Environmental Management Information Systems – Illustrations from Online Communication and Sustainability Reporting

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Abstract: Environmental Management Information Systems (EMIS) are socio-technological systems used as business applications to gather, process, and provide environmental information, inside companies and in exchange with other actors in industry. They help to identify environmental impacts and support measures avoiding these impacts or reducing them. EMIS provide the necessary information support for decision making in companies. Hence, EMIS can be viewed as certain Information Systems (IS) usually implemented in companies as a part of their Environmental Management Systems (EMS). In order to give a tangible example with practical implications, the developments that EMIS have passed the last years are described along the field of “online communication and sustainability reporting” and illustrated by a case study. This area represents an emerging digital and fully ICT (information and communication technologies) supported approach within EMIS, using current internet technologies and services. It makes clear the array of capabilities of latest EMIS to be exploited for the improvement of advanced environmental and sustainability management, finally to the benefit for companies and their various stakeholders. The case study describes the concept and implementation of a software tool with shopping cart functionality providing sustainability reports à la carte so that stakeholders (i.e. users, readers) can create their own report on the fly, exactly meeting their detailed information needs and preferred media out from a single publishing database. This software tool which represents a module of a comprehensive EMIS is implemented as a web-based ICT application. Its performance goes beyond the leading-edge approach of O2 who provides a personalized reporting feature on its website that could be regarded as best practice and pioneering effort in sustainability online reporting, so far.

Keywords: Environmental Management Information System; Online Communication, Sustainability Reporting

1. INTRODUCTION

Environmental Management Information Systems (EMIS) are socio-technological systems used as business applications with the aim to gather, process, and provide environmental information, inside companies and in exchange with other actors in industry. Hence, EMIS can be viewed as certain Information Systems (IS) usually implemented in companies as a part of their Environmental Management Systems (EMS). Perhaps the most known and famous examples of EMS are the world-wide standard ISO 14000 series (ISO 2008) and the European Union’s Eco-Management and Audit Scheme (EMAS) (European Commission 2008). These EMS are applicable for companies and other organizations to evaluate, report and improve their environmental performance. For example, EMAS has been available for participation by companies since 1995 and was originally restricted to companies in industrial sectors. Since 2001 it has been open to all economic sectors including public and private services. Despite some differences between ISO 14000 and EMAS in detail, the central objective is the same, i.e. to improve environmental performance on a continuous basis.
Since its launch more than two decades ago, the field that we call today as “Environmental Management Information Systems” (EMIS) has rapidly evolved (Donley et al. 1998). At first, Environmental Information Systems (EIS) were used primarily in the public sector, e.g. (i) to raise public awareness of the condition of public goods like the atmosphere or recreation areas, (ii) to support political decisions that have effects on nature by tools for modeling and simulation, (iii) and to help executing environmental policy e.g. by monitoring (Page and Hilty 1995). Several years ago, however, a growing market has come about for IS that support EMS. For sure, early pioneers in EMS and few sector-leaders in eco-sensitive industries have had in place some forms of EIS before. But at least since the late 1970s, EIS in business applications became a topic of broader interest in academia, industry, and administration, and – as a result – more widespread and finally an issue in its own right (Rautenstrauch and Patig 2001). The development path that EMIS have passed could be described as a movement away from standalone IS and single tools focused on certain environmental aspects like legal compliance or material input and energy consumption. These rather isolated ICT solutions mostly served basic functions in procurement and production, and hence they could provide solely limited managerial support.

Today, comprehensive EMIS are available that help to assess even a firm’s integrated sustainability performance (i.e. environmental, social, economic, and mutual interrelations). These sophisticated forms of EMIS are based on flexible ICT architectures, often using current internet technologies and services. They are embedded in corporate-wide ICT networks combining business processes and organizational units. Further, interfaces facilitate information exchange with external stakeholders and enable continuous updates from data sources, inside and outside the companies. Such leading-edge EMIS offer a number of opportunities to support decision making, finally almost able to assess companies’ activities in physical and monetary terms: (semi-)automated, in real time, online, and in a tailored fashion (Hilty et al. 2005). Currently, using EMIS is part of companies’ daily affairs, and has entered the business mainstream. Due to technological progress in ICT applications and improvements in computer science, the question should be now to choose the right EMIS that meets current needs and future requirements, but no longer whether to use EMIS at all. The currently limiting factor may not be of technological nature based in ICT but rather organizational, rooted in corporate management and business strategy (Perl 2006).

2. ENVIRONMENTAL MANAGEMENT INFORMATION SYSTEMS

From an academic perspective, research on EMIS is located at the intersection between Environmental Informatics and Business Information Systems (fig. 1).

![Classification of EMIS](Hilty and Rautenstrauch 1995, 295)

While the object of research in Business Information Systems is the design of IS primarily for companies serving industrial purposes, often with a commercial intention, the focus in Environmental Informatics is in the development and application of EIS in general, be it implemented in the public or in the private sector. From a systematic perspective, Environmental Informatics represents a goal-driven field of research, whereas the field of Business Information Systems looks like...
an entity-based one with an industrial focus in business applications at firm’s level. Regarding to these two fields of research and their specific intellectual heritage, it becomes clear that EMIS relate to both, Environmental Informatics as well as to Business Information Systems. On the one hand, EMIS are part of Environmental Informatics due to the environmental focus; on the other hand, EMIS also belong to Business Information Systems as EMIS are developed and designed for companies and implemented as business applications.

The central purpose of EMIS is to support EMS. EMS themselves prototypically fulfill a number of basic tasks, i.e.: analysis, plan, implementation and controlling, and check. These tasks are laying at the heart of any EMS, even the standardized ones like the European EMAS and the world-wide applicable EMS according to the ISO 14000 series. Any basic task in EMS corresponds to certain functions that EMIS may support (fig. 2).

Legal compliance and other stakeholders’ requirements are the driving forces that push companies to improvements so that they may do more than smart ”green-washing”. First, EMIS help to comply with laws and regulations. They provide insights into complex legal frameworks, e.g. on the information retrieval networks for environmental regulations. Further, they assist decision makers in discovering business activities that are of relevance for environmental regulations, e.g. by emission monitoring. Second, EMIS also enable to get feedback from their target groups and to capture requirements from a larger audience. Such feedback loops are usually installed in the form of stakeholder relations management systems. Next, EMIS support material flow management, including material flow modeling and evaluation. For example, EMIS provide help when identifying the material and energy inputs, collecting the relevant data, and preparing an eco-balance. Based upon insights drawn from the eco-balance, EMIS further assist the impact assessment and balance valuation in order to assess environmental impacts due to material and energy flows. Once material flows are modeled and evaluated, EMIS help to improve eco-efficiency. The measures that could be taken range from product life cycles, production processes, to whole companies. These certain entities can be viewed as material flow systems and being optimized in terms of eco-efficiency. Therefore, a number of elaborated instruments offer methodological support, like Life Cycle Analysis (LCA) and Design for the Environment (DFE), just to mention a few. When the measures for improvement in EMS have been implemented and controlled according to eco-efficiency, then all activities and results need to be documented and communicated. Here EMIS provide an array of benefits to improve communication and reporting both, for companies and their stakeholders. For example, EMIS can overcome the restrictions of freestanding documents with limited contents, print media fixation, disclosure in a one size fits all fashion, and one-way-communication. Together, the basic tasks in EMS and corresponding EMIS functions are building a closed loop procedure, finally leading to a process model of continuous environmental improvements (fig. 2).

Figure 2: Process model of EMIS, illustration
Ideally, the different EMIS functions are combined to a coherent system and fully integrated into companies’ IS, while supporting all the tasks throughout an EMS (Rautenstrauch 1999). Despite progression companies have made in recent years and concepts of integration that have been proposed, however, EMIS are usually not incorporated elements, today (Isenmann and Rautenstrauch 2007). Particularly they are not part of Enterprise Resource Planning (ERP) systems. Such an integration has just partly taken place. For example, in my SAP® PLM (Product Lifecycle Management), there is a module on Environment, Health and Safety (EH&S). Its focus though is limited to the documentation of waste management following national laws for handling hazardous goods (SAP 2005). In order to give a tangible example with practical implications, the developments in EMIS are described along the field of “online communication and sustainability reporting” (Isenmann and Bey 2007; Isenmann et al. 2007) and illustrated by insights from a case study.

3. ILLUSTRATIONS FROM ONLINE COMMUNICATION AND SUSTAINABILITY REPORTING

Corporate sustainability reporting is a balanced reporting approach through which companies are communicating the three pillars of environmental, social, and economic performance and its mutual interrelations to various stakeholders. Hence, sustainability reporting can be viewed as the “front end” in the process model of EMIS (fig. 2), communicating activities and performance, inside and outside the companies. Further, it is a driver that stimulates companies to continuous environmental improvements when passing the circle again. At present, the vast majority of advanced environmental and sustainability reports are uniformed documents, usually prepared as one size fits all reports, still. This is even the case for online available reports.

4 CASE STUDY: SUSTAINABILITY REPORTING À LA CARTE – BEYOND BEST PRACTICE BY O₂

The case study describes the concept and implementation of a software tool with shopping cart functionality providing sustainability reports à la carte. Stakeholders (i.e. users, readers) can create their own tailored report in an interactive manner on the fly, while exactly meeting their detailed information needs and preferred media. This software tool is a module of a comprehensive EMIS. It is implemented as a web-based ICT application.

4.1 Challenges

The provision of reports on various media, and tailoring reports according to users’ needs and preferences, while exactly meeting numerous standards, guidelines, and recommendations, are two major difficulties with which companies are struggling at present.

Figure 3: O₂’s reporting feature (2008)
Today, an orthodox disclosure practice which merely provides isolated documents and stand-alone printed reports is not sufficient any longer. A substantial amount of information, matters of communication style, and the provision of tailored communication vehicles on various media are required (Isenmann and Kim 2006). O₂, a global player in telecommunications, provides a personalized sustainability reporting feature on its website (fig. 3). This could be regarded as best practice and pioneering effort, so far: Users can tailor the content by selecting issues from a catalogue, and they can choose the preferred media: HTML to view the report or PDF to print and save the report.

### 4.2 Concept

In order to go beyond this approach in tailored online reporting, a software tool with an elaborated shopping cart functionality was developed (see fig. 4: moving from cell I to cell IV). The conceptual basis is a classification proposed by Lenz (2003): He arranged the different strategies to fulfill target group tailoring along two dimensions (fig. 4): (i) degree of user modeling, representing the overall model of a user or a certain user group, and corresponding to information needs identified and preferences stored in user profiles: stereotyping, individualization, and personalization; (ii) degree of system adaptation, representing the capabilities to adapt the ICT application to users’ needs, and corresponding to the extent of a system’s facilities for tailoring: adapted, adaptable and adaptive applications. Following a generic information management approach (Isenmann and Marx Gómez 2004), three further tasks had to be carried out: (i) modeling the information demand, i.e. conducting a stakeholder analysis and information requirement analysis, (ii) modeling the information supply, i.e. designing suitable XML-based documents (schema, style sheets, document), and (iii) cross matching demand and supply, i.e. designing the software tool.

![Figure 4: Classification of target group tailoring (Lenz 2003, 212)](image)

### 4.3 Implementation

The software tool is implemented as a prototype. In order to showcase the performance and features of this tool compared to current best practice, the content of a digitalized sustainability report of Otto (2004), a German multi-channel retailer, was used. This report was already available as an XML document. At the heart of the software tool’s ICT architecture lies Apache Cocoon (2008), a Java-based, modular-structured open source publishing framework, able to process XML schemas and to transform and format XML documents. It is thus suitable to perform single-source cross-media reporting. Sustainability reports à la carte are made possible, prepared by machine processing, and generated in an automated manner. The ICT architecture allows report contents to be stored, retrieved, edited, updated, controlled and then output cross-media in a variety of ways. The reason why Apache Cocoon has been employed lies, among other benefits, in its sophisticated application logic. The modular components could be arranged in a flexible way, serially grouped in pipelines where different reports are then dynamically created on the basis of an underlying XML-based schema (fig. 5).
4.4 Sustainability reporting à la carte in practice

The procedure of using the software tool is like the following: First, users decide whether they may receive a predefined report corresponding to the information needs prototypical to a certain target group, or whether they may create their own report, exactly meeting their individual information needs (fig. 6). The software tool provides a catalogue of predefined report contents e.g. for investors, customers, employees, media representatives, suppliers, and non-governmental groups. Further, the catalogue also covers profiles exactly meeting the requirements of EMAS and of the GRI guideline (GRI 2006), i.e. the de-facto-standard in sustainability reporting. For example, some users such as local authorities are interested in how the company has met the EMAS requirements in order to aggregate environmental impacts for a certain area.

Figure 6: Software tool for sustainability reporting à la carte, illustration
Second, users can fine-tune in a flexible and easy to use manner what contents should finally be included in their shopping cart (fig. 7).
Third, users can choose different output formats (fig. 8): HTML to view reports in the web browser, PDF and Postscript to save and print reports, and – more important – XML to process data automatically by machinery. Among other aspects needed to link the micro-macro-perspective between single companies and their aggregation to a regional level (Seifert 2000; Rathje 2001), it is the progression in ICT that has now opened the window to better exchange environmental information among companies and within the industrial sector. No less important, the interoperability with public agencies could be improved.

In contrast to the progression O2 and other companies – even the award winning ones – have made the last years, however, current sustainability (online) reporting practice shows significant room for improvements, particularly in interactivity and target group tailoring. The concept and implementation of a software tool with shopping cart functionality shed light on how advanced environmental and sustainability reporting as an integral part of EMIS could be further developed, especially in terms of interactivity and target group tailoring.

5. CONCLUSIONS

The example that has been presented from the field of “online communication and sustainability reporting” is merely a part of a comprehensive EMIS. The whole EMIS includes a number of modules. For example, another module supports the continuous workflow throughout the EMIS process model (see fig. 2), ranging from (i) the extraction of environmental data out from ERP (enterprise resource planning) systems, (ii) the modeling of the material flow network, (iii) eco-balancing, (iv) impact assessment and (v) balance valuation performed by the software tool “Umberto”, through (v) the production of various communication vehicles (Marx Gómez and Rautenstrauch 2001). In total, the whole EMIS allows report contents to be created (semi-)automatically (i.e. the quanti-
tative data), stored, retrieved, edited, updated, controlled and then output cross-media in a variety of ways (the single-source cross-media principle).

Of course, communication and reporting represent just one task that has to be managed within an EMIS. However, the example of the software tool presented here makes clear the array of capabilities of latest EMIS to be exploited for the improvement of advanced environmental and sustainability management, finally to the benefit both, for companies and their various stakeholders, even for public agencies. The case study may particularly highlight that leading-edge EMIS with a module for online communication and (sustainability) reporting could elevate the orthodox “one size fits all” disclosure practice of environmental reports to a sophisticated digital stage. Reports could be developed from being universal documents on print media to valuable communication vehicles which provide substantial and reliable information in a tailored fashion and are available on various media – due to an underlying single source cross-media principle. For example, following the EMAS reporting requirements, then the reports also may guarantee the reliability of the information provided (European Communities 2001).

Numerous stakeholder, be they private, public, or industrial, are no longer satisfied solely with environmental reports and other communication instruments on print media or mere electronic duplicates. Advanced environmental (and sustainability) reporting is becoming increasingly relevant both, for decision-making in industry and for public agencies. Responding to multiple inquiries that a variety of stakeholders are making to companies is time-consuming and costly (Axelrod 2000). Rather than endure these procedures, companies are recognising the value of having a readily available EMIS to provide the data which is needed.

Pioneering companies have started, or in the near future will start to implement, suitable applications. For example, Verie Sandborg, Baxter International’s manager of EH&S requirements, regards a good environmental or sustainability report as an excellent source for responding to formalised requests for environmental or sustainability information (Axelrod 2000). Many of the questions asked are already answered in meaningful reports. Hence, it would be helpful to have proper EMIS with software tools in place supported through an efficient information management. Users could extract the information they need from a publishing database, and create an automatically generated tailored report themselves, i.e. users could generate their own “reports à la carte” simply by selecting keywords, clicking on preferences on a menu, or choosing a certain guideline – perhaps creating an environmental statement according to EMAS, or having a comprehensive sustainability report at one’s fingertips. Especially an environmental statement (a report meeting the EMAS requirements) could be an excellent source and is therefore regarded as a core element of a new corporate performance evaluation system (Perrini and Tencati 2006) including an integrated approach such as sustainability reporting (GFEM and GFEA 2006):

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

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