generate quantitative data on this topic.

Although environment-related management accounting is primarily focused on supporting internal management the high degree of external attention to corporate environmental performance means that external stakeholders also have an interest in the topic. Anecdotal evidence suggests that this is often confined to wanting reassurance that a company is addressing the issues rather than seeking specific financial information. This appears to be partly because they place a higher priority on non-financial rather than financial information but also because they have little respect for figures on environmental expenditure which are based on non-standard definitions. There is a need for more work in this area to examine what environment-related management accounting can provide that would be of value to external stakeholders.

Nor is it only stakeholders who are interested in standardisation. This is also important for benchmarking and national statistical purposes. More work is needed to develop standard definitions of environmental costs - more than one may be needed to take account of the different purposes for which management accounting techniques can support environmental management.

Perhaps the most important - although as yet uncertain - trend will be the extent to which environment becomes a greater cost issue because of increased levies and taxes, introduction of more positive incentives for environmental performance or development of more stringent liability regimes in Europe and other regions. The current slow pace of discussion over carbon taxes or a contaminated land regime in Europe makes it easy to discount this trend, as most business is doing at present. However, it is difficult to see how the goals of sustainable development can be met without this. If and when it strengthens, then environment-related management accounting will be an area of major importance to business - and the concepts and techniques outlined in this issue and other publications on the topic an important strategic resource for both commercial success and sustainable development.

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[5] The report entitled Environmental Accounting in Industry: A Practical Review can be obtained, free of charge, from BT Environmental Affairs Unit, Procter House, 100/110 High Holborn, London WC1V 6LD Fax 00 44 (0)171 4055354 E-mail tuppenc@prc4wc.igw.bt.co.uk

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What Do You Think About...
Some Thoughts On Environmental Accounting

Giuseppe Sammarco and Matteo Bartolomeo

FEEM, Italy

INTRODUCTION

The term "environmental accounting" is a general term, which is widely used to describe a range of activities related to the systematic measurement and interpretation of physical, and monetary flows generated between the firm and the environment.

The definition is too general and wide, and causes different problems. First of all, when you ask someone (who is working in a company and is involved in any environmental accounting activity) what is environmental accounting or environmental cost you often have as many answer as people interviewed.

Moreover, if you ask people who is working in traditional accounting area if they collaborate to take into account environmental issues in a proper way, the answer is that environmental accounting is only an annoying and external relations matter.

Are these considerations due to a misleading concept of environmental accounts? Is there a lack of knowledge? Is it possible to solve this problem starting from a correct methodological approach which links together different accounting systems?

The idea of environmental cost is easy to understand, but it's really difficult to say exactly what is or not an environmental cost, which kind of environmental costs a company must collect, and finally if integration between ecological and traditional accounting makes sense.

This situation is unsatisfactory and may lead, in same cases, to the disclosure of different figures of environmental expenditure in different documents (the environmental report, the financial report or other internal report) because there is no integration between different accounting systems.

What to do? With this short note we try to discuss these problems and give a picture of the situation. In the first part we try to define a general framework which includes several notion of environmental accounts: the matrix of the environmental accounts.

In the second part we describe our interpretation on how companies use these accounts, and how companies are moving towards the integration of these different areas of environmental accounting.

This is only our opinion, which, we would like, could be a basis for more in depth discussion. We would very much appreciate your comments, directly here in Nagu, by fax (+39 2 52036946) or by e-mail (sammarco@feem.it bartolomeo@feem.it) or via letter (Fondazione ENI Enrico Mattei, Corso Magenta 63, 20123 Milano, Italy.

THE MATRIX OF ENVIRONMENTAL ACCOUNTS

Many people think to refer to the same thing when they discuss on environmental accounts, but often they are considering different subsets of the same general framework, depending on what they are going to do with these figures.

In our opinion, the best way to explain environmental accounts is not to define them by a general definition, but to analyse and organise all in a general framework. We have named this framework matrix of environmental accounts (see table 1). It is divided in two parts: monetary accounts and physical accounts. These accounts are both important because a strict relation links them together, as we will see later on.

Let's start from monetary accounts.

Matrix rows identify the scope of expenditure, that is:

1. Prevention, reduction, control of pollution and restoration costs (as defined in SERIEE methodology, which seems to be the European standard for this kind of costs)

2. Compensation cost: this is the cost sustained to compensate the negative effects on human health, property, income or quality of life etc. of environmental degradation caused by production activities

3. Other costs linked to environmental issues and not included. in previous items (e.g. penalties and fines for regulatory infractions)

Matrix columns identify the characteristic of the cost in term of identification and measurability. The first division is between internal and external environmental costs. Internal costs are environmental costs which business incur and for which is held accountable. External costs represent the value of the damage associated to environmental degradation caused by business current operations. Firms are not legally liable for these damages that cannot be compensated through the legal system.

Internal costs are then subdivided in

1. Incurred measurable costs, included in traditional cost accounting. The "only" problem is their identification among many other kind of costs, because traditional accounting is not environmental oriented.

2. Incurred estimated costs: these costs are originated by current company activities in a given accounting period, but expenditure will be done and will be recorded in a future not well determined accounting period. So the liability is certain, but not the monetary value and disbursement. Some companies estimate and account this kind of cost in the correct period (when rise liability) but many others firms ignore their existence up to the moment they have to pay for them (e.g. internal waste stock, restoration, decommissioning etc.).

3. Probable and estimated future costs. This kind of cost is not certain but probable. Their monetary evaluation is the expected value. These costs are normally termed

contingent costs and are not recorded in traditional accounting system. Sometimes they are estimated and disclosed in the notes on the accounts in the financial report.

External costs are linked to physical accounts and represent the monetary value of the damage associated to residual pollution, that is pollution that hasn't been eliminated or abated during the production process. These kinds of cost can be estimated in various ways that can be reconnected under two main approaches: cost caused and cost borne approach:

1. In the cost caused approach costs are associated with economic units actually causing an environmental deterioration by their own activities. The costs caused are determined by applying the maintenance cost concept, an estimation of costs necessary to prevent a deterioration of the natural environment

2. In the cost borne approach the analysis is related to who is bearing the repercussion of environmental degradation and how this burden should be evaluated. In this case the monetary estimation refer to the costs of the impacts of degraded nature on businesses and households. These costs may be valued partly according to market valuation partly according to contingent valuation methods.

Physical accounts have a high importance, because of their strict link with monetary accounts: they are the basis for monetary evaluation of external costs and represent the potential future internal environmental costs.

In fact, the origin of an internal environmental cost is always an external cost, or better, an internal cost is always originated by some kind of pollution accounted in physical accounts. The transformation, from external to internal cost, is due to a voluntary decision or to a more strict pollution regulation.

So, given a level of pollution (which can be valued in monetary terms as external costs) complying with new future regulation may transfer this kind of costs inside the firm.

The analysis of external costs significance, both in physical and monetary terms, is a very good exercise for a firm looking forward.

Turning to the use of environmental costs we can see that in the practice the type of environmental cost collected is dependent on its intended use. Companies' objectives in collecting this information are:

- to monitor more closely all costs in order to improve operational efficiency, investment decisions and product design

- to improve the quality of environmental reporting by incorporating environmental expenditures and pollutants emissions into environmental reports

Depending on what you are doing, normally different classes of environmental costs are collected.

The scope of the environmental report is to report periodically the company environmental management (activities, results and costs of environmental protection) to a wide external audience, and the main interest is in costs A (see the matrix of environmental accounts) and physical data F for the construction of environmental performance indicators, Sometime firms estimate also monetary values of external costs (El or E2).

Management accounting has mainly an internal function, to provide management with the financial information necessary to take decisions. In this case a wider range of costs are collected, that is all costs C and D. The interest in physical accounts can be really low.

Financial accounting reports on the financial status and performance of a company to decision-makers in the company and to customers, investors, lenders etc. Environmental accounting, in this context, generally refers to the practices of identifying and disclosing environmental liabilities in public accounts. Costs B and C are relevant for this purpose. Also costs D are relevant if, in the long term, they will be internalised.

So, depending on the document, different figures for environmental expenditure may be found. Sometimes all these figures are correct for the specific purpose they are collected for. The problem is that every figure represent only a part of the accounting matrix and don't cover the whole set of environmental costs. So, it's important that people working in this area know that the problem they are facing is more complex than it could seem and that the best approach is to integrate data collection in a wide accounting system (and perhaps based on the proposed matrix).

In the next paragraphs we propose our interpretation on company behaviour in environmental accounting and analyse the steps which lead, first of all, to an integration between internal ecological accounting (monetary accounts), external ecological accounting (monetary accounts) and environmental performance measurement (physical accounts), and, last but not least, between traditional accounting and ecological accounting.

ENVIRONMENTAL ACCOUNTS MATRIX	MONETARY ACCOUNTS			
	INTERNAL COSTS			EXTERNAL COSTS
	Incurred measurable costs conventional costs considered in traditional cost accounting	Incurred estimated costs not always recorded in traditional cost accounting	Probable and estimated future costs not recorded in traditional cost accounting	Alternative monetary evaluation approach
Prevention, reduction, control and remediation costs (included image and relationship costs)	**A** Environmental expenditures (SERIEE methodology)	**C** Hidden Costs. The cost is surely generated by current operations, but it will occur at not defined points in the future and the amount can be only estimated - compliance costs - remediation - decommissioning - waste disposal	**D** Contingent costs (the existence of cost, the period of payment and the amount are not sure and can be only estimated in probabilistic terms) - remediation and compensation for future accidental releases of contaminants - fines and penalties for future regulatory infractions	**E1** "Maintenance cost approach" costs which would have been necessary to prevent or to reduce negative impacts of economic activities on the environment and to meet given sustainability standards
Compensation expenditure	**B** Other environmental costs Penalties, fines, compensation to third parties for personal or property damages due to environmental accidents			**E2** "Cost borned approach" cost of the damage caused by pollution. The damage may be valued as the loss of production, income or quality of life resulting from the damage
Other costs connected to environmental matter				

F

PHYSICAL ACCOUNTS

Use of natural resources	Air emissions	Water pollutants	Soil and subsoil pollutants	Waste	Noise
Water Wood [illegible]	CO (ton) NOx (ton) SO2 (ton) PST (ton) COV (ton) [illegible] CFC (ton) Heavy metals (kg) CO2 (ton)	BOD (ton) COD (ton) SST (ton) Others	BOD (ton) COD (ton) SST (ton) Oil (ton)	Urban Toxic	Leq

FOUR STAGES IN ENVIRONMENTAL ACCOUNTING

Stage 0: Environmental compliance oriented accounting

At this stage environmental accounting is still in infancy and there is not any formal neither informal integration between traditional and ecological accounting. The corporate priority for environmental issues is represented by the compliance with legislation without regard for cost minimisation and for benefits in the market of eco-friendly products.

Accounting is precisely divided in two broad areas, the traditional accounting system and the ecological accounting. The lack of integration between the two areas is due to the compliance orientation and to the related separation of responsibilities.

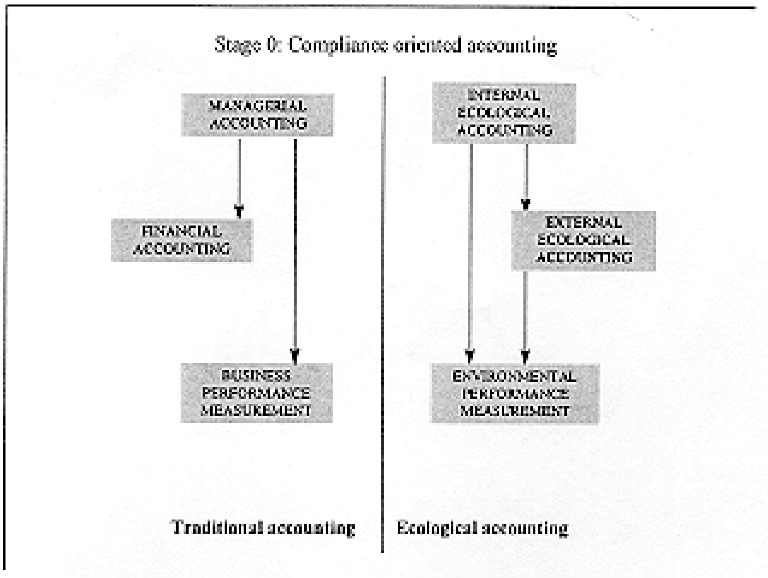
The traditional accounting system does not incorporate environmental concern. Financial accounting does not consider environment related contingent liabilities neither environmental expenditures. In the annual report of the company very little attention is paid to financial implications of environmental performance.

Similarly to the financial accounting, the managerial accounting system does not take into consideration environmental issues in a proper way. Environmental costs are not identified apart from those related to end-of-pipe measures; these costs are not allocated to their sources (processes or products) but are part of overheads and therefore allocated according to misleading cost drivers. In this situation the capital budgeting process does not take into account environment related cash flows (positive and negative) and fails as it is described in the previous paragraphs.

The company has a quite sophisticated internal ecological accounting system focused on physical units mainly related to emissions in different media. The information is collected at site level and aggregated at the corporate level by the environmental department without exchange with the controlling department.

The company publishes an environmental report and/or an environmental statement that contains indication on policies, programmes and quantitative information on production of wastes, air emissions and water discharges.

The environmental performance measurement is based on physical units without regard for the overall performance of the company. The management does not consider the current and potential influence that the environmental performance can have on the economic and financial performance of the company. Environmental performance is simply calculated to assess the compliance with regulation.



Stage 0, compliance oriented accounting

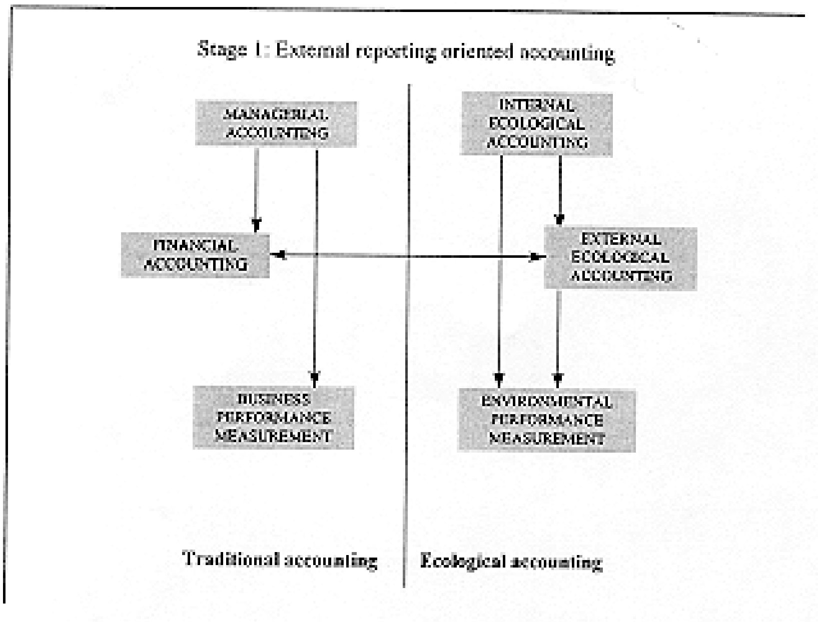
Stage 1: External reporting oriented accounting

This stage generally represents an evolution of stage 0 in particular for companies that face strong environmental pressures from external stakeholders. In addition to compliance with environmental regulation, the company intends to provide consistent, significant and comprehensive information to different stakeholders. The company also attempts to reduce the consumption of natural resources and the emissions to all media.

The accounting system is therefore tailored to achieve this objective; communication instruments used in the company are environmental reports and statements but also the annual report, which includes a section on environmental policies, programmes and main environmental data. Information on environmental expenditures and provisions for environmental liabilities are included in the annual report to accomplish stockholders, financial analysts, banks and insurers requests.

In this situation, environmental officers partly co-operate with the financial accounting department in the collection of useful information to be included both in the annual report and in the environment oriented external documentation systems. Such a co-operation is not yet extended to the controller which has an indirect perception of the link between environment and cost optimisation.

The imbalance in favour of external reporting does not help the company to develop cost-effective environmental programmes, to go beyond legislation and to consider environment as a part of the overall performance of the company. Nevertheless this stage is an important step in the recognition of the environment as a challenge for the core business and should allow the company to seek most effective accounting systems in the future.



Stage 1, external reporting oriented accounting

Stage2: Eco-efficiency oriented accounting

In a perspective of eco-efficiency the links between traditional accounting and ecological accounting are much more developed. Company objective is now eco-efficiency to be achieved through the minimisation of impact, through the minimisation of environment related cost and through the generation of indirect and direct economic benefits related to the environment. The company has also as a main goal the minimisation of environmental impact of products and has therefore introduced a life-cycle thinking approach and uses LCA or similar tools.

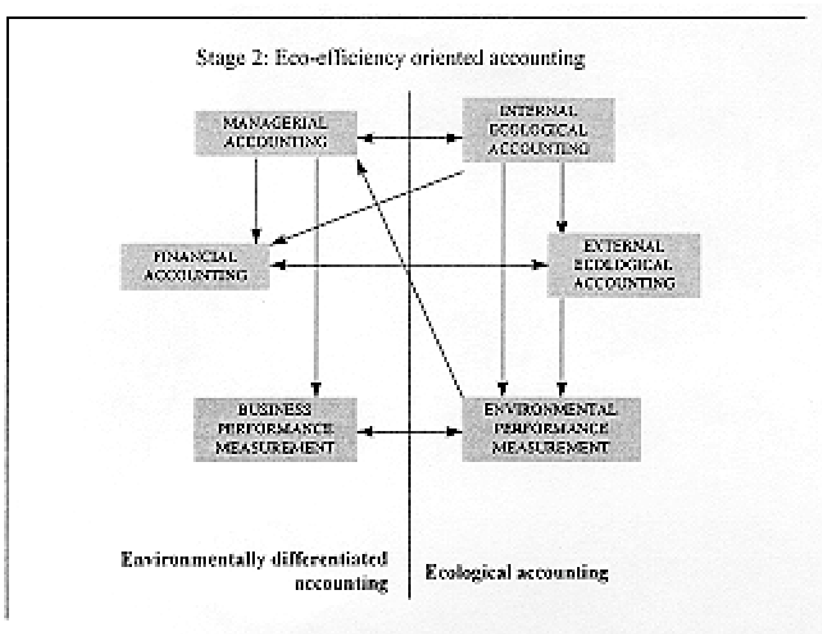
Environmental officers, controllers, financial accounting managers and public relation departments co-operate to improve the internal and external flows of information and to make it useful both to internal and external stakeholders.

Ecological accounting is tailored to measure emissions factors but also environmental impacts and it focuses not only on production process but it considers the environmental impacts related to the entire life-cycle of the product. The continuous flows of information between managerial accounting and internal ecological accounting ensures the identification of cost effective measures, the consideration of the environment in all company decisions and the inclusion of environmental performance objectives into general business objectives.

Traditional accounting has now become environmentally differentiated accountina which means that managerial accounting takes into proper consideration the environment in cost identification, cost allocation and capital budgeting process (similar to the TCA suggestions).

The financial accounting activity is carried out in close relation with external ecological reporting but also with internal ecological accounting systems. Annual reports and special reports for stock exchange authorities include a wide section on environmental issues including information on liabilities, expenditures but also on benefits of a proactive environmental management.

The connection between financial accounting and environmental issues is a consequence of the top management awareness that business performance is clearly influenced by environmental performance. The measurement of environmental performance, while still belonging to the ecological accounting area, is now in relation also with the managerial accounting.



Stage 2, eco-efficiency oriented accounting

Stage 3: Sustainability oriented accounting

At this last stage the overall objective of the company is the economic, environmental and social sustainability. Such an approach requires a unique accounting system which is characterised by:

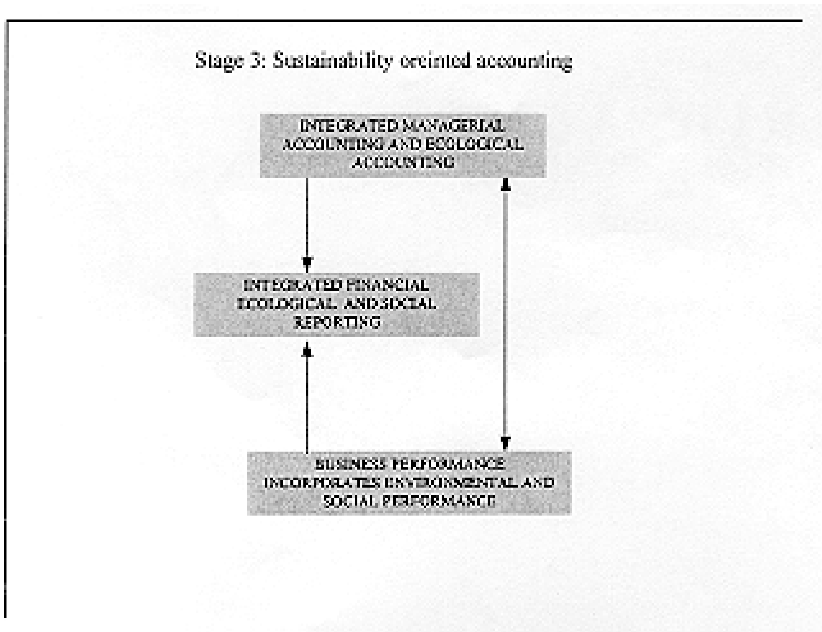
- an integrated managerial and ecological accounting system
- an integrated financial ecological and social reporting

- a business performance measurement system that includes economic, environmental and social values

The managerial and ecological accounting are part of a comprehensive accounting system which integrates economic and physical figures on the inputs and outputs, on the life cycle impacts. This system is assisted by social accounting and auditing procedures that generate information on stakeholder satisfaction and on social performance of the company.

Environmental reports are published on a bi-annual or tri-annual basis and most of the environmental information are condensed in the Company Value Report, incorporating a social, environmental and economic section. This annual report represents the official communication channel between the sustainable company and stakeholders and discloses company performance in terms of sustainability.

Company performance measurement system considers the social, economic and environmental value added of the company. The concept of sustainability is the basis for the calculation of company shareholder value, the measure used by financial analyst to judge the long ten-n profitability of the company.



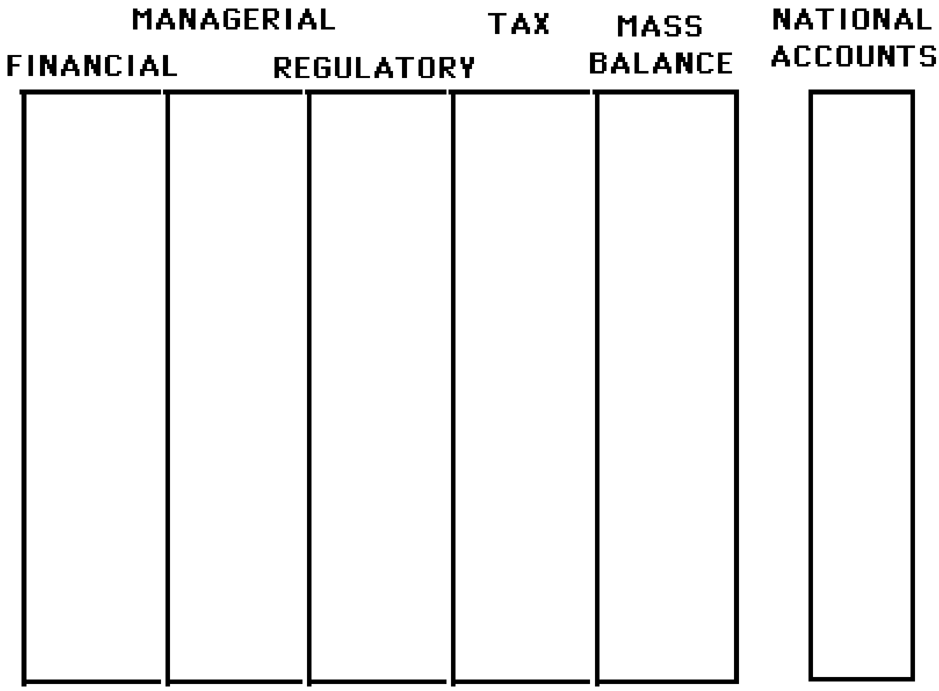
Stage 3, sustainability oriented accounting

What Are We Learning About
Total-cost Accounting & Full-cost Accounting ?

Christopher H. Stinson
The University of Texas at Austin, USA

WHAT IS ENVIRONMENTAL [OR EH&S] ACCOUNTING?

- Personal perspective... no claim for single, one-size-fits-all definition.
- Explicit company-level focus.

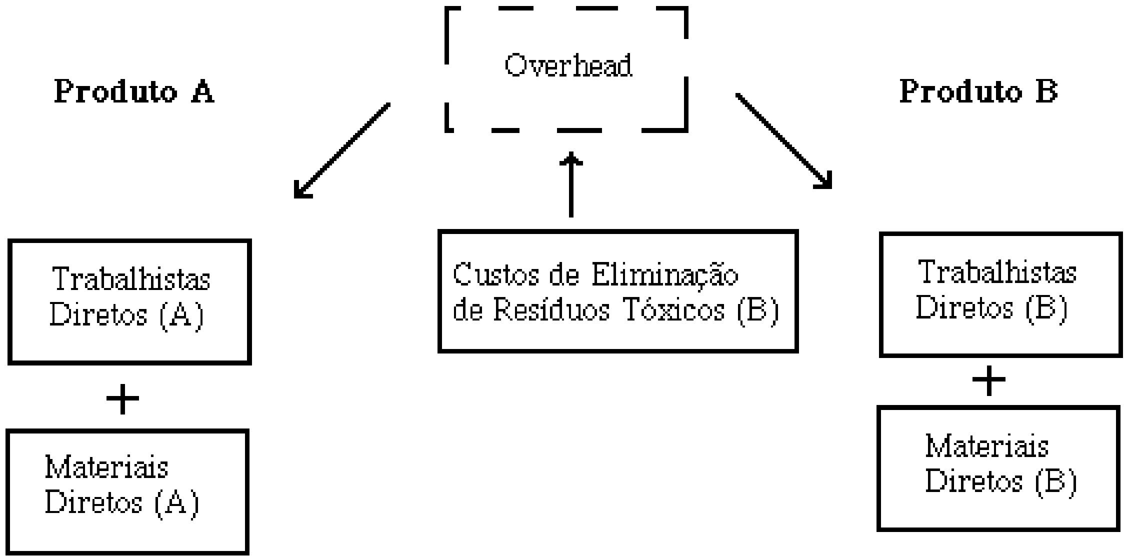


Each "area" of accounting has its own accounting "Standards"

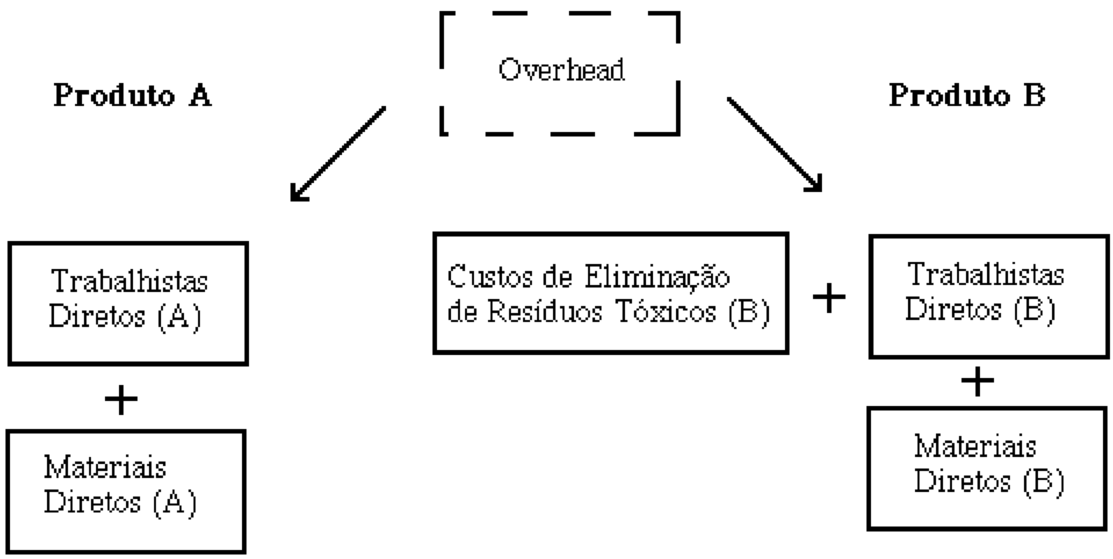
WHAT IS FULL-COST ACCOUNTING ?

- Recognizes economic world has changed faster than many accounting systems.

Old Cost Accounting in NewWorld of Brazilian Business



New Cost Accounting in New World of Brazilian Business



WHAT IS TOTAL-COST ACCOUNTING ?

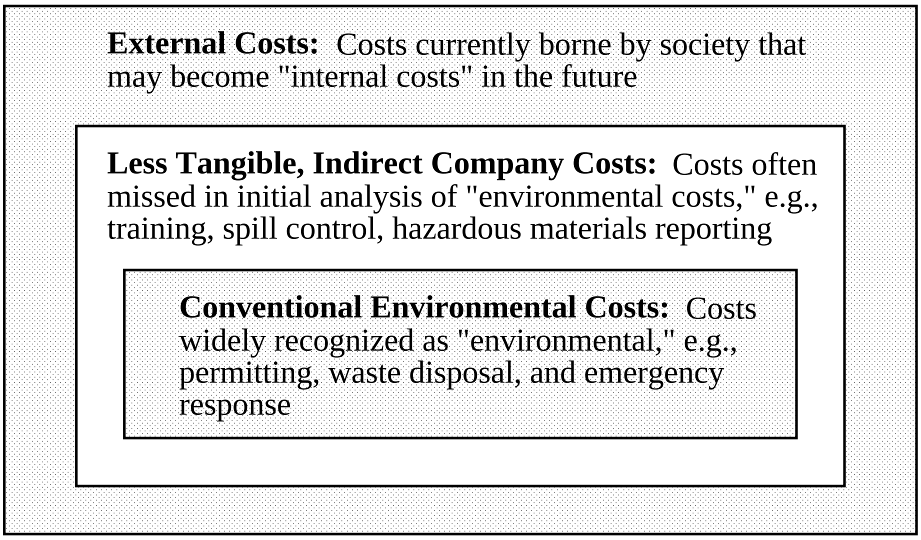


Figure from Pedersen and Stinson (1996) is based on many, earlier Tellus Institute publications to illustrate total-cost accounting from the perspective of a business.

Many conventional cost-accounting systems did not explicitly trace most environmental, health, and safety costs to the production activities that generated those costs (Todd 1995; Hamner and Stinson 1995).

As environmental, health, and safety costs became larger and as the information-system costs of tracking those costs became smaller firms started moving towards total-cost accounting. Total cost accounting considers Less Tangible costs plus Conventional costs (Tellus Institute).

Full-cost accounting also considers economics costs currently paid for by someone other than the responsible entity, i.e., external costs (Tellus Institute).

TYPICAL TIMELINE IN A COMPANYS UNDERSTANDING OF EH&S COSTS

1. Resistance to regulatory compliance requirements
2. Acceptance of compliance; identification of direct costs
3. Identification of indirect costs, e.g., analysis of cost-savings possible by reducing wastes.
   Incorporation of at least some total-cost accounting into management accounting system.
4. Prediction of future compliance costs; incorporation into strategic planning.
   Incorporation of at least some full-cost accounting into management accounting system.
5. Understanding and valuing net benefits from EH&S expenditures.

<u>Internal analysis:</u> Baxter International finds 3:1 to 5:1 payback on EH&S costs (e.g., Baxter's 1996 Environmental Annual Report, Bennett and James 1997).

<u>External analysis:</u> comparison of stock prices and debt interest across firms.

WHY ARE WE INTERESTED IN TOTAL-COST ACCOUNTING?

Who is interested?

- Society (and, as societys representatives, regulators and legislators).
- Stakeholders including local community, customers, employees, investors, suppliers.
- Most business managers... once they understand that anticipate that yesterday's large negative externalities have become large internal costs... but that their cost accounting system may still be treating these as small, internal costs (and, therefore, appropriate to include in overhead) or as yet external costs.

Why are we interested?

- Business managers... to understand cost of product production, to maximize profits (and personal compensation, if linked to profits), etc.
- Regulators (and society)... to understand whether legislative/regulatory attempts to force firms to internalize previously negative externalities are effective.
- To identify and eliminate negative economic externalities.

Who is interested?

- Society (and, as society's representatives, regulators and legislators).
- Stakeholders including local community, customers, employees, investors, suppliers.
- Strategic business managers who anticipate that today's negative externalities will be tomorrow's internal costs. In this sense, total-cost accounting is simply an extension of managerial accounting - attempting to understand costs of production activities.

What about positive externalities? Why focus on negative externalities?

- Firms, governments, and individuals have an economic incentive to invest in activities and commodities where some costs are paid for by outside parties, i.e., where negative economic externalities exist.
- This incentive creates economic costs for individuals who did not choose to incur those costs.
- Third-party investments in projects that generate positive externalities are not viewed as problem by unexpectedly-affected individuals. Also, investors have an incentive to structure projects so that positive externalities are minimized.
- Philosophical and policy issue... how do we encourage firms, governmental agencies, and individuals to invest in projects with positive externalities ?

HOW ARE TOTAL-COST AND FULL-COST ACCOUNTING DONE NOW?

- No single correct method exists. Correct method depends on question being asked.
- No universally accepted set of accounting principles currently exist.
  - Scope of review, e.g., from ultimate origin to ultimate disposal of all atoms passing through the economic control of the enterprise? ... limited to net inputs and outputs at the legal boundaries of the enterprise?
  - How are health, environmental, and other difficult-to-value costs valued?
- Total-cost accounting is a process-level, division-level, or company-wide activity.
- Full-cost accounting can be undertaken at level of...
  - individuals (Wackernagel and Rees, Our Ecological Footprint),
  - businesses (e.g., BSO/Origin),
  - governmental agencies (U.S. GAO 1997), NGOs and other non-profit organizations (World Bank 1996),
  - biogeographical regions, countries (Adriaanse 1993).
- Why undertaken?
  - Intellectual curiosity.
  - Public policy design and planning.
  - Strategic planning for businesses.
  - Customer concerns and demands.
- Examples of total-cost and full-cost accounting efforts include...

  - AT&T Columbus Works - materials tracking shows high rate of loss of hazardous chemical, identifies currently unpriced business risk.

  - United Defense LP howitzer project for U.S. Army: total-cost analysis from perspective of customer once product is purchased.

  - BSO/Origin: full-cost accounting of total resource use by company.

  - Electric cars: full-cost accounting from perspective of society -- are net emissions lower?

  - Styrofoam versus paper cups from perspective of society -- are net energy demands and releases of toxic substances lower for paper cups?

  - Energy-efficient florescent light-bulbs -- analysis on packaging from perspective of consumer -- higher cost product at point of sale/purchase versus lower overall life-time cost to consumer.

DO TOTAL-COST AND FULL-COST ACCOUNTING MATTER ?

- Does full-cost accounting matter to consumer?

  Probably only indirectly... facilitates more-competitive product-pricing.

- Does total-cost accounting matter to consumers ?

  Although many consumers say yes in surveys, purchasing behavior often shows no unless price difference between products is small.

- Do full-cost and total-cost accounting matter to other stakeholders ?

  Yes, especially when internalized and/or externalized EH&S costs seem high.

  Anecdotal evidence (below) suggests yeÓ, especially when internalized and/or externalized EH&S costs seem high... and this perception is affected by the amount of publicity a company receives).

  Example: Intel and Motorola's negative experiences with proposed chip-manufacturing facilities in two U.S. communities.

  Example: Exxon's negative experience with consumers following Valdez oil spill in Prince William Sound, Alaska.

  Example: Shell's negative experience following announcement of approved plan to sink Brent Spar drilling rig in deep ocean.

  Example: High correlation between a firm's reputation for environmental responsibility and Fortune's ranking of U.S. managers Most Admired Companies.

- Do costs considered under full-cost and/or total-cost accounting matter to investors ?

  A. Any capital-market response presumably involves an assessment of the net-present value of the current risks associated with environmental performance.

  B. How can these costs and benefits be measured?

     1. Within-industry comparison of EH&S budget as percentage of sales, net income, total assets, etc. Although this is a commonly-used approach, it doesn't tell managers whether additional expenditures (even if higher than the industry average) would generate greater savings than costs.

     2. Within-firm. Compare prior- and current-period expenditures to estimates of cost savings. (An outstanding example of this approach is illustrated in Baxter's annual Environmental Report; Baxter estimates they get a 3:1 or even 5:1 payback on EH&S expenditures).

     3. Capital market valuation of publicly-traded firms as a function (in part) of publicly-available information about EH&S events and expenditures. This is the method most frequently used by academic researchers.

     4. Across-firm comparison of company value as a function of privately-available information. Requires cooperation of (relatively small) sample of firms.

C. Several studies have examined the correlation between stock-price levels (or price changes) and Òenvironmental performanceÓ, but to date none of these studies have explicitly separated internalized (total-cost) versus externalized (full-cost) effects on equity prices.

D. Blacconiere and Patton (1994) and Blacconiere and Northcut (1997) find a small, but measurable, immediate effect on stock price in the U.S. when legislation is approved that will internalize currently-externalized costs.

   1. Blacconiere and Patton (1994) look at stock price changes in the chemical industry immediately after the Union Carbide plant explosion in Bhopal, India. All chemical industry firms experienced a drop in stock price... probably in anticipation of stricter regulations for this industry. However, firms that had voluntarily disclosed a lot of information about their environmental performance had a smaller drop in stock price than firms that voluntarily revealed relatively little. (Presumably, the level of voluntary disclosure correlates with managementÕs attention to environmental risks and performance).

   2. Blacconiere and Northcut (1997) find a similar result for U.S. firms in response to Congressional proposals for Superfund legislation.

E. Announcements of environmental awards were associated with a three-day cumulative abnormal return of 0.6% - 0.8% (Klassen and McLaughlin 1996).

F. Johnson, Magnan, and Stinson (1997) examine whether stock prices and debt interest correlates the Òenvironmental performanceÓ from 1988-1994 of 275 of the firms included in the ÒStandard & PoorÕs 500Ó index.

   1. Equity prices are affected by...

      a) Hazardous waste cleanup responsibility.

      b) Legal releases of toxic chemicals.

      c) Penalties assessed for EH&S violations.

   2. Possibly surprisingly to some managers, the equity-valuation effect of remediation expenditures (negative effect on stock price) differ from those of abatement and prevention expenditures (positive effect on stock price).

   3. Interest rates on corporate debt (i.e., a measure of bankruptcy risk) are significantly associated only with CERCLA (Superfund) liabilities.

G. study by ICF Kaiser International Inc.'s Consulting Group.

   1. Kaiser examined more than 300 large US public companies.

   2. Acting to improve corporate environmental practices can increase public companies' shareholder wealth by up to 5%.

   3. Three factors especially contribute to sound environmental management: links with fundamental corporate activities, setting high goals, and strategically communicating green practices and progress to "critical" audiences.

4. Copies of this study are available on ICF Kaiser's home page at http://www.icfkaiser.com.

H. Duke University study on investment funds.

1. Richard Clough (Duke University) has just completed a study on the investment return from portfolios invested in the stock of "environmentally responsible" companies.
2. These portfolios generally return one to three more percentage points annually than the holdings of "irresponsible" companies. Over five years, the green portfolio monitored in the study yielded a 17% return, compared to the 15% return of the portfolio for companies within the Standard & Poor 500 Index (InvestorÕs Business Daily 27 May 1997).
3. Clough's measures of environmental performance included the firms' total amount of releases, their number of reported spills, and the amounts of penalties they paid for violations of nine environmental statutes.

I. Even a corporation's reputation with other corporate managers is correlated with the firm's environmental performance.

1. Nine of the 10 companies "most admired" for environmental responsibility rank in the top 6% in overall reputation, according to Fortune's (3 March 1997) annual ranking of "America's Most Admired Companies" according to a recent Green Business Letter (April 1997)
2. Similarly, the ten companies rated the worst at "responsibility to the community and the environment" ranked among the bottom 11% in overall reputation.
3. The top scorers for environmental responsibility were Coca- Cola, furniture maker Herman Miller and Corning. The lowest were Standard Commercial, Archer Daniels Midland and Amerco.

- Should total-cost accounting matter to economically rational business managers ?

A. Absolutely yes.

B. Allows more precise understanding of firm-level costs of current practices.

- Should full-cost accounting matter to economically rational business managers ?

A. Absolutely yes.

B. Debt and equity market investors act as if they modify their investment decisions accordingly.

C. Provides important opportunity for strategic planning, i.e., today's external cost is likely to be tomorrow's newly-regulated and internalized cost (Pedersen and Stinson 1996, Pedersen and Stinson 1997). For example, there are many proposals to tax currently free emissions of carbon dioxide because of societal concerns about global warming (e.g., Hamond et al. 1997).

D. Several trade associations are actively developing tools for Design for Environment (DFE), Life Cycle Analysis (LCA), etc. (e.g., MCC 1996).

ACCOUNTING POLICY ISSUES: HOW *SHOULD* FIRMS DO TOTAL- AND FULL-COST ACCOUNTING ?

- How can negative externalities best be discovered, measured, and (if appropriate) made to disappear?
  - (Of course, this raises Coase's questions: Why hasn't this been done already? What property-rights ambiguities or economic frictions hinder this?).
- Possible approaches include...
  - Voluntary disclosure using internally-generated rules.
    - Advantage: Simple to implement.
    - Disadvantage: May create first-mover cost; difficult to compare reports.
  - Mandatory public reports using internally-generated rules (Cf. mandatory pollution-prevention plans in some states/countries).
    - Advantage: avoids costly rule-making process.
    - Disadvantage: no change required in short-term.
  - Mandatory public reports using externally-generated rules.
    - Advantage: all entities are using same rules to estimate total costs.
    - Disadvantage: rule-making process is cumbersome, time-consuming, and expensive (and this is exacerbated for international guidelines).
  - Governmental identification/review of high-cost externalities followed by mandatory reimbursement of net costs to society.
    - Advantage: Doesn't require all firms to account broadly for full-costs.
    - Disadvantage: Costs of reimbursement distribution may be high; programs originally designed to charge for external costs can be captured by legislatures and converted into revenue-raising programs with little relationship to their original environmental purpose (Fullerton 1993, 1996; Stinson 1994).
- Many international, national, and independent standards relevant to discussions of total- and full-cost accounting already exist or are being developing. Examples include...
  - ASTM Standard PS 14-95 defines define[s] life cycle costing... for pollution prevention programs, integrated resource planning, and pollution prevention activities for non-construction industries.
  - Sustainable fisheries -- Marine Stewardship Council and World Wide Fund for Nature.
  - Certification of forest products -- Forest Stewardship Council accredits certifiers of forest products (currently 5 certification bodies have been accredited as adhering to FSC's principles and criteria).

- EU Eco-labeling criteria -- EU currently requires verification by an independent, ecolabeling body, but US firms have proposed an alternative self-declaration scheme (i.e., firm believes it meets EU eco-labeling criteria).
- U.S. EPA Energy Star program -- self-declaration program for which participating firms sign agreement with EPA, agree to meet EPA's standards, and agree that EPA can conduct verification tests.
- Proposals for labeling of Genetically-Modified Organisms (and food products) are circulating in EU, Australia, New Zealand, and Japan.
- Green Seal (http://www.interchg.ubc.ca/ecolabel/gen.html) and other private ecolabeling programs exist.
- U.S. Federal Trade Commission has Guides for the Use of Environmental Marketing Claims that include guidelines on claiming that products have general environmental benefits, are degradable, are recycled, are ozone-safe, are compostable, etc.

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ENVIRONMENTAL ACCOUNTING AS A DECISION SUPPORT TOOL

Full Cost Accounting as a Tool for Decision-making at Ontario Hydro

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Environmental Decision Making Tools in ICI - Use of Life Cycle Assessment and Total Cost Assessment

Dr David G Heath, ICI Engineering Technology, UK

Environmental Risk Management at Italiana Petroli SpA: An Economic Evaluation

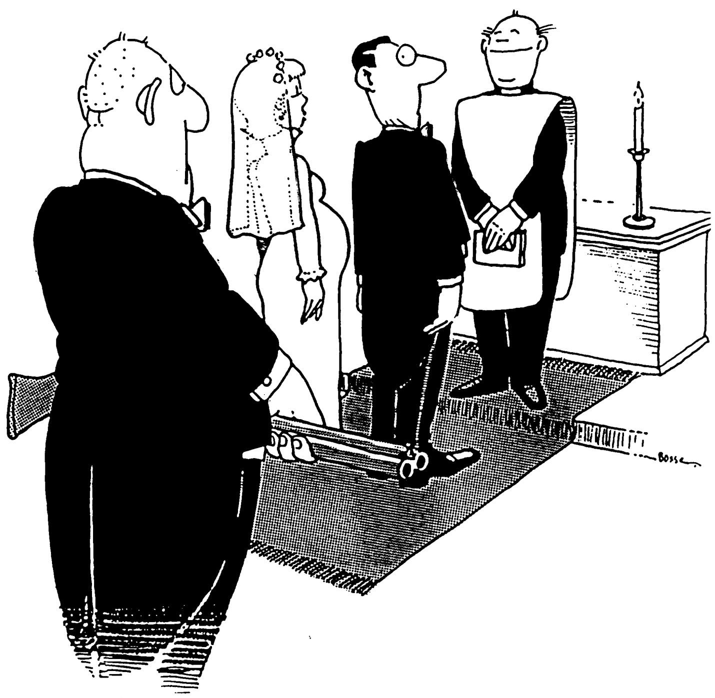
Giorgio Vicini, Fondazione Eni Enrico Mattei, Italy

Removing Emotion from the Environment – A Multi-attribute Stakeholder Wide Approach to Resolving Conflicts in Company Decision Making

Graham Earl, Surrey Centre for Environmental Strategy, University of Surrey, UK

Financial Aspects on Environmental Issues

Doris Rudén, Volvo Car Corporation, Sweden



Decision-making under pressure

Full Cost Accounting as a Tool for Decision-making at Ontario Hydro

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ABSTRACT

The paper describes Ontario Hydro’s approach to full cost accounting (FCA) and its experience in using it as a tool for integrating environmental considerations into its business decisions. It also identifies barriers and opportunities for implementing the concept and illustrates, through examples, ways in which FCA has helped in better understanding the potential environmental costs and liabilities associated with Ontario Hydro’s activities and in reducing the impact and cost of those activities now and in the future.

INTRODUCTION

Ontario Hydro, serving the Province of Ontario, Canada, is one of the largest electric utilities in North America in terms of installed generating capacity. Total in-service system capacity is approximately 29,000 megawatts, transmitted across 29,000 kilometers of transmission lines and 109,000 kilometers of distribution lines. Its customers include 306 municipal electric utilities, which in turn, serve more than 2,800,000 customers, and Ontario Hydro Retail which serves almost 1,000,000 retail customers, including 103 large industrial customers.

Ontario Hydro owns and operates 69 hydroelectric stations, 5 nuclear stations and 6 fossil fueled stations. Ontario Hydro’s electricity generation in 1996 was 55% nuclear, 26% hydroelectric, 13% fossil and 6% other. Total revenue in 1996 was $8.9 billion on an asset base of $40 billion. The company currently employes approximately 21,000 people.

In 1993, the Task Force on Sustainable Energy Development (SED), commissioned by the then Chairman Maurice Strong, identified full cost accounting (FCA) as a key component of Ontario Hydro’s strategy for achieving SED. In April 1995, Ontario Hydro’s Board of Directors approved SED Policy and Principles which provided guidelines for implementing SED in the organization. Two of those guiding principles related to a need for developing a framework for using full cost accounting in decision-making:

- Ontario Hydro will integrate environmental and social factors into its planning, decision-making, and business practices
- Ontario Hydro will practice eco-efficiency, that is continuously add value to products and services, while constantly reducing energy use, material use, pollution and waste

This paper will focus on Ontario Hydro's approach to full cost accounting (FCA) and its experience in using it as a tool for integrating environmental considerations into its business decision-making processes. It also identifies barriers and opportunities for implementing the concept and illustrates through examples, ways in which FCA has helped in better understanding potential environmental costs and liabilities associated with Ontario Hydro's activities and in reducing the impact and cost of those activities now and in the future.

FULL COST ACCOUNTING AND SUSTAINABLE DEVELOPMENT

Full cost accounting essentially entails collecting and considering all costs associated with a certain activity, process or product (through out its entire life cycle) in decision-making.

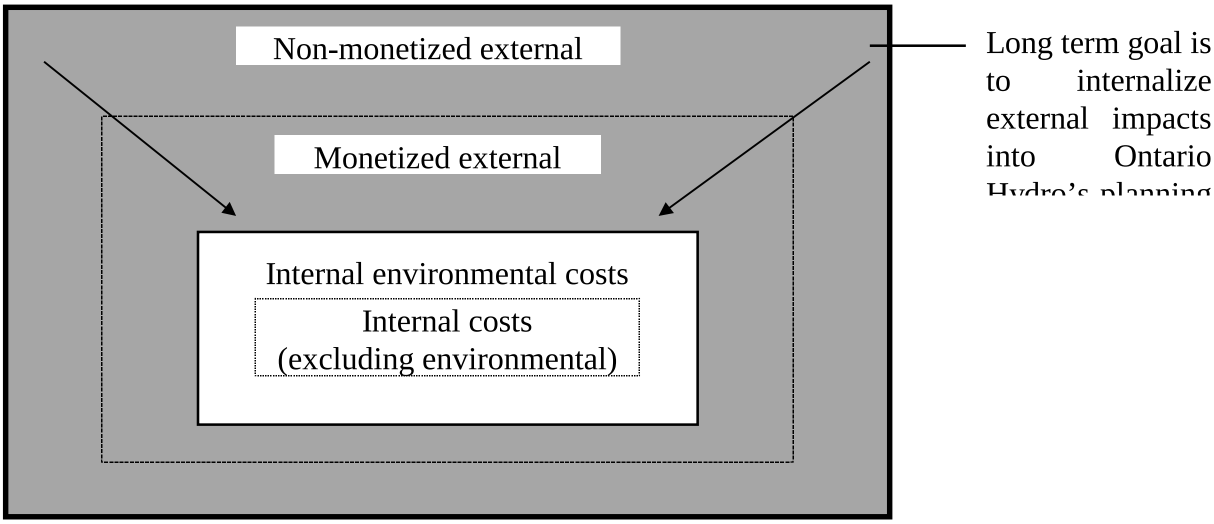
There are numerous definitions of FCA and it is therefore important to define what FCA means to Ontario Hydro. At Ontario Hydro, FCA is defined as a means by which environmental considerations can be integrated into business decisions to:

- better understand and allocate its internal environmental costs;
- better define, quantify and, where possible, monetize the external environmental impacts of
- its activities; and
- integrate environmental impact and cost information (qualitative, quantitative and/or
- monetized) into planning and decision-making.

Ontario Hydro's approach to FCA has been focused from the start on influencing the decision- making processes at various levels in the organization, rather than using it as a cost accounting or reporting tool. Therefore, FCA has been promoted within the organization as a tool for factoring **internal** and **external** environmental costs into the decision-making process, in addition to the financial evaluation, socio-economic analysis, and risk assessment practices that take into account other factors like price, reliability, customer service, financial soundness, uncertainty and risk. Effective integration of economic, environmental and social factors in decision-making would result in:

- cost savings through waste reduction and pollution prevention initiatives,
- early identification and avoidance of future environmental costs and liabilities,
- improved environmental performance and competitiveness,
- transition towards a more sustainable energy future, and
- development of new "green" products and business opportunities.

Figure 1 below illustrates the concept of full cost accounting in more detail.



INTERNAL ENVIRONMENTAL COSTS

The inner core, labeled as internal costs, are the utility's cost of doing business and are often referred to as private costs. These include traditional business costs such as, material, labor, fuel and depreciation. These may also include some internal environmental costs such as, costs associated with meeting environmental regulations or corporate environmental standards (e.g., operating, maintenance and depreciation cost of emissions control equipment, premium paid for use of low sulfur coal as fuel, and on purchase of other "environmentally friendly" products). There are other less tangible (or hidden or indirect) costs such as: costs of contingent liability or production loss from station deratings due to exceedance of regulatory limits, that should also be included in this category. These costs are often not identified, allocated or reported separately within the traditional accounting systems. By ignoring these costs, though, a business unit may fail to account for the true costs of its products and services and thus may make inappropriate business decisions.

Ontario Hydro's approach to FCA differs from other approaches, in that, it includes environmental externalities (societal costs) in its assessments and hence deserve more explanation.

EXTERNAL ENVIRONMENTAL COSTS (EXTERNALITIES)

External impacts (externalities) are the impacts on human health and the environment (natural and socio-economic) resulting from the production or use of a product/service, which are not reflected in its cost or price. An external cost (benefit) represents the monetized value of an externality. An externality exists when the following two conditions are met:

- an activity by one agent causes a loss/gain of welfare to another agent, and
- the loss of welfare is uncompensated. (Pearce and Turner, 1990)

An example of an externality would be human health effects associated with air emissions from fossil-fired electricity generation stations. An example of an externality which has been internalized would be compensation to a farmer for crop damages that could result from ozone.

It is important to note that what Ontario Hydro is trying to incorporate into the decision-making process are the "residual" impacts, or in other words, the environmental and social impacts which remain after all regulations have been met and mitigation and compensation have been undertaken. However, even after Ontario Hydro has complied with all the environmental regulations to control air emissions from its generating stations, there are still residual air emissions that can potentially cause damages to the environment and human health. Ignoring these impacts and costs underestimates the environmental impacts of activities and the resulting costs to society, and may result in inappropriate resource allocation decisions being made. Ontario Hydro believes that explicit consideration of these impacts and costs in decision-making will lead to more sustainable decisions, improved environmental quality, and lower societal costs.

Ontario Hydro has used the Damage Function approach to estimating the externalities associated with its activities, rather than the Cost of Control approach. The Damage Function approach considers:

- site-specific environmental and health data;
- how emissions/effluents are transported, dispersed, or chemically transformed using
- environmental modeling techniques;
- how receptors (i.e., people, buildings, fish, forests) are affected by these emissions/effluents; and
- the monetary value of these physical impacts.

Ontario Hydro has developed preliminary external cost estimates for operating its fossil stations, and for fuel extraction through to decommissioning for its nuclear generating stations. In addition, it has assessed the externalities associated with the hydroelectric stations and other renewable energy technologies like wind turbines, solar, and biomass located in Ontario. In situations where the external impacts cannot be monetized qualitative assessments have been done.

APPLICATIONS OF FCA

Use of FCA in Investment Decisions

All investment proposals that require senior management approval go through a Business Case Analysis (BCA) process. One of the components of the BCA is a discussion of the "SED Implications" of the proposal in light of the SED Decision Criteria. The Decision Criteria is a form of SED screen that is consistent with Ontario Hydro's FCA approach, and focuses on five key elements of an investment decision:

- maximizing resource use and energy efficiency;
- reducing environmental damage/impacts;
- avoiding/improving social impacts;
- increasing the use of renewable technologies; and
- identifying financial gains attributable to SD initiatives.

The analysis of the environmental impacts of the preferred investment option, and the alternatives should consider:

- full life-cycle, where possible, but at a minimum, must consider impacts associated with the design, construction/production, operation/use, decommissioning, and disposal;
- expected damage to ecosystems, communities, and human health, and not be based on the ability to meet existing or proposed environmental regulations;
- identification and evaluation of the potential positive and negative environmental impacts of the alternatives, including impacts which are common among the alternatives;
- quantification and monetization of the potential impacts, where possible, but as a minimum requirement, a qualitative assessment of the impacts; and
- trade-offs which were made in selecting the preferred alternative.

The role of staff specialists reviewing the BCA is to provide advice to the decision-makers (generally the President and CEO) based on an independent review of the SED implications of the business case. Since September 1994 when the SED Decision Criteria were implemented, over 20 BCAs have been reviewed. A majority of these addressed the criteria appropriately and were recommended for senior management approval. In some cases, the SED implications analysis proved valuable in identifying alternatives and developing win-win solutions. The analysis also exposed financial staff, who typically prepare the BCAs, to sustainable development issues and helped fulfill the "systematic reporting" element of environmental due diligence.

In one particular case, a proposed investment decision for a $24 million transmission line refurbishment program, the SED implications were:

- 20% reduction in energy loss in transmission lines through the use of energy efficiency conductors;
- $0.5 million annual increase in revenues through the re-use and re-cycling of removed line components;
- initiation of a program to improve the biodiversity of rights-of-way by restoring and replacing natural habitats; and
- provision of employment and economic benefits to local communities.

This investment decision was approved and the program is now operational.

FCA in Corporate Integrated Resource Planning

The Corporate Integrated Resource Planning (CIRP) process was initiated in the summer of 1994 and was completed the following year. The purpose of the CIRP was to provide strategic advice to the President and CEO on resource allocation decisions for the 1996 business planning cycle. A range of demand-side management and generation supply options were combined into seven plans and evaluated on the basis of their ability to fulfill the following objectives:

- provide competitively-priced energy services valued by customers;
- improve environmental performance and make more efficient use of resources;
- enhance social and economic benefits in Ontario; and

- enhance the financial, operational and human resource viability of Ontario Hydro.

These objectives were used to develop the criteria by which the plans were assessed and evaluated. One of the assessments was an environmental assessment. The environmental assessment was scoped to include the biophysical environment only; impacts on human health and the social environment were considered in separate assessments. The primary criterion established for the environmental assessment was to minimize damages to the environment. The measures used were:

- incremental land use (ha);
- crop damage ($) resulting from ground-level ozone;
- damage to exterior of buildings ($) due to acid gas and particulate matter;
- acidic deposition (mg/sq. m.) on sensitive watersheds;
- waste generated (Gg by type of waste);
- water flow modifications due to new hydroelectric developments (water flow ratio);
- impacts of once-through cooling on littoral zones (index based on number, flow, capacity, and mode of cooling water system);
- greenhouse gas (GHG) emissions (Tg and Tg/TWh);
- radioactive waste in storage (Mg); and
- consumption of non-renewable resources (i.e., coal, uranium, gas, limestone) (Mg).

The environmental assessment for the CIRP represented an advancement from such assessments Ontario Hydro has performed in the past, in two areas. First, the assessment was performed on an environmental damage basis, which was consistent with the FCA Corporate Guideline to use the damage function approach for monetization of environmental externalities. Second, some environmental damages were mapped on a watershed basis and compared to indicators of ecosystem vulnerability. Multi-criteria Analysis (MCA) was used to assist in making trade-offs among the eleven environmental measures in order to select the most important environmental indicators for evaluating the CIRP plans. The maps of the indicators of ecosystem vulnerability were used together with the maps of environmental damages to assist with this process.

FCA for Eco-efficiency Improvement

In late 1996, an eco-efficiency study was undertaken at one of Ontario Hydro’s fossil generating station. Eco-efficiency is defined as a process of continuously adding value to the product (electricity generation) while constantly reducing resource use and generation of waste throughout its life-cycle. In order to accomplish eco-efficiency improvements, it is essential to know the resource input (material, fuel, water, energy) and output (energy, by-products, waste, and releases to the environment) from the station, and their associated costs. This requires taking inventory of all environmental activities and operating equipment required to meet, or exceed, environmental regulations and corporate standards, during station operations.

Total internal environmental costs were estimated to be approximately 21% of the station’s total operating and fuel costs. Emissions monitoring and control, collection and disposal of ash, coal pile management, environmental regulatory reporting and support were identified as major contributors to these costs. Most of these costs were either fixed or were required to run the station well within regulatory limits. However, some eco-efficiency opportunities were identified in the area of heat rate optimization, energy efficiency, by-product sales, equipment service life extension, and resource and waste management. At the time of writing this paper, work on the project is on-going.

Life Cycle Review of Light Vehicles

A life cycle review (LCR) of light vehicles was undertaken to provide input to the Commodity Management Team at Ontario Hydro to assist in their procurement decisions. The objective of the LCR was to compare the life cycle impacts of alternative vehicle fuel cycles: gasoline, diesel, natural gas, propane, and alcohol; with particular focus on life cycle emissions, efficiency and cost. The assessment discounted vehicles that were not commercially available. Although the focus was on environmental impacts and cost, technical and social factors were considered to a lesser degree.

Result of the LCR indicated that the life cycle costs of vehicles that travel long distances (>35000 km/year, generally used by meter readers or operations staff) are the lowest for natural gas and propane fuels. These options offer significant cost reduction and emissions reduction when compared to gasoline-fuelled vehicles. In addition, there are strategic advantages to using alternatively-fuelled vehicles in Ontario Hydro's fleet in the areas of sustainable development, public perception, culture change, and positioning for the future.

Managing Internal Environmental Costs

A pilot project was undertaken at one of Ontario Hydro's thirteen electricity distribution utilities to test and demonstrate the value in knowing the internal environmental costs associated with a business activity. Internal environmental costs and liabilities form a significant portion of the utility's total costs. By knowing exactly what they are, how much they are, and which activities are causing them, the utility can better manage its environmental costs and liabilities. This requires searching for innovative ways of achieving the same or better environmental performance at reduced cost through better planning (i.e., environment built in from the start, not an add-on) and more efficient processes, with minimum waste generation.

Total environmental cost for the utility was estimated to be approximately 8% of its total operating costs. Several opportunities for cost reduction, revenue generation, cost avoidance, and environmental improvement were identified along with recommendations for achieving them. Some of these initiatives are already underway, while others may require further technical and economic evaluation prior to their implementation. The initiatives identified were cost effective and if implemented, were expected to result in a net income improvement of 5-15% to the utility's bottom-line.

Potential Application of Environmental Externality Estimates

Previously, the focus of externality research within Ontario Hydro was to inform significant resource decisions, likely through a Corporate Integrated Resource Plan process. However, with a diminished likelihood of central resource planning, externality impacts and costs will likely now inform a larger number of smaller resource decisions, primarily at the Business Unit level.

As the external impacts and costs are quantified and monetized, the external impacts and costs are expected to be used to:

- support Business Case Analyses;
- assess the environmental dispatching of the system;
- contribute to decisions about retiring or rehabilitating existing stations;
- evaluate benefits and costs of new proposed environmental regulations;
- evaluate benefits and costs of additional pollution control equipment; and
- evaluate environmental externalities associated with imports and exports of electricity.

Research on External Impacts and Costs

Over the last few years, Ontario Hydro has undertaken research to identify, quantify and, where possible, monetize the externalities associated with the generation and delivery of electricity in the province of Ontario.

Preliminary external cost estimates have been produced for the operation of all the coal-fired fossil stations. These estimates include impacts of air emissions on human health, crops, lakes, buildings, etc. In addition, further research is under way, in cooperation with the Federal Government of Canada, to improve the monetized values of the health effects associated with air pollution.

External cost estimates for the nuclear stations have been produced for the full fuel-cycle (i.e., from uranium fuel extraction and mining to electricity generation and decommissioning). In addition, a study has been completed in assessing the perception of risk associated with the operation of the nuclear stations.

Most recently, externality cost assessments have been completed for our hydroelectric stations and other renewable energy technologies like wind turbines, solar PV, biomass, bio-gas and micro-hydro.

In the future, research will be carried out to assess externalities associated with transmission lines as part of the Environmental Assessment process. In addition, research will be initiated to develop an integrated externality assessment framework for the routine quantification, monetization and updating of the externality estimates associated with fossil generation. The research on nuclear externalities will focus on accident risks, long range impacts (e.g., arising from high-level waste disposal), and public perception of accident and radiation risk.

LESSONS LEARNED FROM ONTARIO HYDRO'S APPROACH AND IMPLEMENTATION OF FCA

During the development, testing and roll-out of its approach to FCA, clear barriers emerged:

- FCA is not yet mainstream thinking, it is seen as being in a developmental phase;
- the concept, definitions, and terminology are still not clear;
- it is seen as accounting and reporting framework, rather than decision-making framework; and
- there is legal concern about being held liable for the external costs identified.

However, there are opportunities for overcoming these barriers. Below are some of the lessons learned by Ontario Hydro to date, in its effort to develop and implement FCA.

FCA must be positioned as an approach which makes "good business sense."

In the same way that environmental issues are often not seen as business issues, FCA is not seen as a business issue. Steps must be taken to demonstrate the benefits of understanding the environmental impacts and costs (internal and external) associated with business activities to show potential for reductions in costs now and in future environmental costs and liabilities. If this is done, then FCA will be considered to make "good business sense".

Case studies and projects where FCA has been applied and have contributed to a better business decision, provide concrete examples that may facilitate change in acceptance.

It is important to implement FCA as part of the corporation's Environmental Management System (EMS).

In this regard, it is important to develop corporate FCA Guidelines or policies/strategies and link them to the EMS. It is then best to let materiality guidelines determine degree of implementation.

It is important to establish a champion and rationale for FCA.

In this regard, FCA implementation:

- needs a senior manager in the organization to champion its value and use for business decisions;
- should be developed and implemented as part of a larger context; for Ontario Hydro, sustainable development is that context.; and
- should be clearly linked to investment decisions.

It is critical to clearly define what FCA means for your corporation.

For Ontario Hydro, FCA is a means to facilitate integration of environmental considerations as a component in business decisions. It incorporates internal AND external impacts (qualitative and quantitative) and costs/benefits into business decisions.

For Ontario Hydro, FCA is NOT:

- the only decision-making process, but rather an element that is integrated into existing corporate decision frameworks;
- full blown monetization of ALL internal and external impacts and costs, impacts that cannot be monetized should also be considered, but qualitatively;
- an "Accounting System" (i.e., Financial Management System); and
- full cost pricing.

FCA is multi-disciplinary by its very nature and requires a "team" approach.

The successful development and implementation of FCA requires a team approach with input from a variety of professionals in the organization such as: scientists and planners, environmental economists and management and financial accountants.

Ontario Hydro stresses that it is essential to build bridges between environmental and financial staff (ie., managerial accountants) in the organization. Many of the capital investment decisions are made within the financial area of the organization. If investment proposals are to be considered on more than just private costs, then there must be communication and collaboration between the financial and environmental decision-makers in the organization.

Developing and implementing FCA is a gradual process. It will not happen overnight.

The process of developing and implementing FCA is data intensive and time consuming. It is best to focus on those areas where it is possible to exert the most influence and obtain positive results. It is also important to emphasis potential competitiveness benefits.

Training and communication are KEY to drive the right behaviours of analysts and managers. Analysts and managers need to understand how FCA can help in arriving at better decisions.

Ontario Hydro has also found that engaging its business units in externality research increases awareness of the environmental implications of activities. In turn, this can highlight areas where actions in the present could reduce, and possibly even eliminate, potentially significant future environmental liabilities.

Environmental leadership is important to customers

Ontario Hydro's public attitude research indicates that environmental quality is a priority for customers. Customers also have high expectations that Ontario Hydro will demonstrate leadership in managing the environmental effects of its operations. Ontario Hydro takes these stewardship responsibilities very seriously.

CONCLUSIONS

Ontario Hydro firmly believes that FCA provides a useful tool by which it can better understand and manage its environmental impacts and costs, both now and in the future. However, as Ontario Hydro moves to a more competitive environment, there will be a number of challenges. For example, how can Ontario Hydro achieve continuous improvement in environmental performance without significantly increasing the resources currently dedicated to environmental protection? To gain this advantage, current approaches and expenditures need to be examined and alternatives sought at a lower cost or higher performance level. This approach requires good environmental impact and cost data as well as ongoing monitoring and verification in such areas as pollution prevention, air emissions reductions, and management of conventional and toxic wastes.

Ontario Hydro supports the view that the companies which will be setting the competitive standard in the future will be those companies that see environmental requirements and issues as business opportunities, and not just added costs. For that reason, Ontario Hydro's initiatives will continue to focus on strengthening the relationships among economic/financial, environmental, and human resource management performance to enhance competitiveness. FCA will be a critical tool in the this process.

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Environmental Decision Making Tools in ICI - Use of Life Cycle Assessment and Total Cost Assessment

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ABSTRACT

ICI has used a variety of tools to highlight the importance of the environment to our businesses and to target areas where improvement is required. Initially the focus has been on the reduction of wastes from our operations and the improvement of energy and raw material efficiency. Whilst these will continue to be vitally important areas where we can have direct effect upon the environmental performance of our products, wider issues have been raised; combining good environmental performance with good business performance.

The environment must not always be viewed as a threat always with cost penalties from expensive end-of pipe treatment. Business managers will not undertake environmental projects unless the project is backed up by a sound financial case. The challenge is to develop improvements which are both environmentally and financially beneficial. This has required the adaptation, development and utilisation of new tools such as Life Cycle Assessment and Total Cost Assessment. This paper discusses the use and limitations of some of the conventional techniques we have used and how that is driving us towards considering combining financial and environmental assessment of improvements.

INTRODUCTION

Environmental performance is, along with safety and health performance, a key element in the maintaining the public acceptance of ICI's licence to operate. Without public acceptance of our products and operations we will be unable to produce the value that our shareholders demand.

Standards tighten continuously and we must continually improve our performance to keep pace with these developments. Human and financial resources are however limited and we must prioritise our improvements to achieve the best environmental and business performance possible. This paper outlines some of the techniques we use to attempt to achieve the requirements.

ENVIRONMENTAL OBJECTIVES - 1990 TO 1995

In 1990 ICI set itself some demanding targets to improve its environmental performance. These were aimed mainly at improving the operation of our plants and targeted waste generation and resource consumption. In brief the objectives were:

Energy Efficiency

ICI will establish a re-vitalised and more ambitious energy and resource conservation programme with special emphasis on reducing environmental effects so that we can make further substantial progress by 1995.

In 1995, energy consumption relative to production volume was almost 18% better than in 1990.

New Plant

ICI requires all its new plants to be built to standards that will meet the regulations it can reasonably anticipate in the most environmentally demanding country in which it operates that process. This will normally require the use of best environmental practice within the industry.

All new plants have been built to meet this objective.

Recycling

ICI will encourage recycling within its businesses and with customers.

An increasing number of our products are now re-used, recovered and recycled.

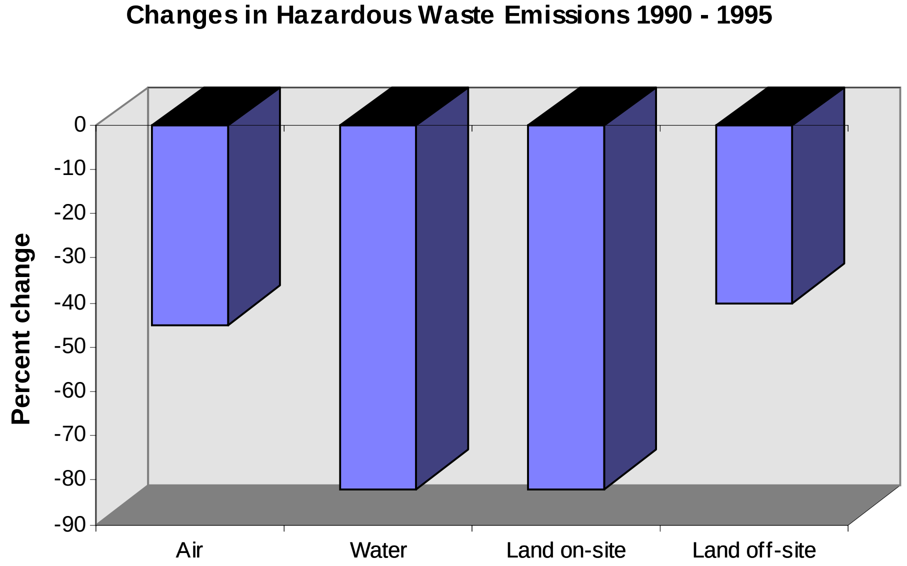
Examples include plastics such as PET and acrylics. ICI is developing new, recyclable products which have the minimum impact on the environment throughout their life. In our SHE Challenge 2000 we have introduced Product Stewardship which covers all aspects of safety, health and environment for our products; from their design through production, sale, use and final disposal.

Waste Reduction

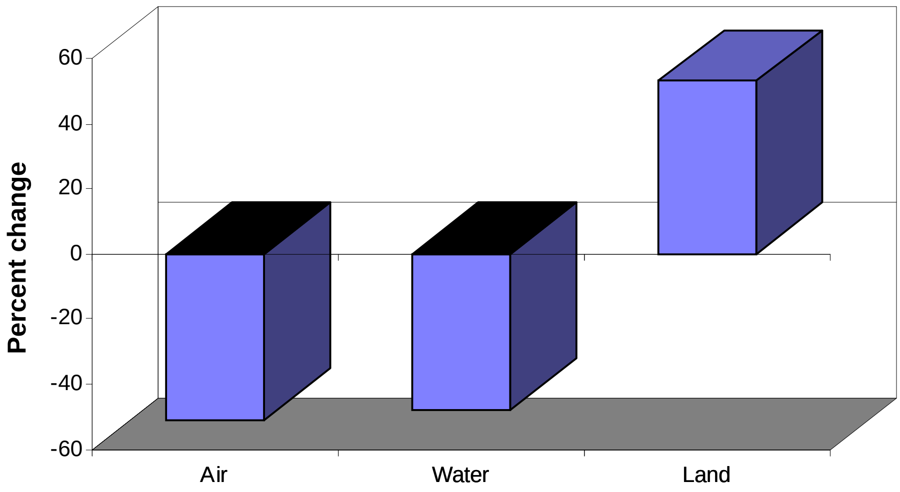
ICI will reduce wastes by 50 per cent by 1995, using 1990 as the baseline year. The company will pay special attention to wastes which are hazardous. In addition, ICI will try to eliminate all off-site disposal of environmentally harmful waste.

Hazardous wastes are down 69% Non-hazardous wastes are down 21% We have reduced our total wastes by 25%.

The shortfall in reaching this objective is the result of decisions we took on two non-hazardous wastes, brine and gypsum. In 1995, they made up 53% (2.1 million tonnes) of our non-hazardous wastes. Disposal of hazardous wastes to land 'off-site' has been reduced by 40%.



Changes in Non-Hazardous Waste Emissions 1990 - 1995



Further targets for the period 1995 to 2000 have been established and published as our "SHE Challenge 2000" targets.

ENVIRONMENTAL BURDEN

Although some considerable progress was made in improving the environmental performance of ICI it was recognised that considering wastes by quantity alone and ignoring the relative potency of the emissions was incorrect.

In response to this ICI has developed a new method to assess the potential harm to people and the environment from chemical emissions called Environmental Burden (EB). EB provides a way to rank the potential environmental impact of our different emissions and thus helps to improve our environmental management and reporting. It will:

- Provide a more meaningful picture of the potential impact of our emissions from our operations compared with the customary practice of merely reporting the weights of substances discharged.
- Help us to identify the most harmful emissions and reduce these first.
- Give the public a better understanding of the potential problems associated with the emissions and show how we continue to reduce the potential impact of our wastes.

Working out the EB involves three key steps. Firstly, identify a set of recognised global environmental impact categories upon which our various emissions to air and to water may exert an effect:

- Acidity
- Global warming
- Human health effects
- Ozone depletion
- Photochemical ozone (smog) creation.
- Aquatic oxygen demand

- Ecotoxicity to aquatic life.

Secondly, assign a factor to each individual emission which reflects the potency of its possible impact. These factors are obtained from recognised scientific literature.

Thirdly, apply a formula, based on the weight of each substance emitted multiplied by its potency factor, to calculate the EB of our emissions against each environmental category. Because it assesses potential harm, EB cannot be used to establish the impact of wastes sent to land. This is because nothing should be landfilled unless it is safe to do so. We therefore continue to report waste deposits to land, divided into those considered hazardous and those considered non-hazardous.

Other key points about the EB approach are:

- Individual chemicals can be assigned to more than one environmental impact category.
- Each chemical has a specific potency factor for each category and these factors can differ.
- Each category has its own characteristics and units of measurements.
- Burdens for each category cannot be added together to give a total EB - it is not appropriate since they are as different as ‘chalk and cheese’.
- EB assumes that all individual operations comply with local regulations.
- EB does not address local issues such as noise and odour.

The EB approach is part of our “SHE Challenge 2000”, a voluntary programme developed to promote continuous improvement in our Safety, Health and Environmental performance. We believe EB could be used by companies in all industrial sectors.

A booklet which describes Environmental Burden and how it is being applied within ICI has recently been published.

ENVIRONMENTAL ASSESSMENT TECHNIQUES

The techniques which we have employed have produced substantial improvement to our environmental performance and their continued application should produce still more improvement. Using these techniques has raised some questions.

These operations-based methods do not include any assessment of the cost of any improvement option and there is therefore no comparison of the costs of improvement compared with benefits that may result. Environmental projects can pay for themselves if the correct option is identified. Using the appropriate financial tools can demonstrate to the business manager how good environmental performance can be combined with good finances.

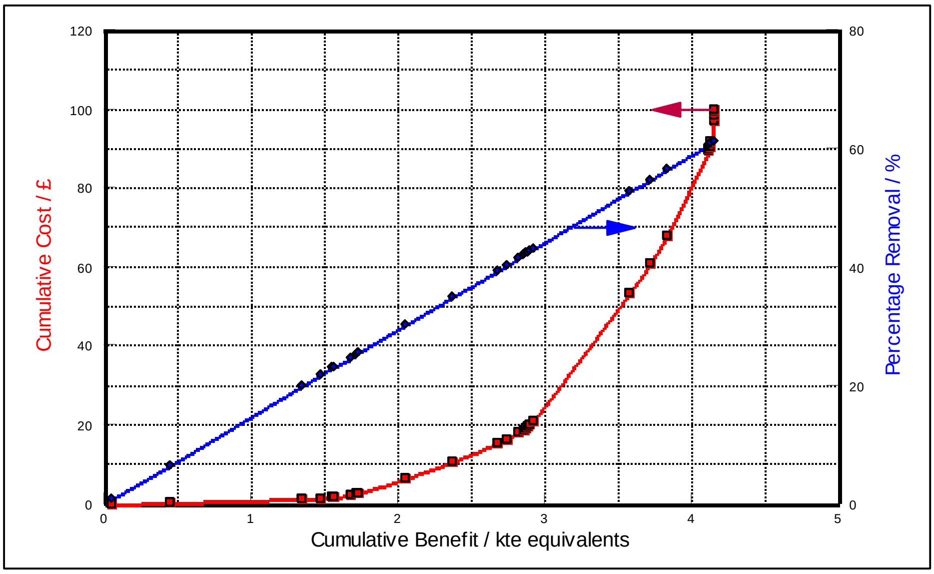
In addition these conventional methods consider only the emissions from our operations and do not consider the emissions from the suppliers of raw materials to us, the emissions resulting from the use of our products by our customers and the eventual consumer and they ignore the effects of final disposal or recycling of the material at the end of life.

As an example of some of the problems we have had and currently continue to have we might cite two examples. Firstly a new treatment option for a waste produced from one of our sites was identified which converted a waste material into a useful by-product. The cost of the existing treatment option was split between all of the operating units on the site as an overhead charge. The charges were therefore levied on all of the units whether they produced waste or not. The cost of the new treatment option would be levied solely on the contributing unit and it was therefore apparently detrimental to the operating unit to select the new treatment option even though overall the total costs would have been significantly less.

Introduction of an improved effluent monitoring system costing 1.5 million pounds reduced environmental emissions and incidents. In addition to these benefits a saving of approximately 0.5 million pounds per annum was produced from the reduction in wastage of raw materials not converted into product, increased production, reduced treatment capacity and reduced regulatory costs.

COST BENEFIT ANALYSIS

Cost Benefit Analysis (CBA) is a widely used technique for including financial costs alongside environmental benefits. An example of a cost benefit analysis of an environmental improvement programme used in ICI is the analysis of Atmospheric Improvements at a UK Site. All of the potential improvement options were assessed for their effect upon the environment and the capital costs. Other costs such as operational costs were not included as they were too uncertain. The CBA then highlighted those options which were most effective and allowed a prioritisation of scarce human and financial resources to be performed.



Cost Benefit Analysis of Site Atmospheric Improvement Projects

Cost Benefit Analysis includes both the environment effect and the cost of improvements but it frequently omits areas which may be important. For example operating costs, potential liabilities, external costs such as permitting costs, non-compliance fines

LIFE CYCLE ASSESSMENT

Life-Cycle Assessment (LCA) is a widely accepted technique for compiling, evaluating and presenting the many possible requirements of a product or service. It is for example the favoured technique selected by the EU for the Eco-labelling scheme.

In the broadest terms LCA can be described as "a process to determine the total effect on the environment of any activity". Interest in the development of the methods for calculating the behaviour of industrial systems began with the methodology of energy analysis, developed in the early seventies in the wake of the oil price rises. More recently growing concern about the global effects of pollution and natural resource depletion has prompted renewed interest in the methods for analysing and amassing the total environmental impact of product manufacture, its use and disposal, and the provision of services such as energy supply and transport.

The purpose of LCA is to provide an objective and open method of describing the environmental performance of an activity. This description can permit soundly based rational decisions to be made and, moreover, justified to others.

Life-Cycle Assessment is the process of

- Identifying the complete environmental burden of a system over the whole life-cycle of a service or product (including manufacture, use and disposal) in terms of the inputs, the natural resources and energy from the environment and the irretrievable discharge of wastes to the environment
- Evaluating the environmental impacts associated with the consumption of these natural resources or the release of these wastes.
- Identifying possibilities for modifying the system to reduce the overall environmental impact.

It is beyond the scope of this paper to go further into a discussion of LCA. It is however instructive to analyse the strengths and weaknesses of the technique when used for business decision making:

<u>Strengths:</u>

- that is a scientifically credible method of generating data on all parts of the life cycle of a product or service
- it includes the whole of the life cycle of the product from raw material acquisition, through intermediate production, energy generation, product manufacture, distribution of customer, customer / consumer use and end of life disposal / recycling / reuse.

<u>Weaknesses:</u>

- the inventory methodology is well accepted and understood however the impact assessments and interpretation phases are currently under considerable development and as yet there are no universally accepted techniques
- the method usually explicitly and deliberately excludes any financial considerations
- the results frequently do not produce clear cut answers

We use LCA extensively in assessing new products and processes for potential environmental issues and for guiding improvement.

TOTAL COST ASSESSMENT

Life Cycle Assessment is a valuable tool in identifying potential environmental issues, determining the effectiveness of possible solution and the resultant effects of suggested changes to the overall system. Inevitably most assessments show a balance of effects with some options better in some areas than others but it is less likely that one options will always be superior to another in very respect.

Life Cycle Assessment deliberately omits any financial considerations from its analysis. However increasingly a reasoned business case is and will be required to get environmental improvements successfully sanctioned. Increasingly the environment will be looked to provide improved financial returns, product differentiation and competitive advantage.

The identification and quantification of actual and potential environmental costs has led to the development of Total Cost Assessment (TCA). Other workers have identified a number of different types of costs which are relevant to these financial decisions.

<u>Tier 0 costs - Direct costs</u>

Direct or normal costs associated with the system under consideration for example, capital cost, interest or capital debt servicing costs, raw materials usage cost, utilities and labour costs. These costs have normally been included in our cost benefit analyses

<u>Tier 1 costs - Indirect or Hidden costs</u>

Indirect or frequently hidden costs associated with the system that are frequently omitted or thought too uncertain to be included in conventional costing schemes. Examples of these types of costs might be disposal costs, waste treatment costs, by-product sales costs(particularly if sold at a price subsidised by the main product)and environmental insurance. These cost are real costs that may not be directly costed to the process and are frequently not be considered in CBA.

<u>Tier 2 costs - Legal Liability costs</u>

Potential costs which may arise from our operations. These potential costs include legal penalties and fines, remedial work, damage and personal injury claims. These costs are potential costs and are not easily estimated. They have rarely been included in the business case for environmental improvement or the assessment of potential liabilities.

<u>Tier 3 costs - Intangible or less tangible costs</u>

Intangible costs such as the effect of poor community relations, poor corporate image, reduced share value and reduced sales from public ill will.

We view it as vital to gaining competitive advantage and added value to have reasoned and reliable estimates of these actual and potential costs (with ranges where possible) and it is from TCA that we hope to gain assistance with the identification and quantification of the tier 1 -3 costs.

The benefits we expect TCA to generate are:

- improved learning and education
- enabling improvement by identifying hidden costs and allowing more rational costing schemes to be developed
- enabling business mangers to see the potential value of product improvement
- generating the financial case to complement the environmental case for improvement
- early identification of potential liabilities

The TCA technique is currently under considerable development and there are some important questions which we have about the developing TCA technique are:

- scientific validity
- quality and reliability of data estimation models
- internal and external use and credibility
- consistency with other techniques such as LCA

CENTER FOR WASTE REDUCTION TECHNOLOGIES TOTAL COST ACCOUNTING PROJECT

A number of groups have provided tools for part of all of a CA methodology and ICI does not wish to invent another tool. However, ICI needs to use a commonly accepted approach and technique even if the results are only used internally for business development. Using a proprietary technique in this area would lack credibility both within and outside the organisation.

The AIChemE have also recognised the need for a common approach to TCA for the chemical industries and has set up a project under the auspices of the Center for Waste Reduction Technologies (CWRT). The project involves a number of North American and European companies who feel the need for a common TCA tool to complement existing financial and environmental tools.

The aims of the project of the project are to

- share experiences in the early applications of environmental tools
- determine the best industry practices in LCA and TCA
- evaluate the existing tools
- define baseline cost and develop cost models
- test models and techniques against data obtained by the contributors
- trial model at contributors' facilities
- prepare guidelines for the use and implementation of TCA for acceptance by stakeholders

This project was started early in 1997 and is due to complete phase 1 by the end of the year. The methodology and guidance will be the property of the AIChemE.

OTHER APPROACHES

A number of other approaches to improving the environmental performance of processes and products should also be mentioned as they potentially bring a different viewpoint to improving the environmental performance of a business. Of particular interest is the Zero Emissions approach which endeavours to maximise use of resources and minimise production of waste by integrating disparate and formerly unconnected industries (industry clustering) and developing key enabling technologies.

CONCLUSIONS

No single tool can hope to encompass all of the important issues associated with a process, product or business.

In ICI we currently use CBA extensively to prioritise the available options and to identify the best ones. CBA however needs more tools to allow it to more accurately asses the environmental impact and the financial cases.

We see LCA and TCA as providing the best estimates of the longer term environmental effects and potential costs.

We frequently use LCA to identify the key environmental issues of a product or business across the whole life cycle of the product(s). At the moment TCA is as yet in its infancy and we are at the development stage of its planing and use.

We foresee using a combination of cost benefit analysis, life cycle assessment, total cost accounting and others techniques at site and business level to

- understand better the effects of our products and services on the environment in the short and long terms
- identify the most cost effective ways of improving our products and services and
- sell those ideas to business managers, regulators and the general public.

It is unlikely that any single technique can achieve a total understanding of the environmental and financial implications of changes to products, process or businesses.

Environmental Risk Management at Italiana Petroli SpA: An Economic Evaluation

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ABSTRACT

This paper focuses the attention on the environmental risk management at Italiana Petroli SpA (IP), an ENI group company that operates in the petroleum down-stream market. It is an economic analysis of the environmental risk management.

The main environmental problem of IP is related to the oil spill from service station tank. IP, in response to recent environmental regulations and privatization plans for the company, implemented a risk management program with an evaluation of the economic effects on the company balance-sheet (income statement and assets and liabilities accounts).

The project is divided in two stages: the first stage identifies the high environmental risk service stations because of it is impossible to do an environmental audit on all the service stations and therefore it is necessary to select a sample; the second stage identifies the economic consequences of an environmental proactive strategy.

The idea of the company is that a proactive strategy is profitable in the medium period, and therefore it is profitable to identify the high environmental risk service stations and implement a preventive strategy only on these service stations.

The first chapter describes the company activities, the environmental effects and the environmental management systems. The second chapter focuses the attention on the environmental risk management and on the economic evaluation.

The author is grateful to Italiana Petroli, in particular to Romano Gonfiotti, Domenico Pizzorni and Stefania Briata and to Matteo Bartolomeo, Fondazione Eni Enrico Mattei, for the information and helpful comments on a previous version of this work.

THE COMPANY

Italiana Petroli (IP), a company of ENI Group, AgipPetroli sector, operates in Italy in the petroleum down-stream sector, dealing with the supplying, the logistic and the trading of petroleum products and the production and distribution of lubricating oil products (figure 1).

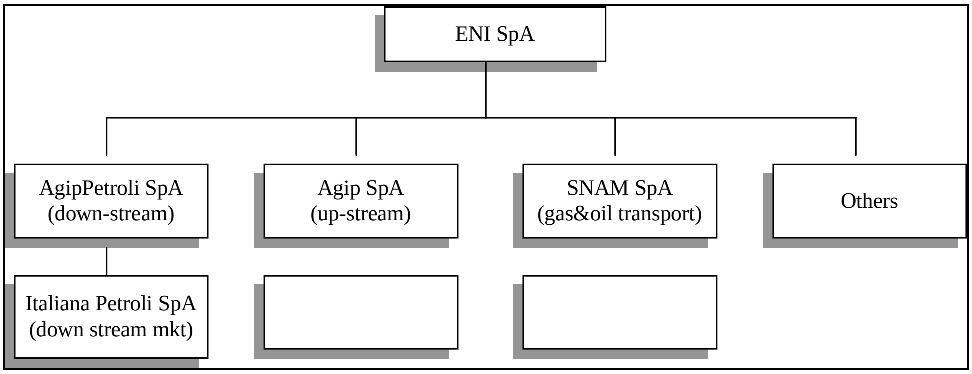
The company was formed in 1912 with the name “NAFTA”, and became part of the ENI Group in 1974. It is a large company with about 1.600 employees, 14.000 station service managers and 8 billion ECU annual sales.

The IP organization is divided into two main divisions: the logistics and the distribution division on the one hand, and the marketing division on the other. Also there is a central division that has not operating functions although it represents a cost centre.

The logistics and distribution division is made up of four inshore oil storage terminals (Vado Ligure, Genova Porto, Napoli and Venezia), one coast storage terminal

(Taranto) and two lubricating oil production plants (Genova Porto and Rho). The company has bought a new oil storage terminal in Cortemaggiore in 1997. All the bulk storage terminals serve as central distribution centers.

Figure 1: ENI group structure



The marketing division is divided into 9 branches which cover all the regions of Italy. The oil distribution network of the company includes 2.829 service stations and about 1.400 franchising service stations.

IP is certified CERTICHIM following the UNI EN ISO 9002 standard, service stations are also going to be certified.

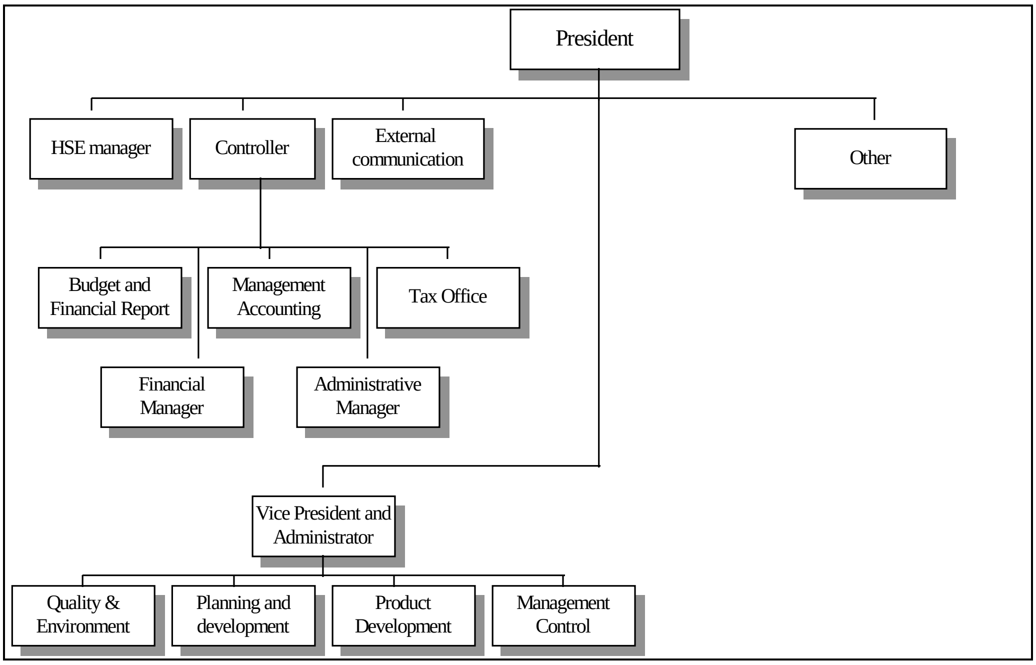
This paper is concentrated on the company at corporate level.

Corporate Organization

The organization of IP, as we have seen, has a double structure and a central division with staff functions. Each division represents a global cost centre which is divided into many different cost centres. We present below the organization chart of the company (figure 2). The HSE function has a staff position, it is situated in the central division and depends directly from the President of the company. The HSE manager provides the guidelines of the policies on the environment, health and safety to the company divisions and it is responsible for their implementation.

As the figure 2 shows, there is a second environment function at staff level that depends directly on the product development manager. In this case, the environmental audit manager officially deals with the toxicity of the products, but he often contributes on the HSE policy implementation too.

Figure 2: Environmental management organization



Company activities and Environmental effects

The main activities of IP are the oil product stock and distribution. Moreover the company produces and distributes lubricating oils and, indirectly, contributes to the supply and refining in the Group plants.

Crude oil supplying and manufacturing

IP manufactured in 1996 about 7.500.000 tons. of crude oil, with an increase of low sulphur crude oil. The demand of low sulphur crude oil has been caused by the progressive adjustment in the voluntary emissions limits (0,05% sulphur) and by the market competition on environmental issues.

Marketing and distribution

As we saw, seven bulk storage terminals that serve as central distribution centre and about 4.200 service stations represent IP marketing organization structure.

In 1995, the quantity of products distributed by the service station network has been about 3,7 million tons and the quantity that has been globally moved by the company amount to 5,6 million tons. IP and AgipPetroli have about 38-40% of the oil distribution market in Italy (Leuzzi, 1997). IP implemented a proactive strategy in the gasoline environmental quality decreasing the percentage of benzene to 1% of the volume and anticipating the law emission limit posed at the end of 1999.

Environmental Effects

Although IP has not very considerable environmental impacts, however it has implemented a specific policy to reconcile economic profitability and environmental compatibility.

The main environmental effects of the company are related to the product toxicity, land pollution and emissions into air. IP implemented a specific policy in order to minimize the impact of its activities on the environment and in particular, in 1996 IP started implementing the *Environmental Report* that could be considered the height of the environmental policy. In fact it requires the company to arrange a set of standardized procedures which have management effects too. We analyze below the company activities that could have environmental effects in various ways and the policies related.

Energy

In the company environmental policy there is a specific issue related to the energy saving. The aim of IP is to minimize the energy use in all the manufacturing processes although the energy consumption is not a crucial point in the environmental management. In particular IP implemented a specific program on the energy use in the headquarters in Genoa in order to give off an efficient use of the natural resources. All the employees are directly involved in the implementation of the project by training courses and incentives.

Water

The company uses water exploited from their own wells and from municipal waterworks. The general policy of the company is addressed to save water in the manufacturing and washing processes. It is now studying and implementing a specific project on water reuse in the bulk storage terminals and in the car washes in the service stations. For instance IP uses in some cases the water collected from the discharges as fire reserve.

Raw materials

IP developed several research projects in order to minimize the products toxicity. The raw materials selection and the quality process improvements represent a focal point in the environmental field. Therefore, IP in co-operation with AgipPetroli, has developed new oil products starting from environmental friendly raw materials and processes. Large investments has been done in this field.

Air emissions

The emissions into air of the company are principally related to VOC emissions. The main environmental effects of the emissions into air are related to the health of the employees that menage oil products in the bulk storage terminals and in the service stations. IP implements a proactive strategy anticipating the law regulations of the VOC emissions recovery. In the company budget for the next five years, the environmental investments related to the VOC emissions recovery in the service stations are about 43 million ECU, excluding the labour cost. At the beginning of 1999 all the new service stations of the company will have the VOC emission recovery system (the law limit is two years later).

IP implemented in 1995 a project for the safeguard of the employees that menage oil products providing specific operating rules and procedures. Monitoring and testing activities on air emissions have been periodically done manifesting that the concentration and the quantity of pollutants emitted into air are in any case strongly below the law limits.

Waste and Wastewater

The company generates hazardous and other solid wastes from the manufacturing processes and the other distribution activities (following the Italian law classification: special, toxic and urban wastes). There are not internal disposal on company sites (except with the temporary disposal), and there are specific agreements with disposal companies for the materials reuse and recycle. For instance, IP is part of the *Consorzio obbligatorio oli usati* for the collection of used oils. All the IP service stations collect used oils (not only IP used oils, but also oils by other producers) and distribute them to the gatherers located in Italy. The oils are then addressed, first, to the reclaiming and, if not possible, to the combustion or disposal in conformity with law regulations.

Land use and waste management

The main environmental problem of IP is related to the oil spill risk from service station tanks. In response to recent environmental regulations, privatization plans and environmentalists pressures, IP has implemented a risk management program (*Ecostart*) with an economic evaluation on the company balance-sheet. We will talk about the *Ecostart* project in the next paragraphs (chapter 2).

Environmental risk

The main environmental issue related to IP activities is represented by the oil spill risk. In particular it is often difficult to menage the oil spill risk because of the high number of tanks in the service stations (each service station could have from two to four tanks).

Therefore it is not easy to identify which service stations have high environmental risk tanks. This is the main environmental issue of the oil marketing companies which could require very high investments or disposal costs if the company has not a proactive policy. Up to now, in Italy and in Europe there is not any law requirements about the characteristics of the tanks.

IP, following the proactive approach of its environmental policy, implemented a specific project (*Ecostart*) for the environmental risk management identifying the main causative factors of the oil spills.

Environmental Management System (EMS)

IP, as we saw, is part of the ENI SpA Group that, since about 4 years became implementing a proactive environmental strategy. ENI SpA provided to all the operative companies of the Group the guidelines and the procedures of the environmental management. All the companies have to adapt their policies to these guidelines and give an annual environmental report to ENI that collects all the information for the corporate environmental report.

The environment has always been a crucial issue at ENI. But the environment is becoming a more relevant issue in ENI strategies, since it is company belief that environment is also a competing factor in international markets and not only a matter of ethics. After the privatization of the Group and the quotation on the Wall Street Stock Exchange, the environmental issue became a key point in the company strategy and information. SEC, the USA Security Exchange Commission, requires a synthetic environmental report every four month and all the companies of the Group are directly involved providing environmental data, strategies and impacts. It is clear that the real incentive in the implementation of the environmental management system is not only a matter of ethics, but an economic issue too. In fact, the environmental management could affect the share quotation value.

As consequence, all the economic evaluation related to the environment are welcome and spurred in the ENI Group companies.

IP, as part of the ENI group, directly controlled by AgipPetroli, developed an environmental management system following the ENI guidelines. We depict below the environmental tools of the company.

Environmental Policy

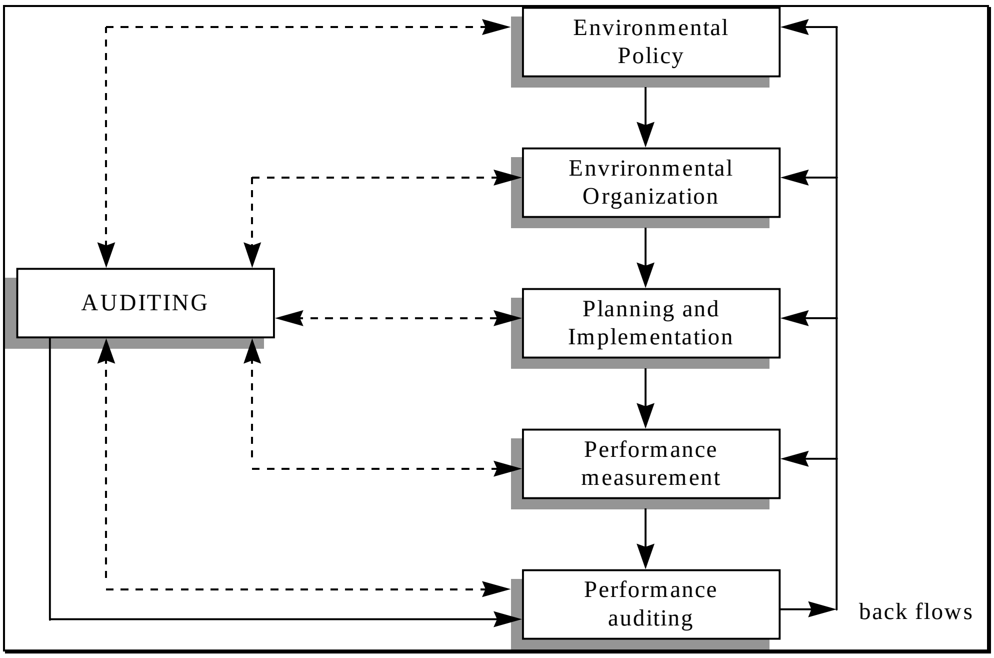
The first step in the IP environmental management has been the development of the Environmental Policy, in which the environmental commandments are identified, formalized and spread to all the employees, suppliers and buyers. The Environmental Policy reflects the guidelines of the Group and provides qualitative targets for what concern natural resources consumption, waste management, risk management, internal and external environmental communication, voluntary agreements, etc. Up to now quantitative targets are not fixed.

The main qualitative targets of the Environmental Policy are the following:

1. Assure the safety and the health in the company activities
2. Safeguard the environment
3. Trade the products as regards as the security and the environment
4. Assure the relationship with the local community.

The IP Environmental Policy provides then the specific procedures for the policy implementation. In the figure 5 we depict the key elements of the environmental management system and the role of the Environmental Policy.

Figure 5: Key elements of the Environmental Management System



The Environmental report and audit represent the key issues in the Environmental Policy implementation. In the next paragraph we describe these instruments and the implications in term of company organization.

Environmental Report and Environmental Information System

The Environmental Report is the height of the EMS and the document addressed to the external public. The first Environmental Report of IP has been published at the beginning of 1997, but it required a long working period in which the EMS has been implemented in the company. The report collects and analyses the IP environmental policies and the physical and economic data from 1994 to 1996. The IP Environmental Report, as that of the group companies, follows the FEEM[6] methodology that, in turn, is based on the EUROSTAT and PERI (Public Environmental Reporting Initiative) methodologies.

The Report is divided into two main parts: the qualitative part that describes the main initiatives of IP, and the quantitative part in which the data on the main pollutants are presented. If at the beginning of the IP environmental project, the Environmental Report was only an external communication tool, now it could be considered a very management tool.

The implementation of the Environmental Report required a complex data collection, therefore IP implemented, following the ENI and FEEM guidelines too, a set of tools which are also management tools. For instance IP uses a software data bank and modifies the accounting methodologies in order to point out the environmental expenses. We depicts below the structure of the environmental data bank and we will speak about the accounting methods in the paragraph 1.5.

The Environmental Information System (*SIA*[7]) is a practical tool for the data collection and management which aims to satisfy the company and public need for comprehensive information on flows of inputs, outputs and monetary values related to environmental issues. Building an environmental balance-sheet, the *SIA* can be useful to identify causes of inefficient management of natural resources, to plan and manage measures to improve environmental performance. Taking into account the economic aspect, IP collects by the *SIA* the physical data consumption of raw materials and emissions and associates them the economic values. In particular the *SIA* foresees a collection and analysis of:

1. physical data on inputs and their related economic value;
2. physical data on products and their related economic value;
3. physical data on emissions and their related environmental expenditures.

Therefore IP tries to link the three accounting sections in order to control the economic impact of pollution control and to assess and manage the efficiency in the consumption of raw materials. The Environmental Information System (*SIA*) is based on the methodology for environmental balance-sheet and it is much more than a simple data collection tool because enables the company to produce a large amount of different reports. Ones of the main idea of the software is to simplify data entry process in multi-site company like IP, and to offer standardized data sources choosing among pre-defined lists. Data entry section collects the information about the consumption of raw materials, goods and services produced and sold, wastes, noise, air emissions, water discharges and environmental expenditures. For each of above topics, many kinds of information are requested. For example, the information of consumption of raw

[6] Fondazione Eni Enrico Mattei (FEEM)
[7] *Sistema Informativo Ambientale* (*SIA*)

materials includes the code of the raw material, name of the crude material, price, country of origin (the objective of this information is to separate between different kinds of local environmental conditions), supplier (for consolidation purposes).

The *SIA* provides information separately by site level and by kind of activity. For instance the marketing activity of the company is separated by the distribution and logistic activity. The software enables the company to aggregate data at site and corporate level. By this way, the *SIA* could be seen as management tool, providing a practical support in the potential environmental conflicts with the local communities.

Moreover, starting from the data base created in the Environmental Information System, it is possible to calculate the most useful environmental performance indicators for a single site or for the company as a whole and to compare environmental performance with different sites or law limits. The amount of wastes is for instance compared to the service station location.

The *SIA* is used in the periodical data collection and offers a continuous check in the environmental performance in order to direct the management of the environment.

Environmental auditing

The environmental audit on the field is a key tool in the environmental management of an oil company. Periodical monitoring and testing are implemented at station services and bulk storage levels. IP has a specific software program which collects all the information of the environmental audits. The audits are carried out by the internal employees of IP which collect data on the structural characteristics of the tanks (age, capacity and typology), the stratum, the lithology, the wells, etc. Generally the audits are periodically carried out on a large part of the service stations and on all the bulk storage terminals.

The internal audits are an important tool of the environmental management because they represent the departure point of all the company strategies and actions on the environment. Also they could be intended as part of the EU project 1836/93 (*Emas*) although IP has not decided to apply the *Emas* scheme yet. The results of the audits are used in the *Ecostart* project on the environmental risk assessment (see paragraph 1.3.).

Accounting System

The accounting system of the company reflects the organization structure. Costs are gathered in cost centres which correspond to the three main divisions of the company, i.e. the marketing, the distribution and logistics and the central division. Each division has in turn many specific costs centres which correspond to specific responsibilities of the managers. Therefore a cost centre can be described as a responsibility centre where managers are accountable for the costs under their control.

There is in the company a staff function that deals with the accounting methodologies and gives to all the divisions the guidelines of the accounting management. Generally IP follows the financial accounting principles of the EU, the guidelines of *the Consiglio Nazionale dei Dottori Commercialisti*, the Italian association of accountants, and the ENI corporate. The result is that each division has not many changing means. For example the marketing division could not create a new environmental liabilities provision if it disagrees with almost one of the above principles.

According to the EPA definitions about environmental accounting (EPA, 1995) the IP accounting system collects the conventional environmental costs. All these environmental costs are gathered by a systematic and standardized accounting system, except the labour cost in some cases. In the financial accounting system there are specific accounts which refer to environmental issues (see par. 1.5.1.).

Contingent costs, image and relationship costs are not gathered by the financial accounting system (there are not specific accounts), but they are periodically collected and analyzed by the environment manager and the controller in the investment decision process (see par. 2). In fact it is necessary to distinguish the environmental costs from the expenses. The company collects all the costs related to an investment because specific investment cost centres are created. The investment environmental cost identification and allocation is therefore more exact than in the standard accounting system where the contingent, the image and other costs are not collected.

At the beginning of 1997, ENI corporate gave a new guideline about the constitution of a future liabilities provision if the Group company could have a potential cost for environmental issues due to past activities. Up to now IP has not any provisions related to the environmental liabilities in its financial accounting system, but the management believes that there will be in the near future.

Costs recording and allocation process

As we saw the environmental costs are gathered in the three main cost centres which correspond to the three main company divisions. In this paragraph we discuss which environmental costs are gathered and how they are allocated.

Headquarters division

The headquarters division carries out a staff function in different fields, e.g. the administration, the marketing policies, the strategy and investment decision-making process, the external and internal communication, etc. The environmental costs that the central division supports are mainly related to office activities and safety and health regulations. Moreover there are other typologies of costs, e.g. service stations monitoring and the costs of the environmental report implementation that are collected at central level even if they refer to the service stations. They are not allocated in the second step to the marketing divisions. Only the most typically environmental costs as the energy, water, heating and the training and information costs are separately gathered in specific accounts. All the others HSE costs are recorded as overheads. There is not an allocation process of the overhead costs because the company aim is to collect the environmental costs at division level[8]. The environmental costs of the headquarters have increased in 1996 because of the D.L. 626/93[9] implementation. In fact this regulation has required a very high effort to the company for the improvement of the workers health conditions. Generally the headquarters environmental costs are very low.

Logistics and distribution division

The logistics and distribution division deals with the bulk storage terminals that serve as central distribution centres. The environmental accounting system has been changed in 1996 in order to collect into separately accounts the environmental costs. IP has

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[8] Moreover the allocation process would not be profitable in a cost/benefits analysis.

[9] D.l. 626/93: workers health and safety regulation.

adopted the ENI corporate classification of the environmental expenses that in turn refers to the EU definitions.

Starting from the beginning of the present year environmental costs will be gathered into the following accounts that have been used at the end of 1996 to implement the 1997 budget:

1. Air and climate protection
    1.1. Air and climate overheads
        1.1.1. Air and climate protection materials
2. Water protection
    2.1. Operating plant costs
        2.1.1. Water treatment
    2.2. Water overheads
        2.2.1. Water protection materials
3. Soil and groundsoil protection and underground water
    3.1. Soil and groundsoil overheads
        3.1.1. Soil and groundsoil materials
4. Environmental reclaim
    4.1. Environmental reclaim overheads
        4.1.1. Environmental reclaim (chemical and physical pollutants)
5. Environmental monitoring
    5.1. Environmental monitoring overheads
        5.1.1. Environmental audit
6. Wastes
    6.1. Operating plant costs
        6.1.1. Industrial waste disposal
        6.1.2. *Consorzio Olii usati* compulsory
    6.2. Waste overheads
        6.2.1. Civil waste tax
7. Health
    7.1. Health overheads
        7.1.1. Health consultants
        7.1.2. Materials and medicines
8. Noise abatement
    8.1. Noise overheads
        8.1.1. Noise abatement materials
9. Safety and fire prevention
    9.1. Operating plant costs
        9.1.1. Working dress
        9.1.2. Safety materials
        9.1.3. Fire prevention materials
        9.1.4. Maintenance service
    9.2. Social costs
        9.2.1. see from no. 9.1 to 9.1.4.
    9.3. Safety and fire prevention overheads
        9.3.1. Accident materials
10. Training and information
    10.1. Operating plant costs
    10.2. Safety training costs (allocation)

Each bulk storage is a cost centre in which all the above accounts are separately collected. Among those, the main environmental cost is the *Consorzio Olio usato* compulsory which costs about 58lire *per* litre of lubricating oil.

All these costs will be checked every three mounts for an intermediary report. The insurance costs are collected into overhead accounts and it is very difficult to allocate them to specific bulk storage.

The labour cost of the workers partially addressed to environmental job is estimated as about 70% of the total.

The allocation of the (environmental or not) costs is limited to the main cost centres - in this case to the logistics and distribution centre - and there is not any allocation to the products or processes.

Marketing division

The marketing division is represented by 9 branches that in turn comprise all the service stations. All the branches are cost and allocation centres. As in the other divisions, also in the marketing division there is a distinction among environmental costs and investments. The company creates a cost centre for each new investment project and all the costs are allocated to it.

On the other hand, if some environmental costs are gathered at headquarters level (e.g. monitoring and environmental report implementation costs), other costs have a specific account at branch level. We depicts below the categories of costs that have a specific account.

1. Disposal costs (waste disposal comprised);
2. Pollution prevention costs referred to ground, wells and stratum of the service stations;
3. Washing softener
4. Washing softener maintenance costs
5. Environmental maintenance costs (e.g. tank maintenance costs)
6. Safety costs
   6.1. Materials buying
   6.2. Extraordinary maintenance costs
   6.3. Safety consulting costs
   6.4. Training and information costs

IP applies these accounting scheme from 4 years at budgeting and accounting level. The main environmental cost typologies in amount term are the disposal costs and the pollution prevention costs (double skinned tanks before the oil spill happens).

The costs about the VOC emission recovery systems are considered as environmental investments, and they have therefore a specific account. The company plans to spend for the emission recovery systems about 43 million ECU in the next five years.

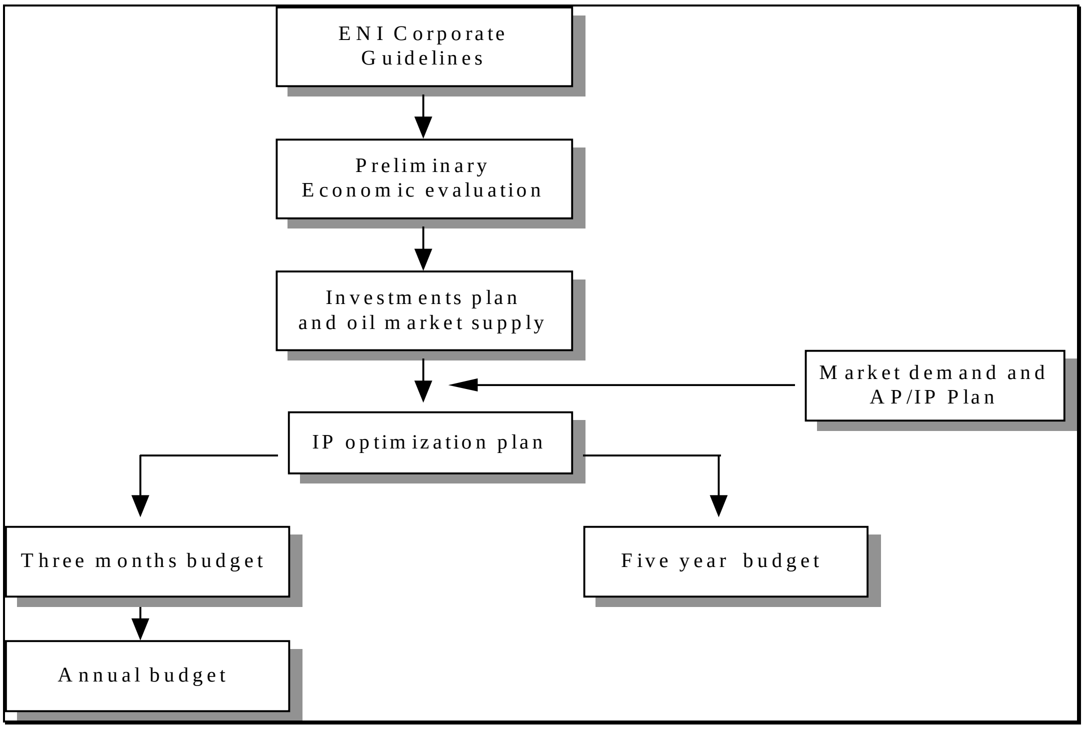
The controller of the company estimates that in the present accounting system about 5 million ECU of environmental costs are not taken into consideration by the specific accounts and are collected into overhead accounts.

Budgeting and Control

The two main steps of the management accounting are budget and control. There is in the company a specific function that directly depends on the vice-president and implements a budget of activities in co-ordination with the other functions.

The first step for the development of the budget is the control analysis at the three divisions level for the last year. Following the sector activity and corporate guidelines, the company carries out a preliminary plan that is checked and corrected by all the managers involved. The budget is than evaluated at quantitative monetary level at real costs considering the inefficiencies too (see figure 6).

Figure 6: Company budget process



The budget has a detailed level, following the management accounting structure, and it is implemented every year for the next and the five next years.

In the controlling phase the exercise costs are compared with the budget costs and strategies information are collected for the future budget decisions. The company has in fact a three months budget that serves to position the annual strategy decisions.

The budget and control operations are common for all the cost typologies (environmental or not).

Investments Decisions and Justification Process

The investment decision process is a common process for environmental and other investments. As we saw, the company implements a five years budget process in which the annual costs of each investment are expressed. The planning manager has therefore to give the complete information about the new investments. Generally IP does not follow a standardized procedure in the investment evaluation, even if general guidelines exist.

The company does not put a limits in the annual investment amount, but it is clear that there is a practical limit given by the planned cash flow in the current year. When the investment total amount of the years is established, it does not could exceed in any case.

IP implements the investment evaluation using the most common financial indicators (i.e. Return on assets, Return on investments, Net present value, Internal rate of return, etc.) even if they are not strictly required for the formal approval of the investment.

At the investment decision process all the managers could be involved if they had a direct interest or specific experience.

The investment proposals are generally carried out by the three divisions of the company about their specific issues. In the second step they are evaluated by the plan management which takes the final decision after the opinion of the administrative board.

Environmental Investments Justification Process

The justification process of the environmental investments approval is the same of all the others investments. The justification process is simplified only when the environmental investments are required by law or HSE regulations.

The standard of the investments approval, which is applied to environmental investments too, is the profitability. IP demonstrated that the profit aim is not incompatible with a policy of the environmental protection, but it could stimulate a pollution prevention policy. We discuss the profitability standard in the next paragraph.

THE ENVIRONMENTAL RISK MANAGEMENT

The environmental risk management is the main environmental issue of the company. In 1995 in order to improve the oil spill risk management, IP decided to implement a specific project about the economic evaluation of the environment preventive strategies. The general idea of the company was that an investment shifting from the reclaiming side to the preventive side could improve both the company profitability and the environmental management.

This project is not part of the standard and periodical environmental accounting, but it is a spot project that has modified the company thinking for the future. As we saw, some typologies of environmental costs are often hidden in many of the conventional cost categories periodically gathered by the company. In this project IP adopts a large environmental costs view, taking into account the environmental costs as future liabilities costs, image costs, etc. which are not included in the standard environmental accounting (EPA, 1995). Even if these costs are not collected by the management accounting system in specific accounts, they are taken into account in order to direct the investment decisions. IP does not exclude that these costs will be gathered by the Environmental Information System in the near future, but it is unlikely they will be included in the financial accounting system. In fact the valuation of these costs is sometimes too subjective.

The project of the environmental risk evaluation could be intended as a costs-benefits analysis with a large environmental costs identification. In the next paragraphs we will describe the project separating the statistical from the economic phase.

High risk station services identification

The first problem of the oil marketing companies is the environmental management of all the service stations. IP includes about 4.200 service stations in Italy with about 16.000 tanks (excluding the tanks of the oil storage terminals). The difficulty to manage the environmental issues of the service stations is related to the monitoring costs of all the service stations. It is easy to understand that the monitoring process in all the tanks could be an over-onerous expenditure. The result is that generally the company does not take correctly into account the environmental risk and supports the reclaim costs after the oil spill happens. In this case the monitoring process is therefore limited to the high environmental risk service stations.

The economic problem of a end-of-pipe policy is the high cost related to the monitoring process in all the service stations. In fact it should require a few days work in the physical, chemical and meteorological data collection and in the continuos analysis process.

In 1995 IP decided to implement a proactive environmental strategy minimizing the effects on the environment (no. of oil spills, oil spilled, land environmental impacts) and optimizing the economic resources. If some economic resources of the end-of-pipe policy are shifted to a proactive policy implementation, the result is that the global costs addressed to the environment could decrease in the medium period (paragraph 2.2.1 and figure 10).

The oil spill risk is moreover a key point in the environmental communication of the company because it represents a social and competitive issue too: the environmentalists, the competitors and the society more generally see the oil spill risk as crucial in the oil companies management. The *Ecostart* project represents therefore not only a response to legislation, but also, at the same level, a market and competitive project. In this view, IP developed an economic assessment of the risk related to its service stations tanks improving the investments and the disposal costs management. The *Ecostart* project has involved therefore many functions of the company as the HSE manager, the controller, the communication manager and others. We depicts below the main environmental causative factors of the oil spills which will be used in the economic assessment of *Ecostart* (see figure 4).

The main environmental causative factors could be divided into four categories:

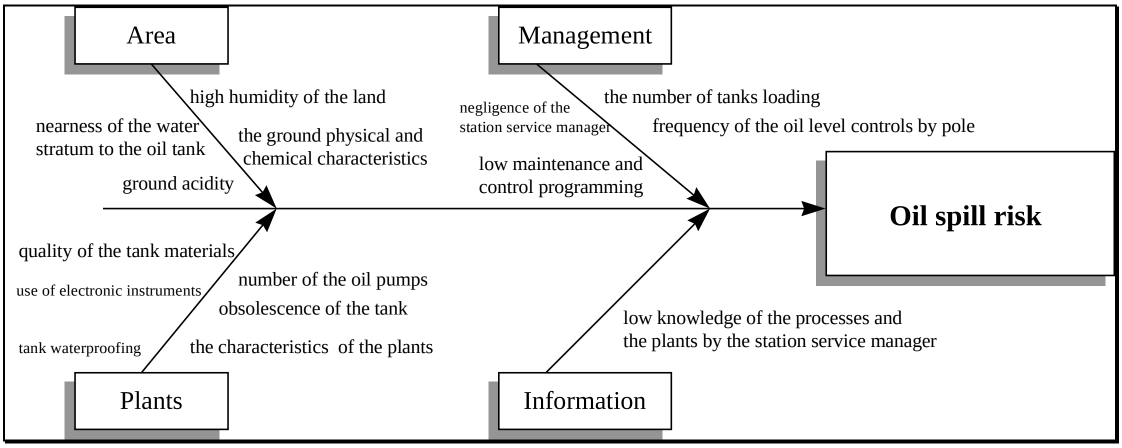
1. Management factors: they are related to the management of the service station manager and to the amount of oil moved; for instance the number of tanks loading, the frequency of the oil level controls by pole, low maintenance and control programming, negligence of the station service manager, errors and inattention in the loading process, etc.
2. Information factors: they are related to low knowledge of the processes and the plants by the station service manager.
3. Plants factors: they are related to the characteristics of the plants installed in the service station; for instance the obsolescence of the tank, the number of the oil pumps, the engineering characteristics of the tanks, the quality of the

tank materials, use of electronic instruments (no use of the pole), tank waterproofing, etc.

4. Area characteristics: they are related to the typology of the land; i.e. high humidity of the land, the nearness of the water stratum to the oil tank, the ground acidity, the ground physical and chemical characteristics.

5.

Figure 4: Causative factors in environmental oil spill risk in the service stations



Data source: *Italiana Petroli SpA, 1996.*

IP adopted a statistical approach as solution of the environmental risk management. If the high risk service stations were identified, the environmental policy should be concentrated only on these stations.

The statistical phase is divided into two steps.

Structural data collection

A data collection on the structural characteristics of 2.830 service stations was implemented using a specific database. Mainly structural data as the number and the typology of the tanks, the capacity and the amount of the products moved, the stratum and lithology kind, the wells, etc. are collected by qualitative information (table 1). All these characteristics are gathered using the information from the service station manager and specific monitoring processes are not implemented. IP has therefore a database on the structural characteristics of 67%[10] of the service stations which can be used as general information. The idea of the project is to establish a link among the structural data and the physical data by a statistical analysis and to extrapolate the results for the population. The structural data represents the dependent variable in the model.

[10] 2.830/4.222 service stations = 67%

Table 1 Collection of the structural data of the service stations

1	No. of tanks (information by the service station manager)	12	Presence of highroad
2	Age of tanks (information by the service station manager)	13	Presence of railways and tramvia
3	Typology of tanks (simple or double skinned tanks)	14	Presence of oil & gas pipelines
4	Capacity of tanks	15	Pipes substitutions in the past
5	Oil products	16	Tank substitution in the past
6	No. of tanks with internal or external vitrification	17	Tank vitrification
7	Town location or tourist area	18	Stratum (information by the service station manager)
8	Distance from industrial area	19	Lithology (information by the service station manager)
9	Distance from civil buildings	20	Oil products sold
10	Presence of subway, tunnel	21	Piezometric gradient
11	Presence of wells (information by the service station manager)		

Data source: *Italiana Petroli SpA, 1996.*

Chemical and physical monitoring and service station risk score

The chemical and physical monitoring on 121 service stations is the second step of the project. IP identified 121 service stations and collected the most important physical data by a monitoring system. 121 service stations, chosen among all the service stations classified by typology are a random sample which is statistically representative of the entire service station network. The data collected by the monitoring process represent the learning data of the statistical model. In fact it is possible to establish a link[11], which has been used for the statistical extrapolation, among the structural and the physical data. The physical monitoring system serves as learning model of the statistical analysis identifying causative factors which affect the quality of the tanks. For instance, using the correlation among the physical and the structural data it is possible to estimate that 95% of the perforated tanks are situated in a ground with high stratum level. The most critical causative factors are the stratum level, the lithology, the tank weight, the presence of water wells, the number of oil spills in the past and the number of tanks in the service station[12]. All the information on the causative factors are collected in this step at physical level.

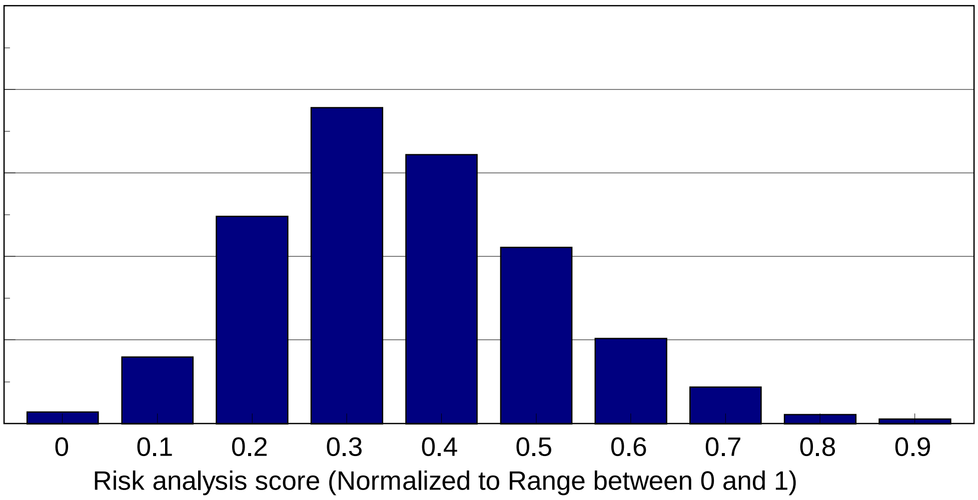
Next step is the attribution of a risk scores to all the service stations using the statistical model and normalizing the results. All the service stations have a risk scores[13] which

[11] The correlation is established using a neural connection model.
[12] The number of oil spills in the past and the number of tanks in the service station are considered as endogenous variables.
[13] 1= high risk / 0= low risk.

could be used in the investment decision evaluation. IP identifies the service stations with higher environmental risk score[14] and concentrates the economic resources on them minimizing also the emission on the environment.

IP evaluates the statistical model as representative of the population because the prediction margin is about 85-88% (e.g. 85-88% is the probability that the result is correct). Figure 7 shows the comparison between the statistical model results and the frequency distribution of the sample of 121 service stations. The chart shows that the main part of service stations have 0.3 risk score (normalized to range between 0 and 1).

Figure 7 Summary of investigations results: comparison with frequency distribution diagram[15]



Total No. c Investigatio	1	6	11	14	21	31	16	15	2	4
No. of sites contaminati	1	3	10	10	12	25	12	10	2	3
A			5	4	7	8	4	2		
B	1	1	4	1	2	3	4	2		
C		2		2		4		1	1	1
D			1			5	2	1	1	1
E				1		3	1	1		
F				2	3	2	1	3		1

Data source: *Italiana Petroli SpA, 1996.*

Economic evaluation

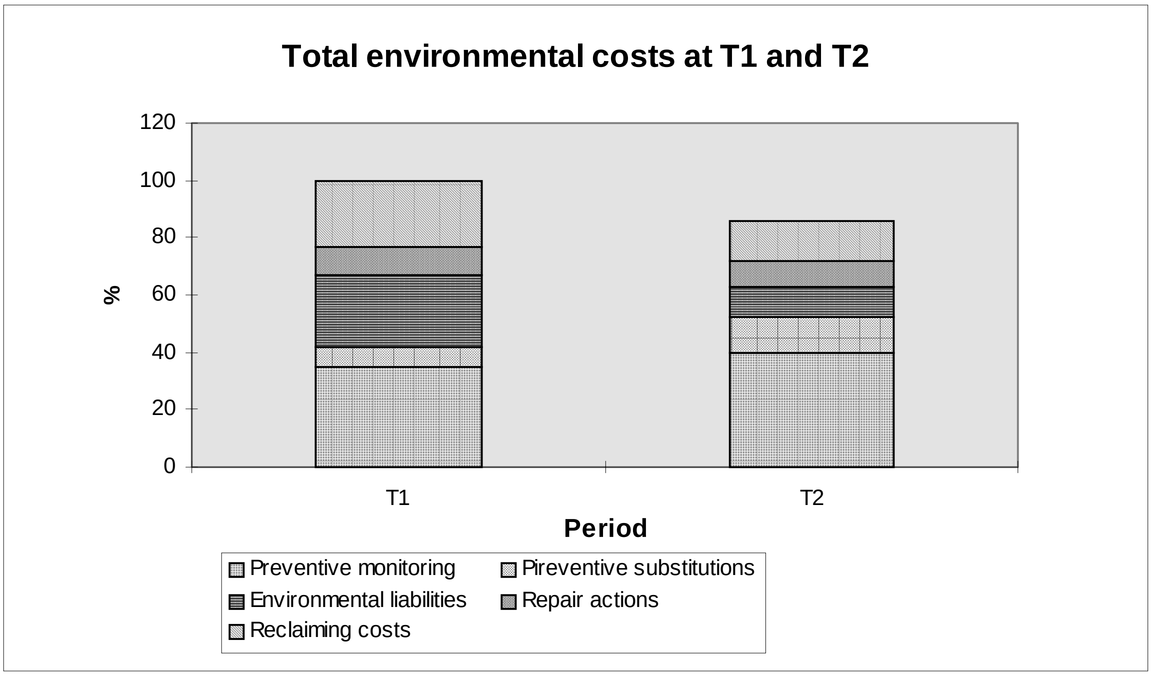
The aim of the project, as we saw, is to reconcile the environmental management risk and the economic profitability.

IP, using a statistical model, provides a risk score to all the service stations and restricts to 16% the number of the service stations with high oil spill risk. The identification problem is therefore solved even if a margin of mistake should be taken into account[16].

[14] The service station with high environmental risk score are about 16% of the total.
[15] In the figure 7 A,B,C,D,E,F identify the typologies of service stations.
[16] The potential mistake is related the statistical analysis and to the definition of the sample. Nevertheless the company evaluates this mistake as negligible.

The second phase of the project is the economic evaluation of the investments related to the oil spill risk. Now the company focuses the attention only on the service stations with higher environmental risk (16%) minimizing the economic impacts of the monitoring and assessment actions. The company will implement a proactive strategy in the higher risk service stations replacing the old tanks with new double skinned tanks, and a end-of-pipe policy where the risk of oil spill is low. The economic evaluation shows that a proactive strategy is profitable in the medium-long period if the future liabilities costs, the image costs, the insurance costs and other contingent costs (EPA, 1995) are taken into account (figure 8).

Figure 8 The environmental costs in the proactive strategy

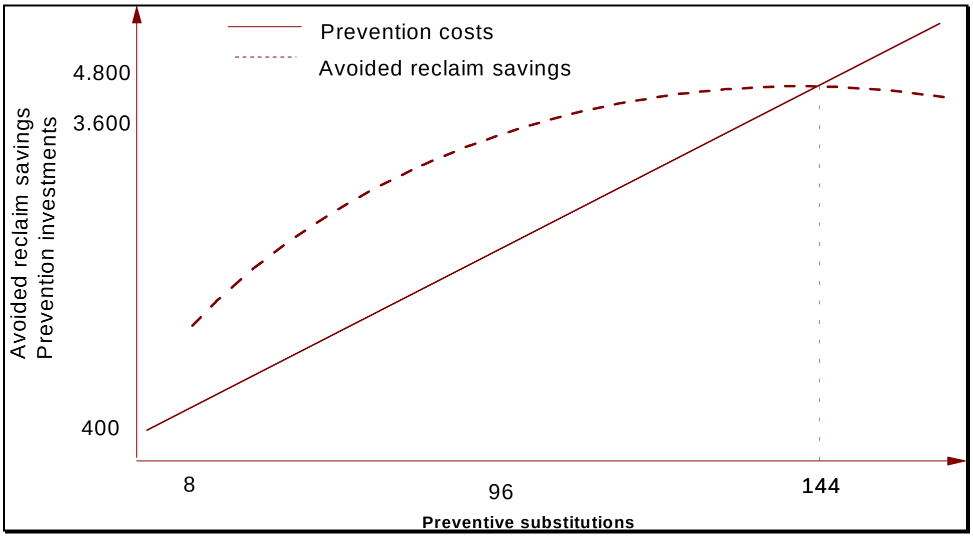


Data source: *Italiana Petroli SpA, 1996.*

We depicts below the costs that IP takes into account (at qualitative and quantitative level) in the economic assessment (table 2). Some costs are provided by the financial or environmental accounting system and others are provided by *ad hoc* accounting process. The costs that are gathered by the standard accounting system are described in the paragraph 1.5.1. The other costs are collected by a specific and not standardized accounting process. The evaluation of these typologies of costs is not part of the company balance-sheet, but it represents an extra-accounting information used in the investment assessment.

The company by the different accounting systems can therefore evaluate the costs related to all the actions of the environment risk management. If all the costs are evaluated and the high risk station services are identified by the statistical model, IP can calculate the optimal level of the service stations of the preventive strategy, i.e. the number of the service stations in which the preventive costs and savings from avoided reclaims are exactly the same (figure 9). In fact the investment will be done only if the savings from reclaim avoided costs are higher than the prevention environmental costs (figure 9). In 1995 the optimal level of tanks preventive substitutions was 144.

Figure 9 Optimal prevention level



Data source: *Italiana Petroli SpA, 1996.*

Table 2 Environmental cost accounting

Costs	Accounting level
1. Measurement and treatment	
Audit (information gathering)	Quantitative
Tank level measurement	Quantitative
Environmental audit	Quantitative
Tank test	Quantitative
Technical procedures (thermal loss measure)	Quantitative
Soil gas survey	Quantitative
Automatic hypsometer (level, temperature and goretex)	Quantitative
2. Substitution and Repair	
Tank substitution	Quantitative
Cathedral protection	Quantitative
Internal vetrification	Quantitative
Double skirt tank	Quantitative
3. Monitoring and Reclaiming	
Spill monitoring and control	Quantitative
Hydrogeological control	Quantitative
Reclaim actions	Quantitative
Land control	Quantitative
4. Other costs	
Insurance costs	Qualitative
Legal costs	Qualitative
Fines and penalties	Qualitative
Fall of the operating risk	Qualitative
Green image costs	Qualitative
Brand loyalty	Qualitative
Legislative changing risk	Qualitative
Capitalization of the management costs	Qualitative

Data source: *Italiana Petroli SpA, 1996.*

As the table 2 shows, the company does not take into account at quantitative level some kind of costs which could affect the profitability of the preventive investments. The figure 8 shows that in the medium period the proactive strategy can bring positive effects on the investment level, but the result on the long period is not yet analyzed. The qualitative analysis of the contingent costs as the insurance costs, the legal costs and the image costs (table 2) is moreover encouraging because they have positive effects both in the balance-sheet and in the income statement of the company.

The conclusion is that the collection at quantitative level of all the environmental costs would show a higher profitability of the preventive strategy.

It is interesting to observe that the preventive substitution of the tanks increases the value of the company because the value of the assets increases. In fact the double skinned tanks investments could be capitalized (increasing the value of the assets).

The result of the proactive strategy is therefore positive[17] both at income statement and balance-sheet levels.

In the next paragraph we will describe the optimization effects of the environmental preventive strategy showing the results on the company financial balance-sheet too.

The optimization effects in a multi period analysis

The aim of the environmental risk assessment model described in the previous paragraphs is, as we saw, to improve the management of the uncertainty related to the environment.

The company, using this model, can menage the risk related to the oil spills in the service stations and can evaluate the medium term effects of the preventive approach. In this part we compare the effects of the preventive investment policy on the income statement and on balance-sheet of the company with the end-of-pipe policy[18].

The analysis has been implemented in the medium period (3 years are taken into account in the economic evaluation). The cost of the money is not taken into account in the analysis, but we can affirm that this hypothesis does not affect the results[19] (the cash flows are not discounted or capitalized). The costs of the different actions are evaluated on the basis of the experience of the past.

End-of-pipe policy with high environmental penalties risk

When the company implements a end-of-pipe policy the main environmental costs are related to the tanks substitution and the reclaiming actions after the oil spill. In this case IP does not select the service stations with higher environmental risk and all the costs are addressed to the *ex-post* actions.

The table 3 shows the costs related to this policy and the effects on the income statement (profit-loss account) and on the balance-sheet (assets). The costs are

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[17] As the data and the economic theory show, the environmental costs of the proactive strategy will increase in the short period, but the final result in the medium-long period will be profitable.

[18] The values presented in this report are provided by IP SpA in the case study. The aim is to provide a quantitative evaluation but they are not necessary related to the real costs of the company.

[19] If the cost of the money was taken into account in the model, the results could only be more positive because of the raise of the costs in the future periods.

evaluated on the basis of the past experience. The effect on the income statement is related to the reclaiming actions that the company implements according to the group guidelines, the image effects and the environmental sensitivity.

Table 3[20] End-of-pipe policy with high environmental penalties risk

End-of pipe policy with high penalties risk

Action	Cost	Max risk S.S. No.	Max risk S.S. Expenses	Other S.S. No.	Other S.S. Expenses	P/L account No.	P/L account Cost	Assets No.	Assets Value
Loss procedure	1	-	-	-	-	-	-		
Environmental audit	1	-	-	-	-	-	-		
Seal test	1	-	-	-	-	-	-		
Vetrification	9	-	-	90	810	90	810	+ 90	+ 810
Tank substitution	25	-	-	90	2.250	90	2.250	+ 90	+ 2.250
Soil gas survey	15	-	-	-	-	-	-	=	=
Piezometers	50	-	-	-	-	-	-	=	=
Reclaim	300	-	-	7	2.100	7	2.100		
Monitoring	4	-	-	-	-	-	-		
Cathodal protection	15	-	-	-	-	-	-	=	=
Automatic meters	15	-	-	-	-	-	-	=	=
Total			-		5.160		5.160		+ 3.060

Data source: *Italiana Petroli SpA, 1996.*

Management at lower penalties risk

The second step is the management at lower penalties risk. In this case the company minimize the risk of potential environmental penalties related to the oil spills, but the company does not identify the higher risk service stations and implements a end-of-pipe policy by only *ex-post* actions (reclaiming costs). In this case the aim of the company is to minimize the penalties risk increasing the reclaiming actions. The direct effect on the income statement of the company is an increase of the costs without benefits on the balance-sheet side.

Table 4 Management at lower penalties risk

Management at lower penalties risk (Base)

Action	Cost	Max risk S.S. No.	Max risk S.S. Expenses	Other S.S. No.	Other S.S. Expenses	P/L account No.	P/L account Cost	Assets No.	Assets Value
Loss procedure	1	-	-	-	-	-	-		
Environmental audit	1	-	-	-	-	-	-		
Seal test	1	-	-	-	-	-	-		
Vetrification	9	-	-	90	810	90	810	+ 90	+ 810
Tank substitution	25	-	-	90	2.250	90	2.250	+ 90	+ 2.250
Soil gas survey	15	-	-	-	-	-	-	=	=
Piezometers	50	-	-	-	-	-	-	=	=
Reclaim	200	-	-	25%	-	45	9.000		
Monitoring	4	-	-	-	-	-	-		
Cathodal protection	15	-	-	-	-	-	-	=	=
Automatic meters	15	-	-	-	-	-	-	=	=
Total			-		3.060		12.060		+ 3.060

Data source: *Italiana Petroli SpA, 1996.*

Proactive environmental management (Year 0)

The company identifies the higher risk service stations and implements a proactive strategy investing in the *ex-ante* actions. In this case the company, using the statistical model described above, can identify the maximum risk service stations. The costs in

[20] S.S. = service station

the income statement are higher than in the *Base* case, but the oil spill risk is minimized for the future periods. In this case the reclaim costs are at the same level of the *Base* case because they reflect the past management. In the future period they will decrease because of the preventive strategy. Some kind of costs are evaluated as investments and are capitalized[21] increasing the value of the company (Table 5).

Table 5 Proactive environmental management (Year 0)

Proactive environmental management (Year 0)

Action	Cost	Max risk S.S. No.	Max risk S.S. Expenses	Other S.S. No.	Other S.S. Expenses	P/L account No.	P/L account Cost	Assets No.	Assets Value
Loss procedure	1	50	50	-	-	**50**	**50**		
Environmental audit	1	100	100	-	-	**100**	**100**		
Seal test	1	60	60	-	-	**60**	**60**		
Vetrification	9	23	207	67	603	**90**	**810**	**+ 90**	**+ 810**
Tank substitution	25	19	475	71	1.775	**90**	**2.250**	**+ 90**	**+ 2.250**
Soil gas survey	15	47	705	-	-	**47**	**705**	**+ 47**	**+ 705**
Piezometers	50	26	1.300	-	-	**26**	**1.300**	**+ 26**	**+ 1.300**
Reclaim	200	9	1.800	36	7.200	**45**	**9.000**		
Monitoring	4	65	260	-	-	**65**	**260**		
Cathodal protection	15	7	105	-	-	**7**	**105**	**+ 7**	**+ 105**
Automatic meters	15	11	165	-	-	**11**	**165**	**+ 11**	**+ 165**
Total			**5.227**		**9.578**		**14.805**		**+ 5.335**
Difference with respect to Base							**+ 2.745**		**+ 2.275**
Total amount							**14.805**		**+ 5.335**

Data source: *Italiana Petroli SpA, 1996.*

Proactive environmental management (Year 1)

The proactive strategy provides positive results in the medium period. At the *Year 1* the company invested in the preventive actions which have positive results in the second period. As the table 6 shows the reclaim costs fall (the number of reclaims decreases to 36) and the effect on the income statement is positive if compared with the *Base* period. Therefore IP can evaluate the benefits of the preventive strategy immediately. In the *Year 1* the company benefits in the balance-sheet can be evaluated 1.600 Lire. As we saw, in this evaluation the image benefits, and the potential avoided costs (e.g. penalties) are not taken into account at quantitative level. In any case the effect on the company accounts would be positive.

Proactive environmental management (Year 2)

In the medium period (*Year 2)* the company can really evaluate the benefits of the proactive strategy: the table 7 shows that the reclaiming costs decrease even if there is an increase in the monitoring costs which are part of the preventive approach[22]. The benefits in the income statement are about 5.600 Lire.

The main interesting results of this evaluation is the multi period analysis in which the different effects of the two strategies are compared (table 8 and figure 10). The proactive strategy can have positive effects on the profitability of the company, but at the same time can improve the value of the assets (and therefore of the company). This

[21] The capitalization increases to 5.335 with respect of 3.060 in the *Base* case.

[22] Comparison between table 7 and table 4.

result has much importance if referred to the market competition in which the purpose is the profit[23].

Table 6 Proactive environmental management (Year 1)

Proactive environmental management (Year 1)

		Max risk S.S.		Other S.S.		**P/L account**		**Assets**	
Action	Cost	No.	Expenses	No.	Expenses	**No.**	**Cost**	**No.**	**Value**
Loss procedure	1	-	-	-	-	**-**	**-**		
Environmental audit	1	-	-	-	-	**-**	**-**		
Seal test	1	-	-	-	-	**-**	**-**		
Vetrification	9	9	83	81	727	**90**	**810**	**+ 90**	**+ 810**
Tank substitution	25	14	356	76	1.894	**90**	**2.250**	**+ 90**	**+ 2.250**
Soil gas survey	15	-	-	-	-	**-**	**-**	=	=
Piezometers	50	-	-	-	-	**-**	**-**	=	=
Reclaim	200	2	400	34	6.800	**36**	**7.200**		
Monitoring	4	65	260	-	-	**65**	**260**		
Cathodal protection	15	-	-	-	-	**-**	**-**	=	=
Automatic meters	15	-	-	-	-	**-**	**-**	=	=
Total without new investment			**1.099**		**9.421**		**10.520**		**+ 3.060**
Difference with respect to Base							**- 1.540**		=
Preventive vetrification						**-**	**-**	=	=
Preventive substitution	70%					**44**	**1.100**	**+ 44**	**+ 1.100**
Soil gas survey (more)						**-**	**-**	=	=
Piezometric (more)	30%					**10**	**500**	**+ 10**	**+ 500**
Anticipated reclaim						**-**	**-**	=	=
Green communication						**60**	**-60**		
Total with new investment							**12.060**		**+ 1.600**
Total amount							**26.865**		**+ 9.995**

Data source: *Italiana Petroli SpA, 1996.*

[23] ENI SpA and IP with the other controlled companies have been recently privatized even if the Treasury is the main shareholder still. The privatization has had positive effects on the preventive strategy implementation.

Table 7 Proactive environmental management (Year 2)

Proactive environmental management (Year 2)

Action	Cost	Max risk S.S. No.	Max risk S.S. Expenses	Other S.S. No.	Other S.S. Expenses	P/L account No.	P/L account Cost	Assets No.	Assets Value
Loss procedure	1	-	-	-	-	-	-		
Environmental audit	1	-	-	-	-	-	-		
Seal test	1	-	-	-	-	-	-		
Vetrification	9	6	52	40	364	46	415	+ 46	+ 415
Tank substitution	25	5	119	57	1.420	62	1.539	+ 62	+ 1.539
Soil gas survey	15	-	-	-	-	-	-	=	=
Piezometers	50	-	-	-	-	-	-	=	=
Reclaim	200	-	-	21	4.200	21	4.200		
Monitoring	4	65	260	-	-	-	260		
Cathodal protection	15	-	-	-	-	-	-	=	=
Automatic meters	15	-	-	-	-	-	-	=	=
Total without new investment			**431**		**5.984**		**6.414**		+ 1.954
Difference with respect to Base							- 5.646		=
Preventive vetrification						-	-	=	=
Preventive substitution	20%					45	1.125	+ 45	+ 1.125
Soil gas survey (more)	15%					56	840	+ 56	+ 840
Piezometric (more)	20%					22	1.100	+ 22	+ 1.100
Anticipated reclaim						-	-	=	=
Green communication	45%					2.580	2.581		
Total with new investment							**12.060**		+ 3.065
Total amount							**38.925**		+ 15.014

Data source: *Italiana Petroli SpA, 1996.*

Table 8 Comparison (3 Years)

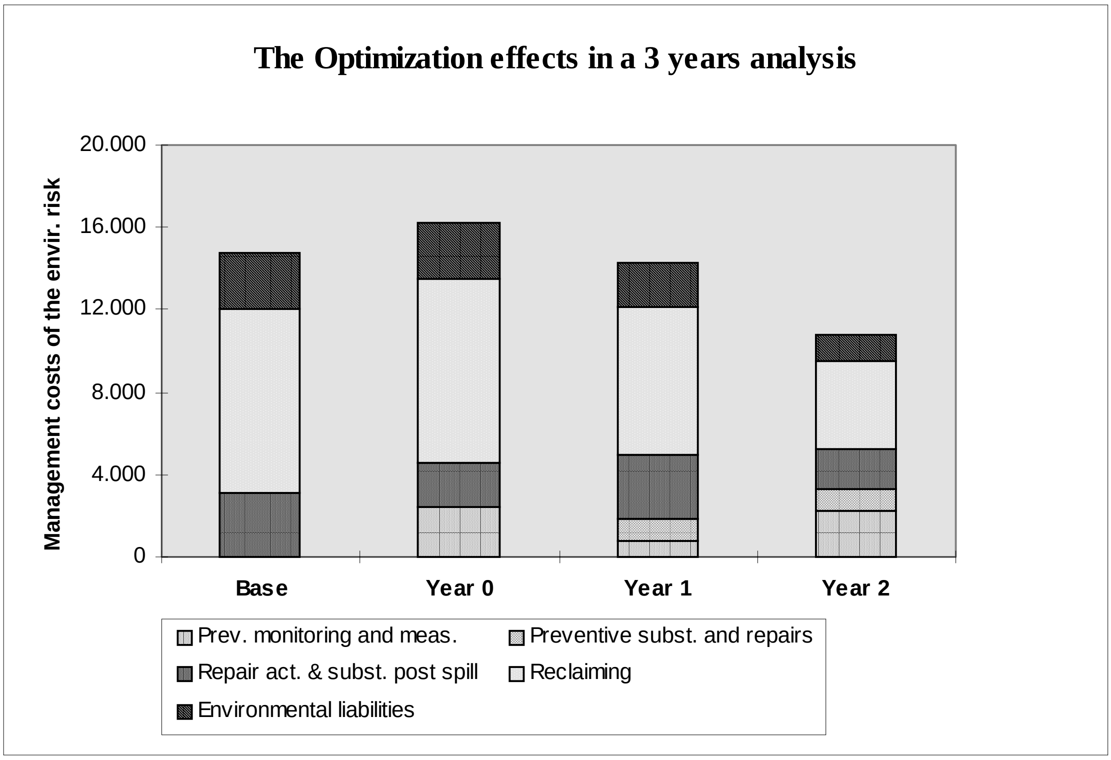
Comparison (3 Years)

		Not optimized	Optimized	Diff. P/L	Diff. assets
With periodical investment (1)		**36.180**	**38.925**	+ 2.745	+ 5.834
With optimized investment		**36.180**	**36.404**	+ 224	+ 5.834

(1) The positive effects of the green image communication are not included

Data source: *Italiana Petroli SpA, 1996.*

Figure 10 The Optimization effects in a three years analysis



	Base	Year 0	Year 1	Year 2
Prev. monitoring and meas.	0	2,475	760	2,200
Preventive subst. and repairs	0	0	1,100	1,125
Repair act. & subst. post spill	3,060	2,060	3,060	1,954
Reclaiming	9,000	9,000	7,200	4,200
Environmental liabilities	2,700	2,700	2,160	1,260

Data source: *Italiana Petroli SpA, 1996.*

CONCLUSIONS

The Environmental Management Accounting at Italiana Petroli has grown spontaneously. Even if the company does not follow the American Literature and there is not some specific links to the economic accounting theory, the environmental accounting has developed specific tools to reconcile the environment and the profit.

IP evaluated the costs of the reclassification accounting data after the initial entry and decided to include the data related to the environment when data are entered. The company has therefore modified the accounts of the management accounting system.

This result shows a flexibility of the company to adapt its accounting system to the necessity of the management.

On the other side, IP has not created specific provisions for future liabilities which could be related to the company activities, and a lot of costs and benefits are still evaluated at qualitative level in the risk assessment analysis. In any case the environmental risk accounting system represents a step of the environmental management system according to the EU Regulation 1836/93 (*Emas*), in particular it is related to the impact assessment.

The aim of the company in the future is to extent the environmental risk evaluation in the economic application: for instance IP is now evaluating the economic implication of the risk assessment on the insurance costs. In fact the company knows which are the high risk station services and could therefore obtain a lower insurance premium.

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Removing Emotion from the Environment - A Multi-attribute Stakeholder Wide Approach to Resolving Conflicts in Company Decision Making

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ABSTRACT

Increasingly, decision makers in industry are being faced with complex and emotive investment decisions created by a conundrum of stakeholder expectations. Investments with the potential to impact on a company's environmental performance are a prime example of this and share many of the following facets:

- They are complex with multi-dimensional impacts many of which are difficult to quantify.
- The decision outcome is stakeholder sensitive.
- Stakeholders often seem to have contradictory or emotional requirements.
- The final decision could face regulatory and/or public scrutiny.

The Stakeholder Value Analysis (SVA) Toolkit which has been developed through a portfolio of industrial applications is presented as a methodology to tackle these challenges. Each stage of the methodology is detailed and an industrial application of the methodology is presented. This is able to highlight the principle strengths of the SVA approach, as follows;

- **Clarifies and structures** complex problems
- Supports a decision team in measuring the **risk of an investment** by seeking and measuring stakeholder views and value trade-offs governing the decision
- Builds towards a decision option which **maximises total stakeholder wide value,** rather than trying to seek consensus
- Provides a **quantitative basis** for defining the nature and extent of conflicts and the significance of these on the decision.
- Provides a central framework to focus attention on the **real issues** and so help to progress the process to a more **logical outcome**.

THE EMOTIONAL CONTEXT OF ENVIRONMENTAL DECISIONS

The environment, and how governments and companies impact it through their decisions, is a complex and often controversial and emotional subject. In part this is explained by the potentially numerous and diverse stakeholder groups24 affected by such decisions many of whom on the surface seem to have contradictory and highly

24 Stakeholder groups are defined here as more-or-less organised group of people who stand to be affected by the implications of a decision and who can directly or indirectly influence the consequences of the decision. For example enraged customers may choose to boycott a certain product.

emotive environmental stances. On the other hand the decision makers25 themselves may be hesitant to engage in debate with these same groups driven by a fear that this may result in a stalemate of conflicting demands or, even worse, in a lengthy, acrimonious and confusing public debate.

Effective management of such debates is complicated by the fact that decisions which can impact on the final environmental performance of a project typically involve multiple objectives and therefore value trade-offs. Furthermore it is likely that the decision process may hinge on intangible benefits, such as environmental image, and the benefits and costs of the investment may evolve over a long time horizon.

A leading example of a decision sharing some of these characteristics is the original and unsuccessful bid for offshore decommissioning of the Brent Spar. Here Shell (the decision maker) and Greenpeace (a stakeholder) ended up talking past each other looking for impact via media play rather than aiming for effective communication resulting in understanding and constructive compromise.

DECISION ANALYSIS - A FRAMEWORK FOR COMPLEX STAKEHOLDER WIDE DECISION MAKING

Clearly when public bodies or private sector corporations are faced with decisions with high stakes, complicated structure and which require widespread justification to the stakeholders of the decision, it is no longer possible simply to avoid trade-offs, consultation and open justification.

One response to this predicament, predominantly from within the public sector, has been the application of Cost Benefit Analysis (CBA) techniques, based around neo-classical environmental economics and its attempts to place financial valuations on environmental (and social) performance attributes. Apart from failing to deal specifically with the issue of stakeholder value conflicts, this technique has faced widespread practical and theoretical criticism for its "dubious theology" [i], and for sometimes producing enormous discrepancies between different approaches and studies. [ii, iii, iv, v, vi]

It is no surprise to the author therefore that there has in recent times been an upsurge in interest, particularly in the public sector, in multi-attribute decision analysis techniques. Decision analysis, as it is more simply known, can be defined on different levels but is perhaps best described by Keeney [vii] as "a formalisation of common sense for decision problems which are too complex for informal use of common sense". Keeney carries on to describe the methodology of decision analysis, which he decomposes into four steps:

1. Structure the decision problem,
2. Assess possible multi impacts of each alternative,
3. Determine preferences (values) of decision makers, and
4. Evaluate alternatives

Arguably, the area which has seen the greatest upsurge in applications in recent years has been energy. Keeney [vii] cites numerous examples in the US, whilst in the UK,

25 Decision makers are the stakeholder group charged with analysing and justifying a decision choice to all other stakeholders of the decision.

the Nirex study, is a good if rather controversial example of the use of decision theory in its strictest sense [viii,ix].

Multi attribute decision analysis is arguably a potentially highly effective tool for use in making difficult decisions involving a mixture of technical, social, environmental and economic considerations. Unfortunately however, the technique’s full potential has often, been stifled through a failure to integrate stakeholder views and values into the decision process. A particularly good example26 of this flawed approach is described by Merhofer [x] and summarised here as Figure 9.

Design of a Restoration Priority System

The decision in question concerns the attempt by the US Department of Environment (DOE) to design and apply a multi attribute priority model (known as the Environmental Restoration Priority System (ERPS)) to allocate budget funds for clean up between different contaminated sites.

Consistent with the DOE's goal to open up the decision making process, the ERPS design team were charged to develop and implement the model through participation with all interested parties. In this regard the process started well with the setting up of an External Review Group (ERG) made up of representatives of affected states, Indian Tribes, national governmental organisations, interest groups and the EPA.

Unfortunately, although members of the ERG were involved in the preliminary design of the ERPS tool, they were subsequently alienated from its final design stages, and perhaps most importantly from its initial implementation. It is no surprise that the ERG members responded with the following statement "..No prioritisation system will be acceptable if it does not provide for meaningful involvement by states, tribes, and other interested parties in the implementation of the system..".

In fact, although a few members of the ERG granted that the ERPS tool had some merit, most insisted that the DOE had ignored their concerns. It is not surprising to find that although the ERG were dissolved this did not put an end to the members active opposition. Ultimately, the DOE were forced to cede that the priority system was "unworkable... because of a combination of technical problems, and lack of regulator and public involvement" and thus led to the shelving of the model after only 2 years use.

Figure 9 Example of an unsuccessful decision process

A NEW AGENDA - INTEGRATING STAKEHOLDER VALUES IN THE CORPORATE SECTOR

Looking now at the corporate sector, it is worth opening the discussion with the now famous example of a decision that went totally wrong - Shell's initial decision to dispose of the Brent Spar at sea. Purely from a short term financial viewpoint based on lost revenues from the boycott of Shell products in Germany, the decision has been a very costly one. This no doubt explains why Shell are now committed to a public consultation, under the heading “The Way Forward”, to try and define the eventual fate of the Brent Spar [xi,xii].

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26 The Nirex studies are equally representative in this respect.

This process was officially started with an inaugural seminar staged by Shell Expro27 in conjunction with the Environment Council on 1st November 1996 to which a mixture of people28, with a wide cross section of views and concerns on the Brent Spar were invited to comment on the possible disposal options and on the criteria for choosing the Best Practicable Environmental Option (BPEO) for the Brent Spar.

Shell for their part claim to want to use the feedback from the inaugural meeting to inform their shortlisting process. At this point it is worth highlighting some of the major recommendations resulting from the workshop sessions held at the first inaugural seminar. Quoting directly from the Environmental Council report [xiii] of this event, with respect to Shell's methodology for defining the BPEO (author's emphasis);

> *"Shell should publish its proposed method (for finding the BPEO) - especially analysis, ranking and weighting and sensitivity analysis to be used in the final BPEO. Get independent authority/expertise to endorse the method - to carry trust and confidence into the process".*
>
> *"Shell need to know how different stakeholders would weigh criteria"*

Similarly in the same report's executive summary, the report's authors state;

> *"This report clearly indicates that the final selection to determine the preferred solution will have to resolve and rationalise widespread concerns over marine, land, and air pollution, then compare and weigh them against safety, risks, costs and societal value"*

On these recommendation therefore it can be concluded that the success of Shell's "Way Forward" [xi, xii] process hinges critically on Shell being able to measure and incorporate stakeholder views on relative priorities into the BPEO decisions process.

Although the situation with Shell is an extreme case it is by no means unique, rather it illustrates many of the problems faced by industry. It is clear that pressures on companies to conform to social values is growing and this is by no means a bad thing for business. Indeed, the Brent Spar case shows that a company must consider not only a wider set of costs and threats, but also benefits and opportunities during their decision process and this process can best be managed by working together with their stakeholders. Although a somewhat alien concept at first for some companies, the process of internalising stakeholder values is by no means counterintuitive to the aim of a business achieving its short and longer term strategic objectives.

DEVELOPMENT OF A TOOL FOR STAKEHOLDER VALUE ANALYSIS

Based on the foregoing analysis the scene would seem to be set. Until recently, many business managers have been isolated from external pressures. However, they are now being forced either directly (e.g. through regulation) or indirectly (by their customers) to consider wider stakeholder demands in their decision process. This phenomenon is

27 Shell Exploration and Production (Shell Expro) are the division of Shell directly responsible for the Brent Spar.

28 Could also be described as stakeholders

nowhere more pronounced than when companies need to consider investment options which may have different levels of environmental performance and consequently may impact different stakeholder groups.

Since these very same stakeholder groups can potentially have a considerable influence on the final impact of a company’s decision, be it on sales revenue, market share or some other strategic indicator, there is a clear incentive to consider these prior to making an actual investment choice.

Clearly the concept of seeking to incorporate the views of stakeholders who would conventionally not be involved in a company’s decision process may be controversial and, to certain decision makers, alarming. In this respect therefore it is important to stress that there are no hard and fast rules on the extent to which stakeholders should be involved. This should always remain a decision context driven question. Stakeholder involvement in the decision process could therefore range from seeking views of stakeholders entirely within the company itself to integrating the views of a wide and diverse external stakeholder audience.

It is with these challenges in mind that the author's Engineering Doctorate (EngD) research project which is jointly sponsored by Paras Ltd and University of Surrey's Centre for Environmental Strategy has resulted in the development of the Stakeholder Value Analysis (SVA) Toolkit. The SVA Toolkit builds on the author’s previously developed Total Value Analysis (TVA) model [xiv,xv] and sponsor company’s Paras financial model for environmental investments [xvi,xvii].

Figure 10 illustrates the SVA Toolkit structure, components and feedback mechanisms.

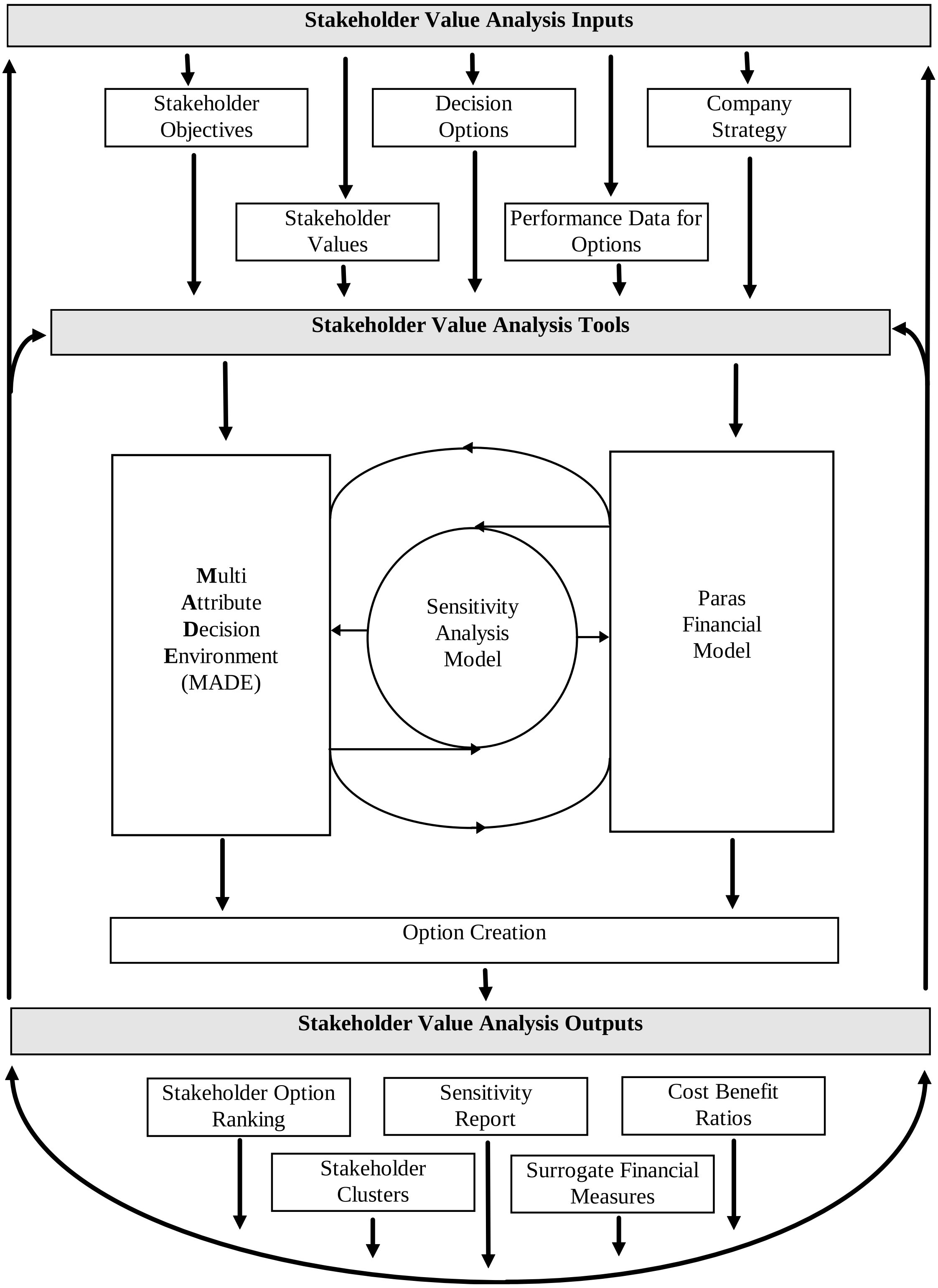

Figure 10: Stakeholder Value Analysis Toolkit29

29 The Paras financial model is the subject of previous papers by the author. Although included within the Toolkit as shown it is not specifically discussed within this paper.

The three basic elements of the SVA Toolkit are;

1. The inputs to the Toolkit models.
2. The Toolkit's decision and analysis models, which include,
    2.1. The Multi Attribute Decision Environment (MADE) which is the central tool used for defining, valuing and processing stakeholder values,
    2.2. The Paras financial model which has been develop by Paras Ltd and supports the financial quantification of a wider array of attributes, e.g. environmental liabilities, insurance and capital costs, and
    2.3. A sensitivity analysis model for checking the robustness of option rankings and the analysis' recommendations.
3. Outputs from the models for use in decision making.

Subsequent sections will outline the theoretical and practical underpinning of the SVA Toolkit and in particular its fulcrum the MADE model.

STAKEHOLDER VALUE ANALYSIS TOOLKIT - STEPS FOR USING THE MADE MODEL

The Multi Attribute Decision Environment (MADE) model provides a framework to capture and process stakeholder wide views, opinion and knowledge (inputs) on a decision. Using a multi attribute decision methodology it integrates these multi variate metrics to produce output performance indicators which can usefully be employed by company decision makers to assess the stakeholder wide implications of possible decision options, and also to assess the implications of the decision on the company's longer term strategic objectives. The steps following by the MADE model are illustrated in Figure 11 below and detailed in the proceeding sections.

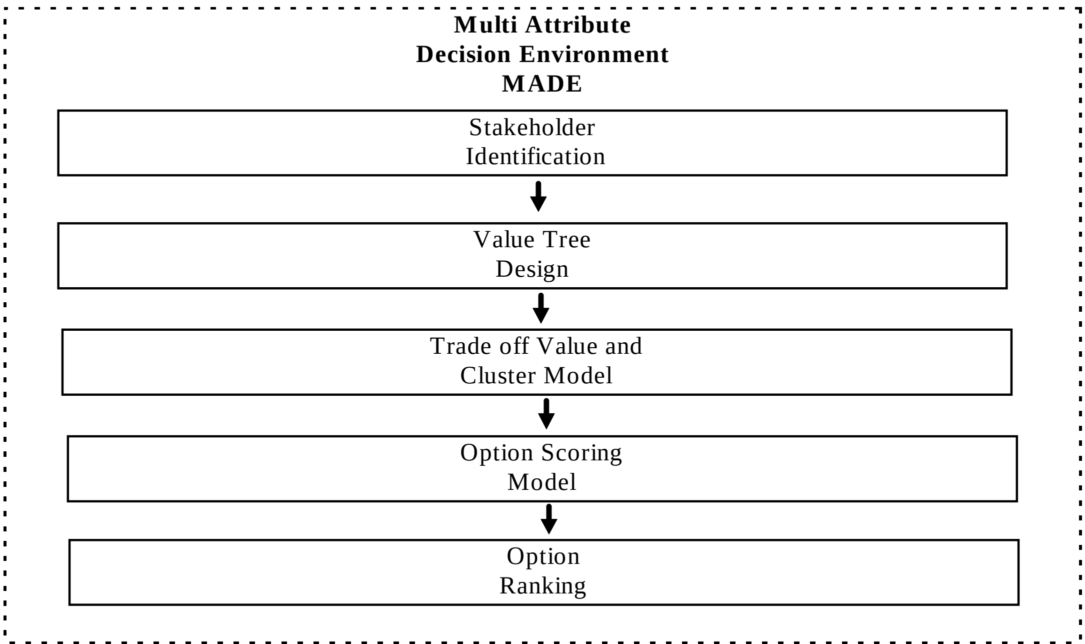

Figure 11 Multi Attribute Decision Environment Flow Scheme

Stakeholder Identification

The first step in the MADE process involves identifying the relevant stakeholders of the decision. In this context the definition of a stakeholder encompasses not only stakeholders external to the company, such as customers, but also includes internal stakeholders such as employees and company owners.

In this respect therefore the SVA methodology is in no way limited by the nature or scope of the decision. The SVA Toolkit is therefore equally applicable for decisions which are not expected to impact externally to the company, in which case only internal stakeholder involvement will be necessary.

The stakeholder identification procedure can result in the identification of a long list of stakeholders. This research has created lists of 15-20 organisations, however it has been relatively easy to "cluster" these groups on the basis of prior knowledge about the views and the people they represent. It is therefore neither necessary nor advisable to interact with all groups. Indeed the research has found it is possible to limit the stakeholders to a short list of between 5 and 10 groups.

Value Tree Design

The next step in the process involves finding out what each stakeholder cares about, the aim being to identify and structure the values (performance attributes) they consider relevant for evaluation of the decision options.

The MADE methodology includes a generic questionnaire to use on a one to one basis with the leading stakeholder representatives. During the stakeholder interviews it is important not to lead or prompt the stakeholder. The author has found it best practice not to offer any suggestion for the likely performance attributes within the questionnaire and leave this task solely up to the stakeholder.

Following directly from the interviews the analyst can for each separate interview structure a hierarchy of values, referred to here as a value tree. A value tree's hierarchical levels follow directly from definition of an overall aim for the project at the top (termed the top level aim), to performance attributes that contribute to achieving the top level aim, to third level sub criteria (which jointly contribute the second level criteria directly above) and so forth. The process starts at the more general (and sometimes uncertain) and moves towards the more particular and concrete. The aim is to reach a level of detail at the bottom of the tree so that different decision options can be directly measured against the bottom level criteria.

The final step is to generate a stakeholder wide value tree. This can be an intellectually challenging process, since firstly the tree could end up very large and secondly to avoid redundancy it will be necessary to merge certain stakeholder "branches" which overlap one another to a common yet equally acceptable representative definition.

The goal, which this work has found to be attainable, is to obtain a structure that from each stakeholder's perspective contains as a subset the values of the group. Likewise from an operational view, Keeney suggests that the decision analyst should ensure that the set of attributes (branches) are complete, operational, decomposable, non-redundant and minimal [xviii]. As such they should effectively provide a "road map" to help the decision makers and stakeholders visualise and conceptualise the decision problem.

Definition and Clustering of Value Trade-Offs

Value trade-offs or weights are the mechanism by which it is possible to reflect the different priorities of stakeholders. The basic premise is that important attributes in the value tree receive high weights, unimportant attributes get low weights. It is therefore possible for different stakeholders to agree on a common value tree even though their value preferences are different since these can be represented through their own weighting of the branches.

Whilst stakeholder-specific weights offer an elegant method to represent each stakeholder's value tree, there are obvious difficulties with this approach. Firstly given a large number of performance attributes it can be a complex and bewildering task to try simultaneously to assign actual numerical weights to all the performance attributes shown in the value tree.

Secondly geometric averaging of the weights defined for different stakeholders can seriously degrade the value of the analysis. For example if one stakeholder group assigns a very high weight (95%) and another a very low weight (5%) to a performance attribute, the average of these two weights, 50%, is not necessary representative for either or both stakeholder group.

The MADE model employs two separate methodologies to deal with these challenges.

Pairwise Comparison Model for Weights and Consistency Definition

The methodology used to support this task is based on the pairwise comparison technique used by Saaty in his Analytical Hierarchy Process [xix]. The pairwise method which lies at the heart of the AHP technique offers an intuitive and appealing method for eliciting the weights stakeholders place on the branches (performance attributes) in a value tree.

The principle advantage of the pairwise comparison method over other weighting techniques is that it allows users to methodically and systematically determine their weights for a value tree hierarchy's performance attributes simply by comparing **pairs** of attributes one at a time. At the same time it is relatively simple to use. This is an essential ingredient if the weights of lay persons are sought.

It is fair to say that there are numerous opponents [xx] and proponents [xxi] of Saaty's pairwise technique as a method for weight definition. It is sufficient to say here that these centre principally around technical issues; for example, which mathematical procedure is best suited for extracting weights from a pairwise comparison matrix. Research by Golany [xxii] which compares the Eigenvector approach proposed by Saaty and used by the MADE weighting model with 5 other methods concludes that the Eigenvector approach is not dominated by any other of the methods investigated.

Although the Logarithmic Least Squares (LLS) method is shown to deal best with situations where there is incomplete information from decision makers, it fails to produce an inconsistency index for the matrix. To date, this research has shown that the calculation of a consistency index is a fundamental and important element of the technique, whilst incomplete information has not been a problem. Consequently the author feels justified in using the Eigenvector method rather than other techniques for calculating weights from pairwise comparisons.

Stakeholder Cluster Method

The underlying basis for the cluster model is that it is possible to find groups or "clusters" of stakeholders who share broadly similar priority weights. A useful technique for finding the stakeholder "clusters" is to invite stakeholders to a group meeting or seminar.

To start the meeting it is useful to carry out a short screening exercise to determine the basic priority ranking (not explicit weights) of values for the various stakeholders. Working from this standpoint it is possible to subdivide the large group into smaller sub-sets of stakeholders with predominantly similar values.

Individuals from each group can then be led through the pairwise comparison method to elicit their weights. Since the calculation is relatively simple results can be fed directly back to the stakeholder. Using their own weights as reference and those calculated for the cluster group as a whole (based on an a geometric average of all weights calculated), stakeholders are then encouraged to discuss and agree on the groups' weights.

Although this process may sound confrontational, in practice the author has found that group members generally find the process leads to a fair and just representation of their priority weights.

Option Scoring Model

This step in the process involves defining the relative performance scores for each option against each performance attribute defined at the bottom level of the value tree. This step of the process is generally much less controversial than the value judgements required in the weighting process. In fact if the value tree has been carefully designed the performance attributes being scored should be well suited to quantitative objective scoring of options by suitably qualified experts.

The performance scoring method employed by MADE departs from the AHP ratio scaling method. Primarily because the AHP method is not suited to relative ratio measurement of final rank scores, and secondly to avoid the pitfalls of rank reversal, a phenomena for which the AHP technique as applied by Saaty is much criticised [xxiii].

Instead the MADE model uses an interval scale “word” model technique. A "word " model uses an absolute scoring system. This means that it is possible to generate scores for each investment option which lie between an upper and lower bound and can be directly compared with one another and to set benchmarks.

The word models used by the MADE tool always follow a fixed template which is set to include;

- A written description for each score from 0 to 100 in intervals of 25.
- An industry and performance attribute specific guide value for each written description.

Using this template it is possible to design word models which are specific for each MADE analysis.

Option Analysis

This stage of the process involves two stages.

1. Ranking options
2. Sensitivity and robustness testing

Calculation of compound performance scores for each option involves multiplying the word model scores by the branch weights and adding these together. These cumulative scores then define the performance score for the next hierarchical level of that branch, which are multiplied and summed in the same way until a top level score is calculated. Calculated scores (ranging between 100 and 0) at the top level of the value tree are then representative of the option's performance in meeting the top level aim for the project. This process can be repeated using weights specified by each stakeholder cluster to determine stakeholder specific option rankings.

Although the results analysis produces a plethora of metrics, they are all linked by a common theme - their relationship within the stakeholder-wide value tree. Consequently this provides a decision team with numerous possibilities for analysing the performance data. The ultimate aim naturally being to reach a decision which best meets the multi performance criteria and trade-off values of the stakeholders of the decision.

At this stage it is useful to check the robustness of the ranking through a sensitivity analyses, which can determine any sensitivities in option ranking to weights and or performance scores.

Option Creation

The final stage of the SVA process involves finding an option which satisfies the majority of the main concerns of the stakeholders. Strictly speaking this process step is not part of the MADE model and is therefore shown separately in Figure 10.

The option creation process step is required because there may not be an option within the list originally considered which is acceptable to the stakeholder set. This step in the SVA process therefore supports the creation of a new option, possibly based on a combination of analysed options which maximises total value of the decision taking into account all stakeholder value trade-offs. Although not strictly necessary it may be necessary to iterate around the SVA loop until a satisfactory option has been identified.

While nothing guarantees that this can be done, detailed assessment of weights followed by an attempt to design options that exploit them by serving highly weighted values is intuitively an attractive and promising approach. At the very least the process itself will help the decision team and stakeholders to focus on the issues of greatest importance. Even if it is found there are irresolvable conflicts, identification of the basis for the conflict will in most cases be an important contribution towards a more rewarding and responsible solution.

APPLICATION AND VALIDATION OF THE SVA TOOLKIT

Development of the SVA methodology has throughout been supported and validated through real life industrial applications. The current research portfolio includes firm proposals with eight multi-national companies. So far this has resulted in five separate applications of the methodology. Of these an application with British American Tobacco is briefly summarised here. Interested readers can also refer to the authors previous publication [xv] which details another test case.

British American Tobacco - Investment to Abate Odour

<u>Objective</u>

To measure the total stakeholder value from the company's decision to invest in a biofilter to abate odour from its manufacturing site.

Stakeholder Focus

The principle pressures faced by British American Tobacco are from stakeholder groups living and working locally to its site. One of the objectives behind British American Tobacco’s investment was therefore to build and improve relations with their local stakeholders.

Methodology

The SVA Toolkit methodology was applied to measure stakeholder priorities and perceptions of British American Tobacco in light of its decision to invest in a biofilter. A two phase approach was adopted as follows.

Internal Stakeholder Value Analysis

Eight separate interviews were carried out with stakeholders from within the company. A wide spread of responsibilities were covered ranging from director to operations manager level. The results of the interviews were used to help define the company objectives for the biofilter investment and also to place this investment into context with the company's plans for site expansion. The principle value drivers of the biofilter identified through the internal interviews were as follows;

- Improve relations with local neighbours
- Improve relations with local decision makers
- Reduce risk of statutory notice
- Help achieve planning permission for new production facilities within the site.

External Stakeholder Value Analysis

In order to measure the biofilter's value impact on British American Tobacco interviews were carried out with key external stakeholder groups.

The following stakeholders were identified;

- Both local Members of Parliament
- Four local ward councillors
- Representatives from both local resident associations
- Environmental Health and Safety Officer
- Planning Officials

Total Value and Gap Analysis

The external stakeholder interviews which were carried out on an informal basis did not attempt to ask stakeholders to numerically score the biofilter’s impact on their relations with British American Tobacco. Instead more open ended questions were asked which encouraged the stakeholder to talk about their perception of the company, how this had changed with the biofilter investment and how important it had been to them that the company had opted for a high efficiency, state of the art, technology option. In general the feedback from this process can be categorised as follows;

1. British American Tobacco’s dialogue process which had included an open day to present plans for the biofilter was seen as a positive step.
2. British American Tobacco is perceived as a good neighbour and one which contributes to the local environs and economy. The biofilter was seen as further proof of this.

3. British American Tobacco has generally responded positively to past complaints. There were high expectations by stakeholders for the company to respond to the odour problem.
4. Decision makers saw the biofilter as the BPEO solution and valued the fact that the company did not attempt to install a less efficient device.
5. Strong indications were given that there would have been resistance to British American Tobacco's plans for site expansion without the commitment to build a biofilter.
6. The biofilter was seen as a natural and "green" solution to the odour problem which added to positive stakeholder perception of the company.

Taken together the stakeholder interviews showed the importance of the biofilter to the maintenance of British American Tobacco's public image and its development plans. Indeed in one of the interviews a decision maker contrasted British American Tobacco's approach to that of another local company which had failed to obtain planning permission on the basis of poor past environmental performance and discord with local stakeholders.

The interviews also examined the relative priorities the external stakeholders placed on the most significant impacts of British American Tobacco's site on the surrounding area and populous. Of the eight impacts studied, odour was consistently ranked as being at least the third most important impact, and the top ranked impact if the overall average across all stakeholders weights was calculated. The decision to invest in a state of the art biofilter, which the local EHO officer has agreed is the BPEO for odour control is therefore shown to strategically address the primary concerns of both local residents and decision makers.

CONCLUSIONS

Increasingly decision makers in industry are being faced with complex and emotive investment decisions created by a conundrum of stakeholder expectations. Investments with the potential to impact on a company's environmental performance are a prime example of this and share many of the following facets;

- They are complex with multi dimensional impacts many of which are difficult to quantify.
- The decision outcome is stakeholder sensitive.
- Stakeholders often seem to have contradictory and often emotional requirements.
- The final decision could face regulatory and/or public scrutiny.

The SVA Toolkit which has been developed through a portfolio of industrial applications offers a methodology to tackle these challenges. Its principal features are;

- **Clarifies and structures** complex problems
- Supports a decision team in measuring the **risk/impact of an investment** by seeking and measuring stakeholder views and value trade-offs governing the decision
- Builds towards a decision option which **maximises total stakeholder wide value,** rather than trying to seek consensus

- Provides a **quantitative basis** for defining the nature and extent of conflicts and the significance of these on the decision.
- Provides a central framework to focus attention on the **real issues** and so help to progress the process to a more **logical outcome**.

FUTURE RESEARCH AND POSSIBLE ALTERNATIVE APPLICATIONS

The research findings at this stage of the SVA Toolkit indicate a number of interesting applications of the SVA Toolkit, which the EngD research project aims to explore further.

These are as follows;

1. **To Support Environmental Burden Choices**. Life Cycle Analysis (LCA) is a thorough analytic tool for calculating life cycle burdens of functional units. One of the major problems with its application is in assigning weights to the environmental burdens. Little stakeholder input is sought and consensus is difficult to find. The SVA Toolkit could provide a medium for stakeholder participation in defining the environmental impact weights and hence help reach a position of unanimity.
2. **To Support Strategic Decisions**: For example to help strategy planners make choices on a company's technology and product portfolios that best optimise the aims and objectives of the its stakeholders.
3. **Communication Strategy Development Tool**: To help companies design and develop their external and internal communications (for example Environmental Performance Report) to bring maximum benefit. This SVA Toolkit would allow the company to measure and prioritise stakeholder information requirements vis-à-vis their environmental performance. On the basis of this information it should then be possible to optimally design a communication strategy that best meets the company's stakeholders information requirements and as a consequence maximises value to the company.

Research into Stakeholder Value Analysis of environmental investments is continuing in the form of a collaborative academic and industrial research project. This is being led by Graham Earl who is a research engineer sponsored by Paras Ltd and funded by the Engineering Doctorate (EngD) programme at Surrey University’s Centre for Environmental Strategy.

In this respect the author is currently actively seeking companies who would be interested in contributing to this research through a test case, be it in the form of past or planned environmental investment decision. He also welcomes any suggestions or queries from interested parties. Readers interested in obtaining a more in depth description and information on the SVA methodology and the other applications in industry are encouraged to contact the author direct.

ACKNOWLEDGEMENTS

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Financial Aspects on Environmental Issues

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BACKGROUND AND PROJECT TASK

In the beginning of the 90's, discussions about the financial aspects of environmental issues started in EU. In 1995 the Swedish government gave the task to the Swedish Accounting Committee to investigate if, when and how financial aspects should be reported. In December 1995, the Volvo Group Environmental Council decided to initiate a project in this area. In spring 1996 KPMG made a pre study. The second phase started in September 1996 with the aim to estimate expenditures for Volvo caused by environmental issues, make a review on environmental reporting from a financial perspective, create input to Volvo's Environmental Report, investigate performance indicators and to increase Volvo's competence in these areas.

FUTURE OPPORTUNITIES ARE CHANGING

Environmental issues are a considerable challenge to business performance but offers also a significant opportunity. Human populations rapidly increase and new markets emerge in the developing world will definitely drive the need for new cleaner technology but offers also a business opportunity. The drive for new technology means new product concepts, new production processes and new logistic solutions. In the end this affects cash-flow, operating income and the balance sheet. Increased legislation and greater use of economic instruments from the authority will influence every link in the financial chain changing the prerequisites for use of products and for company performance. An example of using financial instruments are the fuel price where, in Sweden, the tax is 80% of the price. As The Polluters Pays Principle force the cost of environmental damage into the accounts eco-efficiency will become equated with good business performance and an opportunity to competitive advantage.

FINANCIAL STAKEHOLDERS

As legislation changes, lenders come ever closer to being held liable for environmental damage caused by borrowing companies. As laws, taxes, fines and other financial instruments push costs for environmental damage into the accounts financial analysts and other stakeholders consider the effects on the financial result. In 1996, 88 banks had signed the " Statement by Banks on Environment and Sustainable Development". The statement says that they "regard sustainable development as a fundamental aspect of sound business management" and notes that "environmental risks should be a part of the normal checklist of risk assessment and management". Swiss Bank Corporation and Storebrand, a Norwegian insurance company have developed environmental related performance indicators with which they evaluate environmental performance. In 1996 there were 60 insurance companies that had signed the "Statement of Environmental Commitment by the Insurance Industry". Past environmental liabilities are a threat to insurance industry's solvency. Claims in US faces an estimated $2 trillion in pollution clean-up and asbestos-related claims. Climate change has emerged as another potential risk. Stakeholders assess the management’s capacity to analyse and react in advance to future changes**.**

ENVIRONMENTAL EFFECTS ON FINANCIAL PERFORMANCE

Every company action has to be based on a broad view of likely future scenarios. It is vital for management to understand opportunities as well as risks if future activities are to maximise value for stakeholders over the long term. Environmental issues change materially the risk of an enterprise, therefore it is important to make a realistic estimate of future financial performance based on teamwork and a comprehensive overview.

Companies should strive for eco-efficiency by preventing pollution through good housekeeping, materials substitution, cleaner technologies and that they strive for more efficient use and recovery of resources. As an example the ”Clinton car” has a frame of $2 billion per year for 10 years.

ENVIRONMENTALLY RELATED EXPENDITURE

How much of the cost for a new vehicle project that is driven out of environmental issues are not possible to estimate, due to total integration. Environmentally related research & development cost for VCC (Volvo Car Company), excluding new car projects, have increased from 25% in the first half of 1990s up to an estimated 50% in the later period principally caused by increased focus on fuel consumption. Environmentally related investments have, during the same periods, decreased from approximately 40% to 25% as an effect of increased total investments. A rough estimation was also done for Volvo Truck Corporation where the figures showed a more constant development. Generally, the level of expenses are difficult to assess. A high level can mean that the company has made environmentally related investments in production phase instead of including the environmental aspects in new vehicle projects. Environmentally related operational cost are difficult to assess as there are different local specifications of accounts and that environmentally related accounts are included in a head account that is not related to environment.

DEFINITION OF ENVIRONMENTAL EXPENDITURE:

Environmentally related product development costs and investments have been estimated according to the following definition:

Spending on research & development (R&D), investments and operating expenses where the primary purpose is to prevent, reduce or repair damage to the environment. To deal with conservation of resources are also included. Often investments affect both rationalisation, quality and environment. Classification is made according to the *main driver***.** This definition is in accordance with AAF, The EU Accounting Advisory Forum, presented in December 1995.

Definition of environmental liabilities: Consists of estimated potential future environmental expenditure that are likely to affect the company according to future law. The expenditure includes cost for product development, process, sanitation, handling of waste and indemnity for damages.. Environmental liabilities includes a high degree of uncertainty and should be estimated to the most likely cost. The uncertainty emerge as formulation of laws and the technical solutions are not set by the time of estimation.

INCORPORATE ENVIRONMENT INTO BUSINESS DECISIONS

When we make a decision, we also determine what effect the decision will have on the environment, therefore we must incorporate environment into business decisions. To keep focus on environmental issues, it is essential that internal boards or equal decision groups include environmental competence. This is particularly important in the early phases. When a new vehicle project is decided the effect on environment both in product and process are set to more than 70%. To achieve our environmental objectives we therefore must focus on advanced engineering and product development. During the product projects each gate should include environmental issues. To reach a high return on investment and the company environmental vision it is a key success factor to optimise profitability together with environmental and image improvements.

In the decision we have to remind ourselves of our vision to create profitability through our core values: quality, safety and environment.

ENVIRONMENTAL REVIEW BASED ON LCA

To be able to control environmental issues it is essential to create measures. We should therefore implement an environmental review based on LCA for product and environmentally related investment decisions (as a first step), to be evaluated along with profitability calculation. Two steps are needed, a simplified “Classification” (very negative, negative, equal, positive, very positive) and an complete “Assessment”. To implement this in decision process the request of environmental review should be included in the Volvo Financial Handbook and handbooks for product development. The methods for assessment and classification should be specified in guidelines for VEMS. (Volvo Environment Management System). “Assessment” should be based on existing method, EPS, the method for “Classification” have to be developed. EPS (Environmental Priority Strategies) is a tool that, from a holistic perspective, enables to set targets and track progress. The results are measures for global and local impact. The system does also include a sensitivity analysis.

CLEAR MILESTONES AND ENVIRONMENTAL SCORECARDS SHOULD BE ESTABLISHED.

Is a method for Volvo Management to motivate, communicate and achieve consensus for environmental issues. Performance indicators are an instrument to track progress and ensure that internal recognition and rewards reinforce desired behaviour.

Important to the internal control, report to management and as an information to financial analysts and investors. Absolute figures are needed to inform about effects on environment. Performance indicators should be developed for advanced engineering, product development, production process, product use and recycling.

ENVIRONMENTAL AND ANNUAL REPORT

For the Annual Report there is a recommendation from the Swedish Accounting Committee to demand for an information of the company’s environmental impact. The report should include obligations and costs that have occurred as a result of damage to the environment. It also demands a description of actions to reduce the damage. The definition of environmental cost is according to Securities Exchange Commission (SEC) , includes costs caused by environmental law in Sweden. The recommendation if decided is to be implemented by January 1999. The purpose of the Environmental Report is to inform and educate stakeholders about the company’s environmental performance. The reporting process itself is of value to management. The International Chamber of Commerce (ICC) states that the company shall work for openness towards their personnel and public in respect to environmental questions and that performance should be measured and audited. Future regulations of environmental reporting is not decided although external verification have been discussed. The report should offer relevant environmental information to support rational investment decision for both creditors and shareholders. The report should therefore provide quantified financial information, strategic issues and actions made.

CONCLUSION: FOCUS FROM ENVIRONMENTAL REPORTING TO ENVIRONMENTAL CONTROL

Environmental issues will be one of Volvos most important challenges. The key success factor to reach Volvo’s vision and mission is to incorporate environmental aspects in the core business process.

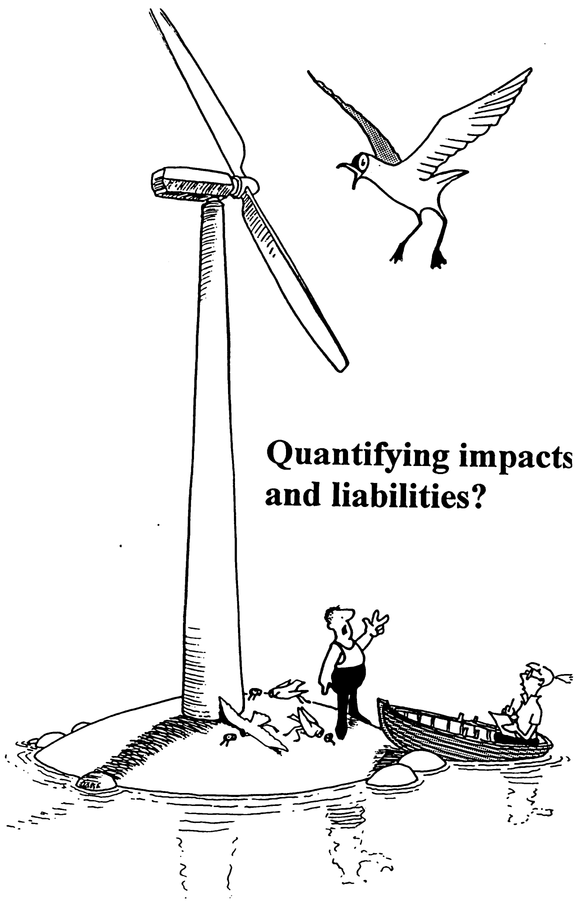
ALLOCATION AND VALUATION TECHNIQUES

Tools for Evaluating the Whole-Life Environmental Performance of Products
Martin Bennett, University of Wolverhampton Business School, UK
Peter James, Sustainable Business Center, UK

A Comparative Study of Total Cost Assessment Models – A Case of Swedish Wind Power
Narayanaswamy Venkatesan, IIIEE, Lund University, Sweden

Assessment of External Costs of Power Production – A Commensurable Approach?
Mikko Hongisto, Imatran Voima Oy, Finland

PIA Computer Programme for Product Improvement Analysis
Karen E. Maas, TME, The Netherlands



Tools for Evaluating the Whole-life Environmental Performance of Products

M. Bennett, University of Wolverhampton Business School, UK
P. James, Sustainable Business Center, UK

ABSTRACT

This paper reports the interim results of a project carried out on behalf of a manufacturer of electronics-based business systems, including property security systems such as intruder alarms. The aim of the project was to assess the relative effectiveness of three alternative methods of evaluating the environmental performance of its products: eco-points, eco-compass, and eco-costing. The methods were assessed by applying them in turn to evaluate two of the company's products (one in current production, the other a potential replacement which is in design). The paper describes the principles of each method, outlines the main characteristics of each product at each stage of their life cycles, reports on the outcomes of the comparison and draws conclusions.

INTRODUCTION

The bulk of lifetime environmental impacts of products are typically determined during the design stage. Attention is therefore being focused on design for environment (DFE), and companies such as AT&T and Philips have identified sophisticated approaches to this. One driver at these companies is an acceptance that, in the long-term, sustainability requires a radical improvement in the environmental performance of products and services, including those based on information and communications technologies. Indeed, leading edge environmental thinkers - and a growing number of policy makers - believe that sustainable development will require a “factor 4” improvement, i.e. reducing the amounts of resources needed, and pollution generated to deliver goods and services to consumers, by at least 300% over the next 20-30 years (von Weizsacker et al., 1997). Some, such as the Wuppertal Institute, believe that even this is only a medium-term target and that in the long-term a “factor 10” improvement will be needed.

This project was set up by XYZ plc, a large manufacturer of electronics-based business systems, in particular (in this project) of property security systems such as intruder alarms. Their aim was to examine the potential offered by different methods to carry out environmental evaluations of their products, both as a guide to product designers and potentially also as a marketing tactic for the benefit of customers for whom environmental performance is a criterion in purchasing decisions. The project was a limited-scale, low-cost pilot study based on a comparison of two of the company’s products (an existing product, and its potential replacement). It was intended to demonstrate and assess the alternative evaluation techniques rather than to produce a conclusive definite evaluation of the products, and therefore proceeded without full life-cycle analysis data, which in any case was not fully available. The objectives were defined as to:-

- assess specific evaluation techniques used by leading DFE companies with respect to their suitability for XYZ plc by applying them to a comparison of two products: Product A and Product B.
- examine the general relevance of environmental accounting to XYZ's product development processes
- make recommendations on how XYZ should proceed with regard to the environmental evaluation of its products.

Note: for reasons of commercial confidentiality, several of the details cannot be reported in this paper, and the recommendations referred to above are not included.

Section 2 describes the two products which were used as the basis for evaluating the alternative techniques. Section 3 outlines the three methods of evaluation - eco-points, eco-compass, and eco-costing. Sections 4, 5 and 6 provide details of the results obtained from their application and assess each on the basis of six criteria:- precision; reliability; comprehensiveness; understandability; convenience; and credibility. Section 7 draws conclusions from the project.

THE TWO PRODUCTS

Amongst other activities, the company manufactures and installs in customers' premises a range of intruder alarm systems, which are permanently on-line to a central control unit through a telecommunications infrastructure. One component in this is a device which interfaces between the physical system on the customer's premises and the national telecommunications system.

Two versions of this component (Products A and B) were used as the basis of this project. Product A is the component currently in use; Product B is a potential replacement which is currently in design. If successful, XYZ plans to replace all the Product A's currently in use with Product B's.

The physical design of both components is largely similar. The main difference is that a sub-component has been re-designed and offers substantially superior features and benefits, in particular:-

- with Product B, faults will be diagnosed on-line from the central control unit and, in most cases, also repaired on-line; whereas with Product A this would require a visit by an XYZ maintenance engineer.
- there is a fast rate of product research and development in the industry. The Product B sub-component will enable a large proportion of potential future upgrades to be delivered on-line, rather than requiring (i) the manufacture of new components, and (ii) a visit by an engineer to install them.

The product evaluation is based on a life cycle assessment (LCA); the main flows and inventory for the two products are summarised below:-

Production

Both products are composed mainly of PVC, but Product B differs from Product A in that it contains more electronic components and therefore contains more metals such as silver and copper, and more non-PVC plastics. However, since full materials composition data was not available, the analysis assumed that both were composed of a given quantity of virgin PVC (the same quantity for each product). Based on a supplier's suggestion, some analysis was also undertaken of a variant made from the same quantity of an alternative material (ABS). It was also assumed that both products had identical production processes, and transportation requirements in production.

Distribution

This was assumed to be identical for both products, with a figure calculated of 20 km per product. There was no data available on the packaging of components during distribution, but these are unlikely to be significant.

Use

For simplicity, the evaluation assumed only a 5-year lifetime for the products. This is likely to discriminate against Product B in the analysis of environmental performance, since its remote diagnostics and ease of component replacement will probably mean a longer service life, and also that dealing with faults will not require on-site diagnostics and maintenance visits. It was calculated that this translated into a significant saving of transport, expressed in average kilometres per product. On the other hand, remote diagnosis of Product B would require additional infrastructure system energy.

End-of-Life

When faulty, Product B can be repaired by replacing components whereas Product A has to be disposed of. New components should also allow upgrading to provide new telecommunications services and therefore make Product B more durable over time. Also, the higher value and metals content of Product B may make re-use or recycling more economical at its ultimate end of life than for Product A. However, since no detailed data was available on disposal routes it was assumed that the two sockets would be dealt with in identical ways. Separate analyses were made of incineration, landfill and recycling options. Due to lack of data, no evaluation was made of the possible re-conditioning and re-use of sockets, although discussions with re-cyclers suggested that this could be an option which might offer both economic and environmental benefits.

THE THREE METHODS OF EVALUATION

Three possible tools of evaluation were examined: eco-points, eco-compass and eco-costing. These methods were selected for evaluation based on their potential relevance to the nature of XYZ’s business, and their availability. These were applied, in turn, to evaluate Product B in comparison with Product A, with each tool being assessed against 6 criteria which were identified as desirable in management information generally:-

- precision
- reliability
- comprehensiveness
- understandability (i.e. comprehensibility)
- convenience
- credibility

These criteria were selected on the basis that the tools had to be not only accurate and reliable, but also useful in practice both for those applying them, and for those receiving, interpreting and acting upon the results.

Based on this, their suitability was assessed for four main purposes which product environmental evaluation techniques can be required to serve:-

1. identifying areas for attention in the product design and development process
2. making choices between different products or different designs of the same product
3. ensuring that products meet specified criteria and/or create no great environmental problems
4. communicating environmental effects to customers and other interested parties.

Eco-points

A number of eco-points schemes have been developed, of which the best known are those used by Philips and Volvo. They are similar in that they cover all life cycle stages - production, distribution, use and end-of-life. For each stage, the user selects the appropriate materials, processes, usage, and transportation details from the options which are provided in the software. The package then calculates an "eco-score" for each of these elements, based on a number of points for a given quantity or usage.

This project evaluated the eco-points approach by testing the Eco-Scan software, which is partially based on the work of Philips. It therefore has an industrial background and is one of the most widely used of commercial packages.

Databases

Three separate databases of eco-points are provided with the Eco-Scan package, allowing users to select which they consider most appropriate to use. These are:

Eco-Indicator 95 - this was developed in Holland in 1995 by a multi-disciplinary team of representatives from industry, science and government, and intended for use in Europe. It contains data on 120 materials, processes, etc.

Idemat 96 - a materials and processes database developed by the Environmental Product Development section in the Industrial Design Engineering faculty of Delft University of Technology. It contains data for 290 parameters, including various modes of transportation, such as by bus, rail, car, motorcycle, and air. It also contains cost data for some of these (primarily materials).

Eco-Indicator 97 - this database contains around 280 eco-indicators which have been collated from public sources by environmental experts from Philips. The database has been tested in practice by both designers and engineers as well as by materials and processes experts, and is in use within Philips.

Users of Eco-Scan can also insert their own eco-points assumptions, if desired.

The Eco-Indicator 97 database was selected for use in this project, based on its industrial provenance.

Calculation of Eco-points

Eco-points scores within Eco-Scan are based on a 'distance to target' methodology. The underlying premise is that there is a correlation between the seriousness of an effect and the distance between the current level and the target level to achieve sustainability. Thus if, for example, acidification would have to be reduced by a factor of 10 in order to achieve a sustainable society, whereas smog levels would require reduction by a factor of only 5, then acidification is weighted in Eco-Scan as being twice as serious.

Some other eco-points systems define targets on the basis of government policies. However, the Eco-Indicator 97 database is based on the judgements of scientists from both inside and outside Philips. The main criteria used are:

- human well-being - with a target of 1 fatality per million inhabitants per year, and minimal health effects
- ecosystem degradation - targets have been chosen at which, over several decades, 'only' 5% degradation of the eco-system will occur.

This results in the following weights:-

Environmental effect	Weight	Criterion
Greenhouse effect	2.5	5% ecosystem degradation = 0.1°C rise every 10 years
Ozone layer depletion	100	Maximum probability of 1 fatality per year per million inhabitants
Acidification	10	5% ecosystem degradation
Eutrophication	5	5% ecosystem degradation
Summer smog	2.5	Minimal respiratory effects and maximum 5% ecosystem degradation
Winter smog	5	Minimal respiratory effects and maximum 5% ecosystem degradation
Pesticides	25	5% ecosystem degradation
Airborne heavy metals	5	Minimal health effects
Waterborne heavy metals	5	Minimal health effects
Carcinogenic substances	10	Maximum probability of 1 fatality per year per million people

This table reveals that high priority must be given to limiting the use of substances which cause damage to the ozone layer, and to the use of pesticides. Furthermore, serious consideration must be given to the diffusion of acidifying and carcinogenic substances.

A number of effects that some might regard as environmental problems have not been included, for the following reasons:

1. Toxic substances which are a problem only in the workplace. Many substances are harmful only if they occur above a certain concentration. Such

harmful concentrations can occur relatively easily in the workplace, while the concentration in the outside atmosphere often remains very low and well below the damage threshold. This is both because in the wider environment the substances are generally greatly diluted, and also because many substances disappear from the atmosphere due to natural decomposition processes. Only substances which actually occur in harmful concentrations are included in the database. This means that a product with a low Eco-Indicator score can still potentially cause poor working conditions because substances are released which are harmful on a local scale.

2. Exhaustion (depletion) of raw materials. Only emissions and other direct health and ecological impacts are considered - the database does not take into account issues of resource depletion.

3. Land requirements. Space requirements for waste disposal and other land-using activities are not considered, on the grounds that they do not directly impact upon human health and ecology (unlike emissions and water pollution resulting from land-using activities, which are included).

Eco-Indicator 97 also has a distinctive approach to end-of-life issues. Where they exist, the environmental benefits of recycling can be recognised in two alternative ways - eco-points can be credited either for the use of re-cycled materials in the manufacture of new products, or for the re-cycling of materials at the end of the life of the old product. Philips argues that even if a product is designed for re-cyleability, this does not guarantee that it will necessarily actually be re-cycled at the end of its life. Hence, the system assigns eco-points instead to the use of re-cycled materials, in contrast with the Eco-Indicator 95 database which credits them to the end-of-life stage. The consequence of this is that the use of PVC within mixed re-cycled plastics is credited with 30% less eco-points, and the use of re-cycled PVC monomer with 90% less eco-points, than if virgin PVC were used. Clearly, the value of the Eco-Indicator 97 database, and of any other such database, is dependent on the credibility of these assumptions and the weightings which they generate.

Eco-compass

The eco-compass has been developed by Dow Chemical to provide a simple, visual summary of LCA data (Fussler with James, 1996). It is based on the indicators of eco-efficiency developed by the World Business Council for Sustainable Development (WBCSD), with some minor amendments (DeSimeone and Popoff, 1997). The eco-compass has six ‘poles’ or dimensions:

- energy intensity
- mass intensity
- health and environmental potential risk
- resource conservation
- extent of re-valorization (re-use, re-manufacturing and re-cycling)
- service extension.

The latter measures the ability to deliver greater service from given inputs, for example by improving durability.

Mass Intensity

"Mass intensity" refers to the physical mass of the materials that make up a product, plus the additional weight of materials displaced or consumed during its production and distribution (this additional element is described as the product's "ruck-sack"). The measure used is "material intensity per unit of service".

Energy Intensity

Energy inputs over the whole life cycle are totalled and converted to "energy intensity per unit of service".

Health and Environment Potential Risk

The following indicators are used, scored individually, then totalled:

Human Health Risks

1. short term acute human toxicity
2. long term carcinogenic, teratogenic and mutagenic effects
3. potential danger of persistent toxins that bio-accumulate
4. emissions to the atmosphere of organic substances
5. potential for creating allergies and irritations
6. accident risk

Environmental Risks

1. terrestrial eco-toxicity
2. aquatic eco-toxicity
3. acidification potential
4. nitrification potential on biological oxygen demand (BOD)
5. global warming potential
6. ozone depletion potential

Re-valorization

All opportunities for use of materials at end of product life are accounted for. This can be in any of the following manifestations:

- re-use
- re-manufacturing
- re-cycling
- incineration for energy recovery

Resource Conservation

This focuses on the nature and renewability of energy and materials needed for a product or process. The exercise is not carried out in isolation: the effect of a particular material on bio-diversity is also important. For example, a crop monoculture which can be grown year after year may be renewable, but if it reduces the habitat of an endangered species then it is not sustainable.

Service Extension

Service can be extended through a variety of ways, including:

- increased reliability
- increased durability
- reparability and upgradeability
- multi-functionality

- shared use.

Again, however, criteria should be looked at not in isolation but in unison - a multi-functional product is of limited extra value if any one of the functions is unreliable.

The Scores

The scoring scale used for each dimension is 0-5, with 2 being the score allocated to the 'base case', i.e. the comparator, or reference point - usually an existing product. The performance of another product or product variant is then scored relative to this, on the following scale:-

0	1	2	3	4	5
only half as good, or worse	worse, but at least half as good	the same	up to twice as good	twice to four times as good	four times as good

A deliberate aim in defining bands of this width is to provide a 'stretch' scoring system which is deliberately biased against environmental improvements which are merely incremental, in order to encourage industry to search for significant 'step' improvements, consistent with the "factor 4' and 'factor 10' philosophy. This should make the method more credible to those environmental activists who have sometimes criticised industry for making only marginal improvements in environmental performance which are insufficient to be consistent with the demands of sustainability. The corresponding disadvantage of this feature is that an eco-compass score of 1 or 3 may have only limited significance, since this can be achieved through only marginal changes for better or worse, and the method would not distinguish between these and more substantial improvements (or deteriorations) of a factor of up to 2.

The eco-compass requires no data conversions or weightings, and is therefore more transparent than the eco-points method. However, it does depend upon the availability of accurate life-cycle data for the key parameters, and the reasons for the six compass poles are not completely self-evident.

Eco-costing

An eco-costing approach analyses the environment-related costs created by a product. Unlike the output from an eco-points or eco-compass analysis, the result is in a monetary form and is therefore expressed in the same unit of account as other primary corporate objectives such as profit and shareholder value. This has the attraction that it can be applied to a wide range of alternatives, not limited to those which are environment-related.

Two different aspects of eco-costing must be distinguished. A narrow interpretation focuses on those environment-related costs which are internal to the organisation; a broader approach considers the external costs to society, either alone or in conjunction with the internal costs.

Internal costs

There is no question that internal environment-related costs are relevant and should be included in any analysis - the issue is whether conventional accounting and project appraisal methods are always adequate to achieve it. There is considerable evidence that environment-related costs are either often treated by conventional costing systems as overheads, or alternatively that they appear only after some time, so that environmentally positive actions (e.g. the introduction of clean technology) which are cost-effective may not immediately appear to be so.

One response to this is to introduce activity-based costing approaches which assign costs to the activities which generate them, so that environmental performance can be recognised as a significant "cost driver". Another response is to develop methods of life-cycle costing which bring into account the long-term as well as the immediate effects of current decisions.

External costs

The broader approach considers the external costs to society of the company's actions. It is not so obvious that this is relevant in business: a hard-nosed short-termist attitude might hold that if these costs are in fact external and will therefore not impact the company's own financial performance, there is no reason to take them into account. The case for not only recognising an organisation's external environmental impacts but also calculating their monetised value depends on two conditions:-

- the *principle* - that it is accepted to be appropriate that external effects should in fact be considered by the business, for whatever reason
- the *method* - that calculating a monetised value of external effects is judged to be the most appropriate method to measure these (rather than other methods, such as the eco-compass or eco-points).

On the first point, two reasons are advanced to justify taking externalities into account in business decisions:-

- that enlightened organisations need to be aware of the external effects of their actions, both for corporate responsibility for its own sake and to protect the organisation's "licence to operate" in the long term
- as environmental factors become increasingly pressing both for business and for society generally, costs which are currently external may become actual and internal, either through market-based instruments of government policy (e.g. environmental taxes) or directly through market forces.

If the principle is accepted, the question becomes one of method: is the calculation of a monetised value of external effects the most appropriate approach? This is not obvious - although the principle and practice is well-established in the public sector, it can be controversial even here, and it is unusual in the private sector. The technique inevitably rests on several assumptions, each of which can be challenged, and which can be objected to not only because of the intrinsic difficulty of measuring the value (which would apply whichever unit of account were used), but also - since the technique necessarily involves assigning a monetary value to human mortality and morbidity - on principle by those who are uncomfortable with the concept of "putting a price on a life".

Advocates of the technique argue that monetisation does no more than make explicit what is in any case inescapable, if only implicitly, since any decision in which both mortality and costs differ between alternatives (and in which both have some influence on the final decision) must indirectly involve some trade-off. Even if this is not taken into account directly by the decision-takers, subsequent analysis of the decisions reached can deduce the effective "shadow prices" which were used in reaching the decisions. The argument for making this explicit is that otherwise the shadow prices actually used may be arbitrary and inconsistent. One UK study (Moody (1977)) analysed a number of safety regulations and other public expenditure decisions, and found implicit values ranging from £50 per life, implied by the decision not to spend on a particular medical screening programme, to £20,000,000 per life saved by a change in building regulations following the collapse of a block of flats caused by a gas explosion.

Economists have developed a number of techniques for costing environmental externalities. The *damage costs* method aims to assess the cost actually caused by the external impact, estimated through a variety of alternative techniques such as contingent valuation, hedonic pricing, and travel cost methods. The *cost of control* approach is less ambitious. Instead of attempting directly to assign monetary values to non-monetary factors such as human lives, it takes as a basis a level of impact which is considered to be sustainable, and calculates the cost of moving from present performance to that level. Estimates have been published for a number of environmental effects, particularly those related to road transport, though there is still considerable controversy over the validity of these figures.

Most of these studies have been carried out by economists primarily interested in the development of public policy rather than as a potential business tool; for example:-

- to argue the case for, and estimate the appropriate levels of, market-based instruments of public policy such as environmental taxes (Maddison et al., 1996, and previous publications in the "Blueprint" series);
- to offer an alternative to the conventional national income accounts, which would replace Gross Domestic Product with a broader measure of "quality of life" such as the New Economics Foundation's "Index of Sustainable Economic Welfare".

The range of environmental impacts to which the technique has been applied has also been limited, with the main areas of interest being:-

- road transport (Maddison et al., 1996)
- energy use (the European Union's ExternE study);
- air quality (Ontario Hydro).

The use of externalities costing in the private sector is less common, though there are a number of reasons why organisations might wish to calculate, or take account of, the externalities created by their processes or products:-

- to demonstrate to customers and others that a particular product, process or activity does not create major externalities, or that it creates less externalities than alternatives.
- to inform decision-making by allowing comparisons between the externalities created by different options.
- to highlight significant externalities in order to provide an impetus for organisational or governmental action to reduce them.

Two examples of the use of externalities costing in business are BSO Origin and Ontario Hydro (Tuppen, 1996). BSO Origin used a cost-of-control approach to produce an "environmental value added" statement, which re-states the conventional profit and loss account in value added form, and brings in quantified values of the business's environmental impacts. The amounts are based on calculations of long-term costs of control in the Dutch National Environmental Protection Plan.

Ontario Hydro uses a damage costing approach, in a four-stage process, to calculate a single monetary amount to reflect environmental impacts arising from different sources of power generation (nuclear, fossil fuel, and hydro) and from different generating stations. They found that the external costs could add up to 1.6 cents to the cost of a unit of electricity (compared with an average internal cost of 4 cents), although since this was based initially on only a limited range of impacts, a wider range might have produced higher figures.

ECO-POINTS EVALUATION

Twelve options were identified for assessment - each possible combination of:-

- three product options:- Product A; Product B, of PVC composition; and Product B, of ABS composition
- four end-of-life options:- landfill; municipal waste; recycling; and incineration.

Eco-points scores were calculated for each of these combinations using the Philips Eco-Indicator 97 database. These showed that:-

1. on the available data, the energy consumption of both products A and B over their life-cycles is dominated by the ‘energy overhead’ of the electronic communications made over the telecommunications infrastructure. This demonstrates that, as a general rule (though not necessarily relevant in this particular case) any changes in volume of usage which might result from a product change are likely to be one of the most important environmental issues.
2. conversely, the reduction in transport emissions from the remote diagnosis and repair which is possible with Product B (though not Product A) is insignificant in environmental terms over the first five years. (However, this conclusion might be changed by an analysis over a longer period, since the failure rates of Product A would probably increase in the long-term).
3. Eco-Scan assigns 1225 eco-points to a kilogram of silver, compared to 9.38 for a kilogram of ABS and 4.24 for a kilogram of PVC. However silver was excluded from the analysis in this project since data was not available on the quantities used in each product. If this data had in fact been available, this - and possibly other non-ferrous metals - might have emerged from an eco-points analysis as a major (and possibly the most significant) environmental issue associated with the product.
4. the Eco-Scan software suggests that, overall, PVC is environmentally preferable to ABS, and that in either case landfill is a better environmental option at end-of-life than re-cycling.

The last result was an unexpected finding, though it was explicable, on investigation, by the judgement - described in Section 3.1 above - made by the Eco-Scan designers on the appropriate point at which to recognise the benefits of re-cycling. This demonstrates how the assumptions contained within such software drive their conclusions, and therefore how carefully they need to be examined.

Assessing an eco-points approach

The eco-points approach was assessed against each of the criteria identified (as described in Section 3 above).

Precision

The method produces results of high apparent precision, since its outputs are calculated and reported to several significant places.

Reliability

The degree of perceived reliability depends on the user's faith in the judgements of the experts who designed the system (in this case, from Philips and Delft University). The results are very sensitive to the weighting and scoring mechanisms on which the particular eco-point scoring system has been based. The quantity of life-cycle data which is available is less critical, since this project demonstrated that meaningful conclusions can still be reached - the impacts of differing solutions can be compared even on the basis of only limited data, albeit rather in isolation from the full environmental picture.

Comprehensiveness

In this project the database covered all the materials and processes which were needed in the analysis, with one specific exception. A review of the full list of parameters included in the database suggests that it is likely to be adequate for most purposes - it is clearly satisfactory for Philips. The system also offers to the user the option to compile their own bespoke database, which could include further items also, though this would then bring the difficulty of needing to reach decisions on weightings.

Understandability

The format and layout (which uses "personal organiser"-type graphics) is straightforward to follow. The terms which are used are not technical or scientific, and descriptors are provided in everyday language. Designers should have no significant problems in understanding it.

Credibility

The scoring and weighting criteria (see section 3.1) are the main factors in determining which options are concluded to be preferable; however these are not universally accepted. The preference shown by the system for landfill as the best end-of-life option, for example, may also be inconsistent with current opinion in the UK (and elsewhere). Also, as the Brent Spar incident demonstrates, it takes no account of possible public reaction if large quantities had to be disposed of at a single time in a manner which was generally perceived to be not environmentally responsible, such as by landfill.

Convenience

The specifications for each product are recorded in the format of a computerised note-book or personal organiser, and options are offered to present the information in the form of graphs or tables. The tables are particularly useful since they enable the scores for the whole process to be compared between two different products. The "wizards" provided for calculating energy usage over product lifespan, and the provision of travel distances between various European locations in particular types of vehicle, also facilitate the user's task.

Eco-Points: Conclusions

The value of eco-points schemes such as Eco-Scan is that they can provide quick analyses of the overall environmental effect of products and of how different elements of the design contribute to this. Their main disadvantage is that they are ultimately dependent on subjective weightings of different environmental effects and that, as with Eco-Scan's bias towards landfill rather than re-cycling, these are not always transparent to users. Hence, they are particularly well suited to identifying areas for attention and for exploring (rather than making) choices between different alternatives. They are less appropriate as a method of communication, since an eco-point score is meaningless in itself, and some users such as customers and other stakeholders may challenge the assumptions upon it rests.

ECO-COMPASS EVALUATION

Several composite eco-compasses were plotted in order to compare different alternatives. The eco-compass for the basic comparison between Product A and Product B is shown as Figure 1.

The analysis was limited by the data available in several ways:-

Energy Intensity

It was assumed that Products A and B comprised identical quantities of PVC, therefore requiring the same quantity of energy in production. No data was available on energy consumption in assembly, production or at end-of-life, so this was excluded. Energy used in transportation - which was assumed to differ only in the use stage, where Product B's remote diagnosis facility reduces its transport effects - was calculated to show a marginally lower quantity for Product B. This meant that in the eco-compass a score of 3 was assigned to Product B.

Mass Intensity

It was assumed that both products had the same mass, so that Product B scored 2 on this dimension.

Health and Environmental Potential Risk

In the absence of detailed data on composition and production processes, the analysis was restricted to the impacts of transport. Externalities data - which is based on calculations of environmental impact - was used as a proxy for health and environmental potential risk. It was assumed that the cost of accidents was 2.3p per km and of emissions 4p per km (Maddison et al., 1996). This produced a marginally lower figure for Product B, which again resulted in a score of 3.

Resource Conservation

There was no difference between the products in the quantity of fossil fuel which was required in the manufacture of the PVC (the main material in both). However Product B required a marginally smaller quantity in use (a difference of approximately 1% - although over a high anticipated volume of production this would still have generated a significant total saving) and therefore scored 3.

By comparison, the ABS variant of Product B required significantly more fossil fuel in manufacture than when made from PVC - overall around 50% worse. However since this fell within the range ("up to twice as good") of a score of 3, the Product B/PVC option still scored only this same rating even when compared against Product B/ABS.

Service Extension

In the absence of definite data, it was assumed that both Product B and Product A had identical patterns of use and therefore both scored 2. However, other features of the product (not considered in this exercise for reasons of confidentiality) could enhance both its functionality and its durability, so that - if it were possible to measure these - it would probably score higher - possibly a 4 or even a 5 - on this dimension.

Re-valorization

No data was available on this, so both products were therefore scored as 2.

As with the Eco-Scan analysis, the limited availability of data meant that a full analysis could not be completed, so that the eco-compass profile (Figure 1) appears to show the two products to be more similar than may actually be the case. Some points which might be expected to change in a fuller analysis are:-

- a much higher ranking for service intensity, based on the ability of Product B to provide higher, and environmentally better, customer service through offering a wider range of options. Some of these could substitute for the purchase of other new physical products, each with their own environmental impacts.
- a more precise estimate of health and environmental risk. If 'precautionary' rather than consensus assumptions were made about the health effects of PVC - based on the recent EPA report on dioxin and on suggestive if inconclusive research on the possible health effects of some additives used in its manufacture - then the ABS alternative would probably be ranked much higher on environmental and health risk potential.
- a much higher ranking for an ABS-based Product B on the re-valorization axis. ABS is a high-value material which it is both cost-effective and feasible to re-cycle, whereas this is not always the case with PVC.

Assessing an eco-compass approach

Precision

The deliberately wide ranges for each point (so that, for example, an improvement of 1% would produce the same rating as an improvement of 99%) mean that precision is low.

Reliability

Reliability is no more than reasonable, since the method requires considerable judgement and aggregation of different aspects within (though not across) the different dimensions.

Comprehensiveness

The six points of the compass cover all major environmental eventualities conceptually. However, the comprehensiveness of an eco-compass analysis largely depends on the data input. The more comprehensive is the life-cycle data, the more complete will be the eco-compass picture. Clearly if the picture is incomplete, it could be harmful to use the compass as a corporate communication tool. Also, since it adopts a holistic approach a compass with limited data input would be of little value to, and could even mislead, a designer.

Understandability

A major attraction of the eco-compass is its visual impact which enables findings to be understood immediately. Conceptually it is very easy to grasp, though details of the scoring system can be obscure.

Convenience

The final stage of plotting positions on the compass from calculations is straightforward, but the two preceding stages can be time consuming:

1. Identifying the relevant data in the first place from the life-cycle analysis.
2. Making the calculations from the data

These activities are more time-consuming than for the eco-points calculation, since for the latter the software performs some of those calculations and data retrieval as part of the distribution of eco-points. Naturally, there will be a threshold beyond which it would be impractical to include more data for reasons of time and resources, but there will also be another threshold below which the outcome of the compass would be unreliable.

Credibility

The eco-compass requires no data conversions or weightings, and is therefore more transparent than the eco-points method. As a ‘stretch’ scoring system, it is also biased against merely incremental environmental improvements, which should make it credible to environmentalists. On the other hand, an eco-compass score or 1 or 3 may have only limited significance if it is based on only marginal changes for better or worse.

However, the method does depend upon the availability of accurate life-cycle data for the key parameters, and the reasons for the six compass poles are not completely self-evident.

Eco-Compass: Conclusions

The eco-compass provides a holistic, visual, overview of products using dimensions which have been subject to considerable discussion and development by the international business community. It is helpful to purpose (2), making choices between different products or different designs of the same product; and with some explanation, also for purpose (4), the communication of environmental performance to customers and other interested parties. It can also, when used as part of a workshop process, contribute to purpose (1), identifying areas for attention in the product design and development process. One problem is that it requires reasonably complete LCA data and also that scoring some of the dimensions can be difficult.

ECO-COSTING EVALUATION

Section 3.3 outlined the distinction between internal environment-related costs (those which are already being incurred by a company or its customers or suppliers) and external costs, which are borne by society and the natural environment. The latter are important for both their social implications and also since there is a trend for such external costs in the long-term to be internalised through taxation and other means. A calculation of the external costs associated with a product therefore offers a means to measure that part of its environmental performance which is not already reflected in the costs being currently incurred by the business.

Internal Costs

A review of XYZ's internal product costings methods was not a part of this project, and in any case the data which would have been required was not fully available. However it did become apparent during the project that there could be opportunities, by making changes at the design and introduction phase, to realise direct environment-related savings for Product B over the life of the project. This is consistent with experience with other companies, where typically whole-life costs are not always calculated in full.

Contact with manufacturers and disassemblers suggested that analysis of environment-related internal costs might reveal opportunities for savings, either for XYZ directly or elsewhere in the supply chain, for example:-

- PVC moulding requires costly ventilation equipment which is not needed for ABS
- use of non-ferrous metals makes mechanical separation from plastics more difficult
- if re-use or re-conditioning is an option, screen-printed logos are easier to obliterate than raised moulded logos.

However, lack of adequate cost data meant that these issues could not be explored further.

External Costs

The calculation of external costs requires two elements of data, in sufficient detail and to an acceptable level of reliability:-

- life-cycle assessment data on the physical attributes of the product, process, etc.: e.g. the energy and raw materials required in production, the distances to be travelled in inbound and outbound logistics and after-sales, etc. (To make a difference in any particular analysis, it is also necessary that these should differ significantly as between the two (or more) alternatives being considered).
- a figure for the external costs incurred for each impact, per unit of impact.

The availability of physical data is equally required by an eco-points analysis (though less so for the eco-compass), and this has already been covered in that section of this paper.

The calculation of external costs per unit of impact is a major exercise, and this study did not attempt to carry out any such exercises but to access the results of past externality costing studies which are already in the public domain. Despite the status of their authors and the rigour and depth of the studies, their results are often contentious and of dubious reliability. This is confirmed by the wide ranges of values produced for the same environmental impact by different studies, as shown in Tables 1 and 2. The differences are due to the different assumptions and methodologies adopted by different studies. Even the keenest supporters of this approach claim no more than approximate accuracy, though they argue that this is still more accurate than an analysis which does not take this step and which thereby effectively assigns a value of zero.

There are three areas where the external costs of Product B could be of economic and social significance, and where internalisation might therefore occur in the medium to long-term. These are:

- acceptance of some of the more pessimistic assessments of the environmental impacts of PVC, particularly with regard to the effects of dioxins and hormone-mimicking chemicals. One scenario could be a ban on PVC, which would require the re-design of Product B. Another could be the classification of PVC as a hazardous material, which would create increased handling and disposal costs.
- more stringent regulations on the disposal of telecommunications equipment, requiring introduction of a take-back loop for Product B (and also for Product A).
- increased transport costs due to fuel levies, carbon and other environmental taxes and other measures to reduce the environmental impacts of road transport (which could work to the advantage of Product B).

Because of the insufficiency of data, it was not possible to calculate a full external cost for Product B as compared with Product A. The study therefore focused on the area where data is most readily available and where in this case there is also the clearest distinction between the two products - transport.

Their respective external costs for road transport were calculated and then summed. Firstly their road transport requirements, expressed as vehicle-kilometres per product, were calculated based on information and estimates provided by XYZ, for the relevant life-cycle stages:-

- transport of components, pre-manufacture
- transport required in distribution
- transport required during use, in servicing

These were then summed and monetised, expressed as pence per passenger/kilometre, based upon the external costs associated with the main adverse environmental impacts of road transport calculated by Maddison et al. (1996):-

- air pollution

- climate change
- noise and vibration
- accidents and injuries
- congestion.

This showed that over the expected volumes of products, there would be a modest but significant reduction in the total external costs of Product B as compared with the comparable total for Product A.

A more extensive calculation would require further data on both physical attributes, and external costs of a wider range of environmental impacts.

Assessing eco-costing

<u>Precision</u>

The total amounts of external costs could be calculated with a high level of apparent precision.

<u>Reliability</u>

The reliability of the results is modest, since - as for eco-points - the outcome depends on the assumptions and weightings, and involves loss of transparency. It also requires the additional - and equally controversial - process of monetising. There is considerable dispute about precise externality figures in almost every area, and the technique is therefore not reliable for detailed calculations or comparisons.

<u>Comprehensiveness</u>

This approach can be comprehensive in principle for internal costs, though in practice key data is often not available. It is comprehensive only for limited areas of environmental impacts - in particular for transport where several studies to calculate external costs have been conducted and the results published. However data on external costs is sparse on other areas of impacts. Organisations would need to make their own calculations if they wished to use the technique in these areas.

<u>Understandability</u>

This is high in general, as the method makes use of the widely understood concept of monetary costs and benefits. However, the methodologies for calculating environment-related costs and benefits can be obscure.

<u>Convenience</u>

All materials, processes etc. covered in Eco-Scan can be assigned a cost figure, and cost calculations made for products. The problems lie more in the extent and reliability of the data rather than in its use.

<u>Credibility</u>

Credibility is potentially high internally since this method expresses the results in monetary terms, although there is room for debate about allocation procedures and other accounting activities. The broad concept of externalities is widely accepted and therefore has considerable credibility. However, the methods for calculating them are more contentious and so disagreements are to be expected on the validity of the actual numbers calculated.

Eco-costing approaches are potentially of great value. Internal costing can highlight short-medium term opportunities for financial savings. External costing can also highlight possible increases in cost - as a prelude to taking action too avoid them - as well as highlighting areas of negative social impact.

At present, external costing seems most practicable in the transport area. Data is available and it is relatively easy to calculate travel saved through use of telecommunications services. However, it is less practicable for other stages of the life cycle where data is too sparse to allow meaningful calculation.

One caveat for eco-costing of products where environmental costs are either in the medium or long-term, and/or are not a high proportion of total costs, is that they will not appear as significant within net present value models which have high discount rates. The major cost issues might be those such as effects on image which can be financially significant but hard to quantify. It is important that these are not neglected in any analysis.

Eco-Costing: Conclusions

Costing approaches can identify the benefits to business and/or society from environmental actions in terms - i.e. money - which are readily understood. They are therefore especially valuable for purpose (4), communicating environmental effects to customers and other interested parties. However, there is no consensus about the costs which should be attached to externalities, and there is also little readily usable data outside the area of transportation. The figures therefore need to be used with care. Their aggregate and non-consensual nature also means that they have little relevance to purposes (1), identifying areas for attention in the product design and development process, and (3), ensuring that products meet specified criteria and/or create no great environmental problems.

CONCLUSIONS

The characteristics of each method, and their evaluation against the six criteria, are summarised in Table 3.

As suggested in Section 3, product environmental evaluation techniques serve four main purposes:

1. identifying areas for attention in the product design and development process
2. making choices between different products or different designs of the same product
3. ensuring that products meet specified criteria and/or create no great environmental problems
4. communicating environmental effects to customers and other interested parties.

This study suggests that each method has its own balance of strengths and weaknesses and therefore that the relative attractiveness of each depends on the relative importance, in any situation, of each of the criteria.

The value of eco-points schemes such as Eco-Scan is that they can provide quick analyses of the overall environmental effect of products and of how different elements of the design contribute to this. Their main disadvantage is that they are ultimately dependent on subjective weightings of different environmental effects and that - as with Eco-Scan's bias towards landfill rather than recycling - these are not always transparent to users. Hence, they are particularly well suited to purposes (1) and (2) - i.e. identifying areas for attention, and exploring (rather than making) choices between different alternatives. They are less appropriate for purpose (4), communication, since an eco-points score is meaningless in itself, and some customers and other stakeholders will challenge the assumptions upon which they rest.

The eco-compass provides a holistic, visual, overview of products using dimensions which have been subject to considerable discussion and development by the international business community. It is helpful to purpose (2), making choices between different products or different designs of the same product, and with some explanation to purpose (4), communicating environmental effects to customers and other interested parties. It can also - when used as part of a workshop process - contribute to purpose (1), identifying areas for attention in the product design and development process, in a broad way. One problem is that it requires reasonably complete life-cycle analysis data and also that scoring some of the dimensions can be difficult.

Costing approaches can identify the benefits to business and/or society from environmental actions in terms - i.e. money - which are readily understood. They are therefore especially valuable for purpose (4), communicating environmental effects to customers and other interested parties. However, there is no consensus about the costs which should be attached externalities and also little readily usable data outside the area of transportation. The figures therefore need to be used with care. Their aggregate and non-consensual nature also means that they have little relevance to purposes (1), identifying areas for attention in the product design and development process, and (3), ensuring that products meet specified criteria and/or create no great environmental problems.

All of these techniques depend on the availability of data on the key environmental effects. Whilst this data does not have to be extremely detailed, it does need to cover all relevant areas. Therefore a pre-requisite for successful product evaluation is cost-effective procedures to gather such data. The absence of such data severely constrained the analysis which could be undertaken for this project. This experience reinforces the lessons which can be drawn from other areas of accounting and performance measurement, that an excessive focus on the development of intellectually fascinating analytic techniques may be of less practical value than more prosaic issues such as data collection procedures.

The eco-points and eco-compass calculations also demonstrate the importance of another central feature of accounting implementation - the allocation of costs or impacts between different costs or impact objects. One of the most significant factors in the eco-points scores was the use made of the telecommunications infrastructure, the figures on which are the outcome of a complex exercise to allocate the aggregate energy requirements of the overall system to different telecommunications activities. Different allocation principles may have produced very different results.

The final conclusion is that none of these techniques - nor any others of which the researchers are aware - provide an unambiguous and unchallengeable approach to the environmental evaluation of products. The results of all methods require interpretation, and arguably they are most effective when used in combination. Above all, they all need to be embedded in a product development process so that they can be used when most effective, and conversely ignored when other approaches would be more suitable.

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Table 1: Estimates of social costs of UK road transport system in £ billion per annum

£ billion per annum

Source	Air pollution	Climate change	Noise and vibration	Accidents and injuries	Congestion
Royal Commission (1994)	.... 4.6 - 12.9 (aggregate)			5.4	
Pearce (1993)	.... 2.8 (aggregate)		0.6	4.7 - 7.5	13.5
European Federation for Transport and Environment (1993)	6.4	2.0	0.4	3.9	
Earth Resources Research (1993)	2.5	0.7	2.1	4.8	15.0
Maddison (1996)	19.7	0.1	2.6 - 3.1	2.9 - 9.4	19.1

Table 2: Estimates of social costs of UK road transport system in £ per passenger-kilometres

£ per 1000 passenger-kms

Source	Air pollution	Climate change	Noise and vibration	Accidents and injuries	Congestion
Royal Commission (1994)	.... 8.26 - 23.16 (aggregate)			9.69	
Pearce (1993)	..... 5.03 (aggregate)		1.08	8.44 - 13.46	24.24
European Federation for Transport and Environment (1993)	11.53	3.56	0.71	7.03	
Earth Resources Research (1993)	4.49	1.26	3.77	8.62	26.93
Maddison (1996)	32.72	0.18	4.32 - 5.15	4.82 - 15.61	31.73

Table 3: Strengths and Weaknesses of Three Product Evaluation Methodologies

	Eco-points	Eco-compass	Eco-costing
Characteristics	Assigns scores to individual impacts and aggregates these into an 'eco-score' - a cardinal measure.	Scores products on a 0-5 (cardinal) scale on six key environmental parameters - a relative (ordinal) measure.	Calculates internal and/or external financial costs and benefits of product's environmental impacts, giving a cardinal measure.
Comprehensi-veness	Excellent as different databases can be used (including self-generated ones).	Six poles cover most, but not all, issues. Also deals with customer as well as environmental benefits.	Can be comprehensive in principle for internal costs but in practice key data often not available. Comprehensive for external costs of transportation but not other areas.
Precision	High	Low (wide ranges for each point)	High
Reliability	Reasonable - no more, since it requires considerable judgement and aggregation of different aspects within (though not across) the different dimensions.	Modest - not transparent and depends on assumptions and weightings.	Modest - as for eco-points, depends on assumptions and weightings, and involves loss of transparency. Also requires additional - and equally controversial - process of monetising.
Comprehensi-bility	Basic principles are clear and well explained in software. However, weighting methodologies can sometimes be obscure.	Aided by conceptual simplicity and clear visual display. However, details of scoring system can be obscure.	High in general as makes use of widely understood concept of costs and benefit. However, methodologies for calculating environment-related costs and benefits can be obscure.
Convenience	Excellent - a user-friendly software package which most people can understand and use within hours.	Easy to calculate if data is present - but needs more data than eco-points.	Requires both environmental and financial data and therefore more time and resources for data collection.
Credibility	Rests on faith in experts' weighting of different environmental impacts - may be high internally but unlikely to persuade sceptics. One possible response is to use normal and worst case weightings.	Increased by limited conversion of basic data and a 'stretch' scoring system which is biased towards radical improvement and will therefore please environmentalists. However, reasons for the six compass poles are not completely self-evident.	High internally in that it expresses findings in monetary terms - but assumptions, for internal and especially external costs, can be challenged by sceptics.
Conclusions	Good for internal use - quick comparisons and highlighting key areas of impact. As results are easily challenged, less suitable for making choices or communicating to stakeholders.	Good for making comparisons and highlighting improvement opportunities, both internally and externally. However, too aggregated for detailed .	Internal costings are managerially persuasive but can be time-consuming to generate and not impact budgets for many years. External costings are useful internally for broad understanding and communication of social benefits and potentially valuable to policy-makers. However, basis of calculations can easily be challenged and difficult to apply outside transportation

A Comparative Study of Total Cost Assessment Models - *A Case of Swedish Wind Power*

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BACKGROUND

'Preventive Environmental Investments' are such investments that they eliminate the occurrence of or minimise the existing as well as expected environmental impacts, at the first place. They are built on the 'anticipate and prevent philosophy'. These investments are fundamental drivers to cost-effective and environmentally sound decisions. For example, investments in 'cleaner technologies' such as fuel cells, wind power, etc., for an utility, would boost the efficiency of the output (reducing the consumption of input resources) while simultaneously preventing or reducing the generation of environmental emissions at the first place.

Due to multi-dimensionality of an enterprise, these investments obviously compete with other developmental projects, for limited capital resources within a company. Therefore, there is a need for proper tools to examine the technical, environmental and economic attributes of these investments. Total Cost Assessment (TCA) tools, each containing unique features, have been developed during the past few years, in order to aid companies to examine their environmentally sound decisions.

This paper aims:

- to study and compare the concept and methodology of few of these tools
- to present the results of application of TCA models for two wind power projects and
- to draw some conclusions and recommendations to the users of TCA models

COMPARATIVE ANALYSIS OF TCA MODELS

Three TCA models were chosen for the comparative and applied analysis of financial evaluation of wind power projects:

- TCA model developed by the Tellus Institute[30], Boston, USA
- MILA model[31] developed by the International Institute for Industrial Environmental Economics, Lund University, Sweden, and
- Paras Financial Model[32] of the Technology and Engineering Consultancy Company, Paras Ltd, United Kingdom

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One of the main reasons for choosing these three models is that they have been tested for various pollution prevention projects and their related applications are well documented and easily accessible. The comparative analysis presented in Table 1 differentiates the uniqueness, similarities and limitations of the TCA models at a glance.

Table 1. Comparative analysis of the TCA models

Parameter Description	**TELLUS**	**MILA**	**PARAS**
Conceptual framework	Expanded costs inventory and time horizon, precise cost allocation and a profitability parameter reflecting the time value of money.	Same as Tellus model, but a more detailed 'waste generation costing'. Balanced consideration of costs and benefits. Extended time horizon is underplayed.	Value chain and company wide measurement of financial implications. Probabilistic approach as against the deterministic approach of Tellus and MILA.
Are preconditions stated in the model? If so, What are they?	Yes. The pollution prevention project should be a pending or rejected one due to reasons of unsatisfactory profitability. Major project technical issues have been resolved. The firm has completed at least a preliminary project financial analysis.	No, Not stated explicitly.	No, Not stated explicitly.
What type of investments are subjected to analysis?	Preventive environmental investments	Preventive environmental investments	Those which may have an impact on the environment and environmental performance of the company and those which are made specifically to achieve an environmental goal.
Cost Boundaries	System = Company, but not clear about and provides no provisions for the inclusion of potential external costs which are likely to be internalised in the long-run.	System = Company External and Life cycle costs are excluded from the analysis.	System = Company. No external costs are allowed inside the model

[32] Moilanen. T and Martin. C, "Financial Evaluation of Environmental Investments", The Institute of Chemical Engineers (IChemE), 1996.

Costs and Benefits protocol	• Usual costs & revenues • Indirect or hidden costs • Liability costs • Less tangible benefits	• Usual costs and revenues • Waste generation and management costs • Environmental regulation costs • Contemporary costs and revenues	• Usual costs and revenues • Hidden costs • Liability costs • Insurance costs • Financing costs • Environmental costs • Public image
What is reference of the model analysis?	Traditional Company Analysis	Company Analysis	Not explicitly stated
Model calculations output	IRR of the discounted cash flows of the preventive investment.	NPV of the cash flows at the starting point of the project. No extended time horizon is allowed due to reasons of increasing uncertainty.	Discounted EMVs of preventive investment
Extent of Validation	Case studies on various industrial sectors are available. Most of them are Small and Medium sized Enterprises (SMEs) of USA	A Case study in a large electrical engineering company in SWEDEN	Documented case studies in two large enterprises, one in Finland and other in U.K
Is the model computer software based?	Yes, P2FINANCE spreadsheet program is available	No.	No.
Applicability to wind-energy investment projects pertaining to Swedish conditions	Applicable. Calculates the relative net benefits of wind energy investment	Applicable.	Applicable. Calculates the EMVs of the wind energy investment
Verifiability of the input data and the results of the model	Easy to verify and interpret the results	Easy to verify and interpret the results	Easy to verify and interpret the results

The three TCA models are similar in costs and benefits protocol and different in their application methodology. The three models show a greater degree of similarity in 9 out of 11 parameters compared.

The Tellus and MILA models are similar in their conceptual framework. The conceptual framework of Paras model is similar to Tellus and MILA models, but for its probabilistic approach in each step. If there is no apparent need to incorporate risk and uncertainty in the project financial evaluations, or the risk and uncertainty of a project are imperceptible and non-quantifiable, then the Paras model boils down to the framework of Tellus and MILA. In reality, it is rather difficult to assign risk factors to each and every aspect of a project parameter.

The Tellus and MILA models start with the identification of preventive environmental aspects of a project and traces its implications back to processes or activities within and across various functions of a company with a view to monetize them. Therefore, the Tellus and MILA models adopt the '*bottom-up*' approach. On the other hand, the Paras model starts with the value chain as well as company-wide measurement of *expected* financial implications of a project and focuses down to achieve its present environmental goals. Therefore, the Paras model adopts the '*top down*' approach.

APPLICATION OF TCA MODELS TO TWO SWEDISH WIND POWER PROJECTS

Further study on the TCA models revealed the following major adaptations in the models in order them to be applied in the test cases of Swedish wind power projects.

- Introduction of a new profitability parameter, Net Return Rate[33] (NRR)
- Inclusion of external environmental costs in the TCA analyses
- application of the general philosophy of TCA (extended time horizon, expanded company costs and benefits inventory, precise cost allocation and a rational profitability parameter reflecting the time value of money and cash flows generated throughout the venture life) and
- drawing the unique features of each model while calculating specific environmental costs and benefits

The two wind power projects of Sydkraft AB, the second largest Swedish utility, selected for the TCA analyses are

- Wind Power Plant, at Nogersund and
- Wind Power Plant, at Rynge

The reasons and the pre-conditions for choosing the wind power projects for the in-depth TCA analyses are

- Wind power investments are preventive in nature as they inherently eliminate the generation of emissions that would have otherwise been generated of the power produced from the fossil fuel resources
- wind power investments are in the agenda of company's (Sydkraft's) future investment strategies and
- there are no outstanding technical questions to be resolved in the selected wind power projects

The preventive environmental benefits of wind power is the elimination of pollutants otherwise would have been released due to the power generation from fossil fuels. But the wind power cannot be compared in absolute terms with power generation from fossil fuels owing to the large difference in the magnitude of power generation between these two modes. When the output from various modes of power generation are grided to the common network, the output from wind power plant, obviates the production of the same quantum of output from gas turbine plants, which cater to the peak demand for electricity.

The reason for choosing the environmental costs of gas turbine plants is that the gas turbine technology is the most recent one (from 1980s) and assumed to be an alternative to wind power production for Sydkraft. For Sydkraft, this would mean the avoidance or reduction of environmental costs associated with power generation from

[33] NRR (%/year) = 100 X Net Present Value / (Total discounted capital X Venture life)

the gas turbine plants in proportion to the quantum of wind electricity produced, while wind power plant is under operation.

A cost assessment of oil fired and natural gas fired gas turbine plants of Lund Energi AB, Lund, was performed and the relevant costs were estimated per average MWh_e produced per year basis. In the TCA analyses, the avoided environmental costs are accounted as preventive benefits of operating a wind power plant. In short, the avoided environmental costs of oil and gas fired gas turbine plants are included in the TCA of wind energy projects using the philosophy of '*benefits due to environmental costs in absentia*'[34].

The inclusion of various company costs and revenues in the TCA analyses for Nogersund and Rynge wind power plants are presented in Table 2.

Table 2. Costs and Revenues Protocol included in the environmental external costs incorporated TCA[35]

Items	Company Analysis	TCA without environmental external costs	TCA with environmental external costs
Revenue:			
Sales revenue	X	X	X
Miljö bonus	X		
Capital Costs:			
Capital Investment	X	X	X
Subsidy	X	X	X
Recurring Costs:			
Direct material and energy	X	X	X
Site Rental	X	X	X
Operation and Maintenance	X	X	X
Insurance	X	X	X
Administrative	X	X	X
Avoided environmental costs of non-operation of gas turbine plants (recurring):			
On-site pollution control		X	X
Monitoring and Reporting		X	X
Safety and Liability		X	X
Pollution taxes		X	
Less tangibles:			
Eco-labeling of wind electricity (applicable only for the Rynge Project)		X	X
Avoided external costs of fuel cycle			X

[34] This is a relative term referring to the precluded environmental costs of operation of gas turbine plant in proportion to the production of wind power
[35] This is applicable both for Nogersund and Rynge wind power plants

During the literature survey, it was found that the environmental external costs due to wind power and fossil fuel cycles were not available at Swedish conditions. In order to simulate the data to the Nordic conditions, the Danish estimates of external costs of wind power and the Finnish estimates of external costs of fossil fuel cycles were used in the TCA analyses. A summary of the results from such analyses is presented in Table 3.

Table 3. Summary of Financial data of TCA analyses -- with and without environmental external costs

Items	Company Analysis	TCA without external costs		TCA with external costs	
		Oil	N.G	Oil	N.G
Nogersund Wind Power Plant					
Capital Investment (MSEK)	12.5	12.5	12.5	12.5	12.5
Less subsidy (MSEK)	4.375	4.375	4.375	4.375	4.375
Net Investment (MSEK)	8.125	8.125	8.125	8.125	8.125
Economic Life (years)	15	15	15	15	15
NPV@7% real discount rate ('000 SEK)	(7765)	(7221)	(7416)	(7474) to (6673)	(7670) to (7600)
NRR (%)	(6.37)	(5.92)	(6.08)	(6.1) to (5.5)	(6.3) to (6.2)
Rynge Wind Power Plant					
Capital Investment (MSEK)	5.54	5.54	5.54	5.54	5.54
Less subsidy (MSEK)	1.94	1.94	1.94	1.94	1.94
Net Investment (MSEK)	3.6	3.6	3.6	3.6	3.6
Project Life (years)	15	15	15	15	15
NPV@7% real discount rate ('000 SEK)	(529)	598	187	75 to 1784	(400) to (335)
NRR (%)	(0.98)	1.11	0.3473	0.14-3.3	(0.7) to (0.6)

To illustrate the effect of potential rise in the CO_2 tax of low sulphur heavy stock (LSHS) furnace oil on the profitability of the TCA analysis, the data forecasts of the three major studies were used to rerun the spreadsheet calculations of the Rynge project. The reason for choosing the Rynge is that it is a commercial business venture. The results are presented in Table 4.

Table 4. The effect of rise in CO_2 tax levels on the profitability of the Rynge Wind Power Project

Study	Rise in CO_2 tax level	End-Of-Period	Company Analysis		TCA	
			NPV ‘000 SEK	NRR %/yr	NPV ‘000 SEK	NRR %/yr
1[36]	7% per year	1990-2020	(529)	(0.98)	2183	4
2[37]	40 öre/l = 16 öre/kWh$_e$ per year	1996-2000			4077	7.6
3[38]	10 öre/l = 4 öre/kWh$_e$ per year	1990-2020			3851	7.1

The NRR of the Rynge project with the current CO_2 tax levels is 1.1% per year. *Whereas, by incorporating the potential rise in CO_2 tax levels of oil, the NRR of the same project is increased to four to seven folds*. This fictitious calculation exemplifies the importance of incorporating potential policy changes into the TCA and the valuable insight provided by such policy instruments in *today's* business decisions.

CONCLUSIONS FROM THE APPLICATION OF TCA ANALYSES

Similarities Between the Three TCA Models

The Tellus and MILA models are similar in all aspects. The methodology of calculating various environmental costs and benefits in Paras model involves incorporation of probabilistic analysis. This is the unique aspect of the Paras model, incorporating risk and uncertainty in calculating environmental costs and benefits of each component of the project. As it was difficult to pinpoint risks, assign a probability factor and estimate the outcome of risks associated with various components of wind energy production, only the identified costs and benefits which were found certain as per the company accounts and were straightforward to calculate, were included in the TCA analyses. Therefore, the NPV and NRR of the Nogersund and Rynge project as per the three TCA models, remain the same.

[36] Page 155, “Urban Travel and Sustainable Development”, European Conference of Ministers of Transport, Organisation for Economic Cooperation and Development, Paris, 1990

[37] Page 27, “Klimatförandringar I trafikpolitiken”, Statens offentliga utredningar 1995:64, Kommunicationsdepartment, Slutbetankande av Trafik och klimatkommitten, Stockholm 1995, SOU 1995:64

[38] Page 26, “Summary of Ny kurs I trafikpolitiken”, Statens offentliga utredningar 1996:26, kommunikationsdepartment, Delbetankande av Kommunicationskommitten, Stockholm 1996, SOU 1996:26

Quantification of ‘Benefits Due to Eco-labeling Wind Electricity’

The Paras financial model, provides an approach for tracing the less tangible benefits due to sales of green products.. More often, in applying TCA models, it is left to the company to choose an apt method suiting to the project under investigation. For the Rynge project, the marketability of the wind electricity provided a basis for estimating the benefits due to eco-labeling wind electricity.

TCA Analyses Versus Conventional Analyses

TCA analysis provides a more comprehensive financial picture of environmental investments and does enhance the overall profitability of the venture, when compared to conventional financial analysis. The quantum of profitability enhancement varies even within the two wind energy projects studied. *For Nogersund, the NRR is enhanced by 4 to 6.65%*, *while for Rynge, the NRR is* *shifted from a negative to positive value*. Therefore, the impact of TCA on a project’s profitability is dependent on project specific environmental and financial attributes.

The TCA and the Environmental Policy Instruments

The TCA application case studies reveal at least two-fold aspects of environmental as well as energy policy instruments such as taxes, subsidies, fees, charges, etc., which a company must consider before proceeding for in-depth financial evaluation:

1. a clear interpretation of such instruments as to their objective, scope and rationale from the policy maker’s perspective and
2. cost implications of both the current and expected policy instruments with respect to the project under TCA evaluation.

The TCA and the Company Environmental Management

The environmental management accounting questions spread beyond the boundaries of the project undertaken for TCA and also these questions are to be answered partly and collectively by various cross-functional departments other than the production within a company. While securing answers to those questions, TCA analyst(s) should make sure to adapt the application of specific models to suit the nature and style of the project management within the company. For example, inclusion of avoided pollution taxes warrant discussion between environment and finance department and estimation of benefits of eco-labeling wind electricity needs the interaction between marketing and environmental affairs. As the TCA investigations go deeper, one might see the need for company-wide and department-wide interactions to secure in-depth information.

TCA’s Demands From the Company Management System

The TCA application demands a precise environmental costing and accounting information system within a company and across the plants and departments. As environmental costing is tied to the existence of environmental management system, and the corporate vision on current and future strategies including environmental issues, TCA presupposes the establishment and operation of a system’s approach to environmental issues within a corporate group.

Incorporation of External Environmental Costs in TCA

While incorporating 100% external costs of oil cycle, the TCA analyses *with avoided environmental costs of oil fired gas turbine plant*, show that the NRRs of the wind power projects are *greater* than that of the same without including external costs. On the other hand, while incorporating 100% external costs of natural gas cycle, the TCA analyses *with avoided environmental costs of natural gas fired gas turbine plant*, show that the calculated NRR of the wind power projects are *less* than that of the same without including external costs.

This indicates that, it is likely in the future, to internalise a portion of external environmental costs of oil cycle. On the other hand, for the natural gas cycle, such internalisation may not be a promising outcome as the present internalised environmental costs are higher than that of the estimated environmental external costs of the gas cycle. These interpretations would be correct only if the assumptions underlying the estimation procedure and the data collection of fuel cycle external environmental costs remain close to the Swedish conditions. Nevertheless, for a business manager, incorporation of such external costs in the TCA models would be a convincing argument from him for the top management to direct corporate future business strategies toward an environmentally pro-active regime.

Assessment of External Costs of Power Production - A Commensurable Approach?

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ABSTRACT

The study charts and assesses the methods of evaluating the environmental externalities of power production in general and the applicability and usefulness of the outcome of the conducted studies to support decision-making. In the practical section of the study, the magnitudes of externalities for existing nuclear power fuel cycle, for modification of regulation practices of Oulujoki river hydro power system and for fuel cycle of wood fired combined heat and power plant were investigated by means of case studies. In addition, the externalities of wind power and photovoltaics were assessed based on studies conducted abroad.

The outcome of the externality studies varies a great deal due to the differing target setting, associated different background assumptions, methods selected, environmental conditions and boundaries of the analysis defined. The results of the conducted studies are not commensurable. Transferring results and their elements from one set of conditions to another poses a problem in terms of assessing the credibility of the results, as many of the pertinent factors are site-dependent. Due to the great uncertainty of the existing estimates, the use of monetary results in designing optimum environmental control measures, in terms of economic efficiency, may lead to erroneous conclusions.

In view of many environmental impacts, commensurableness on a monetary scale should not be treated as self-evident, due to numerous problems related to the monetary valuation of non-market damages. In lack of property rights concerning environmental impacts or in conflict of these, especially when the benefits and costs of an activity are distributed to different groups of people, the different measures of preferences may lead to differing results depicting the value of impacts. In these cases, the definition of rights is an integral part of the valuation and negotiation process.

INTRODUCTION

A decision on energy alternatives requires determination of the values that the far-reaching and multidimensional effects of the decision will have. Decision making based on data as objective as possible and produced by various disciplines is not possible, however, without a subject or, at least, without a method containing subjective assumptions, which will assist in making various impacts investigated in various scientific frames of reference commensurable. The great number of effects and their complexity require the development of systematic approaches.

The exchange of goods and services in the markets by means of monetary units constitutes a system, which reflects individual preferences associated to exchangeable objects in a commensurable way. However, the production of goods and services may cause damages to the welfare of ‘third parties’ through the environmental pathways. These damages are not included in the price mechanism due to the lack of property rights and thus they are not taken into account in traditional economic decision making. The incorporation of these externalities to the economic decision making is an important topic.

This work attempts to bring out viewpoints useful to decision making on the assessment of externalities of power production in general and on the latest methods and results the studies have yielded. The work has concentrated on damage cost and externality studies conducted in Europe /see references/, the valuation methods used and the problems encountered in trying to make the environmental impacts commensurable in monetary terms. Furthermore, the work has completed previous studies conducted under Finnish conditions on nuclear, hydro and biomass case studies. In addition, the applicable information on wind power and photovoltaics was gathered from studies conducted abroad to facilitate the comparison between the environmental impacts of the different energy forms. The major goal of the study has been, however, the assessment of the applicability of externality studies as a method supporting decision making in Finland.

An economically relevant external cost (or inversely benefit..) refers to the share of external damage cost, in terms of price mechanism, which has not been covered by compensations or which has not been agreed upon in connection with the decision making or, in any other way, been taken into consideration thus falling on the party suffering damage and being ‘third party’ in terms of trading. Such impacts (generally benefits) which are transferred in an exchange to third parties are not externalities but are priced and internalised in the market place (e.g. efficiency gains of operations through the use of electricity).

It is important to note, that the definition of external cost is not unambiguous in practice but appears in various forms in the practical applications made in the energy sector. E.g. in recent EU’s ExternE study, a very wide definition is expressed: ”An external cost or an externality arises when the social or economic activities of one group of persons have an impact to another group and when that impact is not fully accounted for by the first group” /EC 1995 b/. In the studies conducted, the approach, for instance, to employment, substitution of resources, government subsibidies and fees as well as occupational health hazards varies. In terms of the applicability of the results, it is important to note that the definitions have been made separately for each study and that, in the different studies, externalities may cover different types of costs. Most often they, however, mean environmental damage costs without taking a stand on whether the value of damage has been considered in the previous decisions or whether the size of damage would require some further action to be taken. In terms of economic decision making, all environmental damage costs are not relevant externalities, some of them are called residual damages by economists.

In terms of the optimal point of economic efficiency, where the incremental investment to mitigation measures would be equal to the decremental environmental damage costs, a certain level of residual damages remains. In terms of economic efficiency, these residual damages have not been considered important. Residual damages might have been taken into account in the decision process concerning the optimal level of controls or they might have been compensated in some form or another i.e internalised into the decision making process.

In terms of practical energy decisions, an accurate division of the environmental damage costs to residual damages and economically relevant externalities is a very theoretical and subtle line because of the great uncertainty of damage costs, the number of administrative controls and economic instruments, eventual overlapping and the range of liabilities of institutions affecting decision making and the complexity of the representativeness of decisions. If the regulations or moral pressure are such as to reduce e.g. emission by the optimal amount, then there are no relevant externalities in the sense that the measured damages should be used for further controls /EC 1995 b/. For example if workers are aware of risk factors of their work, and their contract of employment reflects proper compensations for these added risks, then there is no relevant externality. On the other hand, externality may evolve with the progress of time, when the values and knowledge of society change. The roles of institutions, laws and democratic decision making process are generally disregarded, if the analysis is based purely on neo-classical economic analysis.

The monetary valuation of impacts aims at internalising the damage to the decision making process by making possible the compensation of residual damages in monetary units, at least in principle. In the area of residual damages, 'trading' is thus realized by means of environmental impacts, which means that the impacts are not prevented from emerging but are compensated instead. It is thus of extreme importance that the impacts of new projects are valuated correctly, i.e. the level of compensation is commensurable with the additional damage caused.

ASSESSMENT OF EXTERNAL COSTS OF POWER PRODUCTION

In principle, externality studies can be divided into bottom-up and top-down studies based on their research strategy or basic architecture. Former studies are typically case studies and are conducted on a marginal basis, in such way that damage costs are calculated by means of damage functions for a new incremental investment which is usually some 'state of the art' level of technology. Top-down studies concentrate on an existing situation, use aggregated data about national level damage data and are thus done on an average basis. However, these types of studies are the extremities and practical applications have a lot of individual characteristics, which are compromises between a theoretically desirable model and data and methodological deficiencies, and might include elements from both basic structures.

The bottom-up analysis proceeds from the identification phase (burdens, system boundaries and functional units), to priorisation of pathways, via transfer or dispersion models of various physical agents to assessment of environmental impacts by means of damage functions, and finally to the valuation phase where non-commensurable scientifically investigated impacts are transformed to commensurable units. Thus the scientific information on the impacts is a prerequisite for entering the valuation phase when applying this type of analysis. In recent studies, the valuation phase has been executed by means of premises and assumptions of neo-classical economics.

Depending on the object, different valuation methods are used. Market valuation uses existing market prices to estimate damages. Hedonic valuation examines existing market prices to detect implicit valuation of environmental factors by consumers. Mitigation cost valuation examines the cost of preventing or repairing environmental damages. Control cost valuation examines existing regulatory decisions to detect implicit valuation of environmental factors by government regulators. The last method is non-compatible with the premises of neo-classical economics where individual preferences form the basis of valuation. However, the method has been used in some earlier studies and it is still worth considering in some cases when the object is clearly unexchangeable and its quantification is very difficult.

In the last phase of the analysis, the economically relevant part and residual part are distinguished from the estimated total damage cost by means of taking existing compensations into account. In addition, the uncertainty analysis should be conducted to comprehend the distribution of outcomes due to the uncertainty of source data and major assumptions made. The golden but very challenging aim is to conduct the whole analysis in as transparent, consistent and comprehensive way as possible.

The general taxonomic structure of product-based externality study basically resembles the hierarchical pyramidal model in the following picture. The analysis of studies prepared using the bottom-up method runs from the micro level burdens to the impacts by means of damage functions, whereas the analysis of the top-down type of studies runs from the macro level impacts into the burdens by dividing the total damages into parts. In principle, both research strategies should lead to the same conclusions with the other underlying assumptions tallying.

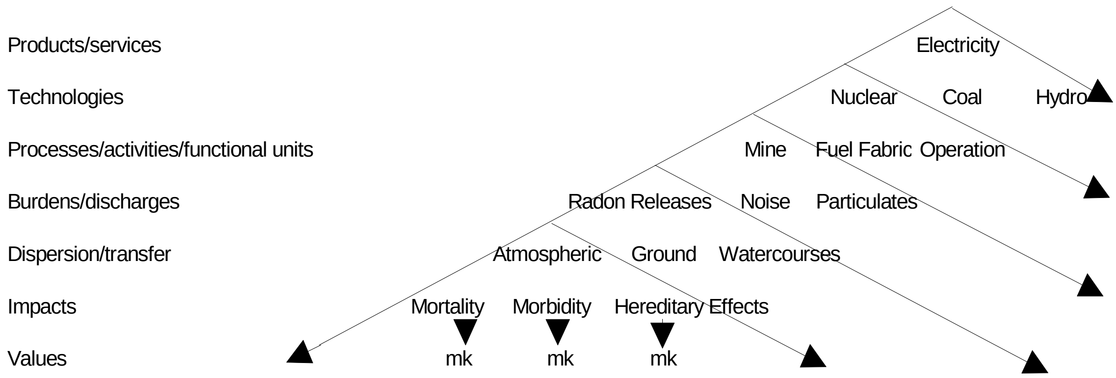

Figure 1. *A hierarchical pyramidal taxonomic structure illustrating the conceptual levels of the impact pathway-damage function method. In principle, all levels are outcome levels, the data of which may be useful in decision making. Traditionally, the outcome of scientific objective examinations has been presented on the impact level. Decision making requires, however, clarification of the subjective values of impacts and answers to the question: what is important ? In externality studies, the costs of the various types of impacts are added up into damage costs per produced commodity.*

It is an important methodological issue that in damage function -impact pathway methodology the valuation is made on the level of end impacts and is then aggregated. However, it is possible that this ”atomistic” approach might lose some vital information on the value of synergistic effects, and thus the general impression might be more than the aggregate of its parts. This problem may explain some of the magnitude differences in the outcomes of bottom-up and top-down studies.

The value of each impact can be connected to the information elements located on an upper level in order to develop factors useful in decision making. In practical applications, it is sensible to combine the categories and form compressed taxonomical presentations of the work. These are necessary tools for gaining a good overall picture of the structure of extensive research efforts, types of impact included, methods of valuation, uncertainty of results and elements not included in the analyses. An example about taxonomical description about coal fuel cycle /ORNL/RFF 1994/ is presented in Appendix 1. These descriptions are key elements when trying to improve comparability of extensive EIA's and externality studies.

In principle, the Damage function -impact pathway methodology can be applied, thanks to its modular structure, in the context of project specific EIAs and company level green accounting instead of analysing whole fuel cycles.

In the end, it is useful to note that it is often scientists or experts who select the priority impacts to be estimated. This approach has certain legitimacy in the definition of the initially gauged importance of impacts on the environment. The population which perceive these impacts and which bear the consequences also have a legitimate interest in the initially gauged ranking of these impacts. It would therefore be desirable that tht they could also participate in the selection of priority impacts. This is the way how the choice process would become more democratic /ENVECO 1997/.

ABOUT THE RESULTS OF EXTERNALITY APPROACHES

The outcome of the increasing body of externality studies varies a great deal due to the differing target setting, associated different background assumptions, methods selected, environmental conditions and boundaries of the analysis defined. In addition, they are very difficult to compare, because they use different methods of categorizing and reporting the results. These properties make in-depth comparison of quantitative results extremely difficult and in some cases impossible. On the other hand, site-specificity of some results and elements of the studies hinder the validation efforts of the results across the different studies. Only the outcomes of global impact categories can be directly borrowed to other applications.

A major problem is that the results of externality studies cannot be validated in the sense of being able to compare them with some objective reality. U.S. Congress Office of Technology Assessment reviewed several environmental studies and concluded that the impact of the assumptions and values implicit in different estimates is large enough so that the isolated quantitative estimates of environmental costs are nearly meaningless. Such estimates become meaningful only in the context of a study's assumptions and for the impacts that are included. OTA states that 'rather than helping to resolve political and social debates, current environmental cost studies often reflect different positions in these debates /OTA 1994/. From this critical perspective, current efforts of US-Department of Energy and European Commission to develop and implement bottom-up damage-function - impact pathway methodology based on neo-classical economic valuation methods can also be seen as an attempt to 'standardise the framework of choices and assumptions'.

Study / publication year	Country	Characterisation, fuels
INFRAS/PROGNOS 1994	Switzerland	TD, average costs, fuels, whole power system, nu, hy, ho, lo, b, g, CH-mix, es
Otterström et. al. 1994	Finland	average costs of emissions, c, ho, lo, b, g, p
Meyer et. al. 1994	Denmark	Technology specific comparison of alternatives, c / w and g / b
EC 1995, a-f 'ExternE'	EU-countries	BU, 'marginal costs' technology and site specific case studies for fuel cycles, c, n, h, lo, ho, w, g, l
Otterström et. al. 1995	Finland	Assessment of profitability of mitigation investment in Helsinki area, c, lo, ho, g, H-mix
ORNL/RFF 1992, not finished	USA	BU, 'marginal costs' technology and site specific case studies for fuel cycles, c, n, h, ho
ESEERCO 1995	USA	BU, 'marginal costs' technology and site specific case studies and program, c, n, ho, w, b, g
Ahonen et. al. 1995	Finland	Site specific fuel comparison by means of damage costs c, b, p, b-p-mix
Gynther et. al. 1996	Finland	Assessment of profitability of mitigation investments in Tampere area, ho, lo, g, p, bg, T-mix

Table 1. *Characterisation of some recent externality studies. Codes: BU-bottom-up, TD-top-down, c-coal, nu-nuclear, h-hydro, ho-heavy fuel oil, lo-light fuel oil, w-wind, b-biomass(wood), g-natural gas, p-peat, l-lignite, bg-biogas, es-energy saving, b-p-mix -wood chips/peat-mixed fuel, H-mix energy system of Helsinki area, T-mix energy system of Tampere area and CH-mix Switzerland's power system.*

The outcomes of recent studies conducted by using the 'state of the art methods' emphasize the impacts of the energy production on public health. Valuation of the impacts has been largely based on the transferred willingness to pay estimates based on literature. In studies conducted after 1993, both in Finland and abroad, the expectation values of the damage costs have varied in magnitude between 0.2-15 Finnish pennies at the 1995 price level per kWh (p/kWh) for coal power and 0.04-2 p/kWh for nuclear power for normal operation. The damage costs of gas power have been less than 1/3 of that for coal power. The estimated damage costs of biomass (wood) power has ranged between 0.3-4.5 p/kWh and for wind power between 0.01-1.5 p/kWh. The damage cost of hydro and wind power cannot be generalized, as these are especially site and projectspecific. The damage cost of photovoltaics depends on the energy sources used to satisfy the relatively great demand of energy needed in the manufacture of the equipment.

The ability of the externality studies to yield reliable results of the values on the consequences of the climate change, nuclear accident risks and impacts on ecosystems is very limited, hence the ranges of the previous results do not represent the full range of uncertainty. In general, ecological impacts cannot be estimated, due to lack of general dose-response functions of populations of species. Only a portion of the potential impacts of the burdens can be determined quantitatively and given a monetary value.

Even the most ambitious studies have concluded that for climatic change, nuclear accidents and ecosystem impacts reliable monetary estimates are not realistic short term objectives. Monetary valuation of impacts is an important tool but other tools for comparing impacts are still needed /EC 1995, a/.

The U.S team concluded that the current research on climate change suggests that the externalities of global warming are an order of magnitude greater than other externalities which their study quantified. However, because of great uncertainty, even about the range of estimates, the study does not endorse any estimates for the externalities of global warming. ”While no scientific studies currently exist to provide reliable estimates, the general scientific consensus is that they are positive (i.e. damages) and that they could be largely relative to those that we quantify in this study” /ORNL/RFF 1994/. IPCC does not endorse any particular range of values for the marginal damage of CO_2 emission either, but has published estimates between $5 and 125$ (1990 USD) per tonne of carbon emitted at the moment. The wide range of damage estimates reflects variations in model scenarios, discount rates, and other assumpions /IPCC 1996/.

Concerning the risk of nuclear accident, both the US and EC teams emphasized the need of risk perception studies: ”The crucial gap in the excistence of reliable quantitative information is on the subjective or perceived risks of severe reactor accidents. Public perception of the risks of nuclear technology is pivotal to its eventual acceptance or demise. The issue of WTP to avoid the perceived risk of accidents, and of its possible interpretation as an externality, is a special topic that needs to be studied further. The concept of considering public (lay) perception in a rigorous way, in addition to expert risk assessment, is an untested approach. The importance of public perception and the untested nature of the approach are all the more reason why more social and integrated science research should be done in this area, so as to put the risk in a better social perspective /ORNL/RFF 1995/.”

In the assessment of the results of different fuel cycles, it should be taken into account that the system boundaries of analyses of renewable energy forms (e.g. wind /Meyer et. al. 1994/ and photovoltaics /Ott et. al. 1996/) deviate considerably from some externality studies which have investigated conventional energy technologies in which only primary effects have been taken into account, and for instance purchased electricity and its effects have not been observed /e.g. EC 1995 e/. Due to the large amount of energy needed in the manufacture of photovoltaic systems, the external effects analysed in the study arise from other energy tecnologies (mostly based on fossil fuels) to a great extent. Owing to this, the results can be understood in such a way that if the prices of other energy forms and fuels increase due to the internalization of the externalities connected with them, the situation would reflect on the rising price of solar power.

DOES THE CURRENT EXTERNALITY APPROACH PRODUCE COMMENSURABLE OUTCOMES ?

As a conclusion of the examined externality studies it can be said that each study is individual and that they differ from one another already in their points of departure and application goals . The potential goals have included, at least, a comparison between the investment decision options, setting of levels for standards or taxes and prioritization of research and control measures. The various studies may focus on describing the existing situation from average perspective or the future from marginal perspective. Mutual comparison of the detailed results from different studies in a useful manner has proved to be extremely difficult (nearly impossible), and in certain cases meaningless, due to their being non-commensurable in methodology. Thus only rough comparisons have been possible /OTA 1994 and Hongisto et al. 1997/.

The differences in the results may be traced back to dozens of factors simultaneously, which in turn is caused by the hierarchical structure of the externality studies and by the fact that the definitions for external costs differ (different impact types have been included in different studies) and the assessment methodologies, as for research architecture and treatment of individual impact types, differ. The examined technologies and the divisions between the outcome reporting categories are different, the boundaries of the analysis, in terms of the sub-processes of the fuel chain, are different, many impacts are site-dependent, also dependent on the environmental circumstances, the boundaries differ, in terms of the examined burdens as well as time and place, the studies apply different valuation methods and the discounting of the results differ from one study to another. The uncertainty of data has also been investigated using various methods. The methodological frame of reference in the externality studies consists of combinations of selections concerning the above factors, and the results depend both on these and on site-dependent factors. In the practical applications, it has been possible to monetise only some of the estimated environmental impacts. Consequently, it is not sensible to generalize, nor make commensurable, the overall results of studies conducted in different countries.

The externality studies are partly based on previous externality studies or on the modules of these. These have then been applied in new circumstances to new energy technologies. The impact functions are often based on meta-analyses prepared from the original studies and the valuation on the acceptance of these same assumptions. It is thus possible that the convergence of the results of studies depends more on the resemblance of the embedded assumptions and ‘borrowed’ values and damage functions than on the increase in knowledge. It is not likely that by combining the various studies and their results it would be possible to build conclusions more reliable than individual studies, i.e. the results of studies cannot be extracted from the method used.

Basically, commensurability between the outcomes of externalities (or damage costs) of different studies and between various impacts in one study is a matter of faith and depends on the level where the comparisons are made. In the end, the commensurability depends on the valuation methods applied. Disputes over the valuation methods mostly center around the utility and accuracy of different types of evidence /OTA 1994/. For example the market, hedonic and travel cost methods draw their information from consumer choices, the contingence valuation from interrogation studies, and the control cost method from the decisions of democratically elected politicians.

Several practical problem areas can be detected, which may lead to non-commensurableness and rule out the use of results from decision making processes. This might happen even if studies have been conducted technically in an excellent way.

1. ethical and equity issues related to the monetary valuation of environmental impacts
2. disagreement on goals on policy level
3. inadequate illustration of overall uncertainties
4. lack of empirical data and reliance on transferred elements or chosen ‘blocks’ of previous studies

5. unknown or unequal boundaries of the analysis (place, time, system, impacts)
6. lack of analysis of certain types of impacts perceived important (risks, effects on ecosystems etc.)
7. possibility of institutional capture by choices of methods and the way the analysis is conducted
8. time delay between source data in relation to actual decision making situations, etc.
9. uneven level of knowledge and accessibility of data associated to various impact types.

SOME PROBLEMATIC OBSERVATIONS RELATED TO VALUATION PROBLEMS OF NON-MARKET - UNEXCHANGEABLE IMPACTS

The valuation of environmental impacts raises serious ethical and other important issues, which are outside the normal domain of welfare economics. If valuation measures are used for the study of many public policy questions instead of the democratic decision making process, it is of outmost importance that the measure of value is generally accepted. Some of the ethical problems are associated to the assumptions which are in turn associated to the property rights, and some are linked to underlying utilitarian premises. Without property rights, exchange is not necessary and thus the valuation of the object in monetary terms is meaningless. However, this does not mean that the object is valueless.

In market conditions, the exchange of goods and services (or some property rights) are made based on voluntary behaviour and choices. The consumer and producer of the goods or services decide when the price or ‘exchange value’ is right and commensurable with the goods or services. Otherwise, the exchange of some property rights (by means of monetary unit) does not occur and the exchange value of those goods cannot be detected and no commensurability in monetary units exists. In these cases there is no overlapping area between consumer’s willingness to pay (WTP) and producer’s willingness to accept compensation (WTA). However, all is not for sale and everything cannot be bought from the markets.

It is known that there is a divergence of WTP measures when the individuals buy and WTA measures when they sell the same object. Hanemann demonstrated that the divergence can range from zero to infinity, depending on the degree of substitution between goods and the fact that one should only expect convergence of WTP and WTA value measures when the goods in question have a very close substitute, a value divergence will exist and expand as the degree of substitution decreases /Hanemann 1991/. It has been shown that for nonmarket goods with imperfect substitutes (e.g. reduced health risks) the divergence of WTP and WTA value measures is persistent even with repeated market participation and full information on the nature of goods /Shogren et. al. 1994/.

It is important to note that it is typical of environmental non-market impacts that property rights have not been defined or there may be conflicts in them and, in general, the situation is not voluntary for an individual and there might not be any substitutes for a ‘bad’ in question (e.g. health risk). In addition, the person might not benefit from the production of incremental environmental burden. Thus, the whole context is different from the market conditions from where the underlying theories have been developed. The finding of divergence of WTA and WTP in some cases from zero to infinity, and reasons behind this, forms an extremely important issue from the point of view of the scope of monetary valuation of the environmental impacts in general.

Applying the economic approach to evaluate non-market - unexchangeable environmental impacts, it is necessary to resort to the WTP or to WTA, as expressed in the CVM studies, as a measure of the individual preferences, in lack of real markets. The person carrying out the CVM studies is forced to make some background assumptions on the property rights of the subject to be valued and on the monetary substitutability of non-market damage i.e 'necessity of exchange', when deciding whether to select the WTP or WTA as the measure of value and how to take any refusals to answer or, possibly, 'unreasonably' high compensation requirements. WTP is constrained by income but WTA is not. Which measure is correct ? The answer depends on the context and especially on property rights. WTA is the correct measure when the individual does have a property right and is being asked to forgo a benefit or to accept a loss. However, when estimating externalities of additional power projects, which might damage the environment, in most of the recent studies the damages have been estimated erroneously by means of WTP measures, which have been transferred from a very different context (mostly from traffic safety studies to the energy sector) to new applications disregarding their context specifity. It can be asked, what makes the use of WTP at low damage levels acceptable when it is clearly unacceptable on high level risks of death ? The use of WTA instead of WTP would eliminate most of the ethical and equity problems concerning monetary valuation of non market environmental impacts, which could also be called 'public bads' due to their publicity and undivided character. However, the rights of future generations and the evaluation of the fauna and flora is still controversial. What do we know about the preferences of future generations in terms of WTA ?

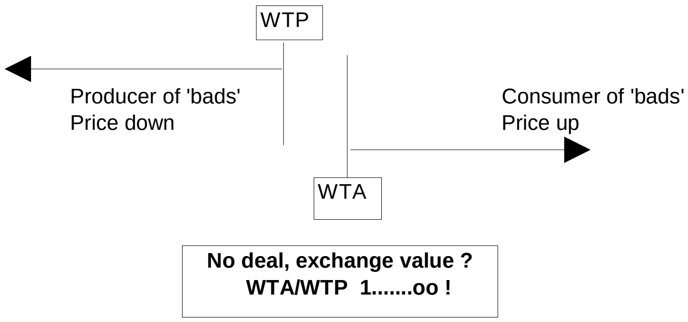

Figure 2. *For most non-market environmental impacts property rights are not set. However, the choice of WTP or WTA includes assumptions on the property rights of the subject to be valued and on the monetary substitutability of damage. The latter is self-evident in case of voluntary trade but not always for 'public bads'. The problem illustrated in this figure restricts the use of economic valuation to impacts that are "thought to be tradeable".*

It can be concluded that the valuation of environmental damage in monetary terms means implicitly an acceptance of a monetary compensation for the damage; this again should lead in the damaged group of people being allowed to decide on the commensurableness of the damage and its monetary value as well as on the accepted level. Otherwise the question whose values to use is left to the hands of analysts, and damage costs of ‘public bads’ can be considered to be born involuntarily and cannot be compared with other market prices of ‘private goods’ born by voluntary exchange, choices and behaviour. This is something very distant compared to the current practise of utilization of scientifically transferred values and the embedded assumption of general monetary substitutability of all environmental impacts.

In the end, the commensurability in monetary units is tested in case of residual damages, which remain after optimization of control measures in terms of economic efficiency. If WTP is used as a measure of value, i.e. property rights are interpreted to belong to the source of damage, and decisions would be made purely on the basis of neo-classical economics disregarding the distribution of costs and benefits, nothing would guarantee e.g. the health and safety of the individuals in the poorer parts of the world (in case of climate change, hazardous wastes etc.) Utilitarian philosophy, which lies in the background of the goal of economic efficiency, may lead to the situation where natural resources or services are allocated to the relatively small groups of people if they gain the most benefit from them. When the basic measure of benefit is the willingness to pay disregarding the question who causes the damages, the monetary valuation of environmental impacts allocates decision power and environmental services to the hands of the wealthiest groups of people.

LESSONS LEARNED FROM CASE-STUDIES

Fuel Cycle of Nuclear Power Plant (2xVVER-440 Pressurized Water Reactor)

The environmental impacts of fuel-cycle of the existing Loviisa NPP were analysed by means on existing literature, recently done EIA following the EU’s ExternE-methodology /EC 1995 e/. Information was gathered regarding all the stages of fuel cycle. Occupational health effects were not considered as externalities, but they were reported. Stochastic radiological health effects were priorised to the most important type of impacts and they were estimated by means of public collective doses and risk coefficients applied in ExternE /EC 1995 e/ based on reference /ICRP 1991/. Due to the linearity of dose-response function, the expectation values of impacts are directly proportional to the collective doses or dose commitments. In addition, the results were assessed by means of monetary values of radiological effects of ExternE-study.

	Collective dose, manSv/TWh				Time
Process of fuel cycle	"low"	"mid"	"high"	Reference	period
Mining and milling /a	1.14E-01	1.71E+01	1.14E+02	UNSCEAR 1993	<10000
Mining and milling /b		1.77E-01		EC 1995 e	<100000
Conv.+enrich.+fuel fabrication		3.20E-04		UNSCEAR 1993	<10000
Operation	1.06E+00	1.77E+00	2.24E+00	L	<10000
Decommissioning		-		L	
Low and medium level waste disp.	1.43E-04	2.86E-04	1.14E-02	Diff.scenarios,L+	<10000
Decommissioning waste disp.	2.29E-06	1.17E-03	1.43E-02	Diff.scenarios,L+	<10000
Spent fuel disposal	0.00E+00	1.36E-01		VTT, EC 1995 e+	<100000
Spent fuel transportation	9.76E-04	1.21E-03		L, 1000km	Transport
Sub total (M & M /a)	1.18E+00	1.90E+01	1.16E+02		
Sub total (M & M /b)	1.24E+00	2.09E+00	2.58E+00		

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able 2. *Estimated global public collective doses originated from different stages of nuclear fuel cycle in normal operation. Estimates were normalized by means of material needs of different processes to produce 1 TWh electricity. The estimated lifetime of the plant is 45 years and total production 350 TWh. Due to the difficulties to obtain information on the fuel fabrication in Russia, generalized estimates were used for upstream doses. In mining and milling /b estimate it is assumed that there are no radon emissions after the closure of a mine or a* *mill. The range of results of operation is based on an annual variation of C-14 releases. + means that the estimate includes some conservative assumptions. The ranges of the results do not present the uncertainty of estimates but mainly the results of different scenarios or studies.*

In the table, it can be noticed that the collective dose estimates of mining and milling (due to radon emissions, UNSCEAR 1993 data) and operation (emissions of C-14 nuclides, half life 5730 years) are clearly the dominating factors when assessing very long time periods. However, if the similar type of methodolody is appied for radioactive emissions of modern coal fuel cycle /UNSCEAR 1993/, its collective dose would be in magnitude 0.3 - 3% of the dose estimates of the nuclear fuel cycle presented in the previous table.

The magnitude of ”expectation values” of estimated stochastic radiological effects corresponding to the collective dose estimates for 1 TWh power production and for different mine & mill estimates are:

(m&m/b - m&m/a)

0.1 - 1.0 fatal cancers

0.3 - 2.3 non-fatal cancers

0.02 - 0.2 severe hereditary effects

If ”low” estimates and m&m/a data had been used, the outcomes would only be 6% of ”mid” values and the ”high” estimates about 600% of ”mid” estimates. If the ”mid” impacts are valuated by means of ExternE’s assumptions, the result would be 3.5 mECU/kWh in 1990 price level. The magnitude of this result is very near the result of Canadian PWR case-study /ERG 1993/. If ExternE’s mining and milling data had been utilized, the outcome would drop to 0.4 mECU/kWh. However, these non-discounted estimates for a period of 10,000 years can be regarded as quite conservative. The matter becomes particularly problematic as there is no other means of proving which level of discount rate would be the right one in the long run.

The radon problem of the mill tailings and ore gangue of the mines highlighted in the completed analysis cannot be regarded as irreversible due to the rather short half life of radon (3,8 days). With appropriate covering methods of the tailing piles, the seepage speed of radon as well as the collective dose of the population ensuing from it can be reduced considerably, if regarded necessary. In the most effective method, the seepage speed of radon can be dropped to as much as below one millionth of that of an uncovered tailing pile /UNSCEAR 1993/. Depending on the measures taken in the future, the radon-derived collective dose based on generalised UNSCEAR data corresponding to one year of operation of Loviisa NPP would be between 0,8 and 800 manSv (for the duration of 10,000 years), which can be compared to the annual collective dose of about 10,000 manSv received from natural radon exposure by the Finnish population.

In addition, the results of the safety analyses were utilised to develop risk-based estimates for potential damages. By means of the probability safety analysis made for Loviisa NPP (PSA levels 1 and 2), and additional dose calculations, the expectation value of public collective dose risk $2.4 \cdot 10^{-10}$ manSv/kWh was obtained on an integration time of 500 years. If this expectation value was evaluated ‘risk neutral way’, the ‘damage cost of health effects’ would only be 0.044 mECU/kWh, which is small compared with the estimates of normal operation. However, this logic contains numerous difficult issues which cannot be considered as solved. The views on the methodology suitable for evaluating accident risks and potential externalities vary greatly e.g. /INFRAS/PROGNOS 1994/.

The external cost estimates of nuclear fuel cycle presented in this analysis are composed exclusively of the expectation values of stochastic health effects of the public. In this situation, the value of statistical life, and the ethical and other methodological questions associated to it, have overriding significance compared with the technical or scientific data at least from the point of view of the public acceptance of the outcomes.

When comparing the results of nuclear fuel cycle to other cycles, in addition to the mutually differing methodologies and scenario assumptions embedded in the analyses of various fuel cycles, the significance of damage costs of nuclear fuel cycle must be assessed in proportion to the distribution of the impacts in normal operation over a very long time span in the future. The adding up of the value of the damages over time is the key question for the damage costs of the nuclear fuel cycle.

As a result of discounting, the present value of damages occurring in the future decreases very strongly. For example, if applying 1% discount rate, ExternE's unit values for health effects and 0.015 manSv/GWa constant annual collective dose of radon releases from mining and milling sites /UNSCEAR 1993/ the present value of damages from <500 years period of time would only be 20% of the value without discounting. For 3% rate the proportion would only be 6.8%. In practical excercise, this would mean that the physical impacts occurring after about 200 years have a very small or negligible effect on the results and thus on the decision making process, if one trusts this type of analysis. The result of external cost of nuclear fuel cycle is extremely sensitive for very small changes in the discount rate assumption. The problem becomes even more difficult than that relating to the changes in the values of the investigated damage types and to the changes in the valuations of people over time. For practical application the rate at which costs and benefits will grow over time is just as important as the discount rate; only the difference between these two rates matters /Rabl 1995/.

In addition, it should be noticed that the methods of assessing radiological health impacts differ considerably from those of the burdens of other fuel cycles, due to their advanced emission measurement and recording systems, transfer coefficient studies and possibilities for internal dose evaluations, and, on the other hand, due to the extremely long timespan over which the assessment was conducted. There is a lot of data available on the transfer of radioactive substances in the food chain; this, together with the linear impact model without a threshold value, enables an evaluation of the magnitudes of health effects by applying a relatively simple method. These methodological differences have to be taken into account in comparing the nuclear fuel cycle evaluation with other production forms. A comparison of plain numerical result estimates is not sufficient.

It is obvious that presenting a reliable point estimate for the damage costs of nuclear fuel cycle is not a defensible approach. Due to the great uncertainties of the analyses, on one hand, and to the multi-dimensionality of the problem, on the other, it is not sensible to present a scientifically justified estimate, compressed into one figure, on the externalities of nuclear power. Each figure presented as an 'objective outcome' contains more or less subjective choices. The absolute results of the damage cost assessment of the nuclear fuel cycle are fully dependent on the selection of the source data and other parameters and on the scenario assumptions embedded in the analyses.

Due to the fact that none of the presented monetary estimates are based on context- and site- specific valuation sudies, it can be argued that the responsibility of the use of these estimates are left to their users Can these outcomes be utilised in decision making processes as commensurable units with other costs, is a open question to various interpretations. The subjective judgement of the authors of this study is that they cannot .

Modification of Hydro Power Regulation Practices of Oulujoki River System

This case study includes the amendment of the regulation practices of the Oulujoki lake and river system. The case was selected to the hydro power implementation because it presents well the future development of the Finnish hydro power. The regulation of Finnish watercourses were mainly carried out between 1950 and 1980. Most of the projects were aimed to satisfy the needs of hydro production, flood damage or water supply. In the course of time, the use of watercourses as well as general attitudes of society have changed. On the other hand, this is a practical example of how the changes of values and attitudes of the population can create externalities even if the physical impacts of power production are remained almost unchangeable. As various uses of waterways compete with each other, it is difficult to compare the advantages and disadvantages of operations in view of various interests.

The Oulujoki water system is situated in Northern Finland. Up to 90% of the basin's lake area is regulated. The regulation is an integral part of the Finnish electricity production system, constituting about 20% of the hydro power in Finland. Of the annual yield of 2 540 GWh in the Oulujoki water system, more than 50% is produced between November and March, when the electricity consumption in Finland is the highest.

Along with the enormously increased recreational use of watercourses and the appreciation of pristine nature and water ecosystems, and on the other hand with the increased need for regulation in the watercourses, there is more and more demand for the revision of the old valid power plant and regulation licences which are partly inappropriate for present needs. The reconsideration of the licence conditions of the previously permanent licences was made possible in 1994 with the amendment of the Finnish water law.

In the future, a typical hydropower project would consist of investigation on the effects of regulations and their development to pay more attention to the need for different uses of the watercourses.

Due to the slow legal process, different players have implemented new regulation practices and mitigation measures on a voluntary basis within the framework of current permits. The voluntary method requires co-operation and feed-back in negotiations and agreements between parties. If successful, it has many advantages to the legislative process. Consequently, it was decided that hydropower investigations should focus on regulation development, not on a totally new project.

A study on watercourse regulation development was carried out in the River Oulujoki watercourse between 1989 and 1996. In the project, the different effects of regulations were investigated, and methods for their assessment were developed. This investigation of the external costs of hydropower is based on the results of the above-mentioned study entity which yielded empirical information /Ruotsala 1992, Kaatra et. al. 1993, Sinisalmi et. al. 1996/. The development which has taken place on the River Oulujoki reflects well the situation of hydropower in Finland in general, because the prevailing situation in the future will include critical inspection of the use of hydropower plants and the regulation of lakes for environmental reasons, and on the other hand development to meet the requirements of the need for different uses of the watercourses.

In the study on the development of the regulation of the River Oulujoki watercourse, the objective was to discover regulation alternatives which would be ecologically sound, socially acceptable as well as economically and technically feasible. In the assessment of ecological soundness, the changes in the water quality, fish stock, vegetation and the organisms in the shore zones due to the regulation development were investigated. Social acceptability was assessed by studying how the people living in the sphere of influence of the watercourse have experienced the changes owing to the watercourse construction and regulation, what kinds of wishes they have, and what their attitudes are towards regulation development.

For the assessment of economical feasibility, the influence of regulation development on the extent of flood damages and losses from the point of view of energy economy was investigated. Technical feasibility was assessed by calculating the hydrological effects of the regulation development alternative in different water years /Kaatra et al. 1993/. Thus, the following were selected as variables under examination: hydrology, flood damages and waterlogging of shores, recreational use, aquatic ecosystems, quality of water, fish stocks and fishing, socio-cultural effects, and energy economy. It is significant that the measures of value were not limited to the methods of the neoclassical economic theory, whereas the problem was approached from as many angles as possible. The alternative regulation practices were compared using a decision analysis interview method /e.g Marttunen and Hämäläinen 1995/, in which the data acquired through the EIA's of various impacts were combined with the values of the local people and interest groups

Most of the effects in connection with the regulation development projects of the watercourse of the River Oulujärvi and the project of raising the height of backwater at Merikoski have been or will be internalized in the implementation costs of the project through various compensations and compensatory actions. Aquatic ecosystems – the fish, vegetation and the environments in general – as well as recreational use are influenced most by the external effects. The following list includes the factors which have been considered as the most genuine external effects, and their monetary values if they have been possible to define.

The summary of the results of the external damages of investigated regulation changes:

- The inconvenience to recreational use due to lake regulation –0,089 p/kWh in total (for annual power production)
- The water logging damages due to lake regulation -0,009 p/kWh (for annual power production).
- Each year an average of 139km2 of the zone produced by the regulated lakes is frozen over

- The inconvenience to recreational use due to the short-term regulation of the main channel of the River Oulujoki –0,012 p/kWh (for annual power production)
- The benefit to recreational use due to the raising of the height of backwater at Merikoski +2,1 p/kWh (for incremental power production of the project).
- Raising the height of backwater at Merikoski have both positive and negative effects on the fish stocks, but the effects have only been assessed qualitatively.
- Raising the height of backwater at Merikoski have mildly negative effects on the vegetation, which have only been assessed qualitatively .

It can be said that in practice there will not be any significant external costs in the watercourse of the River Oulujoki owing to the present old system of hydro power and its regulation. The unincluded effects of the raising of the height of backwater at Merikoski are, in turn, benefits to recreational use, and they can be measured in terms of as much as about 10% of the price of the produced incremental electricity.

The external costs of hydro power are mainly due to the diversification of the needs of the watercourse uses and for instance to the increase in the appreciation of water ecosystems and recreational use in the course of the last twenty years or so. The old permanent regulation and power plant licences have taken into account and fairly comprehensively compensated for the effects mainly to structures, agriculture and forestry, and the use of water, but they have not been able to anticipate the ”increasing recreational use” of the watercourses, which means that these effects have been transferred into external effects of the present situation. It is to be expected in the future that development of regulation for environmental reasons and to meet the needs of various interest groups will become more common.

For the assessment of lake regulations and the effects of short-term regulation on recreational use, the habitats and the fish economy, there are now systematic methods available which can be used to determine the effects and in some cases even the monetary value of the effects. The models yield mainly quantitative results, the reliability of which greatly depends on the quality of the source material used in the model. In the regulation investigations of the watercourse of the River Oulujoki, much emphasis was given to the gathering of source data, which was carried out by interviews, questionnaires, field measurements etc., and the model results gave a good representation of the prevailing situation. The effect estimations in monetary terms, derived from the quantitative values of the effects, for instance for recreational use, are better suited for reciprocal comparison between the different implementation alternatives of the project than to be used as absolute values of damages, although they are most likely to indicate a correct order of magnitude.

By and large, it can be said that the method of assessment developed within the ExternE project /EC 1995 f/ for the external effects of the forms of renewable energy production is also suitable in the Finnish hydropower development project. For each project, the external costs can be examined fairly reliably by integrating different models of assessment and expert appraisals. However, the results must be assessed separately in each project, as for instance even in the above-mentioned development investigation of the regulation of the watercourse of the River Oulujoki it is not possible to add up or transfer the effects of different sectors – lake regulations, short-term regulation and raising the height of backwater at Merikoski.

Most of all, water ecosystems – the fish, vegetation and the habitats in general – as well as recreational use are influenced by the external effects of the lake regulations and short-term regulation. The total monetary value of the external effects of lake regulations is about 0,1 p/kWh, and that of short-term regulation is 0,01 p/kWh, which for both is the equivalent of less than one per cent of the mean price of electricity. The result indicates that most of the effects of the regulations of the watercourser of the River Oulujoki and the energy economy development projects have already been or will be included in the implementation costs of the projects through various compensations and compensatory actions. The Merikoski project indicates that it is possible to develop the regulated watercourses to meet the needs of various uses, when the different effects of the measures are recognized.

Small Scale Combined Heat and Power Biomass Plant 5 MW_e/13MW_h

The externalities of wood power were investigated using as an example a small-scale power plant located in Kuhmo, north-eastern Finland. The plant produces both power and heat. The study has focused solely on the plant’s fuel cycle and power generation phase. In actuality, the plant is fuelled with sawing waste, bark and chips. In this work, however, the wood fuel chain has been described with a cutting waste chain where the fuel is obtained by collecting cutting waste, chipping the waste and transporting the chips to the power plant. Moreover, the investigated fuel chain contains a loading phase.

In the study, the formation of annual emissions were investigated from the acquisition of wood to the operation of the power plant. Most of the net emissions of wood power is produced in connection with the running of the plant. Carbon dioxide makes an exception to that, as its net emission is produced in the acquisition of fuel (if the use of wood is at a sustainable level, it can be assumed that the growth of trees binds the carbon dioxide released in the burning of wood). The carbon dioxide emission during operation is produced by the small amount of oil being burned. In addition, it can be observed that the emissions of nitrous oxides and particles (perhaps also carbon monoxide emissions) are considerable in relation to the operational emissions of the power plant.

Damage estimates of the operation of the plant were assessed by means of the Eco-Sense computer programme /IER 1996/. The program is being developed relating to the European Commission’s ExernE project for the assessment of the environmental impacts of electricity generation on the European level and for assessing the damage costs of the impacts. A test version of EcoSense program exists. The program includes two models for the calculation of atmospheric dispersion of the emissions: ISC (Industrial Source Complex Model), which is used for the calculation of local level concentrations, and WTM (Windrose Trajectory Model), which is used to assess regional emission concentrations and fallout in Europe. The model also includes damage functions, which can e.g. connect increased concentrations of certain pollutants with certain incremental health effects for a known population density.

The results of the estimated damage costs connected to the operation of a power plant and to the transportation of wood chips indicates that the health effects, based on the selected exposure response functions and ExternE’s unit values of damages, are an order or two larger in comparison with crop losses, forest economy or material impacts, which using applied impact functions remained very small in the combined power and heat production. Among the health effects, the focus is on acute and chronic deaths associated to aerosols in a regional level. This impact category would require further research. Sensitivity analyses of various locations of the plant show that the damage costs vary a great deal, depending on the plant location.

In a sparsely populated area it is possible to meet the fuel need of a single and fairly small wood-fired power plant so that the impact of the fuel supply on the forest's biodiversity can also be considered. In case of larger power plant, the fuel need also increases, and this increases the pressure to use so called waste wood more effectively. In such a case, it is possible that the consideration of the biological diversity of forest ecosystems will influence the wood acquisition of the plant. However, so far it is impossible to specify any accurate monetary values for the potential impacts on biodiversity of forests, nor is it possible to apply any simple damage functions, due to the complexity and unknown character of the impacts.

CONCLUSIONS CONCERNING THE USEFULNESS OF EXTERNALITY STUDIES IN DECISION MAKING PROCESSES

If the impacts are made commensurable and are presented in one figure, the underlying assumptions are no longer clearly visible and the outcome may seem more reliable that it actually is. At the same time, elements difficult to quantify, yet potentially significant, may be totally omitted. In these approaches, the assessment process is often regarded as equally important with the end result. It important to recognize that there are numerous problem areas in applying cost-benefit analysis to environmental management (see e.g. Hanley and Spash 1993).

It is of extreme importance that decision-makers understand and accept what impacts and how the reality has been attempted to be projected (and compressed) on the comparison scale and which issues have been left altogether without valuation and why. Therefore the taxonomic structure and the boundaries and assumptions made should be clearly reported.

The uncertainty of data bears a great significance on decision making, however this has not been analyzed and illustrated in studies on hand to a sufficient degree. In progressing from the burden identification phase and the quantification of the impacts to the monetary valuation, the uncertainty increases drastically. In addition, uncertainty may be due to policy or ethical choice, scenarios for the future, technical or scientific reasons or human error /EC 1995 a/. E.g. the choice of intergenerational discount rate is a source of continuing debate as well as the valuation of statistical life with age and location specific questions is an open question. Impacts occurring in the future are dependent on the scenarios selected. In practical work, the most usual assumption is that values remain unchanged. Sometimes it is thought that the values of goods and services that can be obtained from the markets fall with time relatively to the non-market goods like health, pristine nature etc.

In view of the applicability of the results, it is of essence that the assumptions and uncertainty of results embedded in the selection of the method are known to the decision-makers. The use of monetary results in decision making means implicitly the acceptance of the assumptions embedded their assessment e.g. the assumption of the monetary substitutability of all non-market environmental impacts. Due to the great number of assumptions and choices made before the top of the iceberg i.e. a monetised outcome of the impacts can be reached, it seems impossible to carry out work incontestably. It can be considered highly unlikely that the 'objective' environmental cost analyses conducted by the parties with conflicting interests would yield the same results. However, this does not mean that the studies are useless.

Taking into acount these problems and understanding the subjective nature of the decision making process, the best function of the externality studies is to be a medium of dialogues and to serve well- organised background material on the environmental impacts for negotiations between various players on the field. In addition, they may form very useful interfaces to original scientific literature. In this kind of use, externality analyses may be helpful for the negotiators in identifying the structure of the problem as well as the extent and interplay of the various impacts. In the negotiation position it is possible to bring up differences of opinions about 'embedded assumptions' of the analysis. On the other hand, the complexity of the analyses might remove the debate from the sphere of public to the hands of few.

The significance of the various types of environmental impacts is basically a value related question. In negotiations relating to environmental impacts, it is of crucial importance to accept the right of the negotiating parties to have values that differ from those of the other party. In this situation, the standardisation of the measures of value might lead to the standardisation of the values. The unexchangeable nature of most environmental impacts may make the use of economic concepts in practice very difficult.

Decisions are made more and more often on the basis of discussions with various interest groups. Owing to the great number of parties in the decision making, it is usually impossible to distinguish an individual 'decision-maker', and the complexity and flexibility of the various situations must be considered when tools are designed and their serviceability is weighed. It is not the intention to replace the multidimensional decision making process by environmental economic calculations, nor is it possible to develop these calculations to be an decision making machine. Externalities cannot drive decisions. This is due to the fact, that the public responsibility of potential consequencies of major decisions cannot be transferred to the analysts who have made the studies or to the programs and theories applied. There are benefits and damages that cannot be assessed in economic terms, and, on the other hand, it is possible that there is no empirical and 'indisputable' information available that could be applied to the decision, e.g. because of the future-orientation of these decisions.

If the goal is known and generally accepted and the adverse impacts are wished to be minimised to the agreed level, assessment of the costs in the various policy options using by means of the cost-effectiveness analysis is sufficient to support the selection process. No explicit analysis of monetary benefits is needed.

In the tradition of externality assessments, it is also worth noting that the first externality studies in the energy sector were made in the United States to convey information on the values of environmental damages into the decision making processes of power companies operating under the public control as regional monopolies. In this respect, changes in the operating environment, e.g. the liberalization trend in energy markets in Europe, is a factor that should be considered when planning internalization measures: power companies can no longer set, without risking their competitiveness, any 'adders' inferred from theoretical externality studies for the different alternatives in cost-benefit analyses intended to internalize externalities in decision making, unless the competitors do the same. Freeriding prevalent in the markets is a problem which must be taken into account. Freeriders might scrape the benefits of markets, while responsible companies might suffer due to their higher production costs. Marketing of environmental progress of a company is very important for filling this gap. On the other hand, by harmonising taxes or norms the site-dependence of environmental externalities cannot be taken into account.

It is possible to find decision making situations in which economic assessment is not at all or only rarely useful, or it does not offer sufficient or acceptable argumentation for the choices. From this viewpoint, the impacts of the decisions can be divided into two classes: impacts that can be compensated with money (exchangeable impacts) and those that cannot be compensated with money (unexchangeable impacts). Because the borderline between these impact categories is somewhat unclear, the cultural and individual differences in the acceptance of 'monetary compensation' should be considered when economic value analyses are made and especially when the results of these analyses are interpreted to support the decision making. But whose values should be applied in practical decision making situations ? May the analyst choose 'suitable' values from the expanding literature ? It is the people bearing the impacts who should be able to decide on the monetary commensurableness of the impact and its level - not those who make analyses and theories. This highlights the significance of empirical knowledge, without which it would be difficult to justify the acceptance of the implementation of the methods in decision making.

As there are differing opinions on the monetary substitutability e.g. of risks on human life and health and on the reliability of their economic valuation methods, it may be necessary to keep residual damages at a reasonable level e.g. by means of standards and laws, instead of taxes and fees.

In decision making, goals to be considered, besides the economic efficiency, are other possibly conflicting ones, which are extremely difficult to include satisfactorily in the externality studies. These include several other dimensions, e.g. the equity issues associated to the distribution of costs and benefits, sustainability and irreversibility issues associated to certain impacts and depletion of resources and the acceptability of the residual damages in view of human health and safety and nature conservation. These dimensions should also be taken into account when selecting the valuation methods and in assessing the credibility of them. When valuation problems are insuperable, monetary estimates could be combined with other analytical methods such as multi-criteria analysis, to aid decision making processes.

In addition to the optimization of costs and benefits, the principles of justification of practice, controlling of residual damages and consideration of potential surprises should be treated in decision processes as a coherent system, where no part should be taken in isolation.

Considering the potential and restrictions of the economic value judgement of the environmental impact, it can be said that the analysis can only cover one important dimension of decision making. The resulting numerical values should not be considered as an absolute indicator of the public interests. Neither is it possible to give the objective of economic efficiency priority over the objective of social justice. It is important to note that the economic field, which focuses on the trade of goods and services, which are exchangeable and whose property rights are determined, is much narrower than the whole field of social welfare where many important issues are not exchangeable or tradeable and their rights are indefinable.

Availability of reliable scientific data on the environmental impacts of energy production is a prerequisite for the advancing into the valuation phase, regardless of whether the impacts are valuated in a pluralistic way by citizens, politicians and experts or by means of economic approach. The quantification phase of the impacts of energy production cannot so far be regarded as a reliably studied level of outcome either. In the conducted Finnish, and many European externality studies, it has been necessary to resort to American research strategies, valuation studies and often also to damage functions, whose applicability to other circumstances is not known with certainty. The transfer of valuation studies and other sub-elements involves the risk that cultural and site-dependent features are omitted in the decision making process.

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PIA Computer Programme for Product Improvement Analysis

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INTRODUCTION

Cleaner products, healthier products, recycled products. Whether it is for strategical, environmental or marketing reasons, the producer has a growing need of a powerful tool to analyze and modify his production processes.

Over the last few years there has been a growing understanding of the damage to the environment due to economic activities. From an economic perspective the reason for this damage to the environment is that there is no price attached to the use of air, water and land. As a consequence governments try to attach a price tag to the use of the environment by legal and economic instruments.

For business to be able to efficiently and effectively manage the environmental consequences of their economic activities considering both present and future, they will need environmental accounting decision tools. All over the world, the most widely used models are the Life Cycle Analysis (LCA), the analysis 'from cradle to grave', and LCA-based models.

Accounting methods can give better information to producers and consumers at various stages of the life cycle of a system such as product design, risk-analysis, marketing, capital budgeting decisions. This information can affect their decisions and improve the environment. In order for these methods to be really effective for incorporating into the decision process, they should speak the 'language' of the business managers, namely money. Therefor a method is necessary which can combine environmental impact and economics.

One accounting method which has the potential of combining these factors is Life Cycle Costing. LCC offers a great potential value as a tool to incorporate the environment into business decisions, as it gives the effects in the entire life cycle and expresses the effects in monetary value.

LIFE CYCLE COSTING (LCC)

The term LCC has been used for many different accounting methods and several definitions of LCC can be found. In traditional capital budgeting theory LCC is defined as a method of calculating the total cost of ownership over the life time of the asset [Brown and Yanuck, 1985]. Some other definitions of LCC are:

- an economic assessment of competing design alternatives, considering all significant costs of ownership over the economic life of each alternative, expressed in equivalent dollars [Dell'Isola and Kirk, 1981]
- a procurement process which considers the overall total cost, i.e. procurement costs plus life cycle ownership costs, of an item [Dhillon, 1989]

- a technique of examining all the costs, in money terms, direct and indirect, social and environmental, of operating an equipment throughout its entire service life, as an aid to finding the optimal solution to a design requirement [Kinch in Bull, 1993]
- any method to calculate the costs of a system (product or activity) in the life cycle, where costs are measured in monetary units [Schaap, 1996]

The definition of LCC which is used by a method determines which costs are included and which costs are not taken into account. Costs can be specified towards the phases of the life cycle where the costs occur and towards different actors, i.e. who will pay for the costs. A general distribution framework of life cycle cost for the different actors in the different life cycle is shown in the figure below:

	Company costs	User costs	Society costs
Need	market recognition		
Design	R&D costs		waste, pollution, health damages
Production	materials, energy, wages, etc.		waste, pollution, packaging, health damages
Distribution	transportation, storage, waste	transportation, storage	waste, pollution, health damages
Usage	warranty service	energy, materials, maintenance	waste handling, pollution, health damages
Disposal		disposal dues	waste, pollution, health damages
Recycling		recycling dues	

Figure 1: Distribution of the life cycle costs [Alting, 1991]

The current trend is that the company costs are extended towards the costs of the other actors. This means that companies are internalising, some of, the user- and society costs.

Which cost are internalised differs per company and used LCC method?

Most LCC methods take some society costs into account, like the methods from VROM/BDO, ECN, IÖW (PLA) and TME. Some methods focus primarily on societal costs, like the method of IVL, and some take only the traditional cost into account, like Fraunhofer method.

The method which will be discussed here is the PIA method, developed by the Bureau for Environmental and Informatics (BMI), the Institute for Applied Environmental Economics (TME) and the Dutch Unilever Companies (NUB). PIA, Product Improvement Analysis is a software tool to support comprehensive and reliable inventory calculations in the life cycle analysis of products. PIA follows SETAC recommendations on life cycle analysis.

PIA: PRODUCT IMPROVEMENT ANALYSIS

With the use of PIA computer programme for Product Improvement Analysis it is possible to describe production processes and analyze their emissions, use of energy, transport, waste treatment and recycling. Next to analyzing, with PIA it is possible to link and classify processes and find weak parts of the process chains. To compare processes and create alternative scenarios. To build entire libraries of processes, to display data on screen or to store it in files and use it in other programs.

The programme is based on in-going materials and out-going (semi-)products, wastes and emissions. By describing these flows in kilograms and money for each operation or process and by connecting these description through there (half)products a production chain is set up. With this creation of a flow diagram the programme can calculate the total amount of inputs and outputs.

By linking related processes in PIA, a more realistic view on the environmental consequences and costs of a production process is provided. Linking processes is explained as follows: assume product A is used as a major raw material in production process X and product A is also a final product of process A. When process A is linked with process X, Pia calculates the emissions, use of energy, use of transport, costs etc. of process A, pro rata the amount of product A used in process X, and passes it on to process X.

For the presentation of the data there are several possibilities:in the form of a process description, a process tree, an emission matrix specified into amount or abatement costs, a raw material matrix, a cost matrix . Calculations of the effects of a process on certain environmental problems, like green house effect, acidification, ozon depletion, are also provided.

Alternative scenarios for reduction measurements, production processes etc. can be calculated, by replacing linked processes. By analyzing the results on emissions and costs an optimum between the damaging environmental effect and the costs can be found.

The extensive presentation possibilities and clear cut way of calculations made with PIA can support managers during decisions processes and internal communication on possible process improvements.

SOME CASE STUDIES

PIA is being applied by some big Dutch (like Dutch Unilever Companies) and European industries (like Alusuisse-Lonza and Smurfit Lona), European universities, European research institutes like TNO Delft and TME.

TME applicated PIA on a lot of different products and processes to investigate possible improvement options and to select the optimal available solution with respect to environmental effects and costs.

Electricity Production and Environment

The energy sector in the late 1970s experienced an acute resource crisis, while the energy crisis of the late 1980s is distinctly waste-oriented [Chartier and Oppeneau, 1989]. The interface between energy and the environment is of considerable significance and, as a result, the energy sector is particularly affected by the new environment-related demands.

Authorities in the Netherlands demand for emission reduction and cleaner processes. Also the electricity consumers are confronted by these demands, electricity prices increased by the introduction of an "green tax" on electricity.

A lot of research is going on to lower the environmental effects of electricity production. Roughly two ways to reduce environmental effects can be distinguished, by prevention and by end-of-pipe treatments. Prevention holds changing from fossil fuels (like coals) as energy sources to renewable (like biomass, solar and wind) energy sources and improving production processes. End-of-pipe measurement hold, among others, techniques to clean the exhaust gasses.

The possibilities of PIA will be shown by two simplified case studies. The amount of emissions and the abatement costs will be showed for comparison of three combustion processes. And the cleaning effects of three flue gas cleaning systems will be showed, the amount of emission reduction, the amount of additional emissions by the measurements and the costs per kg reduction.

Combustion processes by different energy sources

Four combustion processes are compared. All combustion processes have an output of 1000 GJ. The four energy sources[xxiv] are: coal, oil, gas and wood. The inputs for the different combustion processes are shown below.

Raw Material matrix	Output	Raw Materials			
	GJ	Coal (kg)	Oil (kg)	Gas (m3)	Wood (kg)
Combustion coal	1000	1000			
Combustion oil	1000		24390		
Combustion gas	1000			31.6	
Combustion wood	1000				66670

Table 1. Comparison of raw material use of different combustion processes.

The main emissions and abatement costs per emission are shown in the next two tables. The abatement costs are based on several reports on costs effectiveness of abatement techniques in the Netherlands. The most comprehensive report on abatement techniques is Milieuverkenning by RIVM (National Institute of Public Health and Environmental Protection).

As example, the costs effectiveness of NOx abatement techniques is shown below. The empirical results of techniques are compared with theoretical results.

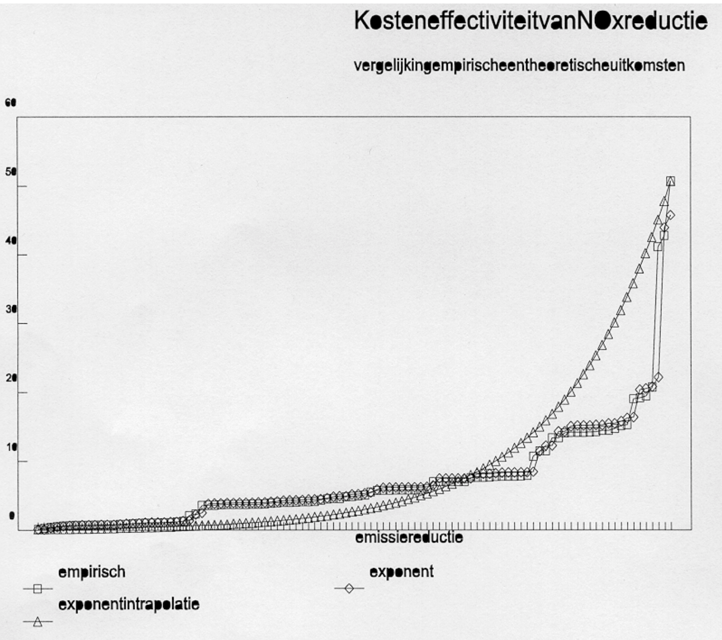


Figure 2. Krozer, J., TME, 1997

Emission matrix (amounts)	Output	Emissions to air				
	GJ	CO2 (kg)	Dust (kg)	CxHy (kg)	NOx (kg)	SO2 (kg)
Combustion coal	1000	80375	95.9	17.1	239.2	546.1
Combustion oil	1000	78000	21.5	8	173.7	658.5
Combustion gas	1000	57000	1	16	31.6100	17
Combustion wood	1000	101600		176	156	4.9

Table 2. Comparison of emissions (amounts) from different combustion processes

Emission matrix (abatement costs)	Output	Emissions to air					
	GJ	CO2 (fl)	Dust (fl)	CxHy (fl)	NOx (fl)	SO2 (fl)	Total (fl)
Combustion coal	1000	16075	86.31	59.85	1794	2457.45	20472.6
Combustion oil	1000	15600	19.35	28	1302.75	2963.25	19913.4
Combustion gas	1000	11400	0.9	56	750	76.5	12283.4
Combustion wood	1000	20320		616	1170	22.05	22128.05

Table 3. Comparison of abatement costs of emissions from different combustion processes

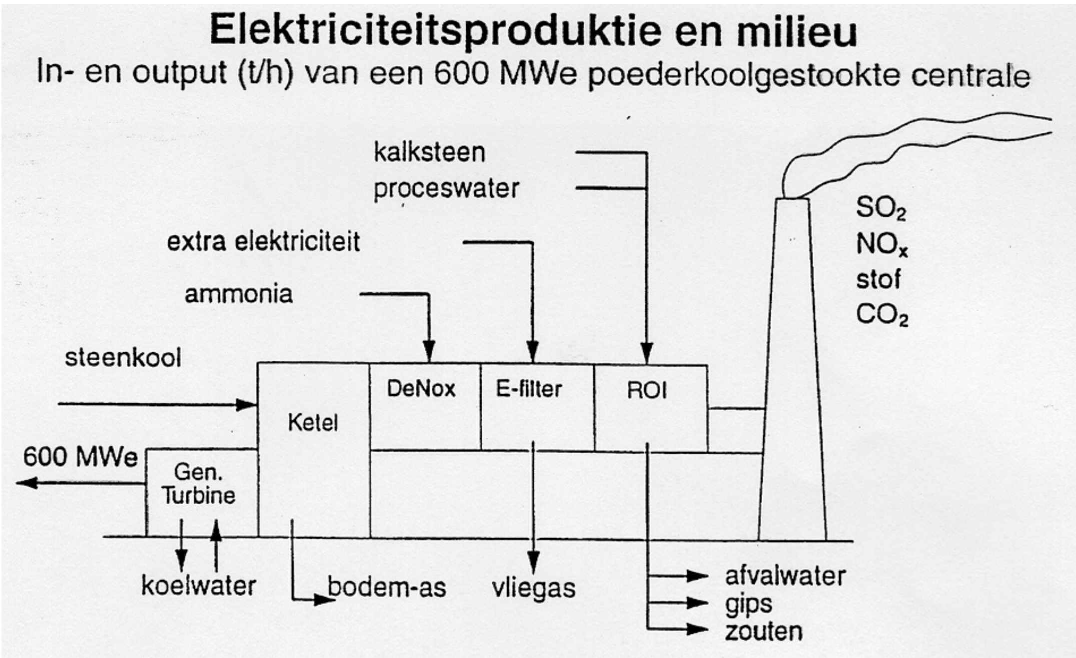
Effects of dues on emissions on the costs could be calculated and possible solutions for obligated emission reductions set by authorities could be investigated. A mix of energy sources can be investigated with respect to the emissions, abatement costs,

costs of the raw materials etc. In this way an electricity producer with several power plants could search for an indicative efficient mix for their total production.

The flue gasses from the combustion processes could be cleaned by several cleaning systems. By linking a cleaning system to a combustion process the indicative effects and costs become clear in a few seconds. The cleaning systems can be linked one by one or all together. By doing this different cleaning scenarios can be compared to the effects on the environment and the investments costs. An indicative optimal scenario can be calculated and shown in several ways by using the possible matrixes in PIA. Some flue gas cleaning systems will be linked to coal combustion power plant.

Flue gas cleaning systems

Figure 2 shows an coal combustion power plant. Three end-of-pipe measurements are installed to reduce the emissions. The DeNOx installations cleans the gasses from NOx, the E-filter filters dust from the exhaust gasses and the ROI reduces the SO2 emissions. Every cleaning technology need additional inputs and the E-filter and ROI produce additional outputs. Some of the outputs can be used in other industries (gypsum and ashes) while others are wastes (salts, waste water).



In a simplified example the effects of three flue gas cleaning systems are investigated. All results are shown in Appendix I. The cleaning systems are:

- E-Filter
- Steam injection
- ROI

First the initial situation is shown. The power plant produces 2696,5 MWh per year. This process causes several emissions. The main emissions are emissions to air (CO2, Dust, NOx and SO2) and ashes as solid waste.

Second the cleaning systems are one-by-one linked to the process and the reduction effects are calculated. The E-filter use an amount of energy of 415 GJ, and reduce the dust emissions with 96 ton, this means a reduction of 99,7%. Output of the E-filter is 96 ton ashes. These ashes can be used by other industries.

The ROI needs next to energy, 105 GJ, limestone as an input. The ROI reduces the amount of SO2 with 12,59 ton, this means a reduction of 91%. Output of the ROI is gypsum, which can be used in other industries. An amount of 96 ton waste water is discharged from the ROI.

The steam injection needs next to energy, 150 GJ, demi-water as an input. Demi-water is produced by clearing groundwater from several substances. This cleaning process causes emissions to water like calcium, nitrates, magnesium and sulphate.

The steam injection reduces the NOx emissions by 2,61 ton, this means a reduction of 35 %.

Thirdly, all cleaning systems are linked to the production process, the total reduction effects and total additional emissions are calculated. The yearly costs of the systems are shown in the last table. The costs are divided into capital, labour, maintenance and operational costs. The costs per kg reduction are calculated. The reduction of 1 kg dust by the E-filter cost fl. 0,03, the reduction of 1 kg SO2 by the ROI cost fl. 2,33, the reduction of 1 kg NOx by the steam injection cost fl. 7,42.

The costs of the steam injection for 1 kg NOx reduction are high. Compared to other combustion processes, combustion by coal produces high amounts of NOx. By PIA it can be investigated how much NOx could be reduced by changing to another energy source.

CONCLUSION

The possibilities of the PIA computer programme are extensive. Unlimited number of connections in the life cycle can be made. Each step in the life cycle can be connected with transport. Each emission and waste can be connected with treatment processes. In support of the comprehensiveness, one can build libraries of processes and products. All data can be unlimited manipulated.

The model could be useful for indicative and fast investigation of different scenarios. The results can be presented in several ways. This could help internal communication on environmental effects.

Life cycle costing is no solution for environmental problems but it can be useful tool for companies to become aware of the environmental effects of their production process and the costs of it. It could support companies to incorporate the environment into business decisions which will be reflected in environmental sound innovations.

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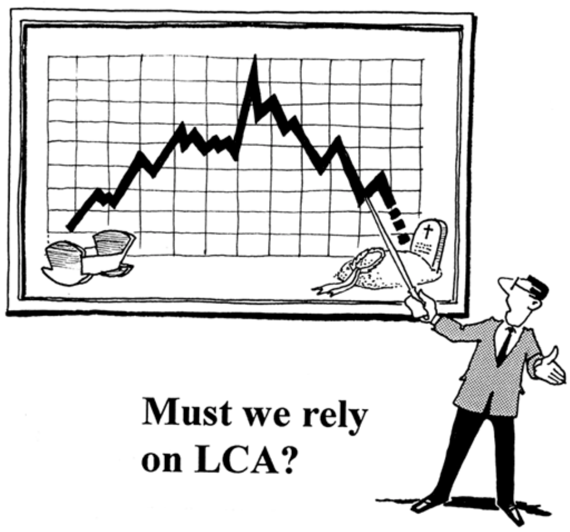
[1.] Data of coal, oil and wood combustion is based on BUWAL data. Data of gas combustion is based on CBS (Central Bureau of Statistics in the Netherlands).

CASE STUDIES OF ENVIRONMENTAL COST ACCOUNTING



Environmental Accounting at Work: Survey Summary and 10 Snapshots

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DISCLAIMER

This report presents a number of Environmental Cost Accounting snapshots and case studies developed in recent years by a diverse group of organizations. The concepts, terms, and approaches represented throughout the report represent many different approaches applying Environmental Accounting (EA) principles and do not necessarily represent the position or views of the US Environmental Protection Agency (EPA). Through the production of this report, the EPA presents a variety of approaches to and applications of EA without intending to endorse any one. Readers may wish to consult An Introduction to Environmental Accounting as a Business Management Tool: Key Concepts and Terms, EPA 742-R-95-001 (June 1995) for more general information about environmental accounting.

The authors gratefully acknowledge the EPA funding from the Office of Pollution Prevention & Toxics, Environmental Accounting Project. Special thanks to Holly Elwood, Kristin Pierre, and Susan McLaughlin for their many helpful comments on earlier drafts of this report. An expanded version will be available in November 1997.

INTRODUCTION

This report demonstrates the financial results of actual environmental accounting applications. It synthesizes 37 cases of companies using various forms of environmental accounting (EA) and offers a more detailed review (snapshot) of 10 of these cases. The snapshots represent applications of EA in a range of small, medium, and large businesses in a variety of industries, and in a range of business decisions. Examples range from a small manufacturer of wooden doors examining an investment in a new lacquer process, to a large, multinational health care products company measuring the value of its proactive environmental management program.

The intent of this report is to document how the application of EA principles can have a direct, positive, bottom-line effect on business operations. This collection of existing snapshots will form the basis of a larger, “living” database of EA snapshots that will be contributed by individual companies and made accessible on the Internet.

This report was funded by EPA’s Environmental Accounting Project to respond to requests from stakeholders for more information on the application of environmental accounting concepts in various business decision making processes. It can serve engineers, accountants, financial analysts, operations managers, environmental managers, and general managers as a reference source on the range and business benefits of applying EA concepts.

OVERVIEW OF CASES

Case Selection

We selected cases from a broad survey of environmental cost accounting literature that documents actual applications of environmental accounting. The selection represents the result of library and Internet searches and discussions with EA practitioners. It contains a variety of applications of EA in a number of different industries and, we believe, presents a fairly comprehensive compilation of published EA cases. This collection is intended to be the beginning of a living database of environmental accounting snapshots that demonstrate results from applying EA to specific business decisions.

Case studies selected are those that quantifiably demonstrate uses of EA in business decision-making. These studies show how businesses more carefully account for costs that are typically left out of conventional accounting practices and analyses. These costs, typically direct or indirect environmental costs obscured in overhead accounts, in most cases were significant and material to business decisions.

The cases reviewed in this report also tend to use profitability indicators that consider longer-term implications for operating costs, and consider the time-value of money when assessing and comparing profit and payback. Accounting practices that look beyond the next quarterly report better reflect the true cost of the processes they measure. Often, environmental costs and benefits materialize over a time frame longer than that considered in conventional analyses. Applying EA concepts in business decisions, as shown in these case studies, can improve upon conventional systems by capturing these costs and savings to better inform management decisions.

Generally, we included case studies that used environmental accounting to provide better information about a product, a process, an investment, or a business operation. The cases represent a variety of approaches to the application of EA, but all have in common the incorporation of environmental costs into accounting practices, providing firms with both economic and environmental incentives to reduce waste and produce more efficiently.

Organization of the Case Studies

Business Decisions Examined

The studies have been organized into three business decisions that environmental accounting concepts have been applied to:

1. *Capital Investments* (22 cases). Many improvements to increase resource efficiency and reduce material use and pollution require capital expenditures. Methods of investment analysis, such as total cost assessment (TCA) – a comprehensive approach to evaluate the profitability of current business practices and pollution prevention (P2) investments – are particularly useful in capital budgeting decisions when a firm seeks to assess the profitability of a potential investment or to choose between several potential investments.
2. *Process Costing* (8 cases). Better information regarding operating costs is useful to a variety of pricing, product mix, investment, and strategic decisions. Understanding the true costs and risks of operations enables managers, engineers,

and operators to make better decisions about how to run and improve their businesses.

3. *Strategic Planning* (7 cases). Quantifying the relative environmental costs of different processes and P2 opportunities provides the information necessary for prioritizing P2 projects, allocating resources, and determining a firm's environmental strategic direction. For example, with scarce capital funds firms find the application of EA concepts to be a valuable means of directing investment towards those opportunities that will provide the greatest return. Measuring the environmental costs and benefits of various activities throughout a facility or business gives managers information they need to plan strategically.

These three categories clearly overlap, and there are several case studies that could fit comfortably into more than one. The purpose of classification is not to draw artificial distinctions between types of EA applications, but to organize and illustrate the variety of business decisions EA can support. In the end, EA concepts can be employed to manage information that can be used in as many ways as businesses can creatively devise. A critical element of being a successful manager is to know what needs to be known and to exploit information about business operations to continuously improve them. The three categories cover the major ways in which environmental cost information has been used in the case studies.

Industry Sectors Examined

The 37 cases represent a variety of industry sectors that break down as follows:

Table 2. Breakdown of Cases by Industry Sector

Number of Cases	Industry Sector
9	Chemicals
7	Metal finishing/fabrication/use
4	Printing
3	Electronics
3	Paper
2	Electrical utilities
9	Other*

*ranges from pharmaceuticals to health care products to auto manufacture

Size of Companies Examined

The companies in these case studies range in size from small, privately-held facilities with fewer than 20 employees to large, multinational corporations, such as Polaroid, Baxter, and DuPont. Table 2 suggests the firms also represent a broad range of the commercial sector, supplying both products and services to intermediate and end-use customers. This diversity demonstrates that both large and small businesses can often benefit from increasing incorporation of environmental costs into business decisions. Potential EA applications lie along a spectrum of complexity and can be tailored to the needs of each business. However, there are costs to applying EA concepts, even on an ad-hoc basis, and these costs have to be measured against expected benefits. Some of the cases, however, show the investment in systems that incorporate EA concepts to be a worthwhile investment with initial costs that may be amortized over many years of improved decisions and decision-making.

Profile of the Cases

Project Backgrounds

What motivated firms in the case studies to experiment with, or adopt EA methods? These firms did so for a variety of reasons and in a variety of settings. Some were reporting on broader company or government policy issues of which EA was an integral component.

Some of the cases report on EA applications implemented by teams assembled within a firm, usually as part of a proactive management effort to improve cost accounting practices. The underlying aim of many of these efforts was to improve management decision making capabilities by providing a stronger foundation upon which smart decisions could be made. In these cases, identification and understanding of environmental operating costs led to strategies for making efficiency and environmental improvements. However, much of the reported EA work was performed by, or in collaboration with, external research and consulting organizations, owing to most firms' lack of experience in incorporating many of their environmental costs into their business decisions. In some cases, an external organization approached a firm about collaborating on a case study in conjunction with an EPA- or state-funded initiative.

In the cases where environmental costs were better integrated into business decisions with external support, the case study usually reports on a financial analysis of an environmental investment, often performed retrospectively (i.e., after the investment had already been made). A retrospective analysis allows the use of real operating cost data instead of estimates from the new investment in the financial analysis. These analyses help the firm to understand the full economic impacts of its investment to inform future decisions, highlight the difference between TCA and conventional accounting methods, and provide a model for other firms desiring to perform their own analyses. Roughly 20% of the cases document analyses that were performed retrospectively.

Costs Considered

To what extent do the case studies embrace a wider range of costs beyond the conventional (those typically recognized in cost analyses, such as raw materials and capital equipment)? We earlier noted that an important element of EA is the consideration of a broader spectrum of costs. However, the majority of the case studies include only conventional and non-conventional/hidden costs in their quantitative analyses; a few include only conventional costs. This suggests the difficult nature of identifying, isolating, allocating, and incorporating less tangible costs (those relating to stakeholder relationships or other costs that may be significant but similarly difficult to quantify) into a business decision. In many cases these less tangibles were deemed unnecessary for the analysis. Indeed, many of the capital investments analyses showed a proposed investment to be sufficiently profitable even in the absence of less tangibles. In other instances, firms that were unable to quantify liability/contingent and/or less-tangible costs did consider them qualitatively. Like other management concepts, the application of EA concepts supports decision-making but does not prescribe it. Ultimately, decisions are made considering not only readily measurable cost, but also "softer" factors such as corporate image, employee safety, or contingent environmental liability. In several of the capital budgeting studies, qualitative considerations played an important role in persuading the company management to make a P2 investment.

A number of cases quantify liability/contingent costs. For example, one firm considered the potential liability of a PCB transformer spill or fire.[39] Conservatively considering the probabilities and associated costs of cleanup, litigation, and lost production, the analysis showed an accelerated phase-out of the transformers to be cost-effective. This example shows how the inclusion of costs omitted from conventional analyses might lead managers to sharper, more proactive management strategies.

A few case studies identify other less-tangible costs and quantify them as part of an analysis. One study of the impacts of a forestry company on the commercial value of the forest estimated values of wildlife and tourism costs. Two small printing companies estimated an increase in product revenues from improved ability to meet customer demand. In these cases, cost estimates admittedly are rough, but even a rough, conservative estimation reflects the true economics of a current or proposed practice better than an estimation of zero, the value implied by the exclusion of a less tangible cost.[40]

Financial Results

What is the range of outcomes reported in the three categories of EA? The *Capital Investments* cases evaluate the profitability of past or proposed investments, or compare the economics of several P2 investment proposals. Almost all of the *Capital Investments* analyses calculated a net present value (NPV) for the project; these values ranged from -$1.4 million to $11 million, with most in the range of $10,000 to $100,000. Some of the highest include: a 5-year NPV of $310,255 for a screen printer; an 8-year NPV of $352,814 for an electronic equipment manufacturer; and a 15-year NPV of $11,633,835 for a diversified chemical company. Two of the 22 *Capital Investments* cases had negative NPVs, but both of these projects contained significant qualitative benefits. One of the projects was approved on the basis of these qualitative benefits. Many of the analyses for which a discounted payback was calculated would pay for themselves in under three years; all but two had paybacks under five years. In a few

CAPITAL INVESTMENTS CASE HIGHLIGHTS

- lowest investment NPV = -$1,400,000
- highest investment NPV = $11,600,000
- typical investment NPV = $10,000 - $100,000
- small firm (screen printer): dry film imaging system investment, NPV = $310,000
- medium-sized firm (electronics): ultrasonic cleaning system investment, NPV = $350,000
- large firm (chemical company): byproduct recovery system investment, NPV = $11,600,000

[39] See the *Large Firm in Auto Industry* Snapshot on Page 235.

[40] See the US EPA's *Valuing Potential Environmental Liabilities for Managerial Decision-Making: A Review of Available Techniques* (EPA 742-R-96-003) for references to means of estimating liabilities.

cases, however, the encouraging financial analysis was insufficient to override doubts about unproved technology, so project implementation was put on hold.

Process Costing, the second category of EA cases, covers both facility-level and product/process level analyses. Most of these studies were undertaken as collaborative efforts; a number are part of a World Resources Institute study, one was funded by the UN to improve accounting and reporting, and another was supported by the Illinois Waste Management and Research Center to demonstrate improved process costing. Three studies in this category were initiated through corporate programs to improve environmental cost accounting. The *Process Costing* cases all helped identify significant environmental costs that previously had not been recognized. The results convinced some of the firms to pursue P2 projects or to continue to refine their EA practices. Others assisted firms to consider potential benefits of enhanced corporate image, of improved customer satisfaction and employee morale, and of the competitive advantage from selling environmentally-friendly products.

Finally, the *Strategic Planning* cases also cover both facility-level and product/process-level analyses. Several were performed as a result of the New Jersey Planning Process[41], which requires an assessment of the costs of using or generating hazardous substances for each process in order to identify P2 opportunities. Others were motivated by corporate commitment to P2 and/or initiation of an accounting system that better incorporated environmental costs. Most of the *Strategic Planning* cases showed that P2 investments could actually save money and that EA helped the facility prioritize P2 options. These applications of EA tended to set the stage for a systematized integration of improved cost accounting into ongoing business initiatives to implement efficiency improvements.

ENVIRONMENTAL ACCOUNTING SNAPSHOTS

Selection Rationale

To give readers more insight into the actual application of EA, 10 case studies have been selected from the pool of 37. These 10 cover a spectrum of applications. We selected these 10 both to demonstrate the versatility of EA as well as the bottom-line outcomes of a range of applications.

Each snapshot contains the following information:

- Business Decision
- Business Benefits
- Company Profile
- Project Background
- Project Description
- Analysis
- Financial Results
- Contact
- Source

[41] These include Witco Corporation, Sandoz Pharmaceuticals, Unifoil Corporation, and Hoechst Celanese.

PRODUCTION PLATING, INC.

COMPANY PROFILE

- ⇒ *Location*: Mukilteo & Redmond, WA
- ⇒ *Size*: 100 employees
- ⇒ *Annual Revenues*: $5,000,000
- ⇒ *Business*: metal finishing, powder coating

Business Decision, Capital Investments

Are capital investments in a less-polluting powder recovery unit and rinsewater recycling system financially justified?

Business Benefits

An $8,000 investment yielded annual operating savings of $10-15,000. For a second investment of $129,000, Production Plating would realize annual operating savings of over $50,000.

Project Background

Production Plating is committed to making pollution prevention (P2) investments to improve its environmental performance while improving operating efficiency and reducing costs. The company believes these initiatives to reduce pollution will make it more competitive and better positioned to respond to future regulatory requirements. The company had recently invested in a powder coating capture and reuse system at the Redmond facility and was considering a rinsewater recycling system at the Mukilteo site. The company hoped to use this analysis to assess the economic viability of the projects.

The analysis was conducted jointly by the company and the Pacific Northwest Pollution Prevention Resource Center (PPRC) to assess the feasibility of total cost assessment (TCA), a decision method designed to enhance capital budgeting decisions in connection with P2 projects. The study was undertaken in response to needs identified by the local metal finishing industry to have access to an effective, practical P2 cost evaluation method. Production Plating volunteered its proposed projects for analysis.

Project Description

The first investment was for a powder coating recovery system. Powder coating is a dry painting process in which the powder is applied to metal parts using a spray gun. The recovery system is coupled to the spray booth's existing filtration system to capture sprayed powder and return it to the spray gun feed container for reuse. The system reduces the total amount of powder needed and the amount of spent powder that has to be sent to landfills as non-hazardous waste.

The second investment was for plant-wide plating rinsewater recycling. The facility had established a goal to reduce the amount of water used and discharged by the rinsewater process. The water is collected in sludge tanks as non-heavy metal, acid/chrome, mildly alkaline/cleaner, or alkaline. These four waste streams go through various treatment and disposal processes that physically occupy five percent of the facility's operating space. An alternative to the current processes was a rinsewater ultrafiltration recycling system that would reduce the volume of water discharged by 90%, increase floor space, and reduce treatment chemical handling and use.

Analysis

COST CONSIDERATIONS	
Powder Recovery	**Year One Savings**
paint savings	$ 10,900
Rinsewater System	**Year One Savings**
labor	$ 15,600
materials	$ 48,400
sludge disposal	$ 5,000
fines/penalties	$ 3,000

Both projects were evaluated using Total Cost Assessment (TCA), a method to enhance capital budgeting decisions in connection with P2 projects. The powder coating recovery system was analyzed in terms of its costs for coating one representative part for which pre- and post-system data were available. The costs of the unit and of subsequent filter replacements and the cost savings from less wasted powder, including lower purchase and disposal costs, were the key cost components included in the analysis. Also included was a tax exemption for which Production Plating was qualified. Contingent/liability and less-tangible costs – including materials handling, future liability, corporate image, customer response, and market share – were considered qualitatively to provide a broader perspective on less tangible costs and savings. The cost of the recovery unit was depreciated on a straight-line basis.

The rinsewater ultrafiltration system was evaluated by comparing current operating costs with expected costs of the new system. The main cost components for this analysis were treatment chemicals, worker and management labor, monitoring costs, filter costs, current and future violation penalties, testing and reporting labor, and sludge disposal costs. The company also qualitatively considered many less tangible benefits such as improved air quality, lower accident risk, freed-up work space, reduced liability, fewer worker injuries, and enhanced employee morale. The cost of the system itself was included and depreciated on a straight-line basis.

Financial Results

The powder recovery system investment yielded a five-year net present value (NPV) of $18,334 with a discounted payback under 15 months. The analysis assumed a certain production level, paint cost, powder savings, and equipment life. A sensitivity analysis showed the production level to be the dominant profitability driver; a reduction by 50% in the assumed production level would raise the payback to 2.5 years. The analysis used an inflation rate of 5% and a discount rate of 15%.

The annual cost of the existing rinsewater system was estimated at approximately $123,000, driven largely by water usage. Projecting over a ten-year period, a TCA analysis of the proposed ultrafiltration system yielded a NPV of $168,697 with a discounted payback period of 2.3 years. This analysis also used an inflation rate of 5% and a discount rate of 15%.

Contact

Chris Montorino, PPRC (206) 223-1151

Mark Wilsen, Production Plating, Inc. (206) 347-4635

Source

Pacific Northwest Pollution Prevention Resource Center, *Analysis of Pollution Prevention Investments Using Total Cost Assessment: A Case Study in the Metal Finishing Industry*. July 1996.

A PAPER COATING MILL

COMPANY PROFILE

- ⇒ *Location*: Northeast US
- ⇒ *Size*: 900 employees
- ⇒ *Annual Revenues*: $XXX
- ⇒ *Business*: coating, laminating, and converting film, paper, and foil substrates

Business Decision, Capital Investments

Is a capital investment in a less-polluting aqueous coating process financially justified?

Business Benefits

For a $900,000 investment, the mill would realize annual operating savings of just under $80,000 with a 6% internal rate of return over 15 years.

Project Background

The mill coats paper with both white grade and color grade coatings. The white grades are made with an aqueous-based coating, the color grades contain solvents and some heavy metal-based pigment. The mill had considered converting its color grades to an aqueous/heavy metal-free coating to develop manufacturing flexibility, respond to emerging demand for aqueous/heavy metal-free coated paper, reduce environmental impacts, and improve worker health and safety.

After spending more than $200,000 three years earlier to convert to aqueous, the mill halted the project due to a possible plant relocation and quality problems during aqueous trial runs. The conversion was later restarted, but was progressing slowly due to capital and labor constraints, operating cost and wastewater volume concerns, and slow manufacturing rates. The mill's Environmental Manager hoped a better financial analysis of the project would reveal a higher economic value, thereby justifying an accelerated conversion.

Project Description

The first step of the conventional paper coating process is the application of the pigmented base coat, which consists of a number of solvents and heavy metals. The base-coated paper goes through a dryer where most of the solvent evaporates and the remainder of the coating sets on the paper. The vaporized solvent is sent to a solvent recovery system where it is drummed for reuse. The 2,220 drums of still bottoms generated by the mill annually from this process consist of residual solvent, pigments, and other impurities, and are incinerated off site as hazardous waste. Some of the volatile organic compound (VOC) emissions generated both during the coating and recovery processes are ultimately vented to the atmosphere.

The aqueous coating process uses a base coat made from water, acrylic latex resin, and a small amount of ammonia and solvent. Once the full conversion to aqueous is complete, the wash water will be sent to an on-site ultrafiltration system from which the water will be sewered and the solids reused or disposed of as non-hazardous waste. Because the aqueous coating has a shorter shelf life, a certain amount of spoilage is expected. Moreover, since this coating has a relatively high freezing point, a new heating system has to be installed in the storage area. Finally, to overcome drying problems, the base coat dryer must be upgraded.

Analysis

COST CONSIDERATIONS	
	Year One Savings
waste management	$ 243,900
materials	$ 85,000
labor	$ 11,000
equipment	$ 35,000
	Year One Costs
raw material	$ 27,000
utilities	$ 87,000
labor	$ 8,000

The investment analysis for a conversion to an aqueous/heavy metal-free process used a Total Cost Assessment (TCA), a method to enhance capital budgeting decisions in connection with P2 projects. This TCA included many costs omitted from the company's original analysis. The cost of new utility systems, for example, was added to the other initial investment costs of equipment, engineering, and training. The company's analysis included annual operating costs only for labor and partially for raw materials and waste disposal. The TCA included annual costs of waste management, utilities, solvent recovery/ultrafiltration, regulatory compliance, and a one-time future liability savings.

Significant reduction of the amount of hazardous waste generated represents a decrease in future liability. This analysis captured this decrease by generating an estimate based on the toxicity and final disposition of hazardous waste. The waste reduction also creates regulatory compliance savings from reduced time spent manifesting and testing hazardous waste. Other considerations identified but not quantified included possible shutdown of the solvent recovery process; enhanced worker safety from reduced flammability, improved industrial hygiene, and fewer material handling problems; and the potential for improved product quality. The TCA used a 16% cost of capital, a 5% inflation rate, a 40% corporate income tax rate, double declining balance depreciation, and looked at the project over 10- and 15-year time horizons.

Financial Results

The TCA for the conversion project yielded a 15-year net present value (NPV) of negative $395,625, as compared to an NPV of negative $203,643 calculated by the company's analysis. The simple payback for the conversion jumped from 7.6 years in the company's analysis to 11.7 years in the TCA. While the TCA showed the project to be even more costly than the previous analysis did, it provided the management with a clearer and more comprehensive picture of both current process costs and the economics of the proposed improvement.

The main savings from the conversion would come from waste management and solvent recovery/ultrafiltration. After the conversion, costs associated with the handling, storage, and transportation of hazardous waste drums as well as waste fees would drop significantly. Operating costs of the ultrafiltration system would be more than offset by the reduced use of the solvent recovery system. However, the conversion would substantially increase utilities costs, including steam, water, electricity, and wastewater generation. The increase in utility costs would be greater than all of the operating cost savings, thus accounting for the negative NPV.

Contact

Allen White or Deborah Savage, Tellus Institute (617) 266-5400

Source

White, Allen L., Monica Becker, and James Goldstein, *Alternative Approaches to the Financial Evaluation of Industrial Pollution Prevention Investments*. For NJ DEP. November 1991. **And** White, Allen L., Deborah Savage, and Monica Becker, *Revised Executive Summary*. June 1993.

White, Allen L., Monica Becker, and James Goldstein, *Total Cost Assessment: Accelerating Industrial Pollution Prevention Through Innovative Project Financial Analysis: with Applications to the Pulp and Paper Industry*. For US EPA. December 1991. **And** White, Allen, L., Deborah Savage, and Monica Becker, *Revised Executive Summary*. June 1993.

TIZ'S DOOR SALES, INC.

Business Decision, Capital Investments

Is a capital investment in a less-polluting coating process financially justified?

Buiness Benifits

For an investment under $190,000, Tiz's Door Sales (Tiz) would see annual operating savings ranging from $137,000 to $180,000 in the first five years.

COMPANY PROFILE

- ⇒ *Location*: Everett, WA
- ⇒ *Size*: 50 employees
- ⇒ *Annual Revenues*: $XXX
- ⇒ *Business*: manufacturer of wood doors and window trim

Project Background

Tiz, established in 1966, has always used petroleum-based paints in its processes to coat wood products. Tiz was considering an ultraviolet (UV) coating process to replace its conventional petroleum-based process. The UV process – whereby wood lacquer is cured by UV light rather than by air drying – would have lower operating costs and would generate less pollution, but would require a large initial capital investment.

The company and the Pacific Northwest Pollution Prevention Resource Center jointly conducted the study to illustrate the use of a comprehensive financial analysis to evaluate the feasibility of converting to the UV process. The larger purpose of the study was to promote pollution prevention (P2) in the wood products manufacturing industry.

Project Description

Tiz currently coats wood products by applying a coat of color stain and two coats of petroleum-based lacquer. After the first lacquer coat, the wood pieces sit for 10 minutes to dry, and after the second, they sit for 20 minutes. The lacquer costs $10 per gallon and loses 70% of its volume to evaporation during the coating process, which generates air emissions and exposes workers to vapors. The UV investment would place a curing oven at the end of the coating line. Immediately after coating, the wood pieces would enter the oven where they would cure in seven seconds (as opposed to

10 or 20 minutes). The UV-curable lacquer costs $25 per gallon, but will lose virtually none of its volume because it does not evaporate during the coating process. Therefore, it would significantly reduce the air emissions from the process. To accommodate the new lacquer, new distribution lines would have to be installed to carry the lacquer from the storage area to the process line, and the spray-gun nozzles would have to be modified slightly.

Another benefit of the UV-cured lacquer is that it does not discolor (yellow) when exposed to sunlight. The yellowing process occurs over an extended period of time, but can have a direct effect on Tiz's operations; Tiz had recently paid a settlement to a customer because of yellowing problems. Eliminating this problem would not only eventually eliminate future settlements, it would also improve the quality of Tiz's products, and thus represent a competitive advantage. Because the effect of eliminating yellowing was difficult to quantify, it was not included in the financial analysis, but it was weighed as an important less tangible, qualitative factor. The benefit to employees who would no longer be exposed to potentially hazardous vapors was similarly considered to be important, but not quantified.

Analysis

The investment in a conversion to a UV process was evaluated using Total Cost Assessment (TCA), a method to enhance capital budgeting decisions in connection wit P2 projects. The initial investment costs included not only equipment, materials, and installation, but also utility connections, site preparation, and savings in permitting costs and insurance. The savings would result from reduced toxic emissions that would eliminate the need for an air permit and would lower explosion risk.

COST CONSIDERATIONS

	Year One Savings
permits/insurance	$ 4,300
materials	$ 124,000
labor	$ 44,800
equipment	$ 3,300
tax	$ 11,900
	Year One Costs
utilities	$ 3,000
rework	$ 48,000

Since the conversion would not affect many of Tiz's operating costs, the analysis focused only on those costs that would change as a result of the investment. These costs included utilities and rework, and savings in lacquer costs, labor, and equipment replacement. In addition, the tax savings from the equipment depreciation were included. The opportunity cost of the capital for this investment was captured in a 6% discount rate.

Financial Results

Different scenarios reflect different potential cash flow streams. Each allowed for different equipment costs, insurance savings, rework costs (with the new system, pieces that are coated improperly cannot be reworked and must be scrapped), and depreciation tax savings. Each scenario was run for both a five-year and a ten-year project life. Across all scenarios, the net present values (NPVs) ranged from $240,420 to $1,817,834 for which the investment would pay for itself, on a discounted basis, in one to two years.

A number of critical assumptions underlying the analysis were individually tested to determine their effect on profitability. These included the expected cost of the new lacquer, the cost of rework, the depreciation method, and the discount rate. Of these, the expected cost of the UV-curable lacquer was the most significant driver, reducing the NPV in one scenario from $450,000 to $100,000 when the lacquer cost rose from $25 per gallon to $30.

Contact

Chris Montorino, PPRC (206) 223-1151

Greg Tisdel, Tiz's Door Sales, Inc. (206) 621-8369

Source

Pacific Northwest Pollution Prevention Resource Center, *Economic Analysis: Converting from Petroleum-Based to Ultraviolet-Light Cured Coating System for Medium-Size Wood Products Manufacturers*. 1994.

A JEWELRY COMPANY

Business Decision, Capital Investments

Is a capital investment in a chemical-reducing ethyl acetate still financially justified?

Business Benefits

For an investment of $16,000, the company would realize annual operating savings of $18,000 in each of the first five years.

COMPANY PROFILE

⇒ *Location*: Sutton, MA

⇒ *Size*: 500 employees

⇒ *Annual Revenues*: $XXX

⇒ *Business*: manufacturer and distributor of jewelry, personal leather goods, and personal accessory items

Project Background

This company has long demonstrated a genuine concern for the well-being of its employees and its community. It has taken an active posture in addressing the environmental concerns of the town in which it operates, often acting well in advance of regulations. Although the facility was in compliance with all applicable regulations, the Environmental Manager was eager to reduce the volume of ethyl acetate used to strip lacquer from its plating racks. The high cost of both the purchase and disposal of the ethyl acetate presented an opportunity for cost savings.

The analysis was conducted by the company's VP of Environmental Affairs with the help of a Massachusetts Office of Technical Assistance representative. A previously submitted proposal for an investment to enable reduced ethyl acetate use had not received corporate approval, despite an estimated 11-month payback. The VP wanted to resubmit the proposal using a more formal financial analysis. The study was included in a training manual for using financial assessment for pollution prevention projects prepared by the Northeast Waste Management Officials' Association.

Project Description

To produce jewelry with a white finish, the facility had determined that silver was the best metal in terms of both aesthetics and manufacturability. To prevent tarnishing, silver-plated pieces must be coated in lacquer prior to finishing. To perform this process, the pieces are placed in plating racks that are dipped in lacquer. After the pieces have been removed, the racks are stripped of the lacquer using ethyl acetate. Once the ethyl acetate is exhausted, it is disposed of as hazardous waste.

COST CONSIDERATIONS

	Year One Savings
materials	$ 19,000
chemical disposal	$ 11,000
manifesting	$ 400
compliance	$ 1,000
	Year One Costs
waste disposal	$ 13,000
utilities	$ 200

The facility investigated options for reducing the volume of ethyl acetate it purchased and disposed of and decided that a solvent recovery still offered the best solution. Several vendors presented bids, among which was a $14,000 unit with a $2,000 installation cost that the facility chose. The new system would be placed in-line with the lacquer dipping operation and would allow the ethyl acetate to be recovered and reused until it lost its ability to strip the lacquer.

Analysis

The investment in a solvent recovery still was evaluated using a financial assessment method intended to include environmentally-related costs that are often omitted from investment analyses. The only initial investment cost was the purchase of the still and its installation. Annual operating cost savings from anticipated reductions in ethyl acetate purchases, disposal of spent ethyl acetate, manifesting labor, and Toxics Use Reduction Act fees. The additional costs from operation of the still are an increase in utility costs to power the equipment and costs of disposing the still bottoms.

The analysis incorporated these costs in a discounted cash flow model that assumed a five-year useful life of the equipment. The model used a discount rate of 15% to represent the firm’s cost of capital, an inflation rate of 5%, and a corporate income tax rate of 40%. The model also considered the tax savings from a straight-line depreciation of the solvent recovery still investment.

Financial Results

The discounted cash flow analysis yielded a net present value (NPV) of $28,279 for the initial $16,000 investment. Compared to the 11-month simple payback calculated in the original company analysis, the discounted payback of this analysis shows that the investment would pay for itself in less than seven months. The weekly operating savings expected from the still installation was estimated to be over $300 just from purchase and disposal costs. The inclusion of depreciation tax savings contributed over $4,000 to the investment’s NPV.

Contact

Northeast Waste Management Officials’ Association (617) 367-8558

Massachusetts Office of Technical Assistance (617) 727-3260

Source

Northeast Waste Management Officials' Association and the Massachusetts Office of Technical Assistance, *Improving your Competitive Position: Strategic and Financial Assessment of Pollution Prevention Projects: Training Manual*. 1994.

A RESINS MANUFACTURER

Business decision, Process Costing

Does improved estimation of operating costs enhance the firm's ability to identify pollution prevention opportunities?

Business Benefits

This manufacturer found that its product costing, in one case, significantly misrepresented the actual cost of producing the product.

COMPANY PROFILE

- ⇒ *Location*: Midwest US
- ⇒ *Size*: 220 employees
- ⇒ *Annual Revenues*: $300,000,000
- ⇒ *Business*: manufacturer of resin products used in paints, coatings, and reinforced fiberglass

Project Background

In accord with the company's commitment to an aggressive pollution prevention (P2) program, the facility in this study joined with the Illinois Waste Management Research Center to more rigorously cost one of its products, Resin A. The exercise entailed a technical evaluation of the manufacturing process and a financial analysis of the product line to determine the cost of waste. The purpose was to improve the facility's understanding of the process to identify and later implement P2 opportunities.

The project sought to identify opportunities to improve Resin A's manufacturing process through capital purchases or optimization of its operating parameters. A longer-term objective was to improve costing systems to facilitate P2 throughout the company. Tellus Institute worked with the company to characterize the existing allocation system and suggest ideas for improvement. In addition to looking at the company's method of allocation, the analysis evaluated the effect of enhanced allocation methods on product costs.

Project Description

Resin A is part of the alkyd resins family of products, one of four the facility produces. The resin products are processed in batch reactor vessels where the raw materials are heated. A solvent solution is added to the reacted resin mixture to change its physical properties. The process generates air emissions and various streams of hazardous and non-hazardous waste. Unlike most of the resin products, Resin A undergoes a final filtering process to remove an unwanted by-product; a process step that generates additional waste. It is because Resin A requires this extra step that it was selected as the focus for the facility's study.

The first stage of the project was to calculate the cost of manufacturing Resin A based on the facility's existing costing methods. This stage would serve as the baseline against which recommended enhancements could be compared. The subsequent stage evaluated alternative methods of costing to more accurately reflect the cost of the product. Rather than develop a new method of process costing, the evaluation began with the existing system and built upon it. Two separate analyses, a surcharge analysis and an allocation analysis, were run to respectively evaluate the impact of (1) the facility's surcharge system whereby cost adjustments are applied to processes thought to have unusually high costs, and (2) the allocation system used to assign indirect costs.

COST CONSIDERATIONS	
	Reallocation Savings
Labor	$ 125,000
	Reallocation Costs
Conversion cost	$ 26,000
Waste	$ 22,000

Analysis

The facility organizes cost data into waste cost and conversion cost. The waste cost includes disposal and transportation fees for off-site disposal and utility costs for on-site treatment. A waste tracking system determines the waste cost for the facility organized by waste type. The conversion cost comprises indirect operating costs that are assigned to individual products. Conversion costs are allocated as direct costs (labor, utilities, equipment depreciation) on the basis of reaction time, as overhead (waste management, administration) on the basis of number of batches, or as fixed costs (safety materials, shipping labor) on the basis of product volume. A surcharge is added on top of these costs when a product requires extra steps, such as filtration, in its processing. Using this method, the facility determines the cost of producing Resin A. Despite Resin A's extra filtration step, it did not receive a surcharge.

The process of manufacturing Resin A was reevaluated to identify any surcharges that might be warranted. The filtration step at the end of the process did represent an extra cost that was not being charged back to the process. This comprised the cost of the filtration labor, filter paper and powder, and filtration waste disposal. The allocation of costs was also reevaluated for three of the process's major costs; operating labor, waste disposal, and environmental management labor. As an alternative method, operating labor was estimated based on actual labor spent on the process rather than an allocation based on the product's reaction time. Similarly, waste disposal costs were estimated based on actual waste generated versus an allocation based on the number of batches produced. Finally, environmental management labor was estimated by determining the portion of the environmental engineer's time spent on the Resin A process rather than by allocation on a product volume basis.

Financial Results

The facility's conversion cost for Resin A is $257,000 for the four million pounds of product manufactured and the waste cost assigned is just under $30,000. The surcharge analysis calculated a filtration step cost of over $650 per batch, which effectively increases Resin A's conversion cost by 10%. Omission of the surcharge therefore put the product's assigned cost significantly below its actual cost.

The allocation analysis found the actual cost of operating labor to manufacture Resin A to be close to $20,000 compared to the facility's allocation of $145,000. Because the process to manufacture Resin A generates substantial hazardous waste, the bottom-up estimate of waste disposal showed actual costs to be $52,000 compared the facility's estimate of $30,000. The facility's focus on waste minimization meant that the environmental engineer spent proportionally more of her time on the Resin A line because the facility had targeted it for improvements. As a result, almost 18% of her time was actually spent on the process as opposed to the 4% assigned via the facility's allocation system. Based on the information uncovered by this project, management can reevaluate the cost of Resin A and better asses the economic value of reducing the product's environmental impacts.

Contact

Deborah Savage, Tellus Institute (617) 266-5400

Source

Savage, Deborah, et al., *Total Cost Assessment: Catalyzing Corporate Commitment to Pollution Prevention in Illinois*. For Illinois Waste Management and Research Center, April 1997.

SOUTHWEST HYDRO, INC.

Business Decision, Process Costing

Does improved estimation of operating costs enhance the utility's ability to identify environmental savings?

Business Benefits

By measuring the C$10.4 million in environmental costs, Southwest Hydro identified C$1-3 million in potential savings.

COMPANY PROFILE

⇒ *Location*: Southwestern Ontario

⇒ *Size*: 75,000 customers

⇒ *Annual Revenues*: C$148,500,000

⇒ *Business*: retail arm of North America's largest utility

Project Background

In conjunction with its parent, Ontario Hydro Retail, and the Environment and Sustainable Development Division of Ontario Hydro (OH), SWH undertook a pilot project to review and analyze the environmental impacts of the utility's operations. The purpose of the project was to identify the operations' environmental costs and to develop recommendations for process improvements to reduce or avoid costs, increase revenues, reduce waste, and enhance SWH's image in its host communities. The intended outcome would enable SWH to better manage its environmental costs and future liabilities and to establish benchmarks for other utilities in Ontario Hydro Retail.

The project was a part of the Sustainable Energy Development Strategy at Ontario Hydro. OH and its business units have been developing methods to integrate environmental considerations into its decision making. This study is a pilot of one method, called Full Cost Accounting (FCA) by OH, which ultimately is intended for deployment throughout the corporation. The FCA was part of former Chairman Maurice Strong's strategy to restructure the company to meet the dual challenges of a dynamic utility industry and sustainable development.

Project Description

The project collected and analyzed the costs of SWH processes and operations with direct or indirect environmental impacts. Environmental costs, in this context, are defined as capital and operating expenditures of initiatives to protect and restore the environment. It did not quantitatively include external environmental costs, or externalities.

COST CONSIDERATIONS

	Annual Savings
Line loss reduction	$ 1-2,000,000
Fuel efficiency	$ 30-80,000
Transformer mgmt.	$ 50,000
Solid waste reduction	$ 20,000
Haz. waste reduction	$ 10,000
Landscaping	$ 25-50,000
PCB management	$ 25-50,000

The collection and compilation of these costs was hampered by the absence of a separate record of environment-related expenditures. Once the operations having environmental impacts were identified, environmental costs were estimated from available data, including interviews with utility personnel and actual expenditures data from 1994-5. These costs, and their associated drivers, were quantified to develop recommendations to lessen the environmental impacts of SWH's processes and operations.

Analysis

The internal review of environmental costs thoroughly examined SWH's operations. The utility developed an input/output model of its operations in which six major categories of processes were identified. Within these categories reside the activities that drive environmental expenditures due to their environmental impacts. The costs associated with these activities were ascertained to the extent possible and included in the overall assessment of SWH's environmental costs. For two of the categories, discrete environmental costs could not be separately identified; in these cases, the full costs of the processes were included. Capital costs were annualized based on the expected frequency of occurrence.

For each of the processes, the utility identified the inputs and outputs associated with the relevant activities, i.e., those having an environmental impact. Costs were assigned to these inputs and outputs based on available data and estimation providing widely varying degrees of quantitative rigor. For the six environmental cost categories, a total of 23 activities were included in the analysis, although 11 of these did not represent a measurable cost or, in some cases, represented a cost avoidance. The activities covered a variety of environmental costs as diverse as 'green' procurement, herbicide use, contaminated land management, settlements with Aboriginal peoples, and renewable technology development.

Financial Results

The total cost of SWH's operations and processes that have environmental impacts was estimated to be nearly C$10.4 million, roughly 8% of total operating costs. Costs associated with waste management accounted for C$7.7 million of that total, driven largely by the costs associated with energy loss from distribution inefficiencies. Land use management accounted for another C$1.5 million due in large part to the costs of line clearing and other forestry work.

This costing exercise enabled the identification of opportunities for cost reduction and avoidance, revenue generation, and environmental improvement. These opportunities have a potential cost savings totaling C$1.2 to C$2.8 million, which would increase net income by 5-15%. These numbers did not include savings that could not be readily quantified nor those attributable to intangible benefits such as improved corporate image and electromagnetic field reduction. The study concludes with both specific and general recommendations for achieving cost savings and for continuing to improve SWH's ability to track and manage environmental costs.

Contact

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Source

Southwest Hydro and Ontario Hydro Retail, *Internal Environmental Cost Review of Southwest Hydro*. May 1996.

US Environmental Protection Agency, *Environmental Accounting Case Studies: Full Cost Accounting for Decision Making at Ontario Hydro*. EPA742-R-95-004, 1996.

LARGE FIRM IN AUTO INDUSTRY

Business Decision, Process Costing

Can improved estimation of potential environmental liability costs enhance the firm's ability to identify environmental savings?

Business Benefits

A thorough analysis of potential environmental liability costs projected savings of over $1,000,000 per year.

COMPANY PROFILE

- ⇒ *Location*: Midwest US
- ⇒ *Size*: >100 facilities worldwide
- ⇒ *Annual Revenues*: >$10 billion
- ⇒ *Business*: manufacturer in automobile industry

Project Background

This firm was concerned about managing potential environmental liability costs associated with the continued use of transformers containing PCBs. An internal environmental team previously conducted a life-cycle analysis of the business-as-usual scenario of replacing the PCB transformers through normal attrition. This preliminary analysis included both conventional costs as well as what the team called environmental costs and risks, but failed to provide sufficient financial justification for a managed corporate-wide phase-out.

Because the project would require an investment of tens of millions of dollars, management wanted to be sure the financial analysis was thorough, conservative, and sound. With assistance from Tellus Institute, the firm sought to assess the previous analysis and develop a methodology for the consideration of contingent liability costs. Tellus worked with the firm to identify these costs and reassess the financial viability of a managed phase-out program.

Project Description

COST CONSIDERATIONS

Contingent Costs per Transformer		
	transformer spill	transformer fire
Clean-up	$ 339	$ 140
Litigation	$ 3213	$ 68
Lost Production	$ 1560	$ 10

At the time of the study, this firm managed hundreds of PCB-containing transformers. The project aimed to fully assess the liability the company faced as a result of maintaining these transformers during their normal lifetime. Allowing the transformers to be gradually phased out, the business-as-usual scenario, would take an estimated 30 years, whereas the managed phase-out would be completed in 5 years.

To support its economic evaluation, the firm sought to determine the probability and costs of acute events related to the PCB-containing transformers; including costs of insurance, litigation, clean-up, production shutdown, regulatory penalties, and possible effects on the firm's corporate image. The original economic analysis accounted for liability resulting from leaks, spills, and ruptures, but failed to consider transformer fires. Furthermore, the previous analysis did not consider repercussions in the production chain in this vertically-integrated company, effects that could have significant financial impact. The credibility and validity of liability estimates would have to be defensible and acceptable to obtain upper management's approval.

Analysis

The analysis used actuarial techniques as the basis for developing expected values for contingent liability costs. Historical information was gathered from a number of sources to estimate and substantiate the probability and associated costs of various events. A framework was first established to identify the potential costs of an acute event, thereby suggesting the types of data necessary to estimate such costs. The most significant costs were the clean-up, insurance, litigation, and production shutdown and losses that would result from a transformer fire or spill. All of these costs, therefore, were contingent on the occurrence of each of the possible events. The ultimate cost to the company is the probability of each event times the magnitude of its respective cost, summed over all events.

The probabilities of each event – a transformer spill and a transformer fire – were estimated using historical databases of actual transformer incidents gathered from publicly-available sources. The costs of clean-ups and litigation similarly were determined by research that provided data on transformer events. Litigation costs were those that would result from personal injury lawsuits relating to chemical exposure and industrial accidents. The analysis considered but finally excluded insurance cost increases because the firm self-insures to cover liability. The final element in the analysis was the consideration of the production effects of an acute event. Because of the high volume and vertically-integrated nature of the firm's operations, cascading effects of a shutdown could be significant. This part of the analysis considered production level, inventory, output value, and the functional relationship between facilities.

Financial Results

The annual total contingent costs per PCB-containing transformer were estimated to be $218 for a transformer fire and $5,112 for a transformer spill (using this expected-value, risk-based methodology). Using these costs, just 200 transformers would represent over one million dollars of contingent cost to the company. This is the business-as-usual cost associated with continued use of the PCB-containing transformers.

The values for the annual costs were determined as the aggregate of the various cost components and their associated probabilities. The contingent cost of a spill – itself a 0.0034 probability – was estimated as $339 for clean-up, $3,213 for third-party litigation, and $1,560 for a production stoppage. For a fire – a 0.000018 probability – the costs were $140, $68, and $10 respectively. For the hundreds of PCB-containing transformers managed by this company, these costs quickly escalate into millions of dollars in annual contingent costs.

Contact

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Source

White, A.L., D.E. Savage, and A. Dierks, "Environmental Accounting: Principles for the Sustainable Enterprise". Originally presented at the 1995 TAPPI International Environmental Conference, Atlanta Georgia, May 7-10 1995.

BAXTER INTERNATIONAL

COMPANY PROFILE

- ⇒ *Location*: Deerfield, IL
- ⇒ *Size*: 184 sites worldwide
- ⇒ *Annual Revenues*: >$9 billion
- ⇒ *Business*: producer of products and services used in hospitals and other health care facilities

Buiness decision, Process Costing

Are expenditures on an internal environmental management program financially justified?

Business Benefits

From proactive spending of $22.2 million, Baxter realized annual environmental income, savings, and cost avoidance of $23.4 million, plus another $51.2 million in cost avoidances from previous years.

Project Background

Over the years, Baxter has demonstrated a strong commitment to improving its environmental performance. In setting and achieving waste reduction goals, making voluntary environmental commitments, and adopting a progressive environmental policy, Baxter has taken strides to go beyond compliance and to integrate environmental considerations into its business. It has developed a number of specific initiatives to improve its environmental performance as part of the normal course of doing business.

One of these initiatives was the development of a financial statement of the company's costs and cost savings associated with its environmental activities.

Referred to internally as the environmental balance sheet, the statement has been refined and upgraded, and has been published for external audiences since 1992. The UK telecommunications company, British Telecom, sponsored this case study of Baxter's environmental financial statement as part of a research effort to improve its own environmental reporting.

COST CONSIDERATIONS

	1994 Savings
Materials/disposal	$ 9,100,000
Recycling income	$ 3,500,000
Energy conservation	$ 300,000
Packaging	$ 10,500,000
	1994 Costs
Corporate, etc.	$ 2,800,000
Programs	$ 9,100,000
Pollution control	$ 10,300,000

Project Description

The central theme of Baxter's environmental financial statement is that environmental considerations are an integral part of running its business. Furthermore, good environmental management requires not just the consideration of environmental issues, but their translation into bottom-line language that speaks to upper management. The environmental balance sheet is a demonstration of the economic benefit of the firm's environmental activities.

The statement serves multiple purposes within the company, and these are mostly for internal uses. The first is to reinforce the firm's commitment to total quality management and its logical extension to environmental management. By measuring the costs of action and inaction, the case that good environmental management is consistent with good business is made more compelling. Such measurement induces managers to take positive actions that can yield simultaneous environmental and economic benefits. Other purposes of the balance sheet are to identify future cost savings opportunities and to enhance the credibility and perceived value of environmental staff. The statement also serves the purpose of informing its external stakeholders of its financial commitment to environmental performance.

Analysis

The development of the statement requires the identification, collection, and assembly of financial data associated with all aspects of environmental affairs. The statement separates the data into two categories: environmental costs; and total income, savings, and cost avoidance for initiatives undertaken in a reporting year. The cost avoidances from previous years are then added to arrive at the total benefit of Baxter's environmental initiatives. The estimation of cost avoidances does not include costs that would have been eliminated through other means. The data collection is an annual process facilitated by a form distributed to all Baxter divisions. Corporate staff synthesizes and verifies the data to the extent possible in order to maintain the statement's credibility.

The environmental costs are split into the proactive costs of the basic environmental program and the reactive costs of remediation and waste disposal. These costs are measured in terms of the quantity of the resource used (e.g., materials, equipment, or staff time) and the price the company pays for the resource. Environmental benefits include cost reductions of ozone-depleting substances, hazardous and non-hazardous waste, and packaging; income from recycling; and cost savings from energy conservation. Although the statement aims to be comprehensive, certain cost elements are excluded from the analysis for a number of reasons. These items include reduction of liability exposure, increased goodwill and employee morale, capital cost differential for environmentally superior lighting, and costs of environmentally-driven R&D. Baxter sees these costs/savings as offset by non-environmental costs/savings, as relatively minor, or as too difficult to quantify.

Finacial Results

The study provided an environmental financial statement for 1994, 1993, and 1992. The total income, savings and cost avoidance in 1994 was $74.6 million, up from $31.0 million two years earlier. The 1994 environmental proactive costs were $22.2 million while the costs of the reactive program were $5.4 million. These costs were nearly offset by the year's savings and income of $17.7 and cost avoidances of $5.7, amounting to a total of $23.4 million. From these numbers alone, the investment in the proactive program was covered by the benefits it yields.

The statement also reports another $51.2 million of cost avoidance in 1994 from efforts initiated in prior years (dating back to 1989). This figure represents waste reduction initiatives from previous years that continue to represent money the company does not have to spend, but would have if the initiatives had not been taken.

Contact

William Blackburn, Baxter International, (847) 948-4962

Source

Baxter International, Inc., *Baxter Environmental Performance Report 1995*. 1996.

Bennet, Martin and Peter James, *Baxter International Inc. -- Environmental Financial Statement*. Study for British Telecommunications, March 1996.

WITCO CORPORATION

Business Decision, Strategic Planning

Can materials and cost accounting enhance the firm's ability to identify and prioritize environmental projects?

Business Benefits

Witco's analysis of its material flows and associated costs facilitated a plan that included a $30,000 cost savings opportunity.

COMPANY PROFILE

- ⇒ *Location*: Newark, NJ
- ⇒ *Size*: 60 employees (at this site)
- ⇒ *Annual Revenues*: $2 billion (total)
- ⇒ *Business*: producer of fatty acids, glycerin, and esters used for the manufacture of plastics, rubber, and personal care and pharmaceutical products

Project Background

The New Jersey Pollution Prevention Act was developed to help businesses overcome the barriers that typically inhibit pollution prevention (P2). The Act mandated a planning process to encourage companies to identify opportunities for environmental improvement. To further an assessment of the success of the Act, the state Department of Environmental Protection commissioned case studies of five firms to evaluate their experiences with the planning process.

Witco was among the first firms in the state to fulfill the Act's planning requirements, was willing to share its experiences, and was identified as having prepared a successful plan. The study sought to assess how the facility implemented the planning process, what lessons it learned, and what implications could be drawn for the state's planing process.

Project Description

One of the elements of the planning process is the development of facility and process materials inventories. The Act requires facilities to quantify their use and generation of hazardous wastes and to estimate the associated costs. The process of measuring these costs is intended to establish a framework within which the facility can fully understand and benchmark its processes to inform P2 management decisions.

Witco first had to define its discrete manufacturing processes and identify the locations where wastes exit each process. The facility then had to collect both facility-wide and process-level material throughput data. The final step of this element of the planning process was the assessment of costs associated with hazardous materials.

Analysis

The collection of materials throughput data required an augmentation of practices already in place to calculate facility-wide totals for Toxics Release Inventory reporting. The significant change was shifting the unit of analysis from the facility to the individual processes. The facility gathered the process-level data by performing materials balances for each process. To do so, it compiled accounting information from numerous departments to estimate the quantity of chemicals stored in inventory, processed, brought on site, recycled, wasted, and embodied in products. To verify the accuracy of the information, the facility took selected measurements of one chemical in order to compare the estimate to the actual use. The planning process also required the facility to normalize the data so that it can be evaluated independent of production volume. Finally, the facility allocated costs – both input (purchase) costs and output (waste disposal) costs – to the specific processes.

Once the first level of analysis was complete, the ultimate value-added component of the planning process could be implemented: identification and analysis of P2 opportunities. Since the audit had identified the various sources and costs of waste generated at different stages of the individual processes, the facility had the information it needed to make improvements. As a result of the planning process, capital investment ideas were developed at the facility as opposed to at the corporate level, and the focus of these investments shifted upstream in the process. From the information collected, the benefits of proposed investments could be more readily evaluated.

Financial Results

Throughout the planning process, the facility expected to reach its goal of reducing the use of methanol by 28,000 pounds annually. This reduction will create a savings to the firm of $30,000 in material and effluent costs. The quantitative nature of the planning process facilitated setting reduction goals and the evaluation of proposed projects to achieve those goals. For example, when the sewerage charges stemming from methanol use were allocated to the processes generating methanol and its use was normalized for production level, the inefficient use of methanol and the high associated cost became evident. Management could then adequately assess the direct economic benefits of improving process efficiency and reducing the use and generation of a costly input material.

Contact

Allen White, Tellus Institute (617) 266-5400

Source

Dierks, Angela, Allen White, and Karen Shapiro, *New Jersey's Planning Process: Shaping A New Vision of Pollution Prevention*. June 1996.

DUPONT DE NEMOURS

COMPANY PROFILE

- ⇒ *Location*: LaPorte, TX
- ⇒ *Size*: >100,000 employees
- ⇒ *Annual Revenues*: $40 billion
- ⇒ *Business*: producer of agricultural pesticides

Business Decision, Strategic Planning

Can improved costing of environmental operations inform management decision making?

Business Benefits

This DuPont facility identified a preferred method of waste treatment with variable costs more than 50% lower than the existing method.

Project Background

As the largest chemical company in the US, DuPont has found itself subject to intense scrutiny and criticism with regard to its environmental performance. Its longtime use of deep well injection (DWI) of wastewater placed the company at the top of the nation's Toxics Release Inventory. In light of this unfavorable attention, the company made a public commitment to positive action to improve its environmental performance.

With its large expenditures on environmental management ($500 million in 1993 for environmental capital projects and roughly $1 billion in environmental expenses), DuPont had much to gain by thoroughly understanding and actively managing its environmental affairs. To that end, DuPont developed and implemented a Corporate Environmental Plan (CEP), part of which focused on assigning priorities to environmental initiatives. The CEP embodies DuPont's environmental commitment by establishing a framework for collecting information, ensuring compliance, and meeting internally-established and externally-publicized goals. One of these goals is the elimination of land disposal, including DWI, of hazardous wastes by the end of the decade.

Project Description

The CEP integrates environmental issues into business planning by providing guidelines for developing environmental projects and identifying the regulations, technologies, and required resources relevant to each project. The cost per pound of waste eliminated provides a comparative metric to prioritize these environmental initiatives, subject to additional consideration of timing and potential synergy with other projects. The development of a cost metric requires a means for identifying and tracking all relevant costs. At the time of this study, the LaPorte facility was establishing an environmental accounting system to enable development of these measurements.

The agricultural pesticide manufactured at LaPorte generates liquid and solid wastes and air emissions. Some of the wastewater from the process is managed with DWI, and some is sent to an on-site biological treatment facility. Other waste streams from the process are incinerated. To achieve corporate environmental objectives, the LaPorte facility seeks to discontinue the use of DWI to dispose of its wastewater. To do so, the facility would have to rely on on-site treatment to process all of the facility's wastewater.

Analysis

To analyze the financial aspects of the elimination of DWI for the process wastewater, DuPont executed a multi-step costing process to determine the environmental costs of the product, one of which was the cost of wastewater disposal by DWI. First, the various environmental costs of two types are identified: (1) Those already specified as environmental – such as waste management and regulatory compliance – and (2) environmental costs hidden within other costs – such as management time spent on environmental activities. The plant estimates that 90% of the environmental costs are captured in these two cost elements. Environmental costs are disaggregated and categorized as fixed or variable, and then further categorized as controllable or non-controllable.

COST CONSIDERATIONS

Estimated Site Environmental Costs	
taxes, fees, legal, etc.	21.0%
depreciation	16.8%
operations	13.9%
waste disposal	12.4%
utilities	11.9%
salaries	9.6%
maintenance	8.5%
engineering services	6.0%

To evaluate the cost of wastewater treatment, the company allocated the full costs of the various treatment options to units of production based on estimated wastewater output. Shortcomings of this method include the inaccuracy of using output volume estimates and the assignment of fixed costs of waste treatment – costs which were incurred in the past and are now "sunk" – to products. To address the former, the facility has installed meters so that actual output data can be used. The allocation method was improved by ignoring the fixed costs and assigning only the variable costs to production units.

Finacial Results

Varying allocation methods for waste treatment had a significant effect on waste management costs. DWI had been costed at 9¢ per pound of effluent treated, of which 7¢ was variable cost. Bio-treatment appeared as a more expensive option at 11¢ per pound, but only 3¢ of that was variable cost. Whereas managers previously had incentive to use DWI to incur less cost through the accounting system, the improved allocation demonstrated that bio-treatment was actually more cost effective by 4¢ per pound.

The amount of savings this improved accounting method will yield depends on both the production volume and the actual volume of wastewater generated, as well as the extent to which the cost assignments remain stable. Nevertheless, the improved environmental accounting practices will enable DuPont to realize a substantial cost savings by eliminating disposal via DWI. At the same time, it will provide managers with better information with which to make future waste management decisions.

Contact

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Daryl Ditz, World Resources Institute (202) 662-3498

Source

Ditz, Daryl, Janet Ranganathan, and R. Darryl Banks, *Green Ledgers: Case Studies in Corporate Environmental Accounting*. World Resources Institute, May 1995.

Total Cost Assessment of a New Biopolymer Product based on a Life Cycle Approach

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ABSTRACT

Two alternatives, that is life-cycles studied in the life-cycle assessment (Part 1); the life-cycle of a diaper including a biodegradable polymer and the life-cycle of a diaper made of a traditional polyolefin; were the starting point for this cost assessment. The aim of the cost assessment has been to develop a tool for facilitated decision-making in product development stage, especially for investment decisions. The study includes an attempt to explore the cost information road map, and the allocation of the indirect costs to the activities. The cost assessment covers the resin production (monomer and polymer production) and the chosen waste treatment processes.

OBJECTIVES AND SCOPE OF THE STUDY

The aim of the project under study is to develop a method based on *a combined life-cycle and environmental cost analysis*. The method can be used for the comparison of environmental impacts and costs of alternative products in investment decisions, product design, in marketing and as a base of information needed for reporting practices. Several other uses for environmental cost information can be listed as well, including

- product mix decisions
- choosing manufacturing inputs
- assessing pollution prevention projects
- evaluating waste management options
- comparing environmental costs across facilities
- pricing products
- capital budgeting /Green Ledgers/

Environmental impacts of a product under development and of a traditional product have been studied with the aid of life-cycle analysis. The product under development is made of renewable materials and is biodegradable. The traditional product is non-degradable.

Diapers made of biodegradable plastics produced from lactic acid have been compared with present diapers made of oil-based plastics. Production chains of some raw material alternatives of biodegradable plastics have been studied starting from agricultural production. Waste treatments suitable for the product alternatives, landfilling, composting and incineration have been compared with each other.

The method to be developed for *the assessment of environmental costs* is based on the results of the life-cycle inventory and on the evaluation of environmental impacts applied to them. The environmental costs can be classified, for example, to direct costs due to emissions and waste management, and to indirect costs due to administrative, regulatory and liability practices, as well as to company internal and external environmental costs, which include both direct and indirect costs. In this study, we take the latter classification as the starting point.

The research work is carried out by the VTT Industrial Environmental Economics, in cooperation with Neste Oy and Neste Engineering. The environmental cost assessment phase will be finished by the end of September 1997. Life-cycle assessment comparison has been reported in June 1997 for internal use by Neste Oy. The project is financed by the Technology Development Centre of Finland (TEKES) and by Neste Oy.

COST ASSESSMENT BOUNDARIES

The original scope of the environmental cost assessment was challenging, even too challenging: To assess life-cycle wide company internal and external costs for two comparable products, diapers made of oil-based plastics and diapers made of biodegradable plastics.

The limitations made in the study and the reasons for doing so are described in the following.

The study concentrates on the company internal costs, either originating from the activities of the company itself or reflected to the company from stakeholders in the form of various impulses. These internal costs include the conventional costs, like investment and operational costs, and the indirect costs, like administrative, regulatory, liability, and less tangible costs. It is emphasized that the information gathering will focus on the company internal environmental costs, not on externalities. The external, i.e. social environmental costs, like the costs of health effects, ozone depletion and acidification, have been valuated in the life-cycle assessment by using existing valuation methods, like the EPS, Ecoscarcity, Effect category, and Tellus methods.

Due to limited research resources, the life-cycle stages to be included in the environmental cost assessment had to be limited. Diaper manufacture and consumption phases of the two studied products are similar. Assessing the cost of these two phases would not lead to any differences between the products. Diaper manufacture and consumption phases are therefore excluded from the scope of this study. In the case of the biodegradable product, the environmental costs of primary production and the plastic raw-material refining (dextrose production and fermentation) would certainly be interesting to assess. However, these were estimated to be too time consuming and were therefore left outside the scope. Oil acquisition and refining were excluded as well.

The boundaries of the environmental cost assessment were defined to cover as well ISBL as OSBL activities of the resin production (monomer and polymer production) and the chosen waste treatment processes. For the conventional plastic product the waste management processes studied are landfilling and thermal treatment, and for the biodegradable product the processes studied are biological treatment (composting and biogas production by anaerobic digestion), landfilling and thermal treatment. *Figure 1* shows schematically the entire life-cycles of the products discussed and the boundaries of the cost assessment.

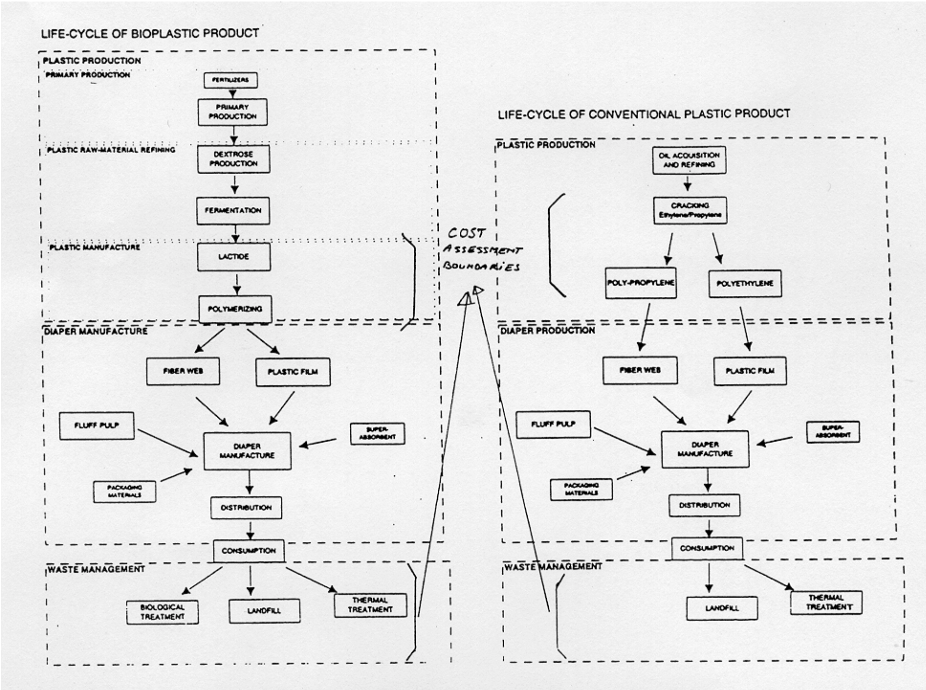

Figure 1. *Schematic life-cycle of the biodegradable versus oil-based plastics production for diapers.*

LIST OF COST ITEMS

After defining the cost assessment boundaries it was decided to list all possible company internal cost items, either originating from the company activities itself or reflecting from the wishes and needs of various stakeholders. The list follows the division into conventional company costs and into indirect company costs. Furthermore, the indirect company costs were divided into sub-groups *environment, health, safety, and other*. These sub-groups correspond to the groups reported in the environmental report of the company. Conventional company costs including the investment and operational costs are generally clear. Some examples of the indirect cost items could, however, be given, *Table 1.*

Table 1. Some examples of the company indirect cost sub-groups and items (fixed and variable).

Sub-groups	Cost items
Environment	Regulatory, regulatory tracking Authority contacts Environmental protection Environmental policy and programmes Inefficient raw-material/energy use Waste management (on-site) Pollution control Reporting Public relations Assessments (eco-audits) Remediation

Health	Occupational health Personal injury costs
Safety	Insurance (property, liability) Preventative risk management Monitoring Product safety Maintenance, spare parts Permits Audits Fire service, guards, …
Other	Administrative, management and supervision Indirect labor (lab., tech.serv., repair facil.) Payroll burden on all labor charges Education, training R&D Planning Marketing Record-keeping, accounting, documentation Penalties, fines …

The list of cost items, which is shown in rough form in Table 1, was used when contacting the company representatives expected to hold the cost information needed.

EXPLORING THE COST INFORMATION ROAD MAP

Rather soon it became obvious that it is difficult to find the right persons to communicate with, when dealing with environmental costs accounting. The terminology and concepts of environmental accounting and total cost assessment (environmental investment analysis) are not familiar to traditional accountants. Several hours were spent describing cost thinking and the advantages of the expanded cost inventory, and of the allocation of the costs to the activities responsible for them. Awareness raising could be considered to represent one of the main results of the study.

It became obvious as well that monetary figures are treated as company confidential information, and not available as such for “external” research purposes. The cost information was reported to be confidential especially in the case of the traditional product resin production case. Solutions to compensate for the lacking cost information had to be found. It was decided to explore the cost information road map and possibly the percentage sharing of the total company costs to show the major cost items.

Some thoughts behind the cost information road map exploration:

There is no universal way to define environmental costs. Varying case by case definitions to suit the intended uses need to be defined. From a strategic perspective, firms must consider all costs. But in the short term, managers generally focus on the most easily controlled costs. Companies routinely distinguish between variable and fixed costs. The conventional accounting distinction between fixed and variable costs can lead to some confusion about the controllability of environmental costs. In the long-run, all costs become variable. Many costs are recorded as variable or fixed, depending on whether they vary with production volume, off-site waste disposal being a classical example of a variable cost item

However, many types of environmental costs can vary with factors other than production. For example, those associated with emissions monitoring and reporting in a plant would change very little with the amount of product manufactured.

Traditionally, most environmental costs within companies are not traced directly to their sources. Rather, they are accumulated in overhead pools and allocated across production processes in proportion to such simple measures as labor hours or units of output. When these environmental costs become significant, and when different parts of an organization contribute to them unequally, tighter accounting can more than pay for itself. Inaccurate cost allocations misrepresent costs, thus sending the wrong signals to managers and other decision-makers inside the company. In product costing, for example, this failure can skew the evaluation of profitability across a slate of products. Using traditional cost allocation methods, products with relatively lower environmental costs subsidize those with higher environmental costs.

At Neste, the existing cost accounting system certainly covers all historical costs of doing business. However, the costs appear somewhere in the line items of the product profitability statements. The costs are perhaps aggregated into a broad expence category such as costs-to-goods-sold or marketing administration.

The search for environmental costs is not just merely a paper exercise. Environmental accounting requires an understanding of the overall business landscape, the company´s core activities and capabilities, and the nature of environmental challenges. While this obviously involves an analysis of general ledgers, the accounting system is only one of the many sources of information. Some other are listed in *Table 2.*

Table 2. Examples of sources of environmental cost information. /Green Ledgers/

Environmental Costs	Information Sources
Permitting Fees and Fines	Regulatory Documents Management Estimates
Maintaining Environmental Equipment	Maintenance Logs Service Contracts
Non-Product Output	Emissions Estimates Production Logs
Process Penalties / Shut-downs	Operating Records
Depreciation	Capital Asset Ledger
Monitoring	Engineering Estimates Management Estimates
Environmental Auditing	Management Estimates
Training	Personnel, EHS Records Management Estimates

This process of gathering information is inherently open-ended and iterative. Several questions will certainly arise along the assessment process. One thing is, however, clear: simply tracking historical costs is not good enough. Supplementing cost accounting with other indicators of environmental performance can help identify potential vulnerabilities before they become major cost factors. Future environmental costs, though inherently uncertain, are inevitable. Laws will change, and regulatory requirements evolve and expand. Actions that are perfectly legal today can create financial liabilities tomorrow. The challenge for managers is to avoid incurring future costs when meeting present demands.

In the following, the cost information road map in the case of polyolefins production (traditional product, resin production), is shown as it was reported by the company representative, Table 3.

Table 3. Cost sources reported, Polyolefins production (Cracking C2 + C3, Polymerization LDPE & PP).

1. **From book keeping values**
2. **Estimate for grass root plant**
3. **From fixed cost accounting / reporting**
4. **From production accounting / reporting**
5. **Total figures available from waste reports**
6. **Known / calculated only at site level / for whole area**
7. **Can be estimated / rough estimation**
8. **Not exactly known / not calculated / not available**

Further studies of the information sources are needed. Too many of the cost items listed in Table 1 were reported to fall in groups 6-8 in Table 3.

EXPECTED RESULTS OF THE COST ASSESSMENT

Further development of the reported cost information road map is still going on. One possibility is to try to find out the percentage sharing of the total costs caused by the polyolefins production. The cost sharing would show which cost items form the most significant part of the costs. Through the assessment results some ideas for further development of the biopolymer process are expected to be found.

The cost information collection for the waste management stage processes is under work. Similar cost items listing as in the polyolefins´ case have been used for waste management. Preliminary results show that the cost information reported by the waste management companies will be rough. However, it is expected to show the magnitude of the operations.

The most important result of the environmental cost assessment part of the study could be defined as communication of TCA-concepts and as awareness raising of the importance of environmental cost accounting.

LESSONS LEARNED

During the study, some perhaps well known lessons learned proved to be true. Company management commitment is needed. In case you don´t have it, you can give up your illusion to expect any good results from your work. Building up information bridges is very time consuming. This means that you need to find right persons to discuss with, either persons who already are aware of the subject discussed, or who are able to adopt the new ways of environmental cost thinking.

When passing through the preceeding lessons reservation of sufficient research resources for the cost information collection is a must. Even at this stage of the study, the awareness raising of the TCA-concepts and of environmental cost accounting is needed. Traditional accountants are very seldom aware of these new concepts.

If the company accounting systems were pre-designed to take into account the environmental costs and their allocation to the processes responsible for them, the adoption of preventative environmental approaches would be possible and eco-investment decisions facilitated. Better accounting for environmental costs is crucial to long-term business sustainability.

However, when discussing in monetary terms, absolute figures can hardly be expected to be found out. Anyway, proper cost assessments can give as good results as the laborous and time-consuming life-cycle assessments of today.

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Assessment of External Costs in EU's Externe Project and Its National Implementation in Finland

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ABSTRACT

The ExternE methodology for assessing externalities of energy production is described generally. This Finnish study is a part of the ExternE National Implementation project, where the methodology was applied to different fuel cycles of electricity generation in 14 EU countries of and Norway. In Finland three fuel cycles were considered: coal, peat and wood derived biomass, which contribute to 3/4 of the non-nuclear fuel based electricity generation. Only health and global warming impacts were significant in monetary terms. An exercise of aggregation the results to the whole Finnish electricity sector is presented. Finally the limitations of the ExternE methodology and the difficulties in monetary valuation of externalities are discussed.

INTRODUCTION

Background and objectives

Externalities are such environmental and social impacts of energy production, the damages of which have typically not been reflected in the market price of energy, or considered by energy planners, and consequently have tended to be ignored. Within the European Commission R&D Programme Joule II, the ExternE Project developed and demonstrated a unified methodology for the quantification of the externalities of different power generation technologies. It was launched as the EC-US Fuel Cycles Study in 1991 as a collaborative project with the US Department of Energy. From 1993 to 1995 it continued as the ExternE project, involving more then 40 European institutes from 9 countries, as well as scientists from the US. This resulted in the first comprehensive attempt to use a consistent 'bottom-up' methodology to evaluate the external costs associated with a wide range of different fuel chains. The result was identified by both the European and American experts in this field as currently the most advanced project world-wide for the evaluation of external costs of power generation (EC, 1995a-f).

Under the European Commission's Joule III Programme, this project has continued with three major tasks: ExternE Core for the further development and updating of the methodology, ExternE National Implementation to create an EU-wide data set and ExternE Transport for the application of the ExternE methodology to energy related impacts from transport. The current report is the result of the ExternE National Implementation project for Finland. The objective of the ExternE National Implementation project is to establish a comprehensive and comparable set of data on externalities of power generation for all EU member states and Norway.

The data in this report results from the application of ExternE-methodology as developed under Joule II. However, because our understanding of the impacts of environmental burdens on humans and nature is improving continuously, this methodology (or more precise, the scientific inputs into the accounting framework) has been updated and further developed.

The National Implementation project has generated a large set of comparable and validated results, covering more than 60 cases, for 15 countries and 12 fuel chains. A wide range of generating options have been analysed, including fossil, nuclear and renewable technologies. Analysis takes account of all stages of the fuel chain, from (e.g.) extraction of fuel to disposal of waste material from the generating plant. In addition to the estimates of externalities made in the study, the project also offers a large database of physical and social data on the burdens and impacts of energy systems.

The ExternE results form the most extensive externality dataset currently available. They can in principle be used to look at a range of issues, including:

- internalisation of the external costs of energy
- optimisation of site selection processes
- cost benefit analysis of pollution abatement measures
- comparative assessment of energy systems

Such applications are illustrated in the national implementation reports from the 15 participating countries.

The Finnish National Implementation

Finland is placed in the Northern Europe between the Northern latitudes of 60° and 70°. Finland has a common land boundary with Russia, Norway and Sweden. The total land area of Finland is about 338 000 km^2, and its population slightly more than 5 million. More than half of Finnish population lives in the southern sixth of the country.

The most particular characteristics of the Finnish energy system are the importance of energy intensive industries, significant energy use for space heating due to the harsh cold climate, and long transport distances because of the sparse population. Consequently, the total per capita energy requirements are larger than in most other countries in Europe. The domestic energy resources are limited to hydro and wind power, nuclear power, peat, and renewable fuels. All of the oil, coal, and natural gas requirements are covered by imports, and some electricity is imported as well.

An important feature of the Finnish electricity generation system is the large share of combined heat and power production (CHP) in the overall electricity supply. Consequently, the average efficiency of fuel based electricity generation is in Finland considerably higher than the average within the European Union, about 57 % in 1994 (Lehtilä et al. 1997).

The selected fuel cycles were coal, peat and wood derived biomass, which together are responsible for about 40 % of total electricity generation in Finland and about 75 % of the non-nuclear fuel based generation. The ExternE methodology is aimed at the marginal approach, which means that the marginal impacts of *new* energy production capacity are of main interest. The selected fuel cycles represent therefore technology, which would be utilised in power plants introduced at present and in near future in Finland.

METHODOLOGY

The methodology used for the assessment of the externalities of the fuel cycles selected has been the one developed within the ExternE Project (EC, 1995). It is a ***bottom-up*** methodology, with site-specific approach, that is, it considers the effect of an additional fuel cycle, located in a specific place. However, this style of analysis has only recently become possible, through developments in environmental science and economics, and improvements in computing power has. Early externalities work used a ***top-down*** approach. Such analysis is highly aggregated, being carried out at a regional or national level, using estimates of the total quantities of pollutants emitted or present and estimates of the total damage that they cause.

The underlying principles on which the methodology for the ExternE Project has been developed are:

Transparency, to show precisely how results are calculated, the uncertainty associated with the results and the extent to which the external costs of any fuel chain have been fully quantified.

Consistency, of methodology, models and assumptions (e.g. system boundaries, exposure-response functions and valuation of risks to life) to allow valid comparisons to be made between different fuel chains and different types of impact within a fuel chain.

That analysis should be comprehensive, we should seek to at least identify all of the effects that may give rise to significant externalities, even if some of these cannot be quantified in either physical or monetary terms.

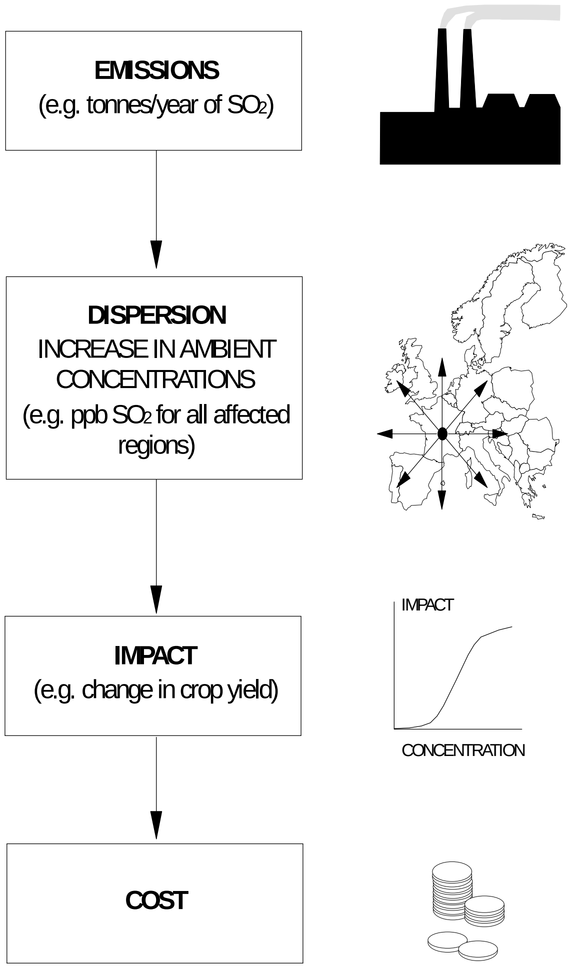

Figure 15. An illustration of the main steps of the impact pathway methodology applied to the consequences of pollutant emissions. Each step is analysed with detailed process models.

These characteristics should be present along the stages of the methodology, namely: site and technology characterisation, identification of burdens and impacts, prioritisation of impacts, quantification, and economic valuation.

The ExternE Project uses the ***impact pathway*** approach (illustrated in Figure 15) for the assessment of the external impacts and associated costs resulting from the supply and use of energy. Emissions and other types of burden such as risk of accident are quantified and followed through to impact assessment and valuation. The approach thus provides a logical and transparent way of quantifying externalities.

Quantification of impacts is achieved through damage function, or ‘impact pathway’ approach. This is a series of logical steps, which trace the impact from the activity that creates it to the damage it produces, independently for each impact and activity considered, as required by the marginal approach.

The underlying principle for the economic valuation is to obtain the willingness to pay of the affected individuals to avoid a negative impact, or the willingness to accept the opposite. Several methods are available for this, which will be adopted depending on the case.

The proposed methodology has also serious limitations, which are discussed finally.

OVERVIEW OF THE FUEL CYCLES ASSESSED

The locations of the three power stations in the Finnish NI study are shown in Figure 16. The main results of these fuel cycle cases are summarised in the following. Damages caused to human health are an important factor in the ExternE results and dependent on the population density in the neighbourhood of the station, also given in Figure 15.

Coal fuel cycle

The power plant of the fuel cycle represents clean coal-firing technology. Meri-Pori power plant was introduced into commercial operation in the beginning of 1994 as one of the world's cleanest and most efficient coal-fired power plants with a condensing turbine. Its pulverised coal boiler is Finland's largest power plant boiler to date. The boiler is once-through supercritical type with one reheat.

The flue gas cleaning ratio and the efficiency of this electricity generating power plant is notably better than those of other similar plants in Finland. The power station is equipped with the most modern gas cleaning facilities. The nitrogen oxides emissions formed in the boiler are reduced by 80 % with the help of the low-NO_x burners and phased combustion and the catalytic denitrification system installed in the flue gas duct of the boiler. In the selective catalytic reduction (SCR) system, cleaning is based on ammonium injection and catalytic cells.

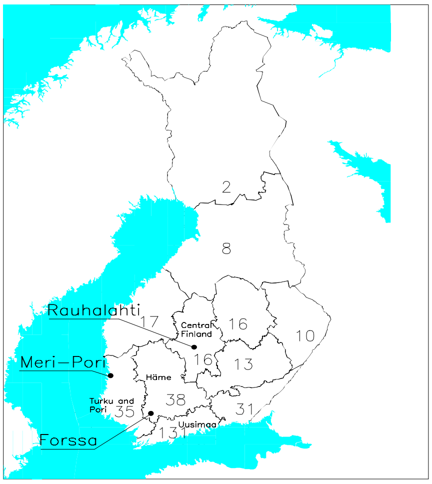

Figure 16. Locations of the power stations in Externe NI, and the inhabitants per km² of land area in the provinces.

The plant runs on coal imported from non-EU countries. More than 2/3 of the coal is derived from Poland and Russia. In this National Implementation project it was assumed that all the coal is imported from Poland.

The major burdens of the coal fuel cycle are the atmospheric emissions of pollutants from the mining and power generation stages, liquid effluents and solid wastes from mining and power generation, and occupational accidents from the mining stage. The major air pollutants are SO_2, NO_x and CO_2. TSP emissions (including fugitive dust) and CH_4 from mining are also significant.

The general selection of the priority impacts of the coal fuel is based on the results in the earlier ExternE project (EC, 1995). The most important of the impacts seemed to be those caused by atmospheric emissions — especially from power generation — to human health. In addition, global warming is now considered as one of the major impacts.

Especially in the coal fuel chain considered here the liquid effluents from mining in Poland seem to have serious environmental impacts but their quantification could not be performed in this project. Occupational health impacts in Polish mines seem to be a very important part of the total health impacts.

The tool for calculating the dispersion of the primary pollutants TSP, SO_2 and NO_x — and the consequent impacts and damages — of power generation, was the EcoSense 2.0 model. Because the computational grid of the model does not cover areas east of Finland, all the air emission impacts especially in the Russian areas nearby are missing in the basic model results. As an approximation the population of northwest Russia totally about 8.4 million people were added to the most eastern gridcells of the model for sensitivity analysis of the results. After that the health damages of SO_2 and TSP were increased by 17 % and the damages of NO_x by 31 %.

The summarised damage results for the coal fuel cycle are presented in Figures 3 and 4 at the end of the paper. The estimated value of a life year (VOLY) was used in the valuation of mortality to airborne emissions.

The health damages were about 4 mECU/kWh (dominated by mortality impacts), crop damages an order of magnitude lower and damages caused to building materials two orders of magnitude lower. The impacts on ecosystems seem to be very difficult to assess, especially the long-term impacts. A task, which is even more difficult, is to give any monetary valuation for this kind of damages. For all the three fuel cycles attempts were made for quantification of the *impacts* only

The primary pollutants TSP, SO_2 and NO_x are all three in the same order of magnitude. NO_x is still the most important of them due to its indirect impact in ozone formation.

When considering the damages of the individual pollutants, CO_2 dominates due to its global warming (GW) impact. The damage estimates of global warming are considered to be much more uncertain, and 4 different damage estimates (3.8-139 ECU / t CO_2) were presented by the Core Project. Using the lowest estimate for GW damage of the coal cycle, the damage is of the same order of magnitude as the damages of TSP, SO_2 and NO_x mentioned above, but using the highest estimate nearly two orders of magnitude higher (about 120 mECU/kWh). Although the emissions of greenhouse gases and their global warming potentials (GWPs) are well-known, the knowledge of the true impacts and damages of GW is still poor.

Peat fuel cycle

The Rauhalahti plant generating electricity, district heat and process steam is located in the Jyväskylä area in Central Finland. This CHP plant has a bubbling fluidised bed boiler. The main fuel is milled peat, but the new combustion technique enables the utilisation of wood fuels such as sawing waste, chips and bark alongside peat. Crushed coal and oil can also be burnt in the boiler. The efficiency of the plant is about 85 %. In 1995 its overall fuel consumption was about 84 % milled peat, 13 % wood, 2 % oil, and 1 % coal.

The flue gases of the power plant go through the electrostatic precipitator, which separates over 90 % from the ash. The fluidised bed boiler reduces the nitrogen oxide emissions formed during combustion by over one third compared with the earlier pulverised boiler. The wood fuels form very little sulphur emissions and decrease the amount of carbon dioxides in the air.

The peat is transported by trucks from peatlands in the vicinity of the plant and the average transportation distance is 80 km.

The major burdens of the peat fuel cycle are the atmospheric emissions of pollutants from the power generation stage. The major air pollutants are SO_2, NO_x and CO_2. Peat is considered a fossil fuel with global warming impacts. The emissions are calculated on net basis. The emissions of the natural peatland are subtracted from the emissions of the calculated phases of peat fuel cycle. Natural peatlands are net sinks of carbon dioxide and sources of methane and nitrous oxide emissions. The amount of the emissions depends on the season.

The most important impacts of the peat fuel cycle are also those caused by atmospheric emissions. Liquid effluents from peatland ditching and peat production have environmental impacts as eutrophication of the neighbouring water systems. Applying the ExternE methodology the human health impacts seem to dominate those directed to other recipients. Global warming is probably the most important impact of the peat fuel cycle. Occupational health impacts of peat production was not considered in this study.

In the basic model results all the air emission impacts in Russia are missing. If this population were added to the model, it is reasonable to assume that the health damages would increase approximately in the same way as in the case of the coal fuel cycle.

Because the power station is of CHP type, the impacts and damages of peat fuel cycle had to be allocated between electricity, heat and steam generation. Here the exergy content was used as the allocation basis. As a result most of the impacts/damages were put on electricity.

Summarised results for the peat fuel cycle are presented in Figure 19 and Figure 20. The damage estimates are those allocated to electricity.

The health damages were about 5 mECU/kWh, crop damages an order of magnitude lower and damages caused to building materials two orders of magnitude lower (as in the coal fuel cycle).

Considering the damages of the individual pollutants, the primary pollutants SO_2 and NO_x are in the same order of magnitude with each other. NO_x is still more important due to its indirect impact in ozone formation.

However, CO_2 dominates due to its global warming (GW) impact. The lowest GW damage estimate of the peat cycle is of the same order of magnitude as the damages of TSP, SO_2 and NO_x mentioned above, but using the highest estimate two orders of magnitude higher (about 140 mECU/kWh).

Biomass fuel cycle

The plant, which represents the biomass fuel cycle, is a new combined heat and power generation (CHP) plant located in the town of Forssa. It began to operate in autumn 1996, and is the first district heat and electricity producing plant of this size using solely wood biomass as fuel. The plant might represent a typical example of future energy technology in Finland that is environmentally more acceptable. The plant produce 95 % of the district heat needed in the town and one third of the electric power the company Forssan Energia send out to the power-distribution network. Flue gases are cleaned with an electrostatic precipitator.

The fuel mix consists of saw dust, bark and wood waste. Almost 80 % of the fuel is produced as a by product from saw mills. Slightly more than 10 % of the fuel is coming directly from the forest and less than 10 % consists of other kind of waste wood. The fuel chips coming directly from forest land will be transported 0 - 50 km and the other wood waste fuels up to about 100 km.

The major burdens of the biomass fuel cycle are the atmospheric emissions of pollutants from the power generation stage. The major air pollutants are SO_2, NO_x, TSP and N_2O. The CO_2 emissions from burning biomass are not taken into account as global warming impacts because the forestry is on a sustainable basis. However, the burning causes small emissions of N_2O, which is a powerful greenhouse gas. The moderate fossil CO_2 emissions are coming from transport and production of the wood fuel and from oil which is used as an auxiliary fuel in the boiler.

The most important impacts of the biomass fuel cycle are those caused by atmospheric emissions from the power generation stage. The human health impacts seem to dominate those directed to other recipients. Global warming impacts are small compared to those of the two other fuel cycles in this study.

The impacts of air-borne pollutants on Russian population are missing in the basic model results shown in the tables and figures later on. As the stack at the coal plant is three times as high as at the biomass plant it can be assumed that the relative impacts on the Russian area are smaller for the biomass cycle than for the coal cycle. The impacts and damages of this fuel cycle were allocated between electricity and heat generation using exergy principle as in the case of peat.

Summarised results for the biomass fuel cycle are presented in Figure 21 and Figure 22.

The health damages were about 6 mECU/kWh, crop damages an order of magnitude lower and damages caused to building materials two orders of magnitude lower (as in the coal fuel cycle). The damages on ecosystems were not quantified, *impacts* only.

Considering the damages of the individual pollutants, NO_x is the most important with damages an order of magnitude higher than those of TSP and SO_2. The indirect impact of NO_x in ozone formation is increasing its importance.

The highest GW damage estimate of the biomass fuel cycle (about 10 mECU/kWh) is of the same order of magnitude as the damage of NO_x.

AGGREGATION

One part of the ExternE National Implementation was the aggregation of the results of the three case studies to the whole electricity generation sector. In 1995 coal, peat and biomass were responsible for about 3/4 of the non-nuclear fuel based electricity generation in Finland. If the three case fuel cycles of the NI study represented some 'average' technologies, it might be possible to find an estimate for the total external costs (caused by airborne pollutants) of the electricity generation sector in Finland.

The Finnish electricity supply system includes almost 400 power stations with a total generation capacity of about 14 000 MW (1996). Small hydro or CHP plants are greatest in number, but the largest 10 plants (including four nuclear plant units) account for about 40% of the total capacity. Excluding the nuclear plants, the largest power plant is the Meri-Pori station which is also within this NI study.

The specific damages for the three fuel cycles (estimated in the ExternE Finnish National Implementation) are given in Two very simple aggregation methods were applied. The more realistic one was based on the assumption that the estimated damages per amount of emission (i.e. specific damages ECU/t pollution) would be quite independent on the fuel cycle technology (although the specific emissions are of course diverse). If the total emissions of the whole electricity generation were known then also an estimate for its total damages could also be calculated. However, it can clearly be seen how even the specific damages (ECU/t) of sulphur, nitrogen and particulate emissions vary in a wide range from fuel cycle to another. It is hard to make any generalisations from these numbers to the whole electricity generation sector in Finland.

Table 3. Estimated specific damages caused by the airborne pollutants for the NI fuel cycles.

SPECIFIC DAMAGES	**mECU/kWh**			**ECU/t**		
Health (VOLY)+oth.	SO_2	NO_x	TSP	SO_2	NO_x	TSP
Coal (Russian pop. incl)	1.23	0.83	0.26	1486	1310	1555
Peat	1.98	1.01	0.19	1027	856	1344
Biomass	0.68	2.33	0.56	1607	1388	2611
Global warming *(mid 1 % estimate)*	CO_2	N_2O	CH_4	CO_2	N_2O	CH_4
Coal	37	0.24	2.76	46	14260	966
Peat	44	0.50	-0.78	46	14260	966
Biomass	0.39	2.96	0.40	46	14260	966

The figures would probably be very specific for every power station and dependent both on the plant itself and its location. Because the damages caused to human health dominate in the ExternE methodology, the distribution of population in a country is here decisive: the total damage is a function of the number of recipients (see e.g. Figure 15). The results from Central European NI studies, where the estimated damages to human health are essentially higher, support these arguments.

The aggregation of total greenhouse gas *emissions* based on the individual fuel cycles is more realistic, because the impact of the GHGs is not dependent on the location of the power plant. On the other hand, the knowledge of the global warming impacts is still very poor. Consequently the basic GHG *damage estimates* (ECU/t pollution), utilised in the ExternE Project, are extremely uncertain.

More difficulties for aggregation are caused by the great share of CHP in Finland resulting in damage allocation problems between electricity and heat.

DISCUSSION AND CONCLUSION

In this study a large number of externalities for electricity generation were calculated based on the methodology and theoretical work of the earlier ExternE Project (EC, 1995a-f) and the Core Project (EC, 1998). The ExternE methodology is an attempt towards the integration of environmental impacts into energy policy. An additional object is the quantification of impacts in monetary terms so that the monetary results could be used (for real!) in economic decision making according to the discipline of neo-classical environmental economics. The outcome of the monetary valuation of the impacts are called the external costs (or damages).

Different types of impacts could be identified in respect of their monetary valuation. Some identified impacts were not quantified at all in this National Implementation study, because earlier ExternE studies had shown them to be of minor importance (for the specific fuel cycle) or no quantification criteria were developed. One group are the impacts on natural ecosystems (through acid deposition) which were quantified in terms of critical load exceedence areas, but for which no monetary valuation could be presented. Further, the valued damages of most impacts were negligible compared to the price of electricity (and thus not usable in practical policy instruments).

In the Finnish study only human health related and global warming impacts seemed to be significant in monetary terms. Their external costs are high enough that they could affect decisions in energy policy, although the health impacts were essentially lower than in some Central European studies. (On the contrary, if the external costs were very high, then they might be feared to be unrealistically high for any politically credible environmental tax (Stirling, 1997). Consequently they should lie in a certain range for being usable!)

There are many uncertainties of diverse character in the results. The statistical uncertainty of the exposure-response functions or parameters is only one type of uncertainty involved.

The choice of the priority impact pathways in this study was mainly based on the experience gained in previous ExternE studies. There might be also some important impact mechanisms not considered at all. It is also possible that the ‘atomic’ approach with distinct impact pathways might lose some vital information on the value of synergistic effects, and thus the general impression might be more than the aggregate of its parts. A fact is at least that modelling and, in general, the understanding of the long-term impacts on natural ecosystems is quite poor. The same applies to actual impacts of global warming.

One type of uncertainty is the validity of the models (including their data base and input data) for the chosen impact pathways or considered phenomena. For example, how accurate is the atmospheric dispersion model applied in the study.

The last part of the pathway is the monetary valuation of the impact, where the uncertainties are also related to the subjective factors of the valuation process.

There is a serious risk of misinterpretations when considering only the final results of the study — the total external costs or damages — without paying attention to the intermediate stages of the impact pathway. A qualitative figure of the externalities, i.e. external impacts before their monetary valuation is also important as well as an understanding of the methodological limitations. The focus is too easily directed towards factors that are quantifiable and theoretically more susceptible, which can lead to bias in the interpretation of results.

It has to be reminded that, even if the theoretical knowledge of impact mechanisms were developed, the attempts towards monetary valuation and damage cost minimisation may not necessarily be the best approach to the problem. Some sustainability constraints may be a better policy instrument than pure social and environmental costs minimisation (Eyre, 1997).

It is also questionable if the different externalities are commensurate in monetary terms. The decision problem concerning the externalities and energy policy is multidimensional, essentially value-laden and plural in character. For good reasons it can be claimed that no purely analytical procedure can fulfil the role of a democratic political process. In other words, there is no uniquely rational way to resolve contradictory perspectives or conflicts of interests. There can be no 'analytical fix' for the problems of environmental appraisal (Stirling, 1997). For example, the way how human life is monetarily valued in the ExternE methodology decides mainly the level of external costs. It can be asked if the valuation should be open to discussion and to a democratic process and not to be chosen by scientists.

However, in spite of the uncertainties and limitations of the methodology, it can be an effective tool in the comparison of similar kind of fuel cycles, new power plant and pollution abatement technologies and different plant locations with each other. The relative differences may be more interesting than the absolute figures of external costs. The strength of the 'bottom-up' approach is that the analysis is case-specific taking into account all the concrete details of the fuel cycle under consideration.

Much more uncertain is the generalisation or aggregation of the results to the whole electricity generation sector, to the total external costs due to its air-borne emissions. The three fuel cycles assessed in this National Implementation do not represent the mean of the whole non-nuclear fuel based electricity generation in Finland but rather newer technology, according to the objectives of the project. Consequently, the specific emissions of these individual fuel cycles and their estimated damages (mECU/kWh) are not a good basis for aggregation. Also the damage estimates per tonne of air pollution (ECU/t) of this National Implementation Project seem to be very case specific, dependent on the location and stack height of the plant. Some 'top-down' approach would probably be a more fruitful basis for estimating the external costs of the total electricity generation sector.

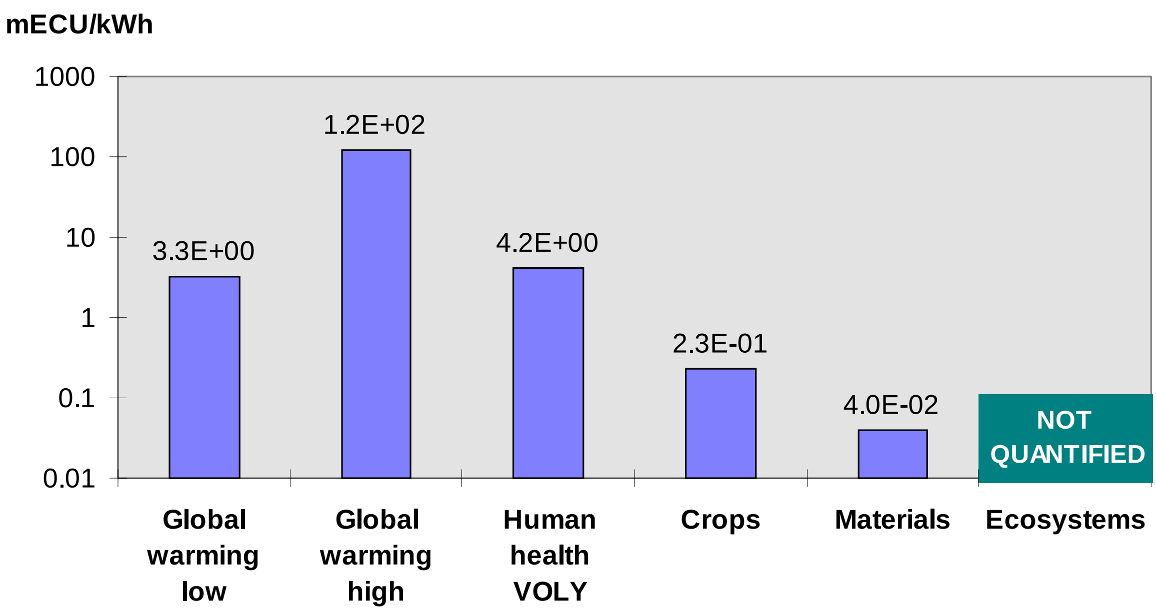

Figure 17. **Total damages of coal fuel cycle by impact category.**

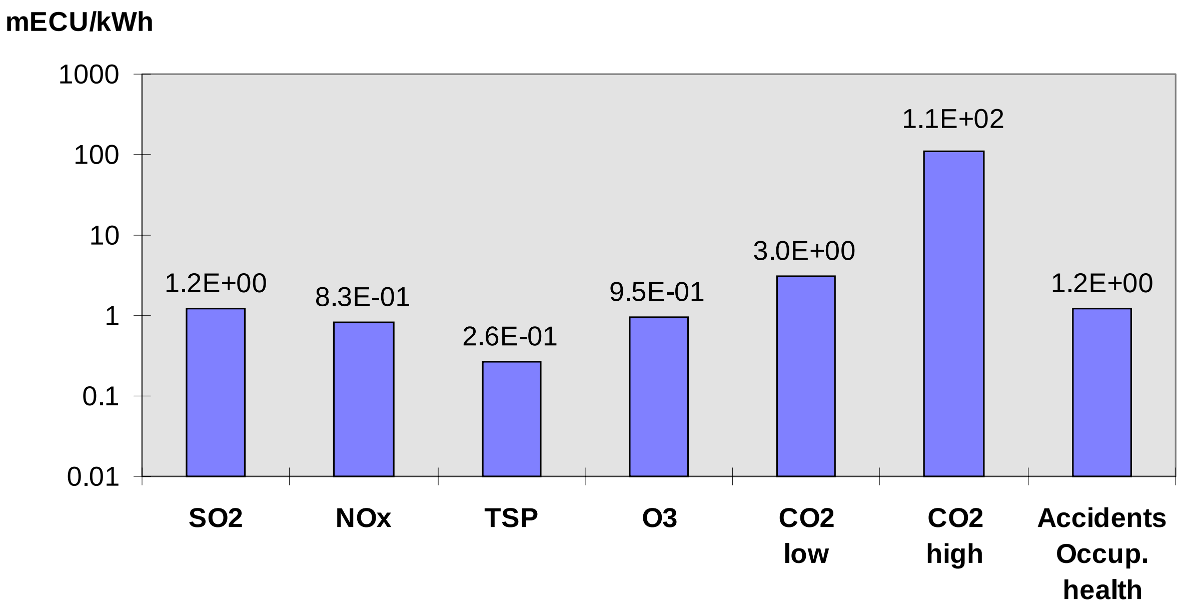

Figure 18. **Total damages of coal fuel cycle by burden category.**

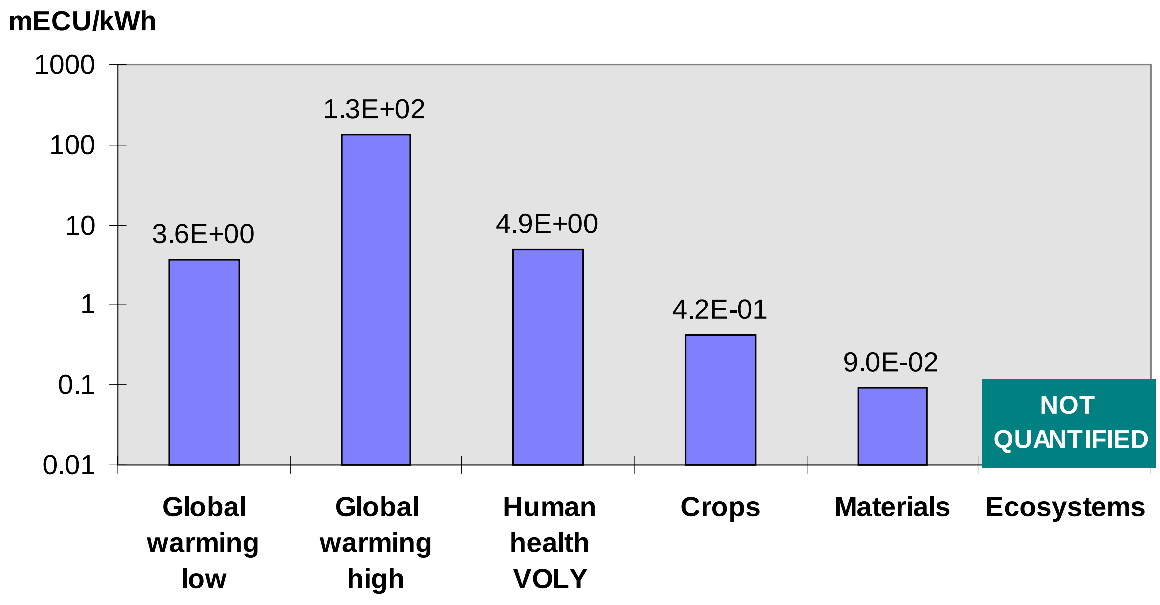

Figure 19. **Total damages of peat fuel cycle by impact category.**

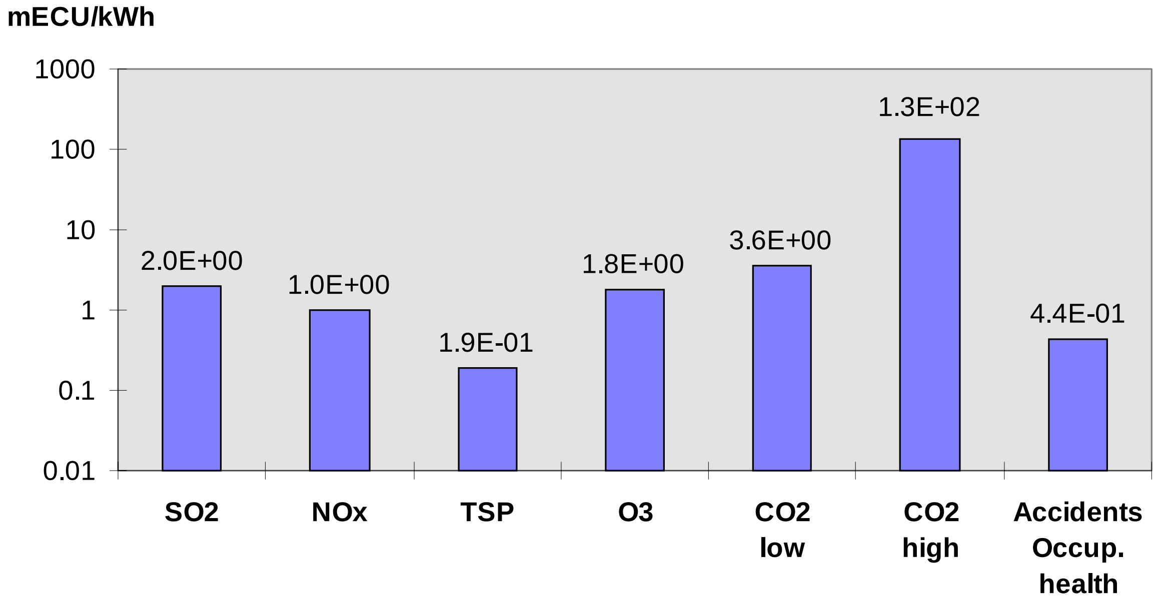

Figure 20. **Total damages of peat fuel cycle by burden category**.

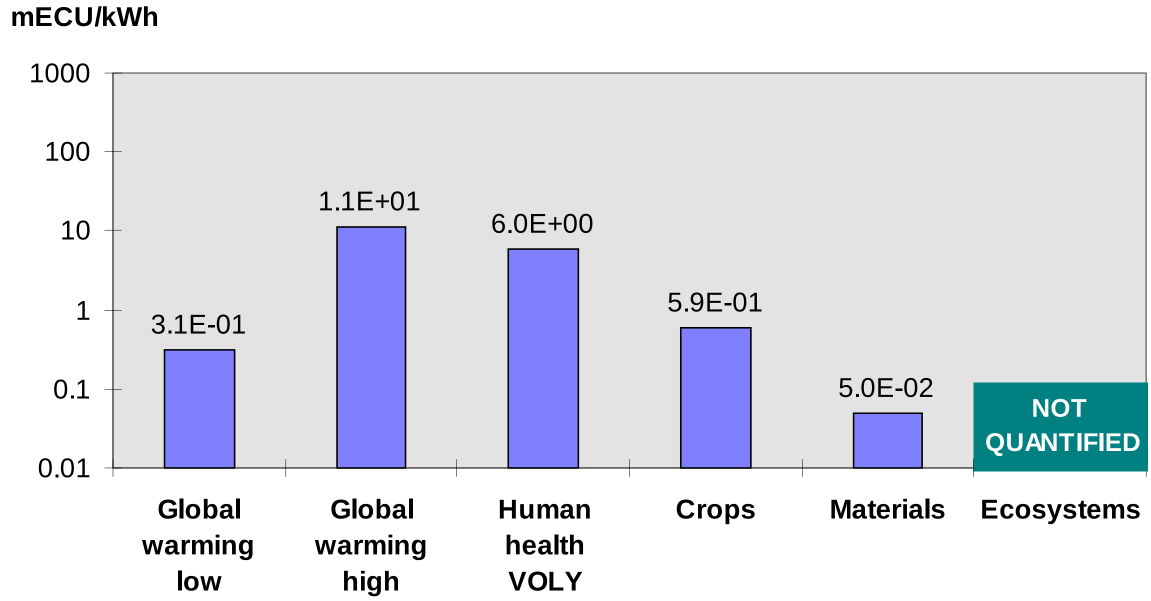

Figure 21. **Total damages of biomass fuel cycle by impact category.**

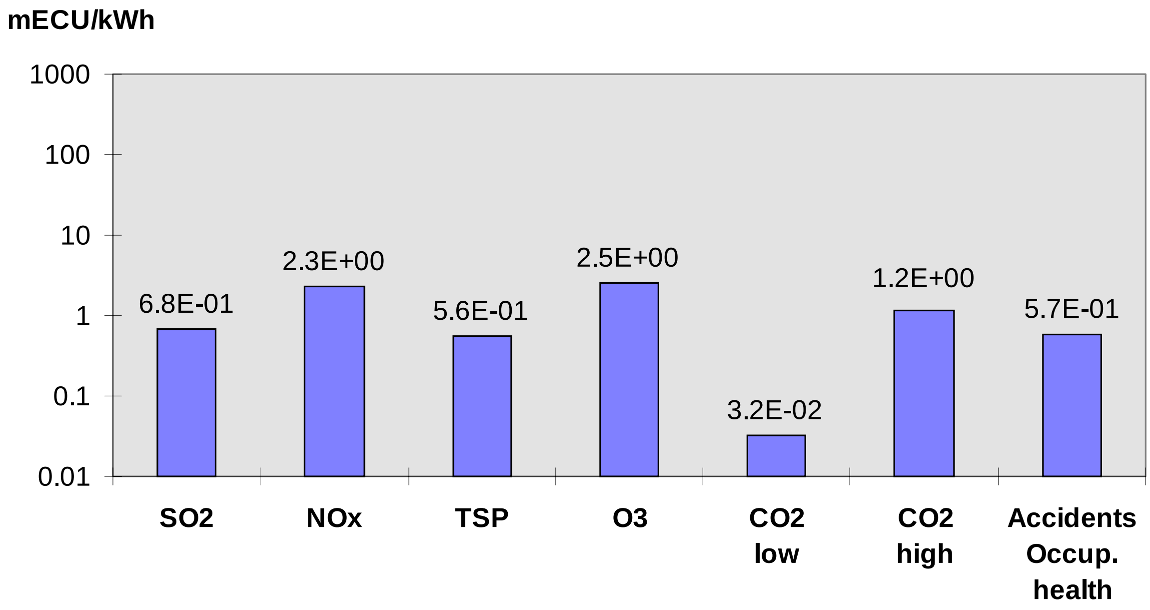

Figure 22. **Total damages of biomass fuel cycle by burden category.**

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Life Cycle Costs of Some Biomass Fuels

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INTRODUCTION

Various biomass sources are used for fuels like wood, fibres, agricultural residues, dung and manure, starch and sugars, vegetable oils and fats, organic waste. About USD 90 billion per year is spent on biomass fuels. Biomass provides about 15% of the total world energy supplies. It is a cheap fuel source. Therefore, more than 50% of the world population depends on biomass fuel while in many developing countries above 80% of the population. Biomass is the fuel source of poor.

So far, biomass fuel has a limited importance in developed countries. Recently, some developed countries have focused the attention on this source. This attention is mainly motivated by the environmental aim to reduce CO2 emissions. The growing biomass stores CO2. Due to the CO2 storage by biomass growth, this energy source is often perceived as a major source of "environmentally friendly" energy.

Much effort is put into production of biomass and processing like pyrolysis of wood, palletization of fibres, anaerobe digestion of manure, distillation and liquedification of sugars, extraction of rapeseed, gasification of waste. The efforts are supported by policies. For example, the Scandinavian countries develop wood combustion by gasification, the United States of America exempt ethanol enhancers for fuels based on sugars, France and Italy introduce tax exemption for the fuels based on sugar and vegetable oils. Also, Austria and Germany promote the "vegetarian", rapeseed oil based methyl-esters (RME) for cars.

Currently, the competitive position of biomass fuel is not promising. First of all, the main biomass products, like foods, pulp and furniture (above 90% of the total biomass market), provide much higher value than fuel. Thus, the growth of biomass for fuel is economically not attractive for farmers. Secondly, the costs of production and processing biomass to fuel are still far above the current world oil prices. The most productive systems for local biomass fuels cost about USD 20-25 per barrel oil equivalent. Thirdly, biomass production needs much space which is scarce and expensive in many developed countries while the highly productive agriculture needs much agro-chemicals [Krozer 1987].

If to foster the biomass production on environmental grounds then the questions arises: what preconditions are needed for sustainable biomass fuel ? This paper focuses on three case studies: (1) the rapeseed oil methyl-ester and diesel for cars, (2) two processing options for biomass waste (gasification with aerobe composting), (3) briquettes of old palms for local fuels. The life cycle costs are assessed to review the (dis)advantages.

CASE STUDIES OF LIFE CYCLE COSTING

Diesel and RME

The first case study addresses the substitution of diesel by vegetable oil crop in temperate climate. Rapeseed is cropped to produce the rapeseed oil for technical and food purposes. The rapeseed oil is esterified into methyl-ester. The rapeseed methyl-ester (RME) can directly be used in diesel engines. The steps in the life cycles of diesel and RME production are: (a) winning and transport of mineral oils for diesel and growing of rapeseed for RME, (b) refining for diesel and extraction with esterification for RME (c) use of the fuel.

The first note is that the basic data of life cycle analyses are discouraging. Three diesel analyses are compared with help of life cycle assessments (LCA) of ETH handbook on fuels and energy, Tellus on packaging and WTLO LCA on diesel and RME. Per ton of diesel, the energy data vary between 2.94 and 3.9 GJ, the water use data between 0 and 4 m3, the waste data between 2 and 128 kg. The studies show various inputs and emissions. Totally, 169 names of compounds are found. There is an agreement between the studies on names of 6 compounds, disagreement on 117 names. The impact can only be assessed for 35 compounds.

Similar holds for RME data. The inputs and outputs in three studies are compared (NRLO 1990, WTLO 1994, TME 1996). There are large differences with respect to yield of rapeseed, the needs of agricultural chemicals and inputs for processing to rapeseed oil and methylester. Appendix 1 summarizes the data. The energy balance of RME production depends on the assumptions about input of fertilizers and use of the agroresidues of rapeseed. The data on input of fuels vary between 8.5 and 31.7 GJ per tonne of RME. The output of byproducts vary between 15.1 - 19.1 GJ per tonne of RME. Table 1 show the energy data of five studies. Unfortunately, the reliability of data is low. Therefore, the life cycle cost assessment can only be indicative.

Table 1 Data on energy equivalents of selected studies in GJ/tonne RME

	Farming and inputs	Rape oil		RME	
		Use	Out	Use	Out
WLTO '94	4.82	6.1		0.74	
UBA '93	18.9	6.9	-9.3	5.9	-9.8
EC '95	13.6	0.3	-11.1	0.5	-6.8
NRLO '90	18.7	2.2	-15.1		
CE '93	12.8			5.3	-4.2
TME '95	7.78	2.6		0.52	

Out: feedstuff and glycerine, excl. energy content of RME (between 30.4 to 37.2 GJ/t)

The costs of diesel and RME production are assessed for transport in the Netherlands. Some 3.4 mln tonne diesel is used while hardly any RME. The production cost of diesel is about Dfl. 330 per tonne compared to about Dfl. 900 to 1100,- per tonne of RME. In addition to the diesel costs, there is a tax of some Dfl. 790 per tonne of use. The social cost of diesel substitution for transport by RME is some 27 000 km2 of cropping land (about 55% of total area in the Netherlands) and the loss of about USD 1.1 billion of taxes per year. Some specific applications of RME (e.g. in agricultural tractors) could be interesting. But, a large scale substitution of diesel by RME needs very strong arguments.

One can argue that RME provides environmental benefits. Thus, if stringent environmental standards are equally put on diesel and RME then the cost of compliance can favour RME. To assess the costs of diesel and RME under stringent regulations, the cost of emission reduction at production and use of the fuels are estimated for the average car mileage of 253 000 km. These costs of controls are added to the current cost of production and use. Table 2 shows the results: the user's and pollution control costs of RME and diesel for a life time of a personal car. All basic data are in Appendix 2.

Table 2 User's and pollution control costs of diesel and RME

	At Production	At Use
Diesel (13.6 tonne in life cycle)		
fuel costs	4485	21745
control costs	2365 (Dfl. 174,- per tonne)	13125
total	6850	34870
RME (use of 14.1 tonne in life cycle)		
fuel costs	29548	32503
control costs	1951 (Dfl. 138,- per tonne)	4959
total	31499	37461
benefits of CO2 intake		-23633
RME with CO2 benefits		13829
Potential benefit RME		21041

At production, the pollution control costs for diesel are slightly higher than for RME. But, less diesel is needed during the use phase. Therefore, the total control costs of diesel and RME are very close to each other. In the use phase, the cost of RME approximates diesel mainly because of lower pollution control costs but RME remains more expensive.

The substitution of diesel by RME provides nett benefits only in case of substantial payments to reduce CO2. If the CO2 intake by RME is included in the accounts, say by a price of USD 12,- per tonne of CO2 then RME becomes economic because of lower control costs. A payment to farmers per unit stored CO2 is the only feasible policy option to provide cheap rapeseed oil (or extra tax on diesel). In all other cases, one should expect social and economic losses of the policies to foster RME. The environmental arguments are rather doubtful because of more intensive cropping with risks of even more agrochemicals use and large additional capture of land.

Options for Waste Processing

The second case study shows that more efforts into processing technologies hardly contribute to lower costs. This is illustrated by assessment of two waste processing options for household organic waste. Waste processing is primarily purposed to reduce waste volume for landfilling. Recently, more attention is given to energy production at the processing plants.

The life cycle costs of gasification and aerobe composting are assessed, based on literature (anaerobe composting is not included because it is more expensive than the aerobe). The main steps in the chain are waste collection, distribution, processing and electricity production. Table 3 summarizes the basic data on materials and energy flows. Appendix 3 specifies some basic data on inputs and outputs.

Table 3 Household organic waste: results on mass and energy flows for a unit of 100 000 wet tonne per annum				
Household organic waste	Energy value GJ/t 16.25			
Energy balance	Gasification		Aerobe compost (*)	
Steps in the chain	mass (t)	energy (GJ)	Mass (t)	energy (GJ)
curbside collection	2.50	-0.35	2.50	-0.35
drying, grinding, sieving	2.50	-0.37	2.50	-0.05
pre-processing	1.15	-0.05	2.44	-0.17
Processing	0.91	0.00	1.21	-0.05
other (transport, cleansing)	0.06	-0.01	1.15	-0.79
Output biomass for fuel	0.06	5.78	0.66	4.79
Effectiveness	98%	31%	54%	21%
* average ash content 43%, assumed energy output 45% of energy value				

The reduction of mass is substantial in case of gasification. Some 31% of the energy value of wet organic waste can (theoretically) be recovered which is higher than the current recovery of at incineration plants (on average 22% of the energy content of household waste). In case of aerobe composting there is less volume reduction because compost is purposed for sales but, also, the energetic contribution is limited. If compost is used for fuel then some 21% of energy is recovered. Thus, in terms of the total waste processing system one should go either for compost or for energy. It should be noted that the total energy contribution of the actual Dutch curbside collection of household organic waste with gasification is below 0.01% of the current Dutch supplies of energy carriers to the electric power plants. If to use all organic waste, e.g. including swill, industrial organic waste and manure, then this contribution can approach 0.5% of the total supplies. Organic waste is not a major energy saving option.

An argument in favour of the waste processing can be that the proceeds of electricity can favour any specific waste processing system. To test this argument, the costs of the waste processing are estimated, including the costs under stringent environmental regulation. Table 4 summarizes the results. Appendix 4 specifies some basic data

Table 4 Household organic waste: costs for a unit of 100 000 wet tonne per annum				
	Gasification		Aerobe compost (*)	
	total mln	USD/tonne	total mln	USD/tonne
curbside collection	7.8	78	7.8	78
transport	0.4	4	0.4	4
Investments	27.0		21.4	
Capital costs	3.6		2.4	
Labour	0.8		0.4	
Other	1.3		1.5	
Total transport costs	8.2	82	8.2	82
Total processing costs	5.7	57	4.3	43
Total Costs	13.9	139	12.6	126
Revenues	2.7	27		
Pollution control costs (*)	2	18	1	7
Nett costs	13	130	13	132

(*) including substraction due to lower electricity use

The results of cost assessments show that the main cost factor is the curbside collection and transport of waste. In both waste processing technologies, the cost of the reversed logistics is around 60-65% of the total costs. Note that the collection of waste is almost independent of any specific processing system. The second issue is the low contribution of energy sales in the total costs. These revenues are similar to any additional environmental regulations like tougher disposal and traffic standards.

The previous notes do not mean that energy winning is useless but one should keep in mind that the optimization of the processing can contradict the logistics. The sensitivity accounts for a three times larger unit indicate that the processing costs decrease while the logistic costs increase. In effect, the nett environmental-economic benefit are low or unfavourable.

Old Palm Processing

The third case study addresses intensive production of biomass on palm plantations. It is purposed to indicate that biomass production for fuel can be economic but environmentally sound but, also, much restricted by the local market.

Palms are cropped in the tropical countries to obtain fruit with palm oil. After 20-25 years of growth, the palms are to high for harvesting fruits. The trees are usually poisoned to prevent pests. Palm leaves are already used for fuel. Also, the mature trunks can be processed into fuel for local purposes, thereby reducing the pressure for fuelwood. The life cycle of palms for fuel covers agricultural inputs, cropping and harvesting, palletization and combustion of palm trunks.

The mass and energy flows as well as the costs and proceeds are summarized in table 5.

Table 5.a. Gains and losses in the palm oil, incl. Production of chemicals			
per ha/annum	Output (gains)	Loss (cost) in chain	Result in chain
Dry biomass, tonne	10	0	10
Energy, GJ	155	37	117
Greenhouse, CO2 tonne equivalent	30	10	21
USD, at low market price	1440	776	664
Water use, tonne	759	2500	-1741
COD emission, kg	0	673	-673

Table 5.b. Possible contribution of palm oil to sustainable development			
	Current world	Extra needs	Total effect
Area, mln ha	5	7	12
Dry biomass mln tonne	50	70	120
Energy equivalent (TJ)	587	822	1409
Nett mln tonne GWP 50	103	144	247
Benefits mln (USD) (*)	3321	3720	7041
Water misuse mln m3	8703	12185	20888
Abatement mln t COD	3364	4710	8074
(*) extra needs at 20% lower market prices			

The intensive oilpalm plantation produced about 80 tonne biomass per hectare, roughly 10-14 tonne dry biomass. After subtracting the emissions of CO2 equivalents in the life cycle, this biomass stores some 30 tonne CO2 equivalent per hectare of land *and* it provides much nett gain because of oil production. High water consumption and COD emissions can be solved by technological improvements.

If the biomass is used then, on the world scale, almost 250 mln tonne CO2 can be stored, after subtracting CO2 emissions in the life cycle. In addition, some USD 7 billion nett gains can be attained by sales of oil without getting into CO2 trading. These possibilities appeal to be exemplary for the so called "win-win" policy albeit the issues of land capture, water use and abatement of biodegrables must be solved.

However, at present, the fuel from palm trees is hardly utilized but only as the most inferior fuel. In many developing countries, this fuel source must compete with the other local source of energy, mainly fuelwood, charcoal and kerosine. Beneath, in Table 6, the costs of palm briquettes are estimated and compared with the main competitors.

Table 6 Briquettes of old palm (USD/ha), based on 9 tonne briquettes per ha per year	
Energy equivalent GJ/tonne	18
Cost of sawing	353
Cost of transport	213
Cost of mechanic press	13
Cost of palletizing	60
Costs of distribution	66
Overheads (25% of costs)	88
Total costs, excl. sawing	439
Costs USD/GJ briquette	2.7
Ghana sales USD/GJ (household fuels)	
Wood & charcoal (87% share)	1.5
Kerosine (3% share)	4
Electricity (10% share)	69

The main cost factor in the chain of palm for fuel is the cost of transport of trunks on plantations. This constitutes some 50% of the total costs. Thus, one can search for a better briquette technology (as it is often done) but, this does not provide enough cost saving.

The main bottleneck is on the market side because of the availability of cheaper biomass mainly fuelwood and charcoal. In case of Ghana, that is a small producer of palmoil, the share of fuelwood and charcoal is about 87% of total household fuels. The price of biomass is (still) much below the cost of palm briquette. Palm briquette could compete with kerosine and electricity but these energy sources are used mainly by the population in the cities. If to sale briquettes in cities, one has to cover additional distribution costs. In effect, the costs of briquette approximate the price of kerosine.

The only option to foster energetic use of old palm trunks is by policies that drastically restrict the use of fuelwood or charges on kerosine. The effect of these policies is an increase of the local prices for wood, charcoal or kerosine. However, severe social tensions should be expected because of this policy affect severely the poorest parts of population.

CONCLUSIONS

All three case studies of life cycle costing show that economic alone, including stringent environmental regulations, does not provide enough incentives to foster large scale use of biomass fuels. Some local use of biomass residues for fuel (e.g. wood chips) is economic due to abundant cheap raw material. However, the transport and processing for fuel markets depress the competitive position of biomass in comparison with the non-renewable fuels. The biomass fuels become economic if the politics put a price on CO_2 emissions (even as low as USD 10-15 per tonne CO_2 equivalent) and restrict the mining of forests in favour of forestry farming.

The advocates of biomass fuel argue that policies should foster this development. The agricultural policy can protect farmers' income by subsidizing fuel production based on unit of CO_2 storage. The waste policies can support waste processing technologies for energetic purposes, arguing that the technologies contribute to energy supplies and CO_2 prevention. The forestry policies can restrict fuelwood use on the argument of habitat protection. The opponents of these policies can argue, based on the life cycle costs, that biomass fuel is too much dependent upon the local politics to become a sustainable options in the near future.

The contribution of sound life cycle costing is that the political arguments and interests can be separated from the environmental-economic arguments. The life cycle costing is helpful to consider the social costs (RME case), sound priorities for in the chain (waste case) and local markets (palm case).

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APPENDIX 1 LCA DATA ON DIESEL AND RME

Tables 1 Emission data on diesel production of ETH-Zurich, Tellus-Boston, IMSA-Amsterdam

Specific compounds	Air	Water	Waste
Total quantity	42	123	4
found in 2	4	41	1
found in all	3	3	0
Non agreement	35	79	3

Data on Rapeseed methylester (RME) of two Dutch studies: units kg/tonne RME

	NRLO	WTLO	TME
Agricultural step			
Yield kg/ha	3500	3700	2780
Nitrates	142	120	99
Phosphates	32		42
Other fertilizers			126
Pesticides	1	3.23	11.2
Processing to RME			
Rape seed	2757	2545	2500
Hexane		10	3.9
Others		124	138
Waste water		425	

IMSA/NRLO: Dutch agricultural situation

TME: CETIOM large scale agriculture

APPENDIX 2 EMISSIONS AND CONTROL COSTS.

Table Pollution control costs **production** of RME and diesel excl. supplies of inputs

All per tonne fuel	Emission kg/t	Reduce	Cost fl./kg	Total fl.
Pollution control costs in RME chain				
N (water)	9.9	50%	4.2	21
P205 (water)	12.7	80%	6.1	62
Pesticides (water)	0.2	90%	4.2	1
Pesticides (air)	2.2	18%	4.2	2
Hexane	3.9	70%	10.3	28
CO2	164.0	60%	0.2	23
SO2	0.7	64%	1.9	1
Nox	0.3	90%	4.2	1
Pollution control costs Diesel				
CH4 (air)	2.2	84%	0.04	0
CO2 (air)	312.0	61%	0.06	12
Nox (air)	0.03	58%	20	0
SO2 (air)	0.5	80%	2.6	1
VOC (air)	7.2	89%	8.4	54
Various to water	12.3	95%	8.5	99
Chemical waste	0.4	100%	0.9	0
Industrial waste	17.8	100%	0.4	6

Table Emission and pollution control cost **in use** of a car (life time above 253 000 km)				
	Emission g/km	Reduce	control fl/kg	Life time fl.
Diesel				
VOC	0.00031	75%	5.54	325
Nox	0.00084	50%	20.87	2213
CO	0.00140	0%		0
particles	0.00038	65%	0.00	0
SO2	0.00024	95%	3.61	208
CO2	0.20100	49%	0.40	10109
VOC tank	0.00006	95%	18.62	250
Total diesel (user phase)				13105
RME				
VOC	0.00028	0%	0.000	0.00
Nox	0.00109	50%	16.43	2265
CO	0.00126	0%	0.00	0
Particles	0.00018	0%	0.00	0
SO2	0.00000	0%	0.00	0
CO2	0.19497	49%	0.11	2615
VOC tank	0	0%	0.00	0
Total RME (user phase)				4879

APPENDIX 3 DATA ON ENERGY AND MASS OF WASTE PROCESSING

Gasification of GFT waste per 1000 kg dry matter, external energy inputs only							
Step	Input	Quantity	Unit	Output	Quantity	Unit	Remarks
curbside collection	GFT-waste	2500	kg	GFT-waste	2500	kg	
	Biomass	16.3	GJ				of GFT waste
	Transport	0.4	GJ				
drying and grinding	GFT-waste	2500	kg	GFT	1150	kg	15% water remains
	Electricity	0.4	GJ	Water	1350	kg	Use of process gas
process	GFT-waste	1150	kg	Ash disposal	240	kg	Temp. 850 C
	Electricity	0.00	GJ	Steam	910	kg	
	Transport ash	0.1	GJ				
gasturbine	Steam	910	kg	Electricity *	5.78	GJ	10.48
	Electricity	0.00	GJ	Gas	11	m3	
ventgas cleansing	Particles	60	kg	Filter	60	kg	
	Transport filter	0.0	GJ				
Energy efficiency:	Input	16.25	GJ				
	Output	5.78	GJ				
	External energy *	0.78	GJ				
	Nett efficiency	5.00	GJ				
	effectiveness	30.76%					

Aerobic composting of GFT waste per 1000 kg dry matter, external inputs only

Step	Input	Quantity	Unit	Output	Quantity	Unit
curbside collection	GFT-waste	2500	Kg	GFT-waste	2500	kg
	Transport	0.4	GJ			
sieves	GFT-waste	2500	Kg	GFT-waste	2438	kg
	Electricity	0.05	GJ	Residues	63	kg
process	GFT-waste	2438	Kg	Compost	1213	kg
	Electricity	0.17	GJ	Percolate wat. (*)	1225	kg
sieves and grinding	Compost	1213	Kg	Compost	1150	kg
	Electricity	0.05	GJ	Residues	63	kg
compost sales	Compost	1150	Kg	Compost sold	1150	kg
	Transport	0.79	GJ			
Efficiency:	GFT waste	2500				
	Compost	1150				
	%	46%				
	GJ total	0.79				

APPENDIX 4 DATA ON COSTS OF WASTE PROCESSING

Costs of gasification GFT waste, capacity 109500 tonne/year											
User costs dfl. mln	Investment	Capital costs	Operational costs				Total costs	Revenues	Nett costs	User Costs	
			Labour	Maintenance	Others					Dfl./t wet	Dfl./t dry
curbside collection										142.5	356.3
transport GFT waste										7.3	18.4
drying and grinding	3.8	0.5	0.1	0.1			0.7		0.7	6.5	16.2
proces	33.4	4.4	1.0	0.9			6.3	3.1	3.2	29.4	73.6
gasturbine	11.9	1.6	0.4	0.3			2.2	1.8	0.4	3.9	9.7
ventgas cleansing											
total gasification	49.2	6.5	1.5	1.3	0.0		9.3	4.9	4.4	39.8	99.5
total costs	49.2	6.5	1.5	1.3	0.0		9.3	4.9	4.4	189.7	474.1

Environmental costs of gasification of GFT waste, capacity 109500 tonne											
	1995				2000					User & environ.costs	
dfl./tonne dry material	Air	Water	Disposal	Total	Air	Water	Disposal	Total		Dfl./t dry matter	
										1995	2000
curbside collection										356	356
transport GFT waste	0.8			0.8	0.9			0.9		19	19
drying and grinding	2.3	0.0	1.6	3.8	3.5	0.0	1.6	5.1		20	21

proces	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		74	74
gasturbine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		10	10
ventgas cleansing	7.8		48.0	55.8	7.8		69.0	76.8		56	77
total gasification	10.1	0.0	49.6	59.6	11.3	0.0	70.6	81.9		159	181
total environmental costs	10.9	0.0	49.6	60.4	12.1	0.0	70.6	82.7		535	557
total environmental revenues	-35.8	0.0	-24.4	-60.3	-54.4	0.0	-25.1	-79.4		-60	-79
net environmental costs	-25.0	0.0	25.1	0.2	-42.3	0.0	45.5	3.3		474.3	477.4

Costs of aerobic composting of GFT waste, 109500 tonne capacity

User costs	Investment	Capital costs	Operational costs				Total costs	Revenues	Nett costs	User Costs	
dfl. mln			Labour	Maintenance	Others					Dfl./t wet	Dfl./t dry
curbside collection										143	356
transport GFT waste										7	18
sieves	8	1	0.1	0.1	0.1		1		1	10	26
proces	23	3	0.4	0.4	0.6		4		4	39	97
sieves and grinding	8	1	0.1	0.1	0.1		1		1	12	30
compost sales					1		1		1	11	28
total composting	39	4	1	1	2		8		8	72	181
total composting/collec.	39	4	1	1	2		8		8	222	555

Environmental costs of composting, capacity 109.500 tonne

	Air	Water	Disposal	Total	Air	Water	Disposal	Total		User & Environ.costs	
dfl./tonne dry GFT waste										Dfl./t dry matter	Dfl./t dry
										1995	2000
curbside collection										356	356
transport GFT waste	0.8			0.8	0.9			0.9		19	19
sieves	0.3	0.0	3.3	3.6	0.5	0.0	3.3	3.8		29	30
proces	1.1	2.5	7.0	10.5	1.6	5.0	13.2	19.8		107	117
sieves and grinding	0.3	0.0	3.3	3.6	0.5	0.0	3.3	3.8		34	34
compost sales, excl. heavy metals	1.8			1.8	1.9			1.9		30	30
total composting	3.5	2.5	13.6	19.7	4.5	5.0	19.9	29.4		200	210
total composting/collec.	4.3	2.5	13.6	20.5	5.3	5.0	19.9	30.3		576	585

APPENDIX 5 DATA ON THE GREENHOUSE EFFECT OF PALM PLANTATIONS

Greenhouse from palm oil plantation (20 years life time)					
Out			In		
Palms trees	140	tree/ha	P Fertilizers	8	kg/ha/a
Weight adult tree	0.6	tonne	Mass P (chain)	16	kg/ha/a
Moist tree	80%		N Fertilizers	112	kg/ha/a
Moist fruit	60%		Mass N (chain)	187	kg/ha/a
Total biomass	84	tonne/ha	Total fertilizers	120	kg/ha/a
Dry biomass tree (1)	8	t/ha/a	Pesticides	3	kg/ha/a
Biomass fruit	5	t/ha/a	Mass pest. (chain)	5.6	kg/ha/a
Biomass oil	3	t/ha/a	Total mass	0.21	t/ha/a
Total dry biomass residue	10	t/ha/a	Mass water used	2500	t/ha/a
Mass water (in tree)	759	t/ha/a	Energy eq. chain	7.92	GJ/ha/a
Use of biomass (2)	155	GJ/ha/a	CO2 equiv.(4)	5.89	t/ha/a
Total Carbon (3)	9	t/ha/a	CH4 effluent (5)	0.49	t/ha/a
CO2 eq.	30	t/ha/a	CO2 effluent	0.38	t/ha/a
			CO2 eq. effl.	3.80	t/ha/a
			Fuel use on site	29	GJ/ha/a

Externalities Assessment - From Theory to Practice: Road Traffic Emissions

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INTRODUCTION

Several road traffic costs, such as road construction or arrangement of traffic control, are rather easy to express in money. However, road traffic also includes such costs which the market mechanisms take into account only partly or not at all; for example, traffic noise or environmental pollution.

The Ministry of Transport and Communications in Finland made a decision in September 1994 that environmental costs should be assessed when planning new transport networks. The Finnish National Road Administration (Finnra) has already since 1992 taken into account the impacts of road traffic emissions and noise and their costs in the socio-economic calculations of road projects. By date all Nordic road planning authorities have developed pricing methods for exhaust gases and noise.

EXTERNAL COSTS ASSESSMENT - FROM THEORY TO PRACTICE

Environmental economics including monetary valuation of environmental impacts is the focus of vigorous research both within and outside Europe. In the United States the legislation in some cases requires monetary valuation of environmental impacts as part of the cost-benefit analysis of regulations and large-scale projects and to assess the value of environmental damage caused by accidents.

International agencies, e.g. the Asian Development Bank and the Inter-American Development Bank, have prepared or are preparing guidelines for the valuation of environmental impacts of projects considered for funding in the project appraisal stage.

In Europe, policy analysts are being required to take account of environmental aspects in their decision making and to undertake cost-benefit analysis of viable options. The fifth Environmental Action Programme "Towards Sustainability" of the EU clearly indicates the need for the assessment of externalities and monetary valuation. The Communication from the Commission to the Council of the European Parliament entitled "Directions for the EU on Environmental Indicators and Green National Accounting - The Integration on Environmental and Economic Information Systems" (COM(94)670 21.12.1994) also states a specific action for improving the methodology and enlarging the scope of monetary valuation of environmental damage. Further, the European Commission's White Paper entitled "For a European Union Energy Policy", states that the internalisation of external costs is central to energy and environmental policy. In the Green Paper "Towards fair and efficient pricing in transport" (COM(95)691), the Commission argues, that fair and efficient pricing should constitute an essential component of a transport policy strategy and that it can contribute significantly to reducing some of the main transport problems.

The most significant research projects on the assessment of external effects of energy fuel cycles are the separate and joint research projects initiated by the DG XII of the European Commission (1995 a) - f)) and the US Department of Energy (US/DOE 1992 and 1994 a) - e)). In Europe the project is named "ExternE". The objective was to develop a consistent "bottom-up" methodology to evaluate the external costs associated with a range of fuel cycles. Follow-on projects of the ExternE are, among others, a series of national programmes to implement the methodology for reference sites throughout Europe, and the extension of the methodology to address the evaluation of externalities associated with transports. Ekono Energy Ltd participates in these projects and has carried out a number of national studies in the field (e.g. Otterström et al. 1994 a, 1994 b, 1995, 1996).

METHODOLOGICAL ISSUES

There are many approaches to assess environmental costs. One method is to assume that there is a balance between environmental costs and the costs of abating harmful emissions so that the funds used for controlling emissions are equivalent to the environmental costs avoided. However, these costs are equally high only at one equilibrium point, the finding of which is questionable without knowing the magnitude of the effects. Another method is to assume that funds used for repairing environmental hazards afterwards would represent the environmental costs incurred. Repairing and compensating the environmental effects is problematic, and the money used for corrective measures usually represents only partly the real harm. This is due, for example, to the fact that not all effects already arisen can be remedied. A third approach is to seek to estimate the actual costs of the environmental damage, as has been done in the recent Finnra study under review.

In damage valuation it is not necessary that the same technique (Contingent Valuation Method, Conjoint Analysis, Delphi technics, Hedonic Pricing Method, Household Production Functions, Travel Cost Method, etc) is applied to all impact categories. What is essential in damage valuation is the attempt to capture as fully as possible the total economic value of the damage in question, e.g.:

- Crop losses, if moderate, can be valued using market prices for crops, which in many cases can be assumed to capture the total economic value of the damage reasonably well.
- Health impacts can only partly be valued using market prices for medical expenditure and health care, while some components of the total economic value are clearly subjective and the corresponding damage not abatable by medicination (inconvenience, remaining suffering and pain etc). The contingent valuation method can be used for capturing such components of the total economic value.
- The market value of dwellings varies by location and indicates preferences for a set of characteristics of the dwellings (among which ambient noise level is one). Hedonic pricing can therefore be used for assessing the total value of noise damage based on the perception of purchasers in the market.

CASE: ROAD TRAFFIC EMISSIONS

Development in Finland

The Finnish National Road Administration made the first study of the impacts of road traffic emissions and noise and their costs already in 1992 (Finnra 1992 a, Finnra 1992 b). On the basis of these studies these costs were taken into account in the socio-economic calculations of road projects.

When the 1992 study (Finnra 1992 a) was prepared, only a few or no appropriate research results were available about the effects of road traffic emissions and noise. Since then the research and knowhow have increased markedly both in Finland and abroad. Finnra asked Ekono Energy Ltd to make a study with the aim of updating the previously used methods and values in the pricing procedure.

The study now completed (Finnra 1997 a, Finnra 1997 b) will be used to check the pricing principles and unit prices of the damage caused by road traffic emissions and noise for the socio-economic calculations in road projects. Besides for the use of cost/benefit calculations, the study also provides additional information for discussion about the external costs of different forms of traffic.

Valuation Procedure Followed in the FINNRA 1997 Study

The valuation method used by Ekono Energy in the study for Finnra is described phase by phase in the following:

1. Finland was divided into the urban area and the rural area. The effects studied in the rural area are forest and cultivated plant damages, and the effects in the urban area are materials damages and health effects. Of global effects, the study has concentrated on climate change caused by greenhouse gases.
2. Emissions from road traffic and the concentrations and depositions of the relevant emission components were examined. Thus, the goal was to clarify what quantity of the concentration road traffic causes per each emission component in population centres and correspondingly how big depositions traffic causes in the rural area.
3. Effects caused by emissions were surveyed. The aim was to find exposure-response functions, which show the damage by means of concentrations (or depositions) (for example, how many emergency room visits are caused per 100,000 people when the particle concentration rises by one microgram in cubic metre)
4. The purpose is to express the value of damages in money. As noted above, the valuation can be based either directly on market prices (for example, forest growth losses are valued on the basis of timber prices) or on the WTP people otherwise have expressed (for example, by means of a questionnaire survey asking "How much would you be ready to pay for to reduce respiratory infection risk by x%, which would mean an average of y colds less a year?). Climate change has been valued by applying two different approach methods; the extent of the damage and on the other hand, economic control instruments needed for halting the growth in emissions.
5. The combined damages are used to calculate damage values per a litre of fuel and a kilometre driven. Since in population centres the calculation concentrated on the

damage to people and materials and in the countryside ecological effects were examined, the resulting unit damage values deviate from each other.

6. Noise damages have been assessed using the Hedonic Pricing Method, so that the fall in property values has been examined as a function of the noise level.

Results; Environmental Cost of Fuel Related Emissions

Damage in Finland

The following two diagrams summarize the environmental costs estimated in the Finnra 1997 study. Besides "the best estimates", the diagrams also show the estimated ranges. It should be noted that some potentially significant values are not included in the estimates. Such are effects on the aquatic environment, culture historical values of buildings and monuments and values of biological diversity associated with forests, and landscape and recreational values.

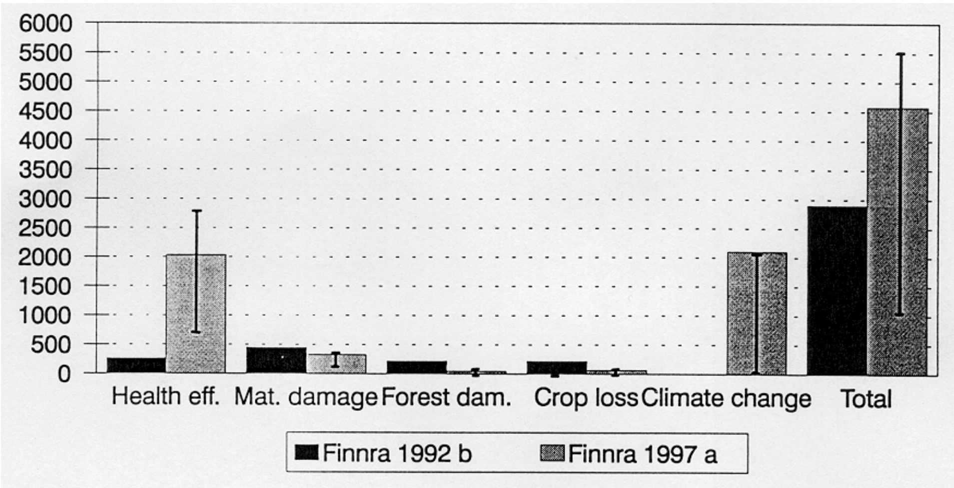

Figure 1. Results (million FIM annually, ECU 1 = FIM 5.7) of the previous study (Finnra 1992 b) and this study by effects. Vertical segments show the estimated range.

In addition to the above estimates made in 1992 (Finnra 1992 b), the working group set by the Finnish National Road Administration estimated the discomfort value of exhaust gases to be about FIM 300 million/a, and using economic control instruments climate change was valued at FIM 1500 million/a (Finnra 1992 a). Discomfort was divided equally among nitrogen oxides, hydrocarbons and particles (in addition to the values shown in Figure 2).

New estimates differ from the previous ones in particular with regard to health effects, for which the new estimates were notably higher, and with regard to ecological effects, for which the new estimates were lower. The estimates of climate change are based on the application of economic control instruments, but the new estimate also includes methane and nitrous oxide emissions (in addition to carbon dioxide emissions).

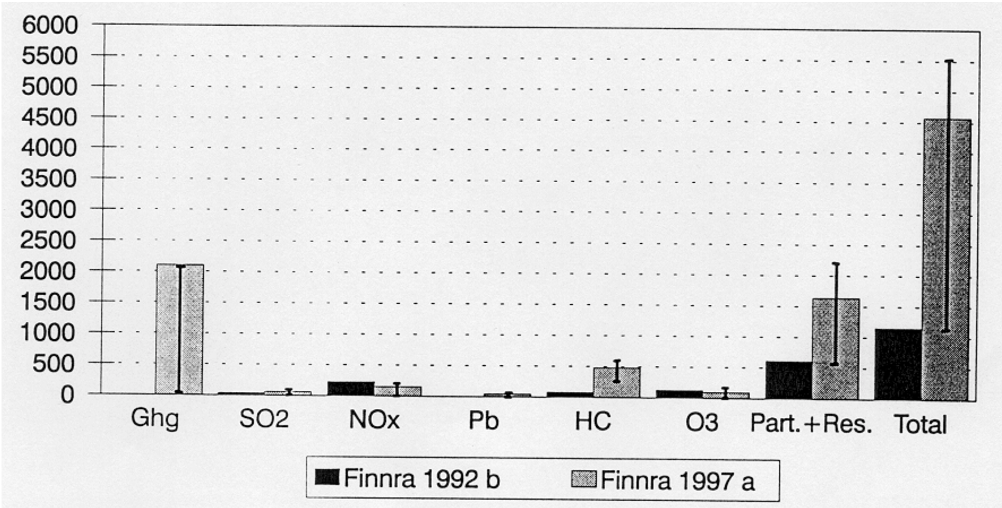

Figure 2. Results (million FIM annually, ECU 1 = FIM 5.7) of the previous study (Finnra 1992 b) and this study by emission components (greenhouse gases, sulphur dioxide, nitrogen oxides, lead, hydrocarbons, ozone and particles incl. resuspension).

Among emission components, particles and emission-based particles dominate and the new estimated figures are considerably higher than the previous ones. Hydrocarbons are also estimated to be higher. As regards other components, the differences are smaller.

Damage abroad

The new emission estimates cover the whole fuel chain and not only exhaust gases as the previous estimate. Most of Finnish sulphur dioxide and nitrogen dioxide emissions are carried abroad. This is also the case with road traffic fuel emissions. In addition, indirect emissions emerge when oil is produced and transported and when petrol is refined. To clarify these, the Finnish damage values were used to calculate unit damage values (FIM/kg) for the emission components, which were then applied to the emissions emerged abroad or travelled there.

The direct application abroad of the unit damage values for damage in Finland may overestimate the damage of "exported" emissions, since most of the emissions in Finland affect a large number of people and thus, health effects are emphasized. The emissions from the beginning of the fuel cycle most probably affect a small number of people, primarily those who work in oil fields and are involved in transport of oil. Some of the long-range transported emissions may also fall out into the sea. For this reason, the figure used to estimate the damage abroad caused by sulphur dioxide, nitrogen oxides, hydrocarbons and particles was half of the unit damage value calculated on the basis of the resulting damage in Finland.

The calculation of the damage abroad caused by Finnish road traffic fuel emissions resulted in about FIM 870 million/a. The most marked individual emission component is nitrogen oxides, the damage caused by which was valued at about FIM 714 million/a.

Environmental cost per vehicle kilometer and fuel used

The study has assumed that all emissions emerged in population centres stay there and cause health effects and materials damage and affect climate change. Correspondingly, emissions emerged in the countryside have been assumed to cause effects on climate change and in addition to that, only on forests and cultivated plants (including effects abroad). As a result, we have different unit damage values for city and road driving.

Table 1. Damages caused by different motor vehicles per kilometrage and amount of fuel consumed or km driven (p 1= FIM 0.01, ECU 1 = FIM 5.7).

	Light traffic, no cat.	Light traffic, w/cat.	Heavy traffic, Model -90	Heavy traffic, Model -95
City, p/km	7,3	4,6	83	50
Road, p/km	5,1	3,5	27	21
City, p/l	69	46	198	119
Road, p/l	64	44	64	50

The figures in the above table do not show the damage caused by dust lifted up by road traffic. By dividing this damage by the estimated 1990 kilometrage we arrive at an average damage of 4,9 p/km in population centres. A fairer division would not only be based on kilometres driven, but also on the weight and speed of motor vehicles.

Results; Environmental Cost of Noise

A doctoral dissertation (Vainio 1995) recently published in Finland deals with environmental costs of traffic. The paper applies the Hedonic Price Method (HPM) and the Contingent Valuation Method (CVM) to estimating noise and exhaust gas emissions in Helsinki.

According to the Hedonic Price Method, the price of a dwelling drops by 0.36% (on average FIM 18420) as the noise level rises by 1 dB(A). According to the WTP survey, people's WTP for a fall of one decibel would be FIM 5160/a, which, according to the author is equivalent to FIM 51600 as a lump sum.

The results of the CVM survey are 2-3 times as high as those of the Hedonic Price Method as revealed by Table 2. Possible reasons are many. The differences may be due to the shortcomings in the survey or to the fact that the results produced by the different methods really deviate from each other.

The number of those exposed to traffic noise has been estimated in the study of Finnra completed in 1992. This study divides people into three groups: those exposed to a noise level of (1) 55-65 dB(A), (2) 65-70 dB(A) and (3) over 70 dB(A). A noise level of lower than 55 dB(A) was not assumed to cause any harm.

Table 2. Traffic noise-caused costs in Finland in FIM million/a using the Hedonic Price Method (HPM) and WTP studies (CVM).

	55 - 65 dB	65 - 70 dB	> 70 dB	Total
HPM	2238	872	359	3469
CVM	3858	2189	1189	7236

Total costs are thus about FIM 3.4-7.2 billion a year. Because of the uncertainty factors related to the CVM study, estimates received from the HPM were used in the

Finnra study (Finnra 1997). The value of noise damage was therefore estimated at about FIM 3470 million/a, which is about 0.67% of Finnish GDP in 1990.

Uncertainty factors related to the estimate are, for example, omitting other noise sources, except road and air traffic, and uncertainty about how well noise has been eliminated from the other factors affecting the price of dwellings. In addition, the WTP assessed using the HPM may be based on the noise level at the time of showing the flat rather than on an average noise level. Generalization of the results of the original study to cover the whole country and the application of an average size and price are also sources of error.

Comparison of New Results with Previous Estimates

The results of the assessment is presented in Table 3 for the damage of Finnish road traffic fuel emissions and noise. For comparison, the damage estimates used by the Finnish National Road Administration (for the year 1989) are also given (Finnra 1992 a).

Table 3. Summary of estimated environmental damage caused by road traffic emissions, million Finnish marks (FIM) annually (ECU 1 = FIM 5.7).

Effects	Finnra 1997 (base year 1990)	Finnra 1992 a (base year 1989)
Health effects	2 040	560
Materials effects	330	450
Forest damage	50	220
Crop losses	60	220
Climate change	2 100	1 500
Effects abroad	870	Not estimated
Noise effects	3 470	1 600
Total (rounded)	8 900	4 500

It was not possible to estimate all effects. Ecological effects in population centres (parks, etc.) and health effects in the countryside have been omitted. The values of damage to buildings and constructions of considerable culture historical significance have not been assessed. The effects on biological diversity and possible recreational uses are not included in the estimates. No effects on waterways have been assessed, as they are probably rather minor. Further, the road traffic emissions damaging the ozone layer are also low. Of the health effects, the most marked ones appeared to be morbidity risk caused by particles and cancer risk caused by hydrocarbon compounds. As regards materials damage, the wearing and fouling of construction materials were assessed. The forest damaging effects which were taken into account included acidifying sulphur and nitrogen dioxides and ozone. The ozone concentrations of cultivated plants were analyzed when assessing crop losses. Climatic changes are primarily caused by carbon dioxide, but also nitrous oxide and methane.

The most significant methodological changes between the previous and new values are:

- New estimates are based on the emissions of the whole fuel chain, and not only on exhaust gases and resuspension
- A clear difference has been made between the damages to urban and rural areas, and the results for these areas (FIM/km) differ markedly from each other
- More recent data on health effects due to air pollution has been available, since health issues are the subject of intensive research. As a result, new estimates of health effects are higher than the previous ones.
- New estimates are based on exposure-response functions. As regards health effects (morbidity and mortality risk), they are based on WTP estimates and as regards marketable commodities (roundwood and cultivated plants) on market prices. Greenhouse gas emissions have been valued by means of economic control instruments needed for halting the emission growth.
- The calculation method of the new noise estimate differs markedly from that of the 1992 estimate (Finnra 1992 a), which was based on the assumption that at a noise level of 55-65 dB the proportion of those experiencing disturbing noise was 33%; at a noise level of 65-70 dB 50% and from a level of over 70 dB upward 100% and that the unit price is FIM 5000/person exposed.

Despite rapid advances in valuation of environmental effects, valuation techniques and their areas of application continue to undergo development. Uncertainty is especially associated with some health effects, forest damages and economic consequences resulted from climatic changes. For that reason, results and valuation techniques have to be further revised under new research data.

CONCLUSIONS

The estimates made of external costs are to some extent results of calculation examples. Even though they include many uncertainty factors, they indicate the order of magnitude of damages and what effects and components are potentially the most significant. On the basis of the calculations made, health effects dominate the damages caused by road traffic fuel emissions. Health effects would be in the range of billion Finnish marks (FIM billion/a), whereas forest damages and crop losses would both be lower by a factor of ten (FIM 0.1 billion/a). On the other hand, the effects of "exported" sulphur dioxide and nitrogen oxides are mainly ecological effects. So, the total ecological effects are also of the order of billion Finnish marks annually (FIM billion/a). Global impacts are as great as health effects if the basis for valuation is considered to be economic control instruments needed for halting the growth in emissions. The value of noise damages was estimated to be over FIM 3 billion/a.

The values of damage on buildings and monuments of considerable culture historical significance and the non-timber values related to forests, such as biological diversity, landscape or recreational values, have not been assessed. The assessment of global impacts contains a particular amount of uncertainty.

The sum of the above damage estimates (about FIM 8.9 billion/a) accounts for about 1.7% of Finnish GDP (1990), being divided as follows: climatic changes caused by greenhouse gas emissions about 0.41% of GDP, damages caused by other emissions and resuspension about 0.63 % of GDP (of which the damage emerging abroad was valued at about FIM 900 million/a, equivalent to 0.18% of GDP) and noise-caused damages about 0.67% of GDP.

Since damages caused by road traffic fuel emissions and noise are most obviously significant when valued in money, their further research and valuation is well justified. Results and valuation methods should also be checked when emission levels change or more accurate research results are available.

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Comparison of Waste-disposal Costs in Small- and Medium-sized Business in Mexico, Brazil, and U.S.A.

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MOTIVATION FOR RESEARCH PROJECT:

- Concern that small- and medium-sized businesses are not as actively and voluntarily involved in Total-Cost Assessment as they profitably could be.
- Likelihood that new waste-disposal (and other environmental) regulations will disproportionately apply to small- and medium-sized businesses.
- Concern that economic cost of compliance will overwhelm small- and medium-sized businesses.
- Concern from U.S. businesses that cross-border competition will be affected by lower compliance costs in Mexico (and, in the future, Brazil).

GOALS OF RESEARCH:

- Identify waste streams from industries with large number of SMBs.
- Estimate waste-disposal costs and simple predictors of those costs.
- Estimate across-country differences in waste-streams and disposal-costs.

SCOPE AND METHODS USED IN PROJECT:

- Surveyed SMBs in three states: Texas, U.S.A., in Nuevo Leon, Mexico, and in S‹o Paulo, Brazil.
- Questionaire with followup.

RESULTS TO DATE:

- Mexico and Brazil surveys completed; U.S.A. surveys being completed.
- Preliminary analysis of results.

MOTIVATION FOR RESEARCH

- Concern that small- and medium-sized businesses are not as actively and voluntarily involved in Total-Cost Assessment as they profitably could be.
- Likelihood that new waste-disposal (and other environmental) regulations will disproportionately apply to small- and medium-sized businesses.
- Concern that economic cost of compliance will overwhelm small- and medium-sized businesses.

- Research adds to Texas Natural Resource Conservation Commission (TNRCC) analysis of air and water emissions from small- and medium-sized businesses (e.g., The Cost of Clean Air, TNRCC 1995).
- U.S.-Mexican trade agreements (primarily, NAFTA) have raised concerns that Texas small- and medium-sized businesses will face cross-border competition with firms facing substantially lower compliance costs.
- Discussions of similar trade agreements with Brazil have raised similar concerns.

GOALS OF RESEARCH

- Identify waste streams from industries with large number of SMBs.
- Estimate waste-disposal costs and simple predictors of those costs.
- Estimate across-country differences in waste-streams and disposal-costs.
- Begin to develop predictive model of magnitude of waste(s) generated as a function of industry, firm size, location.

SCOPE OF PROJECT; PROJECT METHODS.

Surveyed SMBs in one state in each of three countries:

- Texas, U.S.A.
- Nuevo Leon, Mexico
- S‹o Paulo, Brazil.

SURVEYED SMBs IN THE FOLLOWING INDUSTRIES:

	Texas	**Nuevo Leon**	**Sao Paulo**
Auto Body and Repair	10	10	-
Gasoline Service Stations	10	10	-
Dry Cleaners	10	8	-
Printing Shops	10	8	10
Commercial Painters	10	-	-
Hot Mix (Asphalt)	10	8	-
Metallurgy	5	6	4
Furniture Manufacture	8	9	4
Machinery Manufacture	-	6	5

SURVEY METHODS:

- Identified trade associations for each industry.
- Explained project and obtained cooperation of trade association.
- Obtained SMB contacts from trade associations.
- Initial telephone contact with SMB contact to explain project.
- Emphasized project was not concerned with compliance.
- Mailed/faxed questionaire (next page).

- Follow-up phone calls or site visits to resolve ambiguous answers.

**** SAMPLE WASTE DISPOSAL QUESTIONAIRE -- CONDENSED ****

The University of Texas at Austin -- Graduate School of Business

Business Name____

Type of Business____

Contact Person____

Phone #_____________________________Fax #______________________________

Please answer the following questions as completely as possible.

1. How much and what types of waste does your business produce? Please list them under the appropriate category below.

Hazardous Amount

____

____

Non-Hazardous Amount

____

____

2. How does your business store waste on site before disposal (i.e., plastic barrels, steel drums, etc.)?

____

____

3. How does your firm dispose of its waste?

____

____

4. How much does it cost your firm to dispose of the different wastes?

____

5. How did you determine this cost for this questionaire?

6. How many full-time or full-time equivalent employees does your business have?

7. Is there any other information that you feel is relevant for this survey?

RESULTS TO DATE

- Mexico and Brazil surveys completed; U.S.A. surveys partially completed.
- Preliminary analysis of results:
  1. Within-industry, across-country:
     a) Waste products are similar.
     b) Relative waste amounts can vary substantially.
     c) Waste-disposal costs vary substantially (U.S.A. highest, Mexico lowest)
  2. Within-country, across-industry:
     a) Waste products vary substantially.
     b) Waste-disposal costs vary substantially (e.g., U.S. painting lowest).
     c) Firm-size correlates with cost; Ònon-linearÓ relationship is common.
- Initial conclusions:
  1. For Texas, some industries with SMBs will face high compliance costs.
  2. For Nuevo Leon and S‹o Paulo, increased enforcement will raise compliance costs for all industries surveyed.

ENVIRONMENTAL PERFORMANCE EVALUATION

Eco-efficient Portfolios

Franz Knecht, Swiss Bank Corporation, Switzerland

Development of Environmental Performance Indicators in the Energy Sector

Hannu Härkönen, Imatran Voima Oy, Finland

Development and Use of Environmental Performance Indicators at Ontario Hydro

Takis Plagiannakos & Mark Skuce, Ontario Hydro, Canada

Key-indicators for sustainable performance.

Eco-efficient Portfolios

Franz Knecht
Swiss Bank Corporation, Switzerland

INTRODUCTION

Aproactive environmental strategy can reduce a company's business costs and improve its position in the marketplace. SBC's Environmental Performance Analysis is designed to zero in on this effect, using evaluation methods developed in collaboration with outside experts. This enables SBC to offer investors an opportunity to put their money into portfolios containing companies whose economic and ecological performance is highly rated.

SBC ENVIRONMENTAL PERFORMANCE ANALYSIS

By integrating ecological aspects into its management, its products and its production processes, companies can cut costs and give themselves an edge in the marketplace, with a positive impact on shareholder value. To gain the benefits of such situations, SBC is incorporating an Environmental Performance Analysis into the criteria it applies to selected portfolios, to complement its standard analytical techniques. The objective is to identify companies with outstanding performance on both counts, ecology and economics. This sets SBC's products apart from the existing assortment of funds on the market which invest in environmental technologies, as well as green funds that use strictly ethical criteria. The new service is a response to growing customer demand for investment vehicles that include an ecological dimension, which was clearly indicated by a market study at one of SBC's main branches in Switzerland. The most important factors in the success of such investment products are a transparent screening system and a return in line with the market, at least in the medium term.

HOW DOES ENVIRONMENTAL PERFORMANCE INFLUENCE SHAREHOLDER VALUE?

Environmental efficiency is already affecting corporate finances today and in all probability will have even more impact in the future in a number of different ways:

<u>Ecologically optimised products</u>

- tend to be innovative products.
- have built-in competitive advantages: the attention to environmental impact represents an additional sign of quality. Many firms have strong environmental guidelines for their own sourcing, and consumers are increasingly being swayed by ecological criteria.

<u>Ecologically optimised production processes</u>

- harbour considerable potential for cutting costs: expensive resources and outlays on waste disposal are saved.
- can improve the company's safety record and legal position.

- reduce the exposure to liability and the associated insurance premiums.

FIRMS with functioning environmental management systems

- are also likely to have a comprehensive management system in place at the level of the corporate group as a whole: good environmental management is an indicator of competent management in general.
- have a communication system that provides the public with full information on ecological subjects as well as other themes; the corporate image and relations with stakeholders inside and outside the company are enhanced.
- often have early warning systems to also alert management to ecological trends at an early stage: potential financial burdens caused by developments such as stiffer environmental legislation or "green" taxes and ecological levies can be anticipated and appropriate measures can be introduced.

The aspects outlined above can be illustrated by the following examples:

Baxter International, an important manufacturer of medical and pharmaceutical products (1994 sales USD 9.3 billion), calculated the costs and revenues (or savings) arising from its environmental efforts in 1994. The result was definitely positive: the costs worked out at USD 27.6 million against a total contribution to revenues of USD 74.6 million.

Electronics giant Rank Xerox estimates that it has saved several hundred million dollars through the group-wide implementation of its product recycling programme known as asset recycle management (1995 environmental report).

Dow Chemical introduced a package of 10-year objectives in 1996 as part of its environmental strategy. The planned measures in the areas of energy, waste, process safety (incidents and business interruptions), cleanups, etc., are expected to result in cumulative savings of USD 1.8 billion by the year 2005.

Sony has reported on a test of stereo TV sets by a Dutch consumer magazine, in which the Sony model scored poorly, in part because of a deficiency in environmental features. Competitors' models were rated as "best buys" , partly due to environmental considerations. Immediately after the test came out, Sony's market share dropped 11.5% while its rivals expanded their penetration noticeably. Sony now has special purchasing guidelines to make sure the materials employed are environmentally acceptable.

In 1993, Volvo introduced a new line of trucks with improved ecological performance (especially reduced fuel consumption and lower emissions). These environmental factors were used as a significant marketing argument alongside the standard features of the product. Volvo attributes its 35% increase in market share for 16-ton trucks partly to the vehicles' environmental benefits.

All these examples make it clear that good environmental performance can give a real boost to shareholder value in the longer run. This makes it interesting for investors to have portfolios available that include a selection of such shares.

The companies cited above do not represent isolated cases. Academic research and studies by industry trade groups are both focusing on the influence of ecological measures on shareholder value, and coming up with new management ideas.

FACTOR FOUR AND ECO-EFFICIENCY

Amory Lovins and Ernst Ulrich von Weizsäcker, who advised the SBC Environmental Performance Analysis team as members of the board of experts, identified more than 50 examples of product groups with high resource efficiency in their book, "Factor four, Doubling Wealth Halving Resource". The principle is that output can be doubled with half the input for a factor of four improvement ecologically and economically. "Factor four" describes a new kind of progress driven by an increase in resource productivity. The book's authors give examples of cases where applying the "Factor four" principle would generate more prosperity while consuming fewer resources. There is no need to stop consuming or to impose curbs on consumption.

"Hypercars", for instance, made from synthetic resins, require only a quarter of the fuel used by conventional autos thanks to their 50% reduction in weight and use of hybrid power sources. "Superinsulation" panels for homes can be created with a membrane layer and a filling of heavy gases as heating elements rather than thermal drains. Substituting video conferences for business trips would save both time and energy many times over. Arrangements for the leasing of chemicals and raw materials would lead to efficient use of these resources.

A phased realisation of such improvements would enable a company to boost its environmental efficiency as well. This idea was presented in 1992 as a contribution the corporate sector could make to sustainable development. The World Business Council for Sustainable Development (WBCSD), to which Swiss Bank Corporation also belongs, defined the concept as a management philosophy which should provide incentives to the economy to become more competitive and more innovative, while at the same time exercising greater responsibility with regard to the environment. The eco-efficiency criteria presented above make it clear that resource-efficient production, and therefore cost-efficient production, lead to steady improvements not only in environmental performance but also in business performance.

The concept of "eco-efficiency" and the examples with regard to "Factor four" serve as the basis for SBC's Environmental Performance Analysis. Environmental performance is analysed in both quantitative and qualitative terms.

THE INVESTMENT PROCESS

The portfolios invest exclusively in companies with a record of good environmental as well as economic performance. The new element in this investment approach is a twofold strategy, targeting both "ecological leaders" and "ecological innovators" for investment (see above). With this two-pronged strategy, SBC's ecological portfolios give investors a chance to profit from the strong growth often experienced by small and medium-scale enterprises marketing innovative, environmentally beneficial products, and at the same time to share in the security and performance of blue chip stocks.

BEST IN CLASS

Investments are diversified to cover all major sectors of the economy. This makes sense from the standpoint of ecology as well as risk. No particular industry is excluded as a high polluter, because it is precisely the resource-intensive industries which can have a significant direct impact on the environment, if they conduct their business in an eco-efficient way. Investing in firms with the best ecological performance in their industry (ecological leaders) helps to improve the environment, because these companies set the standard for their sectors (see Graph 1).

MULTISTAGE SELECTION PROCESS

Stock picking follows the four-step procedure outlined below:

1. Evaluation using "traditional criteria" of financial analysis.
2. Environmental evaluation: analysis of company information and outside data using company questionnaires designed for the specific industry.
3. Plausibility check: the quality of the analysis must stand up to external quality examination. The companies selected achieve permanent progress when the designated criteria are adhered to consistently.
4. Synthesis of financial and environmental evaluations, investing only in firms with above-average scores on both counts (see Graph 2).

EVALUATION OF ENVIRONMENTAL PERFORMANCE

The environmental evaluation of the companies consists of three steps:

<u>Preliminary examination</u>

The first preliminary soundings determine whether a company is basically suitable for consideration. This preselection uses qualitative criteria (e.g. environmental communications and management systems, adherence to Environmental Charter).

<u>Analysis of company documentation</u>

A checklist of criteria related to eco-efficiency is developed, to help evaluate environmental performance. Drawing on the documentation and other information from the company, a questionnaire drawn up by SBC is completed as far as possible.

<u>Company questionnaire</u>

Finally the questionnaire is sent to the companies to supply the data which is still missing. This step-by-step procedure facilitates cooperation with the companies by reducing the amount of work they have to do. Moreover, the questionnaires are not sent out indiscriminately but only to preselected companies. The firms are additionally requested to provide as detailed background information as possible, to serve as a basis for the evaluation of their environmental performance. The direct dialogue with the people responsible for this area at the companies generates valuable feedback. The questionnaire covers seven main areas (see page VI). This analytical framework is adjusted for specific industries to identify the strategies worked out in each case for the ecological challenges they face.

- In the construction sector, great emphasis is placed on the energy efficiency and service life of materials and buildings.
- In the car industry the targeted factors include (among others) fuel consumption across the entire vehicle fleet and the development of alternative concepts of mobility.

- For electronics companies, strategies to reduce energy consumption and increase product life, as well as returns policies and recycling systems, carry considerable weight.
- Wholesalers and retailers are judged on their ecological purchasing guidelines, the provision of environmental information to consumers and transportation management, among other points.
- Energy utilities score well with regenerative energy sources, customer counselling and financial incentives to conserve energy.
- Banks are scrutinised for the integration of ecological risk into their loan approval process and the availability of environmental investment products, along with measures to reduce consumption of energy and paper.

The search for ecological innovators focuses mainly on the decidedly future-oriented sectors, products and services. Having established the target groups, the leading suppliers are identified. Admission to the fund, however, only occurs if the company in question also meets the key criteria for eco-efficiency in production and management. The plausibility check takes place after the questionnaire has been evaluated.

Plausibility check

This has two objectives. On the one hand, the results of the analysis are subjected to a "quality assurance" procedure, checking the evaluation against external, independent sources of information (databases, environmental organisations). On the other hand, the plausibility test itself extends the range of the criteria applied. Other areas of corporate governance are examined besides ecological aspects. This increases the chances of pinpointing potential future risks for the company and its investors. The results are then aggregated with those of the Environmental Performance Analysis and can thus lead to an upgrading or downgrading of the previous findings.

The plausibility criteria include requirements that products of selected companies should generally be designed for peaceful purposes and that the risks of processes and products should be insurable.

CHARACTERISTICS OF AN SBC PORTFOLIO INCORPORATING ECOLOGICAL CRITERIA

A broad spread of countries and industry sectors makes it possible to put together a portfolio which largely reflects the statistical properties of the global equities universe (MSCI World), see page VII. Despite the strict ecological criteria the portfolio of 102 different shares shows a beta of 0.99 and a standard deviation of 17.6%, putting it very near the risk coefficients of MSCI World. While the portfolio has similar country and industry weightings as MSCI World, there is some variation in the choice of stocks. The environmental "screening" process and the "best in class" stipulation result in substantially fewer shares being selected. And since sectors with a high stock market capitalisation are relatively prominent in MSCI World, the portfolio correspondingly includes more companies from the chemicals and financial sectors than from the paper industry.

Ecological and economic criteria were given equal weight in the selection of shares. Companies with an unsatisfactory environmental performance and a positive rating from the financial analysis point of view failed to "make the cut", and this applied as well to companies where the situation was reversed. The main thrust is investment in ecological leaders, which are often blue chip companies. This was a way of pursuing a market yield for the portfolio.

Standing behind this ecologically optimised and broadly diversified portfolio is a partnership between top-grade financial analysts and leading authorities on the environment. On the financial analysts side, the portfolio is in the hands of SBC specialists. The team performing the Environmental Performance Analysis is supported by consultants from the Basel-based Oekomedia AG and a board of experts2.

Scientific board of experts

Leading figures in the study of environmental issues were recruited for the board of experts. The board of experts serves the following functions:

- Supporting the development and application of the environmental evaluation methodology
- Assistance with ecological trend analyses
- Information about and contacts with companies.

Communication

The SBC specialists maintain regular contacts on the subject of environmental performance with the companies studied. This dialogue can provide valuable feedback to the company concerned about its positioning within the industry and its optimisation possibilities.

DEVELOPMENT OF ENVIRONMENTAL PERFORMANCE INDICATORS IN THE ENERGY SECTOR

Hannu Härkönen
Imatran Voima Oy, Finland

INTRODUCTION

Electricity is generated from a variety of natural resources. The environmental impacts related to electricity generation depend on the resources utilized and conversion processes applied. Environmental impacts can be identified in most phases of the life cycle of electricity products; extraction of fuel resources, fuel manufacturing, transportation, storage, conversion at a power station and transfer and distribution to the end consumer. Electricity generation contributes to a wide range of environmental impacts from depletion of natural resources to global climate change.

A number of technologies are available for reduction of emssions, and consequently the environmental impacts, from the various phases in the life cycle of electricity products. Historically the society has encouraged utilities to introduce these technologies by imposing environmental regulations or by applying various types of economical incentives. In recent years the increasing environmental awareness among all stakeholder groups of power utilities has enhanced the role of environmental performance among key issues for good business success.

Electricity producers have responded to the challenge by developing environmental management systems and environmental reporting. Meaningful environmental reporting calls for recognition of the significant environmental issues and definition of appropriate performance indicators for them. The indicators should be measurable, auditable and transparent to the readers.

DEVELOPMENT IN ENVIRONMENTAL REPORTING

Historically environmental reporting has been reporting to the regulatory authorities to demonstrate regulatory compliance. The increasing interest among other stakeholder groups has led to widening of the scope of environmental reporting, because the needs and expectations of various stakeholders differ from each other. Many companies have responded to the growing needs first by incorporating environmental information into their annual reports and later also by publishing separate environmental reports on annual basis.

IVO Group has included environmental information in its annual report since 1974. More systematic aggregation of environmental data started in 1991, first for internal use and from 1993 onwards for public environmental reporting as well. IVO's approach is to produce a rather comprehensive report with a lot of detailed information to fulfill the needs of specialist readers. Consequently, the report may be too ”heavy” for a casual reader, but on the other hand it is not possible to produce separate environmental reports to all stakeholder groups.

Today, IVO publishes key environmental information on its intenert home page, too.

ENVIRONMENTAL PERFORMANCE INDICATORS

So far, the environmental performance indicators used by most companies in their environmental reporting are related to emissions and other types of sources for environmental burden. This type of data is managed by the companies, is readily available and reflects at least the level of environmental impacts caused by companies' operations.

The environmental indicators IVO is currently using in environmental reporting can be divided into the following categories:

- use of natural resources
- emissions into air
- emissions into water
- solid waste management
- environmental costs.

Use of Natural Resources

Use of natural resources (fuels and water) are reported as total quantities used at individual power plants and at corporate level. IVO uses many types of fuels in power generation: uranium, coal, gas, peat and biofuels. The total quantities are unambiguous as such and reflect IVO's contribution to the decrease of fossil fuel reserves. However, they do not measure the efficiency of the conversion processes applied. One object for future development might be introduction of an indicator for the efficiency of fuel use.

Emissions Into Air

The most significant environmental impacts caused by generation of electricity from fossil fuels are related to emissions into atmosphere.

<u>Reporting of emissions</u>

IVO reports CO2, SO2, NOx and particulate emissions from individual power plants and at corporate level. All emissions are reported as total quantities. SO2 and NOx emissions are also reported as per used fuel energy. Emissions per used fuel energy demonstrate better the efficiency of air pollution control measures and the level of regulatory compliance.

A comparison with the total emissions in Finland are also reported.

<u>Life cycle approach</u>

Life cycle method can be used to assess the overall emissions (or impacts) related to manufacturing, use and disposal of various types of products. So far IVO has had only one electricity product on the Finnish market. The electricity supplied to customers typically consists of own production, shares from other utilities, purchases from other companies and import from Russia and Sweden.

For the environmental specification of IVO's electricity we have calculated the emissions of SO2, NOx and CO2 per supplied kWh of electricity. The calculations are based on the domestic production and acquisition pattern. While the exact data of imported electricity is lacking, the emission pattern has been assumed to be equal to the domestic pattern. As far as emissions into air are concerned, the error is marginal.

The specific emissions of IVO's electricity are compared with the average emissions from Finland's electricity generation.

For IVO's own production we have also calculated emissions from fuel acquisition. The general data used gave figures in the order of magnitude of 10-20% of the emissions of the power generation phase.

Emissions Into Water

The discharges of waste waters from power generation are generally small. Waste heat released in the cooling waters from the condensing power plants is the most important factor causing environmental loading. The requirements for reporting discharges to waters varies from plant to plant; new power plants have more stringent requirements than the old plants.

In the annual environmental report we have reported the following discharges into waters:

- heat
- total suspended material
- nitrogen
- phosphorus.

Waste Management

Ashes (fly ash and bottom ash) and desulphurization products (mainly gypsum) are the most important byproducts from power generation with solid fuels. We use to report the annual accumulation of the byproducts at individual power plants and at the corporate level.

IVO has studied systematically properties of the byproducts to develop applications for utilization. In recent years IVO has been able to sell a considerable part (typically > 50%) of the byproducts for useful purposes. Ashes are mostly used for landfill purposes and gypsum for manufacturing of plasterboards. The rest of byproducts is disposed of at local landfill sites. The corporate level utilization ratio (ratio of utilized volume to the accumulated volume) has been reported as an indicator for the success of efforts to enhance utilization of byproducts.

Environmental Quality Indicators

In Finland local environmental authorities and big industrial companies are responsible for monitoring environmental quality. Environmental monitoring is in most cases carried out as joint projects, where local authorities or environmental consultants do the job and costs are shared between communities and industries.

Typical objects for monitoring of environmental quality are:

- local air quality (SO2, NOx, particulates, deposition)
- bioindicator studies (lichen surveys, needle anayses)
- cooling water recipients (water quality, fishery)
- runoff of disposal areas.

The results of environmental monitoring are reported by the local authorities and so far the data has not been included in IVO's environmental reports. In most cases the total environmental burden and the consequent environmental impacts at a certain location are sum of many factors and the contribution of any single source of pollution can not be easily defined.

Environmental Costs

Direct environmental costs related to energy generation can be divided into capital costs and annual operating costs. Environmental costs are not earmarked in any way in IVO’s accounting and environmental costs cannot easily be extracted out of the normal accounting system.

Major capital investments are organized as separate projects and the total capital costs can be calculated of the individual project accounts. The problem that often arises is whether the investment can be classified as productional or environmental. IVO’s approach has been to report only the undisputable environmental investments.

Operational costs can be didived into costs for

- operation and control
- maintenance and repair
- energy and auxiliary materials.

Operation and control of environmental systems at power plants are closely integrated to the operation and control of the whole power plant and cannot be easily separated. Maintenance and repair costs are to certain extent accounted for the system or component in consideration. The question then arises which facilities at a modern power plant can be defined as environmental protection systems and which not. Cost for energy and auxiliary materials can be estimated with reasonable accuracy.

Company’s annual environmental expenditure is not an unambiguous indicator as such. High environmental expenditure can indicate high level commitment to continual improvement of environmental performance. On the other hand it can result from efforts to keep the performance of environmentally poor production facilities at a tolerable minimum level. Reporting of environmental expenditures should be supported by a description of the environmental status as compared to regulatory compliance or company’s own environmental objectives and targets.

So far we have not reported environmental liabilities. In recent years they have been quite small, perhaps with the exception of liabilites for the Finnish Nuclear Waste Management Fund. Identification and assessment of environmental liabilities is an obvious object for future development.

TOTAL COST ASSESSMENT

In an open energy market price is a very strong incentive for customers to choose their electricity supplier. Environmental values may have some weight in their decision making, but at least in Finland it is hard to find big industrial enterprises who would be willing to pay anything extra for claimed environmental superiority. Hence, the direct environmental costs are the key figure to control and the question arises what could a company do with profound knowledge on external costs.

Some potential applications might be:

- marketing, to demonstrate that the externalities are not very high and that the total costs are even lower than those of the competitors. This can be an inviting option for companies with low total costs.
- to support decision making to favour generating technologies which cause the lowest total environmental cost. Information can be difficult to use if the options available are limited by political decisions or technologies with the lowest total cost have the highest production cost.
- to educate national policy makers and the markets to favour solutions with lowest total cost. This option is the most inviting in Finland, where extension of hydro power and nuclear power are prohibited by political decisions.

As reported by Mikko Hongisto in this seminar we think that great uncertainties are still related to the methodology for external cost estimation. Some of the main issues are that the response functions are poorly known and site specific. Valuation of environmental impacts is highly subjective and the results gained at a certain location cannot be directly transferred to another environment. As yet, total cost as an environmental performance indicator is neither easily measurable and verifiable nor very transparent.

In an open energy market the most important signals to a power producer come from the customers. Environmental awareness among various customer groups is steadily growing. Many power producers are responding to this by developing energy products and services with different environmental profile. In the long term this development leads to the right direction without the need for complicated models for monetization of the whole variety of complex environmental issues.

Energy production in all countries is subject to various administrative controls. Development of national energy policies is often a battlefield of strong environmental passions where scientific evidence does not necessarily play the major role. Total cost assessment is certainly one tool to supply more information to the discussion. However, it should always be kept in mind that any numerical values provided by various total cost assessment excercises inevitably include a number of subjective valuations and choices of political nature. The central assumptions should always be made clear to the decision makers to highlight the whole basis for decisions.

The Development and Use of Performance Indicators at Ontario Hydro

Takis Plagiannakos & Mark Skuce
Ontario Hydro, Canada

EXECUTIVE SUMMARY

In 1993, Ontario Hydro developed a Sustainable Development Indicators (SDI) framework which is used to report publicly Ontario Hydro's progress towards sustainable development. The SDI work contributed to the Corporate Performance (CP) framework, that was developed to drive behaviours and measure progress towards key corporate strategic goals including sustainable development. A subset of the indicators that are included in the CP framework is linked to senior management compensation.

Ontario Hydro is planning to integrate further the measurements of sustainable development into the CP framework through the use of two composite performance indicators: resource use efficiency and, environmental performance. Information about Ontario Hydro's environmental and sustainable development performance can be obtained through its annual progress report towards sustainable development, or by accessing its on-line Web site.

ONTARIO HYDRO

Ontario Hydro, serving the Province of Ontario, Canada, is one of the largest electric utilities in North America in terms of installed generating capacity. Total in-service system capacity is approximately 29,000 megawatts, transmitted across 29,000 kilometres of transmission lines and 109,000 kilometres of distribution lines. Its customers include 306 municipal electric utilities, which in turn, serve more than 2,800,000 customers, and Ontario Hydro Retail which serves almost 1,000,000 retail customers, including 103 large industrial customers.

Ontario Hydro owns and operates 69 hydroelectric stations, five nuclear stations and six fossil fuelled stations. Ontario Hydro's electricity generation in 1996 was 55% nuclear, 26% hydroelectric, 13% fossil and 6% other. Total revenue in 1996 was $8.9 billion on an asset base of $40 billion. The company currently employs approximately 21,000 people.

Ontario Hydro, currently a public utility, is preparing for the transition from a monopoly situation to a more competitive environment and in October 1996, a new corporate structure was announced. The new structure is based on a holding company model comprised of three "signature" businesses: a Generation company (comprised of nuclear, fossil and hydroelectric Business Units); a Transmission company; and, a Retail sales, distribution and services company. The three companies are supplemented by a small Corporate Centre and a Corporate Business Development group. Ontario Hydro believes that this corporate structure will enable it to successfully compete in a more competitive environment.

THE EVOLUTION OF SUSTAINABLE ENERGY DEVELOPMENT AT ONTARIO HYDRO

In the Spring of 1993, at the direction of the then Chairman Maurice Strong, Ontario Hydro formed an internal Task Force on Sustainable Energy Development. Its mandate was to develop and recommend a strategy for sustainable energy development for the organisation. In the Fall of 1993, Hydro's Board of Directors accepted a 10-point strategy set forth in the "*Strategy for Sustainable Energy Development and Use for Ontario Hydro*" Task Force report. One of the themes of the strategy was that while sustainable development can be viewed as a set of operational principles to guide decision-making, there is also value in considering sustainable development as a context for decision-making. A key recommendation of the strategy called for the development and use of a Sustainable Development Indicator (SDI) monitoring and reporting framework. The purpose of the SDI framework was to measure Hydro's annual progress in attaining its mission which is:

> *"To make Ontario Hydro a leader in energy efficiency and sustainable development, and to provide its customers with safe and reliable energy at competitive prices".*

In 1994, the 10-point Task Force strategy was consolidated into the following five elements of sustainable energy development:

- promoting energy and resource use efficiency
- environmental integrity
- increasing use of renewable energy
- financial integrity
- social integrity

In March 1995, Ontario Hydro's Sustainable Energy Development Policy and Principles were approved by senior management and then the Board and committed the Corporation to:

"Apply the principles of sustainable development throughout its businesses. Ontario Hydro will increase its competitiveness and promote a more sustainable energy future by focusing, initially, on the efficient use of resources, continuous improvement in environmental performance, and diversification of its energy services and products."

The principles, which provide a framework for decisions and actions that may be undertaken in support of the five Sustainable Energy Development (SED) elements, address areas such as eco-efficiency, working in partnerships, applying the precautionary principle, and monitoring and reporting.

In order to track specific corporate and business unit performance in these areas, Ontario Hydro developed an SDI framework for monitoring and reporting on a set of 27 indicators. This established an analytical basis for technically assessing performance against a comprehensive set of internal benchmarks. For comparison, Ontario Hydro began to monitor a number of external utility and other organisations pursuing sustainable development. The SDIs and monitoring / reporting process are discussed more fully in the next section.

Ontario Hydro's Sustainable Development Report for 1995 marked the transition from annual environmental performance reporting to an annual report on its progress towards sustainable development. SDIs were used as the standard against which performance is gauged. Indeed the latest report, entitled 1996 Performance Report - Progress Towards Sustainability, continues and reinforces this commitment.

FOCUSING EFFORTS: MEASURING PROGRESS TOWARDS SUSTAINABILITY

One of the more challenging aspects of pursuing a commitment to a sustainable future is devising a means of measuring progress towards that goal. Ontario Hydro has identified five areas and several indicators to meet this challenge.

A number of criteria were considered in evaluating and selecting potential indicators of sustainability. Indicators were selected if they were generally recognised as important, understandable, and corporate in nature. Indicators also needed to reflect corporate strategy, policy and programs, have available data, or data that could be obtained at reasonable cost, and promote a stronger linkage between environment and business. The five areas and selected indicators are described below.

Energy and Resource Use Efficiency: Efficiency, as a concept of thermodynamics, is defined as "outputs over inputs". Increasing efficiency in terms of energy and resource use allows for improved financial and environmental performance simultaneously. Increased efficiency equates to both improved competitiveness and to an enhanced ability to meet economic, environmental and social objectives. Ontario Hydro’s indicators for this area are:

- total electricity used and transmission losses as a percentage of sales
- fuel conversion efficiency
- water withdrawals
- fuels and other commodities consumed
- internal energy savings

Environmental Integrity: Operations should not adversely impact the receiving media of local, regional or global ecosystems. A starting point is to measure and reduce, where feasible, the rate of emissions that result from activities related to design, development, operation, and decommissioning of facilities as well as from procurement and material management. Environmental integrity is improved by reducing the wastes, effluents and emissions resulting from operations. The indicators Ontario Hydro developed for this area are:

- greenhouse gas emissions
- ozone-depleting substance emissions
- acid gas releases
- hazardous wastes
- environmental expenditures
- waste management
- levels of radioactive waste produced
- compliance violations
- reportable spills

Renewable Energy: This area measures the use of, and priority given to, renewable energy. The provincial (and global) economy currently relies on many non-renewable and non-indigenous energy forms. Increasing the capacity to meet its energy needs through renewable, indigenous energy sources offers the potential to enhance the stability and security of energy supply in Ontario while reducing the capital outflow. Ontario Hydro's indicators in this area are:

- energy generated from renewable sources
- energy generated from advanced renewable energy technologies (e.g. wind, solar)

Financial Integrity: Financial integrity is determined by Ontario Hydro's ability to consistently generate positive cash flows from its asset base and to strengthen its equity position over time. Positive cash flows allow the organisation to make ongoing investments in upgrading its capital and human resources thereby enhancing its competitiveness. Indicators which are typically reported in its corporate annual reports are:

- net income
- debt ratio
- interest coverage
- total unit energy cost

Social Integrity: Social integrity is determined in part by the best utilisation of Ontario Hydro's human resources and by interactions with the communities it serves. To successfully respond to changing market and ecological conditions, Ontario Hydro will need to foster a work environment that encourages innovation, experimentation and greater employee involvement. Ontario Hydro's indicators in this area are:

- employee accident severity
- employee productivity
- number of public fatalities
- number and severity of environmental complaints
- corporate citizenship program
- payments in lieu of taxes
- aboriginal grievances

This detailed approach to measurement and reporting has helped integrate environmental, economic and social dimensions into the decision-making process. By implementing this framework, along with an ongoing process of benchmarking, the company has been able to ensure that its performance objectives continue to be relevant and challenging. This approach is consistent with Ontario Hydro's commitment to continual improvement and leadership in sustainable development.

Hydro has decided that the SDI framework will continue to form the basis for assessing and reporting publicly on corporate and business unit SED performance. On an annual basis, Hydro will monitor and report the performance of a subset of those SDIs as part of the Corporate Performance framework which is discussed in the next section. A subset of the sustainable development indicators is used in the framework to drive performance in those areas that are important from a corporate perspective.

ONTARIO HYDRO'S CORPORATE PERFORMANCE FRAMEWORK

Ontario Hydro has had a Corporate Performance (CP) framework in place for a number of years. The CP framework has the following objectives:

- align the Corporation and its Business Units to the Corporate Mission and long-term strategic objectives;
- measure how successfully the mission is being accomplished;
- drive behaviours and achieve performance levels, balancing short and long-term strategic objectives;
- tie specific performance measures to compensation;
- improve the integration of the performance targets into the Business Plans;
- reflect matters of corporate significance; and
- be amenable to benchmarking and independent auditing.

The CP framework is composed of a set of financial and non-financial indicators that are considered to be key drivers of behaviours or performance. It is designed not only to track past performance in specific Key Results Areas (KRAs) but to change behaviours and initiate actions to meet short-term as well as long-term strategic objectives and targets. A sub-set of the indicators included in the CP framework is linked to senior management compensation.

Table 1 shows the five KRAs and the indicators used to establish targets and track performance in 1997. Each KRA focuses on certain goals and has its own performance indicators:

Table 1: Key Results Areas: Goals and Performance Indicators

	Goal	Indicators
Customer Focus	Keep electricity bills as low as possible while providing reliable energy services that meet customers needs	Customer Satisfaction Index, Average Electricity Price Change, Customer Delivery Interruptions
Stewardship	Use energy and natural resources efficiently. Continuously improve environmental performance to ensure the long-term sustainability of Ontario’s economy and environment	Spills Volume Lost to the Environment, Carbon Intensity Rate, Annual Internal Energy Savings, Nuclear Special Safety System Performance, Nuclear Reactor Trips
Employee Focus	Develop and maintain a skilled, motivated and safety conscious workforce. Make full use of intellectual resources.	Accident Severity Rate
Financial Viability	Be financially sustainable and sound. Ensure long-term viability.	Net Income, Amount of Debt Reduction
Competitiveness	Prepare Hydro for a more competitive electricity marketplace. Enhance quality of products and services.	Customer Retention/Economic Development, Labour Productivity, Total Unit Energy Cost of Electricity

INCORPORATING SED INTO THE CORPORATE PERFORMANCE FRAMEWORK

In 1996, the annual review process revealed that three of the major SED areas - Environmental Integrity, Resource Use Efficiency and Renewable Energy - were not well represented in the CP framework. In order to address this problem, Ontario Hydro reviewed the indicators included in the SDI framework and opted to further focus its measurement and assessment process. Two composite indicators were designed: namely, a Resource Use Efficiency composite indicator to focus on "inputs" (i.e., fuel, water, energy material etc.) and an Environmental Performance composite indicator to focus on "outputs" (i.e., emissions, effluents and wastes). The two indicators are currently being developed with the participation of all the Business Units.

Resource Use Efficiency Composite Indicator

The need to focus on Resource Use Efficiency has been supported by the following developments over the last few years:

- The focus on improving resource utilisation is driven by Ontario Hydro's mission statement "...to become leader in energy efficiency and sustainable development...";
- One of the four objectives of the 1995 Corporate Integrated Resource Planning Process, undertaken to provide guidance for investment decisions, was "to improve environmental performance and make more efficient use of resources";
- Business Units have identified resource utilisation as an important strategic area and they are working towards developing plans to improve efficiency;
- Resource utilisation efficiency is consistent with the concept of "eco-efficiency" which challenges businesses to produce more useful goods and services while using resources more efficiently and reducing environmental impacts.

Long-term targets have been set for the indicators in consultation with the Business Units. The Resource Use Efficiency composite indicator and its associated targets are expected to drive the following behaviours:

- reduce resources used in the production and delivery of electricity and other areas of Ontario Hydro business;
- reduce production and material management costs;
- reduce waste and associated costs; and
- encourage development of new business opportunities.

Environmental Performance Composite Indicator

Ontario Hydro's SED approach acknowledges that meeting environmental regulations as a minimum requirement, and encourages the organisation to look for environment-business advantages. The company's strategy is to:

- look for pollution prevention opportunities rather than end-of-pipe solutions which are often more costly;
- pursue voluntary actions and take initiatives to meet emission/effluent standards in order to manage the costs, process changes, and time frames more effectively; and,

- consider market-based mechanisms, like emission reduction trading programs which generally give the business more flexibility in achieving government-established emission standards in a more cost-effective manner.

Adopting aggressive targets for the environmental composite indicator and its components are expected to drive behaviours to:

- reduce releases to the local, regional and global environment;
- minimise waste and increase re-use and recycling;
- improve nuclear safety; and
- reduce community impacts.

Key Characteristics of the Composite Indicators

The composite indicators under development reflect the following characteristics:

- they include well-defined performance indicators;
- they assess performance relative to long-term targets;
- they use a simple and transparent performance scoring methodology;
- the performance indicators are appropriately weighted; and
- the results are calculated and plotted.

Figure 1 illustrates how different sub-components could contribute to the overall performance of the composite indicator. Figure 2 illustrates how each Business Unit could contribute to the overall performance of the composite indicator.

Uses of the Composite Indicators

It is expected that the composite indicators in particular will be used to:

- **assess progress towards sustainable development:** The composite indicators focus on three SED areas (Environmental Integrity , Resource Use Efficiency and Renewable Energy). As a result, they provide a useful measurement of the overall progress that Ontario Hydro is making towards sustainable development.

- **report progress towards long-term corporate targets:** The scores of the composite indicators will measure the Corporate and Business Unit performance relative to their long-term targets. For example, a score of 35% for either the Environmental Performance Indicator or the Resource Use Efficiency Indicator means that the Corporation has achieved 35% of its long term performance targets in that area.

- **facilitate effective communication:** Ontario Hydro’s annual sustainable development report is comprehensive and reports on a large number of indicators. The two composite indicators combine a number of indicators, using a consistent and transparent calculation framework, in order to illustrate if real progress is being made. By design, the composite indicators will also identify areas where performance needs improvement.

- **management performance:** The two composite indicators provide information for management to assess progress towards short-term and long-term SED strategic objectives and targets. They also report progress relative to the baseline and indicate the contribution of each Business Unit to overall performance (see Figures 1 and 2). The two composite indicators can be used as a management tool to drive performance in specific areas, can be included into the CP framework and can, if desired, be linked to the compensation program.

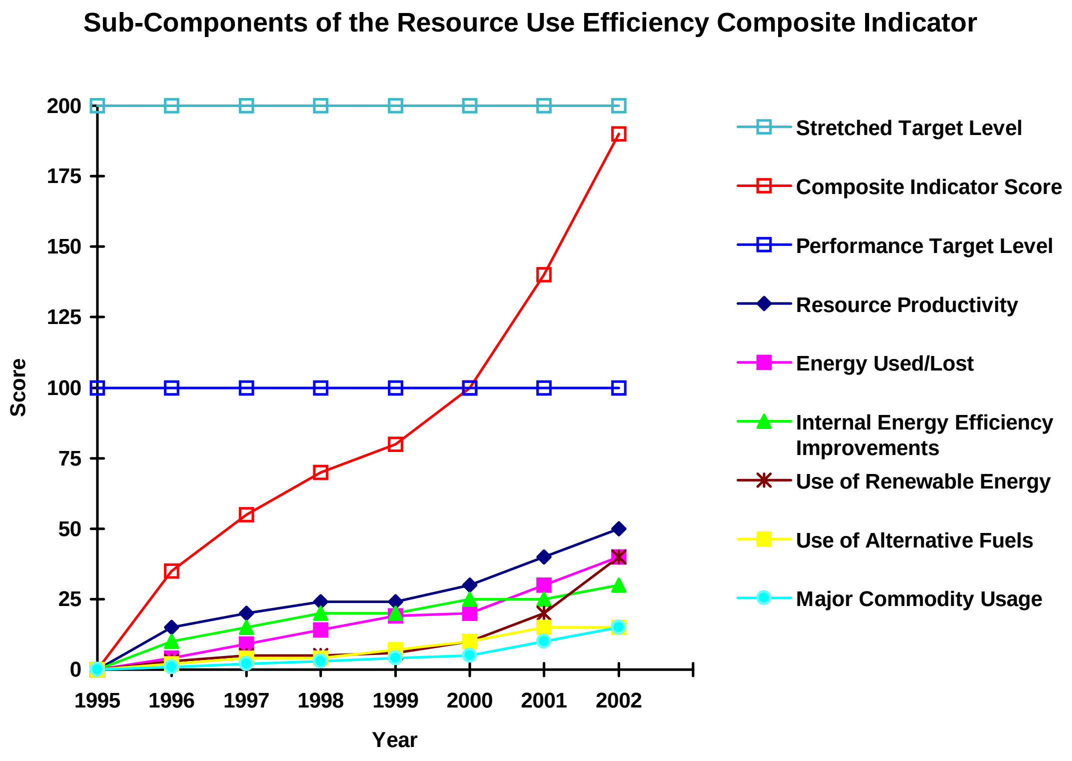
Communicating Results

Environmental performance results are regularly reviewed by senior management and are reported quarterly to the Environment & Public Policy Committee of Ontario Hydro's Board of Directors. Other stakeholders, including government and environmental non-government organisations, either receive regular reports, are participants in meetings/discussions, or obtain information about Ontario Hydro's environmental and sustainable development performance through its on-line Web site.

Lessons Learned

- Measuring progress towards sustainability requires a number of different techniques. In this respect, sustainable development indicators have been beneficial to Ontario Hydro in that they have drawn in a range of factors, not just the environmental ones which Hydro had traditionally used.
- Composite indicators are an advantageous method of focusing assessment and measuring, as well as communicating overall corporate performance. Composite indicators are expected to significantly enhance Hydro's ability to report progress towards sustainability.
- Composite indicators, in conjunction with the measures and targets that comprise them, can be used as an effective management tool to drive behaviours and improve performance. To be effective, they should be tied to compensation.
- At Ontario Hydro, SED has significantly contributed to improving effectiveness and competitiveness. In addition, the identification and quantification of performance indicators has yielded a positive benefit in terms of public accountability.

- **Figure 1**



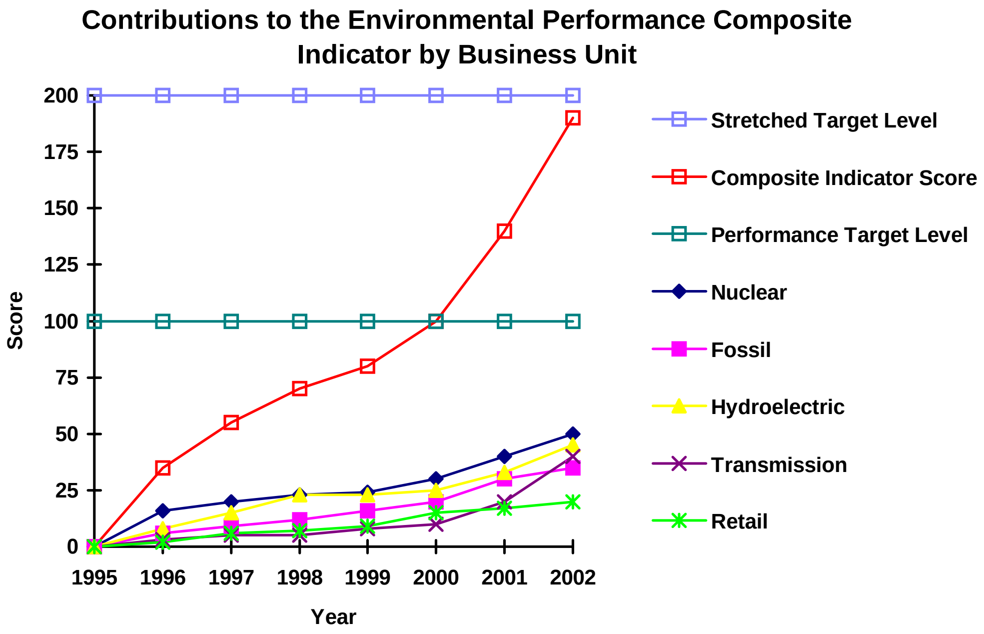
Notes:

1. “Performance Target Level” is that level which is consistent with the corporate strategic objectives but is constrained by the resources dictated by the business planning process.

2. “Stretched Target Level” is that level that is consistent with the corporate strategic objectives but is not resource constrained and is based on external benchmarking information or other factors.

3. The data in this Figure are illustrative and do not reflect actual or planned performance.

Figure 2



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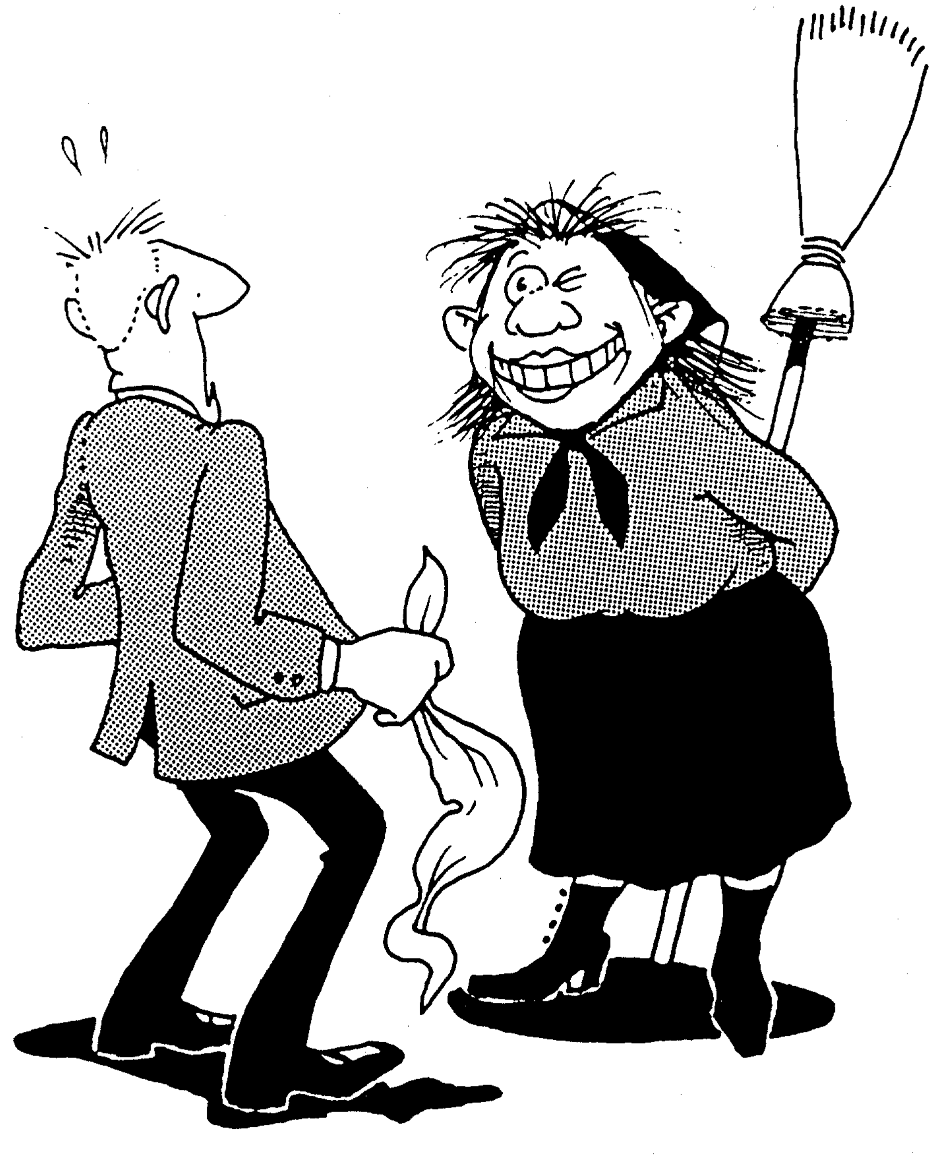

**Getting the point
but missing the target.**

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