ACCOUNT - a Software System for the Core Functionalities of an Environmental Management Information System

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1. System Architecture of an Environmental Management Information System (EMIS)

On of the main requirements for environmental management information systems (EMIS) is the availability of a company's material and energy flow information. (Hilty 1995, 200). This consideration holds for virtually all EMIS that are currently offered commercially. These systems concentrate on environmental and industrial safety management and contain the following modules (Arndt/Günther 1994, 148-149):

- *material information management*;
- *health and safety management*;
- *equipment monitoring/hazard prevention*;
- *waste management*;
- *law investigation*.

Each of these modules is more or less dependent on the material information management module. The health and safety management module often has connections to the handling of hazardous substances. The waste management module is based on material information about the type and quantity of a company's waste. Material flows are also relevant for the equipment monitoring/hazard prevention module, in particular the emissions of the equipment. The supply of legislative, regulatory and other policy requirements, is also based on a company's material flows, especially in Germany because of the material-oriented environmental and industrial safety legislation.

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For those reasons, the supply of a company's material and energy flow information can be defined as core functionalites of an EMIS. These core functionalities should be supplemented with a document management and information system for:

- law investigation (beyond material interdependencies);
- establishing and maintaining an environmental management manual;
- establishing and maintaining an environmental auditing plan.

Our functional model for the core functionalities of an EMIS is based on the standard LCA method for life cycle assessment of the German Federal Environmental Agency (Umweltbundesamt), an ecological balance sheet for examining the comprehensive environmental impact of a product, starting with the extraction of its raw materials up to its disposal. This method includes four components (Arbeitsgruppe Ökobilanzen 1992, S. 24-26):

- *Goal Definition*: definition of the alternatives and system boundaries in the LCA;
- *Life Cycle Inventory*: examination of material and energy flows, vertically for the life cycle of the defined alternatives, and horizontally for the inputs and outputs (quantities) of each defined process step in the life cycle;
- *Environmental Impact Assessment*: evaluation of the environmental impact based on quantities of the inventory analysis, such as global warming, ozone depletion, human toxicity, environmental toxicity, acidification, photo-oxidant formation, space requirements, nuisance (smell, noise);
- *Valuation*: valuation of the results of the component's life cycle inventory and environmental impact assessment.

We use this method that has originally been designed for life cycle assessment for our EMIS system architecture because the life cycle assessment’s structure is directly transferable to the requirements of companies. Furthermore, the LCA is good method for mapping the company’s environmental data. So we can define material and energy flow inventory (input/output balancing), environmental impact assessment, and valuation as components of the EMIS core functionalities.

The reporting component, which realizes the user-driven reports of the stored environmental data, completes the core functionalities (Arndt/Günther 1994, 152).
The goal definition component of the LCA standard method is referring to maintenance of environmental metainformation in an EMIS. Similar to the LCA method that depends on the transparency to the goals and system boundaries, the potential users of an EMIS should know which relevant information is principally available and how this information can be retrieved. Especially the decisive elements of the valuation method used should be pointed out in the EMIS. This kind of information is called metainformation, i.e., information about information.
In Germany and Austria, public agencies are currently introducing the Environmental Data Catalogue (UDK), a metainformation system and navigation tool that documents collections of environmental data from the government and other sources. Potential users of the system include government agencies, industry, as well as the general public. The UDK was started in 1990 by the Environmental Ministry of the State of Lower Saxony, funded as a research project by the German Federal Environmental Protection Agency (Lessing et al. 1995, 391-399).
The idea of a *company's* environmental data catalogue (CEDC) is to catalogue the environmental data sources and to give *access* to the environmental data of a company. The CEDC establishes the connection between the core functionalities and the other functionalities of an EMIS.
The EMIS software should be tightly integrated into the existing computer applications in a company. The material and energy flow inventory must be able to access the company's database systems, using them as environmental data server. Existing word processing software can be useful for the component valuation. The reporting component should be based on existing spreadsheet and presentation software.

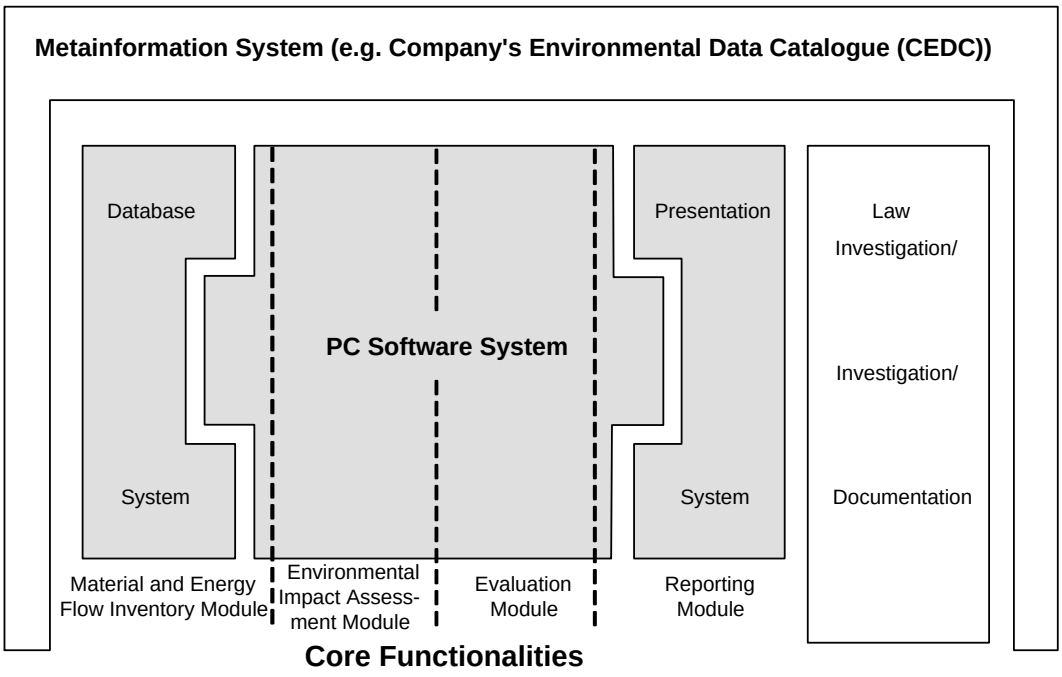

Figure 1: General architecture of an EMIS

2. The ACCOUNT System

ACCOUNT is an interactive software tool for a company's ecological balance sheet. The basic architecture of ACCOUNT is designed according to the common standards of Microsoft Windows. It is therefore relatively easy to integrate this PC-based software system into the computer environment of a company. ACCOUNT is developed in ObjectPascal with Borland DELPHI.

The ACCOUNT system has six modules, covering the four major steps of the EMIS core functionalities: material and energy flow inventory (input/output balancing), environmental impact assessment, valuation, and reporting. In ACCOUNT we support the association of economic and ecological information in a company's ecological balance sheet. The reporting module of ACCOUNT processes only simple kinds of reports such as input/output balance sheets. For extended reporting the user of ACCOUNT has the opportunity to export the environmental data to a separate spreadsheet and presentation software tool.

In the following we discuss the material and energy flow inventory (input/output balancing), environmental impact assessment, and valuation modules of ACCOUNT.

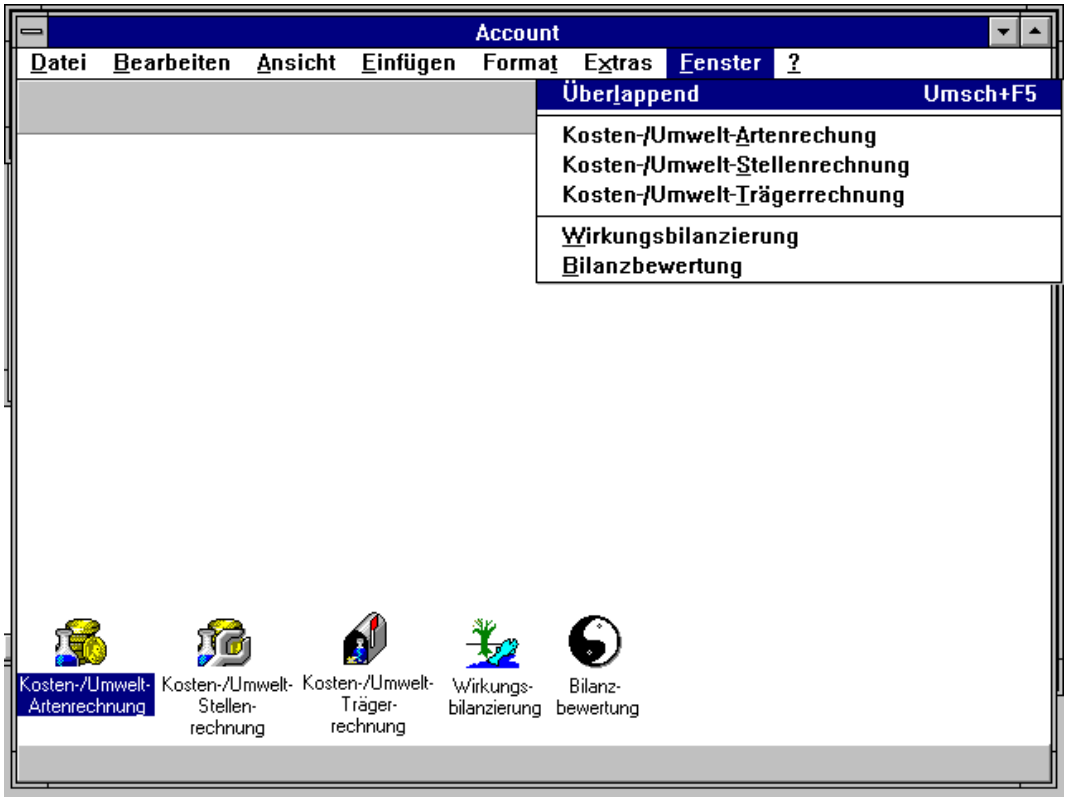

Figure 2: The ACCOUNT system

2.1 Material and Energy Flow Inventory

The material and energy flow inventory of an EMIS and the common cost accounting are based on nearly the same data. Long before the discussion of ecological balance sheets (input/output balancing), the common cost accounting was examined as an information system for environmental management (Fleischmann/Paudtke 1977, 2). Even earlier, the common cost account system was discussed as a base for developing an EMIS (Braun 1974, 53-58). Therefore we suggest to develop an EMIS inventory module for material and energy flows and the corresponding costs. In the long run the goal is *one* accounting information system for the environmental and cost effects of the company (Arndt/Günther 1995, 772).

The structure of the material and energy flow inventory in ACCOUNT is therefore analogous to the cost accounting, consisting of (Arndt /Günther 1996, 79-80):

- *Cost/Environmental Accumulation (ecological balancing of the company)*: collection of the material and energy flow information of a specified period, each material and energy flow contains information about its quantity (in physical mass or energy measuring unit) and costs. The cost/environmental accumulation is the basic component of this ecological balancing system.
  To reduce the costs of collecting material and energy flow data, ACCOUNT utilitizes the data import of the company's cost accounting system because most of this data is useful for the cost/environment accumulation component. After that the user of ACCOUNT can edit manually the environmentally relevant data that the company's cost accounting system does not contain, such as emission data. As in the company's bookkeeping, the user can edit different entries (material and energy positions) for a material or energy flow in a certain period. Each material or energy position belongs to a material and energy class. The material and energy class is a period aggregation of a set of material or energy positions that are physically or technically similar. The other components and modules of ACCOUNT use only the material and energy class data.
  ACCOUNT does not map the structure of the company's material and energy flows directly. When drawing up a common balance sheet, the reporting module processes the complete ecological balance sheet of the company, a department, or a product. This has the advantage of being analogous to the common business accounting (bookkeeping). It also avoids hierarchical navigation through the material and energy flow data. Instead of a hierarchical material and energy flow data structure, ACCOUNT uses the primary keys of the common business accounting system as far as possible. Because those keys often differ from keys useful for an ecological balancing, the user is able to add ecological balancing keys to each material and energy flow class.

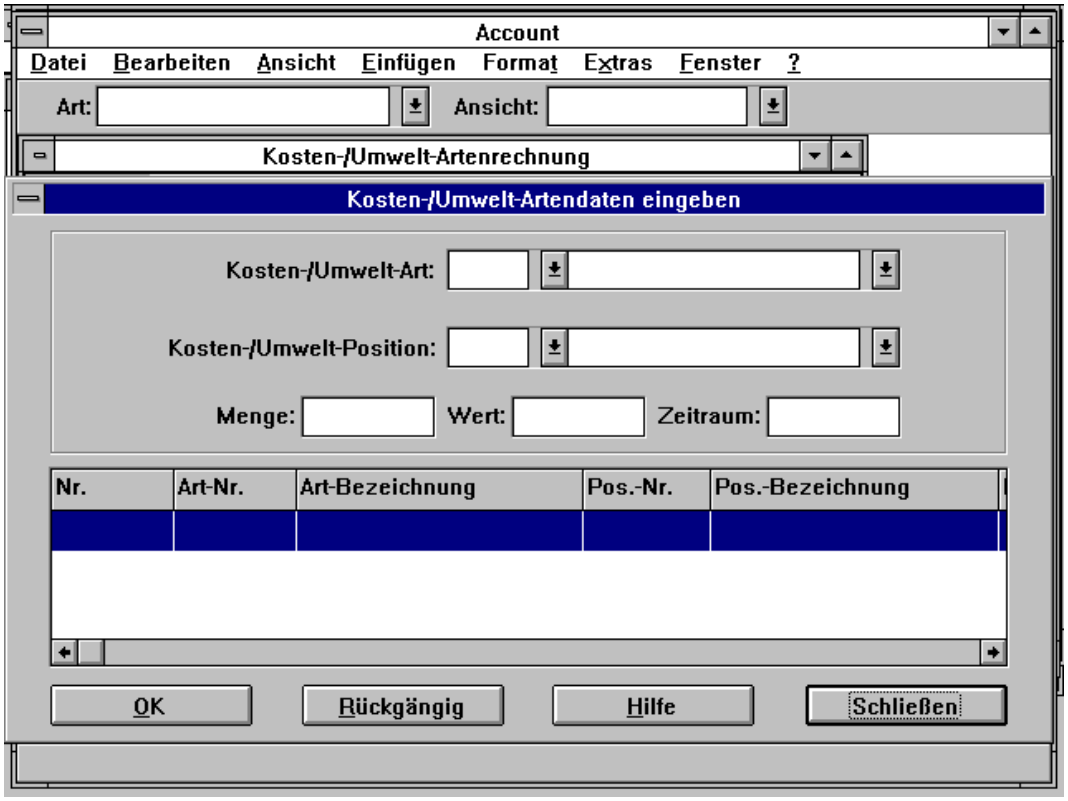

Figure 3: The ACCOUNT user edit interface of the cost/environmental accumulation component

- *Cost/Environmental Department Accounting (ecological balancing of production systems)*: calculation of the department's material and cost flows in an accounting spreadsheet.
  In the cost/environmental department accounting component, the user can distribute the results of the cost/environmental accumulation to the departments of the company. The evaluation of the distribution keys can be done with common cost accounting methods and by using the bills of materials (BOMs) and work schedules. Depending on the structure of the company's common cost accounting, it is favourable to import the department distribution keys of the common cost accounting.

- *Cost/Environmental Product Accounting (ecological balancing of products)*: calculation of a product's material and cost flows per unit (*Cost/Environmental Unit Product Accounting)* or per period (*Cost/Environmental Period Product Accounting).*
  The common cost accounting of products is designed as an internal information system of companies. Ecological product balance sheets are normally discussed

as life cycle assessments. Therefore the company would have to evaluate external material and energy flow information and their corresponding costs. Therefore the cost/environmental product accounting could not have a structure analogous to the common product cost accounting.

The problems of evaluation external environmental information is the reason for two types of ecological balance sheets (Braunschweig/Müller-Wenk 1993, 57-68):

- *Core Ecological Balances*: registering the direct material and energy flows inside the company,
- *Complementary Ecological Balances*: registering indirect material and energy flows outside the company (e.g. consumer).

The obligatory type for an environmental management is core ecological balance because of the direct responsibility of the management for the internal material and energy flows and their corresponding costs. Performing a complementary ecological balance should be optional for companies. In ACCOUNT we therefore only support the core type of product ecological balancing. For a complete product life cycle assessment (core and complementary ecological balance), the user should use other software tools that are more suitable for this approach.

2.2 Environmental Impact Assessment

Because of the considerable civil liability for environmental damages resulting from industrial equipment - especially in Germany - a company has to evaluate its environmental impact. The ACCOUNT environmental impact assessment module processes the relation between a material or energy flow and an environmental impact category. The first step of the environmental impact assessment consists of an examination of the company's various kinds of environmental impact. We then use the input/output balancing form for the next step in the environmental impact assessment. The input data is the result of the registered emission data of material and energy flow inventory. The output data for each input emission data is one or more impact category. While the input is measured in quantities, the output data (the various kinds of impacts) is just described qualitatively. For this examination the environment of the company (where the environmental significance of the impact is evaluated) is a black box.

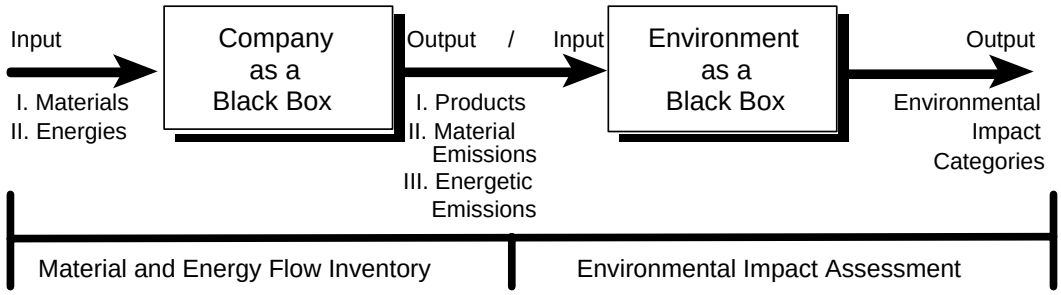

Figure 4: Interdependencies between material and energy flow inventory and environmental impact assessment (Arndt/Günther 1996, 82)

2.3 Valuation

The goal of the valuation component is to establish and maintain the company-specific valuation method. Because of the civil liability for environmental damages, we are reluctant to recommend seemingly exact valuation methods, like the on-index valuation. Based on the results of the environmental impact assessment, our valuation method is a combination of the ABC classification (Hallay/Pfriem 1992, 92-94), which is very common in logistics, and an argumentative approach.
By using the Object Link and Embedding technique (OLE), the user of ACCOUNT can use existing word processing software for the valuation process. The user can create a word processing object link for each impact category.

3. Conclusions

ACCOUNT is a software system for the core functionalities of an EMIS referring to aspects of environmental costs and civil liability for environmental damages. In ACCOUNT we suggest an approach of registering material and energy flows with their corresponding cost. With this approach the system can easily manage the company's cost and environmental information. The pragmatic assessment and valuation of the company's environmental impacts help to reduce environmental risks.

References

Arbeitsgruppe Ökobilanzen (1992): Ökobilanzen für Produkte: Bedeutung - Sachstand - Perspektiven, Reihe Texte des Umweltbundesamtes 38/92

Arndt, H.-K./Günther, O. (1994): Umwelthaftung - Anforderungen an das Umwelt-Controlling und an betriebliche Umweltinformationssysteme, in: Hilty, L.M./Jaeschke, A../Page, B./ Schwabl, A. (Hrsg.): Informatik für den Umweltschutz, 8. Symposium, Hamburg 1994, Bd. 2, Marburg, S. 145-153

Arndt, H.-K./Günther, O. (1995): Umweltkostenrechnung - Eine alternative Grundlage für ein produktionsorientiertes Umweltinformationssystem, in: Kremers, H./Pillmann, W. (Hrsg.): Raum und Zeit in Umweltinformationssystemen, 9. Symposium, Berlin 1995, Teil II, Marburg, S. 765-773

Arndt, H.-K./Günther, O. (1996): Ein Umweltdatenmodell für die betriebliche Stoff- und Energiebilanzierung, in: Scheer, A.-W./Haasis, H.-D./Heimig, I./Hilty, L. M./Kraus, M./Rautenstrauch, C. (Hrsg.): Computergestützte Stoffstrommanagement-Systeme, Marburg, S. 73-83

Braun, F. (1974): Rechenschaftslegung zur Umweltbelastung und zum Umweltschutz von Industrieunternehmen: Grundriß für Manager, Berater und Wirtschaftswissenschaftler, Berlin

Braunschweig, A./Müller-Wenk, R. (1993): Ökobilanzen für Unternehmen: Eine Wegleitung für die Praxis, Bern/Stuttgart/Wien

Fleischmann, E./Paudtke, H. (1977): Rechnungswesen: Kosten des Umweltschutzes. In: Vogl, J./Heigl, A./Schäfer, K. (Hrsg.): Handbuch des Umweltschutzes, Loseblatt, Grundwerk, Kap. III-7, Bd. 8, Landsberg a.L., 2. Aufl., 1987, S. 1-23

Hallay, H./Pfriem,R. (1992): Öko-Controlling: Umweltschutz in mittelständischen Unternehmen, Franfurt a.M./New York

Hilty, L. M (1995).: Betriebliche und überbetriebliche Umweltinformationssysteme als informationstechnische Infrastruktur für das Stoffstrommanagement. In: Schmidt, M./ Schorb, A. (Hrsg).: Stoffstromanalysen in Ökobilanzen und Öko-Audits, Berlin/Heidelberg/ New York, S.193-205

Lessing, H./Günther, O./Swoboda, W. (1995): Ein objektorientiertes Klassenkonzept für den Umwelt-Datenkatalog (UDK), in: Kremers, H./Pillmann, W. (Hrsg.): Raum und Zeit in Umweltinformationssystemen, 9. Symposium, Berlin 1995, Teil I, Marburg, S. 391-399