CHAPTER 9

APPLICATIONS OF AN ENVIRONMENTAL MODELLING SYSTEM IN THE GRAPHICS INDUSTRY AND ROAD HAULAGE SERVICES

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Abstract. Environmental management is an increasingly important part of strategic management in companies, and the significance of environmental issues is increasing in business worldwide as companies form large global networks. The environmental pollution caused by industrial countries – especially air emissions – is a topic of global concern, but environmental debates often focus on finding the guilty companies instead of suggesting schemes for preventing environmental harm. Companies and administrators should aim to develop their environmental decision-making; to this end, the environmental modelling system and its applications presented in this article have been designed to identify, analyse, manage and report environmental factors in relation to operational and financial functions in business processes. The model addresses the process, environmental and financial aspects of operations on the basis of process management, environmental management and environmental business accounting. The model can also be used to determine alternatives for cost-effectively improving environmental performance. The environmental modelling system enables a company to:

1. Identify key environmental aspects of operations.
2. Analyse, manage and report current environmental performance
3. Determine the relationship between pollution abatement measures and internal environmental costs and investments
4. Compare alternatives for cost-effectively decreasing environmental loads generated by business

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1 INTRODUCTION

The difficulties in dealing with environmental issues in a company come from the number of business processes that have environmental effects: all operations, not just production plants, can have negative impacts on the environment. The definitions of environmental effects in business operations should be established in the definitions of the operational processes, and through these the environmental management system of a company may be designed and developed. Decision-making on environmental issues needs a systematic method to deal with all the factors that cause environmental loads. Firstly, procedures should be designed to consider business processes from an environmental point of view, and secondly, a company needs to analyse the financial factors of environmental issues concurrently with process and environmental factors. In other words, both the environmental loads and costs should be included in the framework.

A framework that can deal with business processes from both an environmental and financial point of view needs a systematic model to manage existing links and relationships between operational, environmental and financial factors. In addition, the model should make it possible to plan investments needed to realise improvements, thereby abating environmental loading generated by business processes, and to consider environmental performance and economic efficiency in alternative propositions. All these requirements mean a modelling system needs to be designed that can manage all the aspects and interrelations of environmental and financial factors of business processes.

The viewpoints presented above include the following requirements for a systematic approach to environmental decision-making:

- Concurrently identifying and analysing the environmental, financial and process factors of business processes and defining the interrelations of these factors.
- Determining the current environmental performance as well as legislative and internal environmental costs on the basis of the factors defined above.
- Identifying and analysing potential alternatives to improve environmental performance cost-effectively.

This method of environmental modelling includes the main guidelines for identifying environmental aspects in relation to operational and financial factors in companies. According to the environmental aspects defined, a company's environmental performance and internal environmental costs can be determined, and these factors can be used when a company searches for alternatives to improve environmental efficiency. There are four classes of environmental factors – energy and water consumption, purchases, transportation and waste management (including reuse and recycling) – which have many similar features in several business fields. But the detailed variables of the environmental model must be defined for different areas of business, such as the forestry industry, electrical industry, logistics companies, etc.

The environmental modelling system is based on the method of environmental accounting. In order for the modelling system to be a useful tool for business fields in environmental decision-making, a computer-aided application – the Environmental Internet System – is needed as a practical tool in daily environmental management.

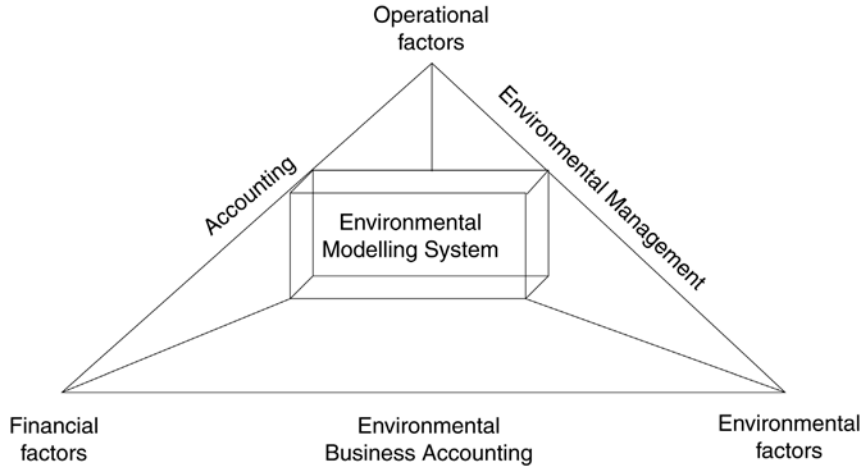

Figure 1. *The framework of the environmental modelling system (modified from Pohjola, 1999 p. 10).*

2 THE FRAMEWORK OF AN ENVIRONMENTAL MODELLING SYSTEM

2.1 Environmental business accounting

Environmental business accounting was first discussed in the 1990s in Europe and the United States. 'Accounting for the Environment' (Gray et al., 1993) which was published in the United Kingdom in 1993, and the research reports published by the Environmental Protection Agency and the Tellus Institute in the USA, are considered the leading publications in the field (Bennett and James, 1997a). In 1996, Epstein published one of the first research papers on environmental performance and cost accounting.

> Increased environmental legislation, public opinion and stakeholders' requirements put pressure on companies to develop their environmental management, accounting and reporting (Halme, 1997, Hofstra and Suerink, 1995, Mätäsaho and Niskala, 1997, van der Bosch and van Riel, 1998). The management of

environmental issues concerns every company because all business operations include environmental aspects (Gray et al., 1993). In general, companies manage the process and financial factors of business processes using the systems of process management and accounting linked together. However, environmental functions, which also need to be analysed and managed, are inherent in a company's operations, but seldom recognised and analysed formally (Shrivastava, 1995).

Developing a system to recognise and improve environmental aspects entails many challenges to existing management and accounting systems. The first significant task is to identify and analyse the environmental factors of business operations and manage them using an environmental management system integrated into the total management system (Epstein, 1996a, Welford and Gouldson, 1993). Secondly, internal environmental cost factors in relation to environmental factors should be defined and analysed for accounting the internal environmental costs of an organisation (Bennett and James, 1997a, Parker, 1995, Schroeder and Winter, 1997). Finally, environmental aspects and their financial factors should be reported so that the decision-making processes in business can be developed (Heiskanen et al., 1997, Spengler et al., 1997).

Environmental performance evaluation and cost accounting are essential methods for analysing alternatives for environmental decision-making, which requires information on the process, environmental and financial functions of the activities, and operations in business (Bennett and James, 1997b). The aim of environmental business accounting is to produce cost information on environmental and financial performance, thereby enabling decision-making on operations, processes and products to include environmental viewpoints (Epstein, 1996b, Schroeder and Winter, 1997, Wills, 1994).

Before environmental business accounting can be developed, a company should develop a system to manage and control its environmental aspects (Klassen and Laughlin, 1996). However, a company needs to extend its understanding of environmental management with the help of environmental business accounting in order to meet the requirements of integrated environmental decision-making.

2.2 Environmental business accounting as part of the framework of environmental accounting

Environmental business accounting is a part of environmental accounting. Environmental accounting as a concept includes both national and business accounting, and deals with both financial and non-financial information (EPA, 1995a, Schaltegger, 1997).

In this study, environmental business accounting is defined to cover the aspects of financial and management accounting in the framework of environmental accounting as defined by EPA (1995a p. 28) as follows: environmental national accounting, environmental financial accounting and environmental management accounting. This definition is rooted in the contemporary discipline of business accounting, covering environmental business accounting needs for both external and internal corporate stakeholders (Klassen and Laughlin, 1996, Schaltegger, 1997).

> Environmental accounting has connections to environmental economics, sustainable development and environmental management. Environmental economics describes interrelations between the environment and its economic aspects (Field, 1997). Sustainable development outlines the ecological use of natural resources (Callan and Thomas, 1996). Environmental management and environmental management systems are the foundation for a systematic approach to environmental aspects in business (Klassen and Laughlin, 1996, Welford and Gouldson, 1993).

Environmental aspects are often linked to quality management in companies because environmental management systems include features that are similar to quality management systems. In general, environmental issues are seen as a part of Total Quality Management (TQM), but according to the arguments concerning environmental aspects above, environmental management requires an extension of TQM. Epstein (1996a p. 66) defines Total Quality Environmental Management (TQEM) as follows: "The TQM principles are applied to environmental management to provide a systematic approach and methodology for continuous improvement in environmental performance." Hence, TQEM forms a method to manage environmental aspects systematically and according to the principles of continuous improvement.

> Environmental business accounting consists of two components: environmental performance evaluation and environmental cost accounting. Environmental performance is an indicator of the ecological effects generated by business operations (Epstein, 1996b). Current environmental performance is defined using evaluation methods such as environmental impact assessment (EIA) and life-cycle assessment (LCA), which are used to identify and estimate direct and indirect environmental loads (Gray et al., 1993). Environmental cost accounting is a method to define internal environmental costs in relation to process and environmental factors of business processes (EPA, 1995a). Environmental risks, liabilities and costs included in business processes are determined according to environmental performance evaluation and ECA. The context of environmental business accounting is depicted in Figure 2.

The framework of a systematic approach to environmental decision-making involves the definition of environmental, financial and process factors and their interrelations needed in the identification phase of a decision-making process. In addition, the framework includes the structure of measurement systems for environmental and financial performance needed in the development phase of decision-making.

> A systematic approach to environmental decision-making processes should take into account the external and internal requirements of environmental aspects in business (EPA, 1994, Miller, 1996, Wolters et al., 1995). Significant external requirements derive from environmental legislation and external stakeholders (Freimann, 1997, Spengler et al., 1997), and in addition to environmental regulations, government incentives and subsidies attempt to advance innovations in pollution abatement (Dobers, 1997, Field, 1997, OECD, 1989). Increasing requirements by various interest groups, such as business partners and customers, also place environmental demands on companies (Chadwick, Garrod and Larsson, 1996, Renn, Blättel-Mink and Kastenholz, 1997). Internal functions include logistics operations, management accounting and the demands of internal stakeholders (Linnanen, Böström and Miettinen, 1994, Moilanen and Martin, 1996). The number of individual factors involved in external and internal requirements is large, and the interrelations between the different requirements also extend the scope of environmental issues (WCED, 1987).

Decision-making processes need accurate information on environmental loads, risks and liabilities, and the legislative and internal environmental costs generated (Wolters et al., 1997). The need for relevant information is an important reason for developing a systematic approach to deal with business functions in relation to environmental factors and costs (Schaltegger and Sturm, 1996). Such an approach should cover the following three dimensions:

- Identification of environmental factors on the basis of external and internal requirements.
- Identification of environmental financial factors.
- Definition of interrelations between environmental, financial and process factors.

Environmental factors should be defined on the basis of an analysis of the requirements and demands of external and internal stakeholders (Earl, 1996, Moilanen and Martin, 1996). The description of business processes is crucial in identifying existing environmental factors in a company (Spengler et al., 1997), and an input-output model of business processes assists in understanding the interrelations between process and environmental factors (Pollack, 1995, Strong, 1995).

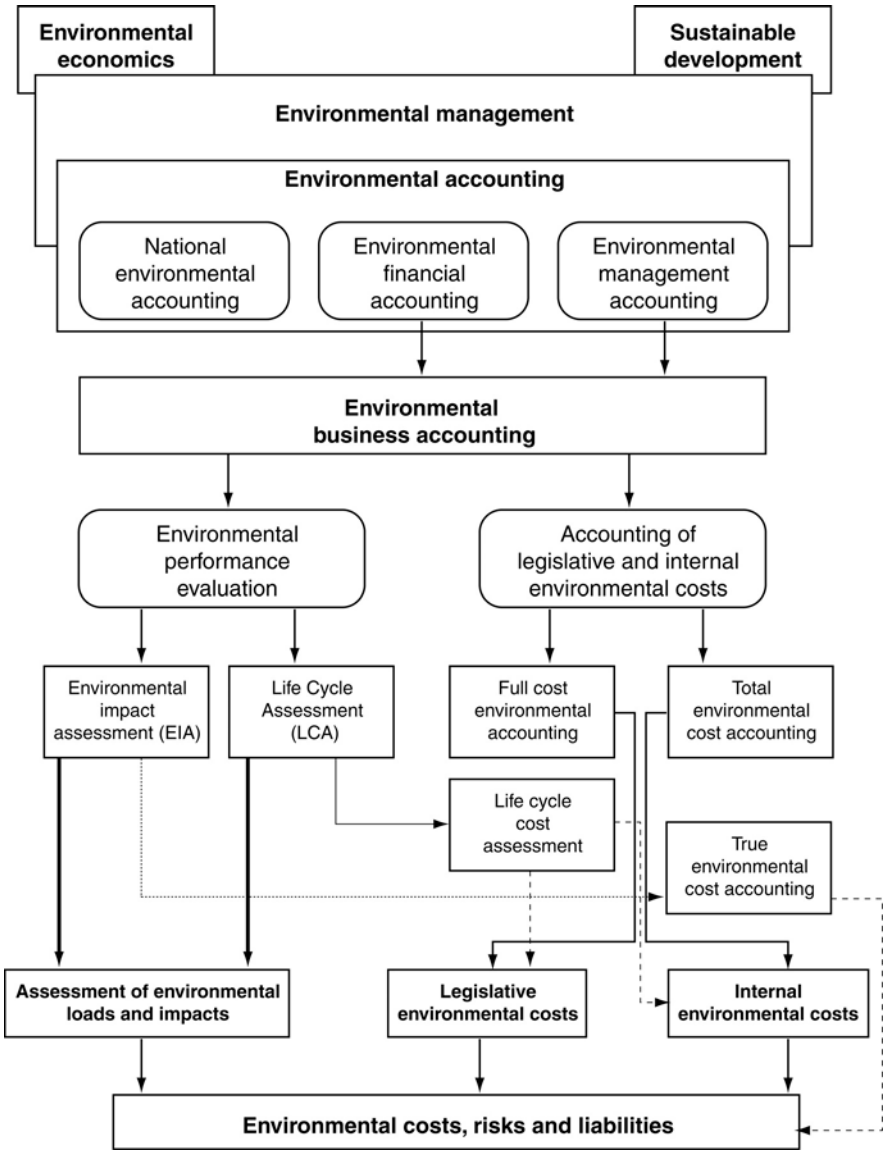

Figure 2. *The context of environmental business accounting as part of environmental accounting (Pohjola, 1999 p. 21).*

A prerequisite for identifying and planning investment costs to improve environmental performance cost-effectively is the determination of legislative and internal environmental costs in a company (EPA, 1995b). Data on legislative and internal environmental costs (direct, indirect and investment costs) are an essential tool for designing and planning environmental improvements in business (Epstein, 1996b).

2.3 The method of an environmental modelling system

The aim of modelling environmental aspects is to combine functional and financial management with environmental management to generate information for decision-making. The modelling of environmental aspects requires two elements: a system to analyse current environmental performance, legislative and internal environmental costs, and alternatives for improving environmental issues; and a system to analyse and manage environmental decision-making processes.

The generic environmental model is developed to connect the process, environmental and financial components of business processes for analysing, managing and reporting environmental aspects and their interrelations. On the basis of the definition of these components, the current environmental performance of business processes and the financial performance of environmental aspects are determined. The relationship between the elements of the generic environmental model is depicted in Figure 3.

The factors used to determine environmental loads are defined on the basis of operational processes. For example, energy consumption includes three components used to determine environmental loads: the amount of energy, the shares of energy sources used to produce energy in power plants, and the emission coefficients of energy production. As another example, transportation consists of four sectors: road haulage, railway traffic, shipping and air traffic, which include their own factors for determining environmental loads. The general environmental factors of transportation are fuel consumption, transport distance or time, weight of freight and the environmental coefficients of the fuel used. The waste management module includes the factors of energy consumption used to determine environmental loads generated by landfill waste management and the factors of transportation to determine the environmental loads caused by waste transportation. In addition, waste burning has its own emission coefficients. Environmental loading factors can vary between different business fields – purchases of raw materials, substances and products, for example – but the basic factors of energy and water consumption, amount and quality of packing materials, amount of transportation, and amount and type of waste are often similar.

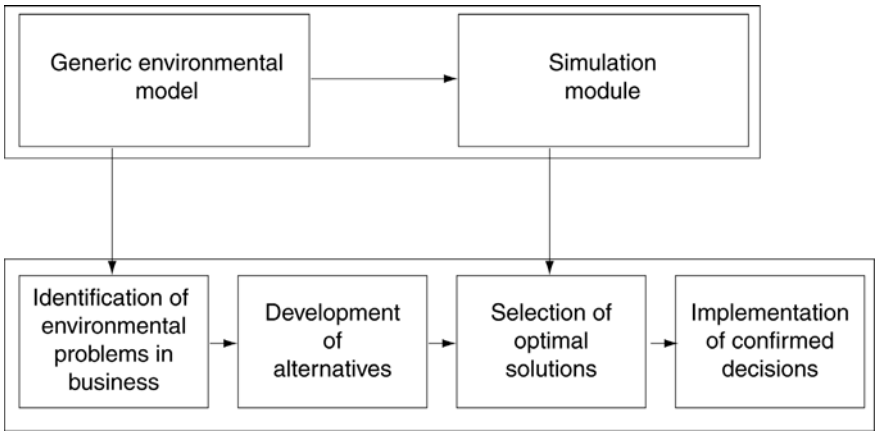

Figure 3. *The foundation of environmental modelling (Pohjola, 1999 p. 57)*

The financial factors consist of costs generated by environmental legislation, the environmental factors of operations, environmental liabilities, and potential revenues from recycling and reusing materials. In the generic environmental model, the principle for determining environmental costs is based on the link between process and environmental factors: if a factor of a process causes indirect or direct environmental loads, it generates environmental costs. Revenues gained when reused or recycled materials, products or goods are sold are included in the accounting of financial factors, which will be determined according to environmental issues in various business fields; the methods for defining environmental costs being similar in most companies.

The first phase of the framework for environmental decision-making is designed to identify, analyse, manage and report factors for defining the current environmental performance of business processes and the financial impacts of environmental aspects in a company. The second phase of the framework includes the determination of the current environmental performance in relation to outputs of operational processes and the financial performance of environmental aspects as measured by legislative and internal environmental costs.

The financial performance of environmental aspects is defined as the relation between the legislative and internal environmental costs and the outputs of process and environmental factors in relation to the pollution generated. The costs of environmental liabilities are not taken into account in the generic environmental model, but they are estimated on the basis of the environmental risks assessed, the environmental loads generated and the financial factors defined.

The simulation module is based on the description of business processes in the generic environmental model. Only the variables of the process, environmental and financial factors specified in the generic environmental model can be simulated. The accounting rules of environmental loads and costs in the simulation module are similar to the rules for accounting current environmental loads and costs. The accounting of investment costs is done using general accounting methods, such as payback periods, net present value or annuity. The environmental risks related to the alternatives are estimated on the basis of the amount and type of environmental loads, the assessments of environmental impacts generated by emissions, effluents and waste, and the environmental and process factors. Environmental liabilities and their costs are assessed by the company on the basis of environmental risks and the financial performance of environmental aspects. Consequently, the simulation module offers a method of managing the three phases of the decision-making processes concerning environmental improvements to business processes.

2.4 Computer-aided application of environmental modelling

The purpose of a computer-aided application to combine operational, environmental and financial functions of business processes is to assist companies in managing their business processes from an environmental point of view. A computer-aided application enables a company to analyse, manage and report the significant factors of environmental loading caused by business operations; it should have a dynamic design structure because the system has different requirements for different kinds of business.

The *Environmental Internet System* (EIS) is a tool for companies (particularly SMEs) to monitor and improve their environmental aspects and performance. The EIS was designed to complement firms' environmental management systems by collecting and managing environmental data. In addition to harmonising the information collected on environmental issues, the EIS also encourages companies to use the same meters and indicators to evaluate their environmental performance and offers a basic form of environmental reporting, such as the Environmental Statement required by EMAS. Environmental reports can be compared using coordinated metrics and indicators, and information for national environmental reports can be collected. The EIS tool is a web-based application, so no special software is required beyond a browser, though you do need to buy a licence to use it. For an SME, this is currently about EUR 1,500 per year. The EIS application has five main elements:

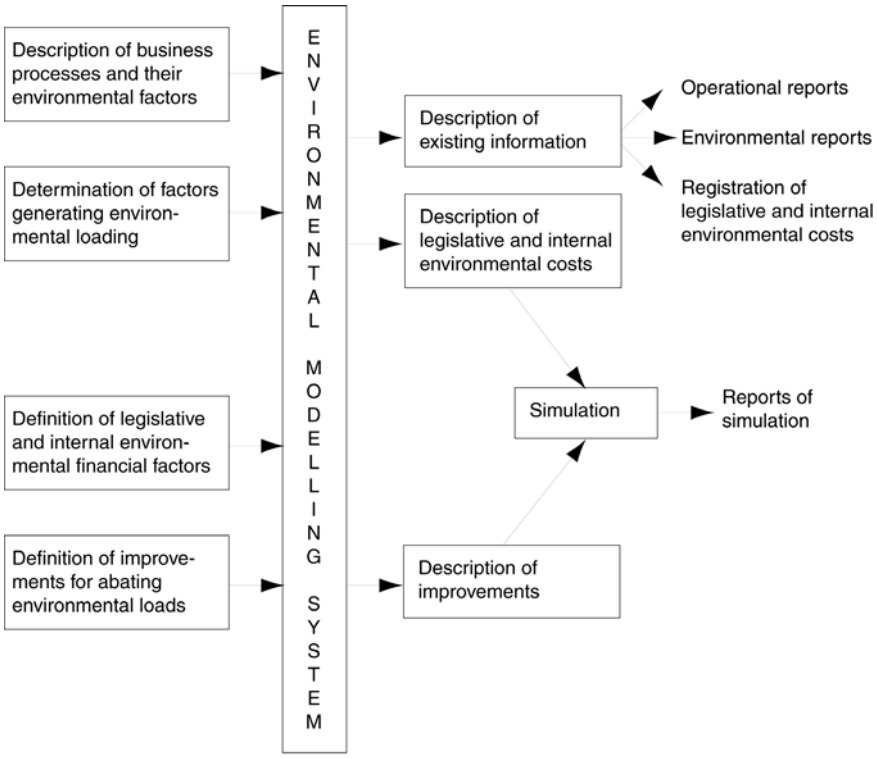

Figure 4. *The framework of an environmental model for analysing operational, environmental and financial factors in the business processes of companies (Pohjola, 1997).*

1. Defining the environmental strategy of a company

This element contains the key business operations and the main environmental requirements for a business field, as well as alternatives for each part of a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis.

2. Information on a company's business processes

Data on operational processes and their financial implications includes the following:

- Amount and costs of raw materials and other purchases
- Amount and costs of energy and water consumption
- Distances and costs of transportation
- Amount of waste and costs of waste management.

3. Elements for documentation of the EMS
By means of this element, data on environmental agreements, audit programmes, persons who are accountable for developing environmental issues, and further information needed to develop a firm's EMS are entered into the tool.

4. Training tool
The training tool was developed to help EIS users clarify environmental expressions and terms, and it can also be used as part of a company's environmental education programme.

5. Reports generated by the EIS tool
Environmental reports are classified into three categories:

- Documentation of the environmental management system
- Environmental reports for customers and government
- Environmental reports for internal use, containing information on operational, environmental and financial indicators used in the firm.

The core idea of EIS is to qualify information collected on environmental issues and the metrics used to evaluate environmental performance, but equally to improve environmental reporting. The EIS enables cooperation between firms (particularly those operating in the same field) on related environmental issues, allowing them to exchange information and experiences and further develop the tool. The structure of the tool is shown in Figure 5.
On a technical level, the EIS uses a Linux database accessible over the Internet. Apart from the annual licensing costs, EIS is also inexpensive to use because the only cost is the Internet connection. This web-based tool is offered to companies as a service of Bitblit Ltd, a Finnish IT firm.

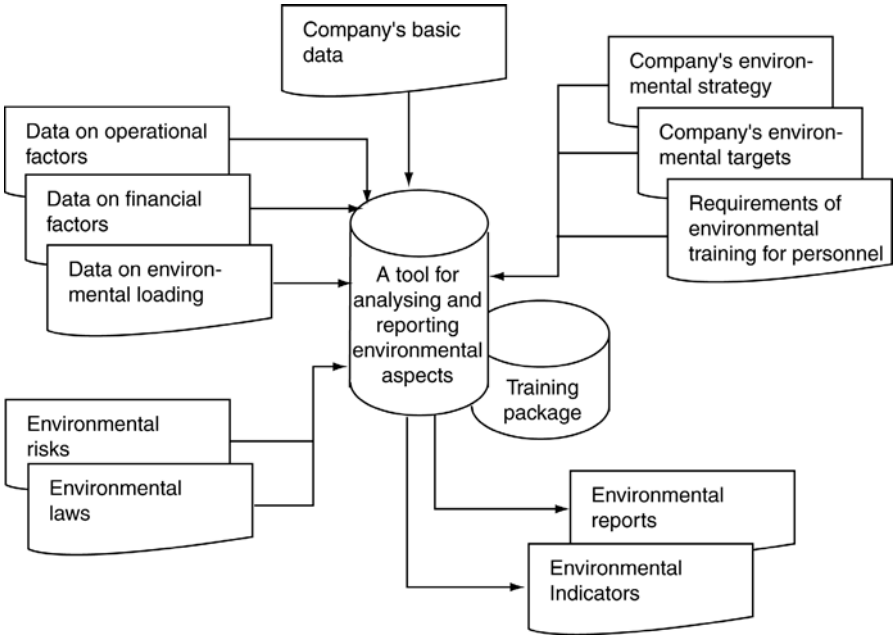

Figure 5. *The structure of an Environmental Internet System*

3 TWO EXAMPLES OF AN ENVIRONMENTAL INTERNET SYSTEM (EIS)

These two cases represent two different business fields: the graphics industry and transport services. The graphics industry is also an example of logistics chains and covers energy consumption, transportation and waste management – an important environmental area for this industry. Transport services include the phases of transportation (loading, transporting and unloading) and data on maintenance works and fuel consumption, which can be entered into the modelling system.

The case studies were carried out according to a uniform framework. Firstly, the business process was selected and its process, environmental and financial factors were defined. Secondly, the measurements of variables and the values of environmental parameters included in the model were defined, and the computer-aided model was adapted to the case study. Thirdly, the current environmental performance was analysed, and alternative improvements were identified.

3.1 The graphics industry

The main environmental issues of the graphics industry include the consumption of paper and various solvents, and the amount of hazardous waste generated. The amount of energy and water consumption is considerable, and logistics operations cause direct environmental loads. The EIS tool (www.4eis.net) is currently in use in

Table 1. *Environmental metrics of the graphics industry*

Accounting level: annual or monthly total

	Operational factor	*Data source*	*Reporting unit*	*Measurement unit*
Acquisition	Paper and board Newsprint Fine paper Magazine printing paper Other cardboard Chipboard Labels Corrugated board Others	Store bookkeeping	Tons	Tons
	Dissolvents	Store bookkeeping	Litres	Litres
	Repro chemicals	Store bookkeeping	Litres	Litres
	Printing inks	Store bookkeeping	Litres	Litres
	Glues	Store bookkeeping	Litres	Litres
	Printing plates	Store bookkeeping	Block	Blocks
	Product packages	Store bookkeeping	Kg	Tons
	Acquisition packages	Store bookkeeping	Kg	Tons
	Damping solution additives	Store bookkeeping	Litres	Litres
	Amount of acquisition transportations	Store bookkeeping	Km	Tons
Purchases	Purchases, paper	Bookkeeping or Bills of freight	Tons	Tons
	Purchases, dissolvent	Bookkeeping or Bills of freight	Litres	Litres
	Purchases, repro chemicals	Bookkeeping or Bills of freight	Litres	Litres
	Purchases, toner	Bookkeeping or Bills of freight	Litres	Litres
	Purchases, glues	Bookkeeping or Bills of freight	Litres	Litres
	Purchases, printing plates	Bookkeeping or Bills of freight	Block	Blocks
	Purchases, product packages	Bookkeeping or Bills of freight	Kg	Tons
	Purchases, acquisition packages	Bookkeeping or Bills of freight	Kg	Tons
Delivery	Delivery transportations	Logistics database	Km	Km
Energy and water consumption	Consumption, electricity	Metrics of buildings	kWh	MWh
	Consumption, heat energy	Metrics of buildings	kWh	MWh
	Consumption, fabrication water	Metrics of buildings	m3	m3
Process factor	Amount of used paper	Counting value	Tons	Tons

	Operational factor	*Data source*	*Reporting unit*	*Measurement unit*
Waste management	Recycled paper	Waste bookkeeping	Tons	Tons
	Recycled cardboard	Waste bookkeeping	Tons	Tons
	Assorted waste	Waste bookkeeping	Tons	Tons
	Scrap metal	Waste bookkeeping	Tons	Tons
	Hazardous waste	Waste bookkeeping	Tons	Ton
	Waste water	Metrics	m3	m3
	Waste management transportations	Bookkeeping	Km	Km
Personnel transportation	Personnel transportation	Bookkeeping	Km	Km
Environmental costs	Costs, acquisition transportations	Bookkeeping	Euros	Euros
	Costs, delivery	Bookkeeping	Euros	Euros
	Costs, electricity	Bookkeeping	Euros	Euros
	Costs, heat energy	Bookkeeping	Euros	Euros
	Costs, fabrication water	Bookkeeping	Euros	Euros
	Waste management costs, paper	Bookkeeping	Euros	Euros
	Waste management costs, cardboard	Bookkeeping	Euros	Euros
	Waste management costs, assorted waste	Bookkeeping	Euros	Euros
	Waste management costs, scrap metal	Bookkeeping	Euros	Euros
	Waste management costs, hazardous waste	Bookkeeping	Euros	Euros
	Waste water fee	Bookkeeping	Euros	Euros
	Costs of personnel transport	Bookkeeping	Euros	Euros

six Finnish printing houses; the main environmental metrics used for accounting and calculating are shown in Table 1.

The calculating rules for environmental loads were defined when operational factors were defined and the system for collecting data on these factors was planned. The EIS includes the database which contains all the rules for calculating various environmental loads; the database also includes the environmental parameters needed for calculation, which were provided by research centres such as the VTT Technical Research Centre of Finland. Environmental loads calculated in the EIS are shown in Table 2.

The initial project involving four Finnish printing houses started in 1999 and finished in 2000. It defined environmental indicators for that business field, which are still used today when printing houses report their environmental issues. The indicators are shown in Table 3.

Table 2. *Environmental loads calculated in the EIS*

Load	*Calculating unit*	*Reporting unit*
Power production Carbon dioxide CO_2	Kg	Tons/year
Power production Carbon oxide CO	Kg	Kg/year
Power production Sulphur dioxide SO_2	Kg	Kg/year
Power production Nitrogen oxides NO_2	Kg	Kg/year
Power production Hydrocarbon HC	Kg	Kg/year
Power production Particles	Kg	Kg/year
Transportation Carbon dioxide CO_2	Kg/km	Tons/year
Transportation Carbon oxide CO	G/km	Kg/year
Transportation Sulphur dioxide SO_2	G/km	Kg/year
Transportation Nitrogen oxides NO_x	G/km	Kg/year
Transportation Hydrocarbon HC	G/km	Kg/year
Transportation Dinitrogen oxide N_2O	G/km	Kg/year
Transportation Particles	G/km	Kg/year
Transportation Methane CH_4	G/km	Kg/year

3.2 Road haulage/LIFE02 project

The main direct environmental loads of transport services are generated by fuel consumption, dust, noise caused when trucks are used and hazardous waste from vehicles maintenance works. Fuel consumption and distances driven can be measured accurately, but dust and noise measurement are more complicated and the determination of environmental effects generated by them can be only estimated. In addition, indirect environmental loads are generated by vehicle manufacture. EcoTra is a tool for collecting data and calculating and reporting environmental indicators in road haulage. The tool was developed as part of the LIFE project 'Environmental Management Systems for Small and Medium-Sized Companies'[1]. The environmental metrics of road haulage are shown in Table 4.

Table 3. *Indicators of printing houses*

Indicator	***Unit***
Environmental efficiency	
Consumption, electrical energy/amount of used paper	kWh/tons
Consumption, heat energy/amount of used paper	kWh/tons
Consumption, fabrication water/amount of used paper	m^3/tons
Amount of dissolvent/amount of used paper	Litres/tons
Amount of chemicals/amount of used paper	Litres/tons
Amount of assorted waste/amount of used paper	Litres/tons
Maculature/amount of purchased paper	Tons/tons
Amount of acquisition and delivery transportation/amount of used paper	Km/tons
Amount of waste transportations/amount of used paper	Km/tons
Amount of personnel transportation/amount of used paper	Km/tons
Amount of hazardous waste/amount of used paper	Tons/tons
Economic efficiency	
Energy costs/amount of used paper	Euros/tons
Water costs/amount of used paper	Euros/tons
Disposal costs of hazardous waste/amount of used paper	Euros/tons
Waste disposal costs paper/amount of used paper	Euros/tons
Waste disposal costs other/amount of used paper	Euros/tons
Transportation costs other/amount of used paper	Euros/tons
Environmental loading	
Energy consumption CO_2/Quantity of paper used	Tons/tons
Transportation CO_2/Quantity of paper used	Tons/tons

Table 4. *Environmental metrics of road haulage*

Operation factor	*Data source*	*Reporting unit*	*Measurement unit, Accounting level*
Distance driven	Driver gives data or it is collected by a black box*	Km	Km, Drivers/month or Drivers/year Km, Drivers/customers (the accounting done for a vehicle and for a company)
Road journey	Driver gives data or it is collected by a black box	Km	Km, Annual or monthly total
Town journey	Driver gives data or it is collected by a black box	Km	Km, SAnnual or monthly total
Freight	Driver gives data or bill of freight	Tons	Tons, SAnnual or monthly total
Volume	Driver gives data or bill of freight	m3	m3, Annual or monthly total
Loading time	Driver gives data or it is collected by a black box	Hour	Hours, SAnnual or monthlyr total
Unloading time	Driver gives data or it is collected by a black box	Hour	Hours, Annual or monthly total
Total work time	Driver gives data or it is collected by a black box	Hour	Hours, Annual or monthly total
Status of journey			
Fuel consumption	Driver gives data or is collected from oil companies	Litre Litre / 100 km	Litres, Fuel consumption/ month or Fuel consumption/ year (accounting done for a vehicle and for a company)
Maintenance and repair	Driver gives data	Euro	Euros, Annual or monthly total
Tyres	Driver gives data	Euro	Euros, Annual or monthly total

* A black box is a mechanical device installed in a vehicle for registering distances driven and fuel consumption.

The environmental loads calculated using the EcoTra tool (the EIS being used) are shown in Table 5.

Table 5. *Environmental loads calculated by EcoTra*

Load	*Calculating unit*	*Reporting unit*
Carbon dioxide CO_2	Kg/km	Tons/year
Carbon oxide CO	G/km	Kg/year
Sulphur dioxide SO_2	G/km	Kg/year
Nitrogen oxides NO_x	G/km	Kg/year
Dinitrogen oxide N_2O	G/km	Kg/year
Particles	G/km	Kg/year
Methane CH_4	G/km	Kg/year
Hydrocarbon HC	G/km	Kg/year

The types of hazardous waste measured are shown in Table 6.

Table 6. *Types of hazardous waste*

Type of waste	*Data source*	*Reporting unit*	*Measure unit, Accounting level*
Oil filters	Bookkeeping	Litres/year	Litres, Annual or monthly total
Waste oil	Bookkeeping	Litres/year	Litres, Annual or monthly total
Tyres	Bookkeeping	Euros/year	Euros, Annual or monthly total

Environmental metrics of energy and water consumption of buildings are shown in Table 7.

Table 7. *Metrics of energy and water consumption*

Objective	*Data source*	*Reporting unit*	*Measure unit, Accounting level*
Electricity consumption	Bookkeeping	MWh/year	MWh, Annual or monthly total
Heating energy consumption	Bookkeeping	MWh/year	MWh, Annual or monthly total
Water consumption	Bookkeeping	m^3/year	m^3, Annual or monthly total

Indicators used for environmental reporting were defined in collaboration with Finnish transport companies some years ago. There are a few companies which have used these indicators in their reports.

Indicators of road haulage are as follows:

Fuel consumption	Litres/100 km
Tyre usage	Euros/100 km
Maintenance costs	Euros/100 km
Repairing costs	Euros/100 km
Hazardous waste costs	Euros/100 km

The process management procedure and environmental management systems varied between different companies. In the case studies in which a process management system was not outlined, the definition of process factors required more time than the author had expected. The lack of a documented environmental management system was not a critical aspect because the only benefit for modelling in companies using environmental management systems was in data collection. Several companies started to form their own environmental management systems when they tested the modelling system. However, when a company had to measure and collect data according to legislative requirements, the testing of the environmental modelling system was more systematic. Existing accounting systems did not include cost allocation, and so the collection of data on the internal environmental cost factors defined was difficult. Consequently, when a company has good knowledge of its processes and process factors, the definition of environmental factors can best be realised. The definition of internal environmental cost factors is not a problem, but the collection of cost data on environmental aspects is frequently difficult because firms do not use the method of cost allocation, but account for internal environmental costs in their overheads.

4 CONCLUSIONS

The focus of this study is environmental business accounting in relation to environmental management. The method of the environmental modelling system developed in the study connects environmental performance to process management, financial aspects and management accounting in business processes. The environmental modelling system is designed to address the needs of managing environmental aspects in relation to the process and financial factors of business processes, and the requirements for environmental management caused by internal and external stakeholders. The two examples presented above proved that the environmental modelling system enables companies to use a systematic approach to environmental aspects in relation to process management and management accounting. The examples – the graphics industry and road haulage services – show how companies are using the method to achieve better environmental reporting and improve their environmental performance. The application of the model to the graphics industry is now in use by

six Finnish printing houses, while the application to road haulage services is being tested in ten logistics companies in Finland, Hungary and Portugal.

The method of the environmental modelling system includes the following steps:

- Defining the process, environmental and financial factors of business processes, and their interrelations.
- Determining environmental loads, risks and liabilities on the basis of the factors defined above.
- Determining the elements of environmental business accounting:
- Current environmental performance.
- Legislative and internal environmental costs.
- Determining financial performance of environmental aspects.
- Reporting information on the current environmental performance and the financial performance of environmental aspects.
- Identifying processes and operations in which environmental performance can be improved.
- Identifying the conditions for developing the environmental aspects of processes and operations selected.
- Defining alternative solutions to improve environmental performance in relation to financial performance.
- Simulating the solutions selected by determining environmental loads, assessing the environmental risks and liabilities generated by the alternatives, and calculating the profitability of the investments planned.
- Comparing the environmental and financial outcomes of alternatives with the current environmental and financial performance.
- Selecting the solutions that are the most effective in improving environmental and financial performance for use in decision-making processes.

The environmental modelling system was developed using the modelling framework and the applications of the three basic environmental models designed by Pohjola as part of her PhD thesis (Pohjola, 1999). The modelling of environmental aspects included in a business process could be realised in each case study, but the extent of these studies varied according to the size of the company, so the modelling framework, a basic environmental model and its computer-aided model, needed to be adapted for each case study. The method of the environmental modelling system can be used in companies which operate in different business fields, and can be adapted to the needs of small, medium-sized and large companies. Consequently, the environmental modelling system developed in the thesis forms a method to identify, analyse and improve environmental aspects as an integrated part of business management.

The scope of the environmental modelling system was limited in terms of external environmental costs, comprehensive life cycle assessments and environmental impact assessments, and analyses of the social and ethical consequences of business processes. According to Gray, et al. (1993), Epstein (1996c), Klassen and Laghlin (1996), Linnanen et al. (1994), Schaltegger and Sturm (1996), and Welford and Gouldson (1993), the first phase in environmental improvement is to manage environmental aspects in relation to companies' own business operations. The second phase is to develop an environmental management system, which enables an organisation to extend the consideration of environmental issues to external issues, such as social environmental costs and comprehensive life cycle assessments. Ethical questions related to environmental issues cover various political, global, local and economic viewpoints, and the research field is extremely wide. However, the connection between business operations and ethical questions is included in the principles of sustainable development, which is generally considered relevant for the environmental strategy and policy of companies. Consequently, when the understanding of and responsibility for environmental issues increases in business, the environmental modelling system is a method to advance companies' knowledge of environmental aspects, thus enabling an extension of the scope of environmental management to social and ethical fields.

NOTES

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