EnviroInfo 2011: Innovations in Sharing Environmental Observations and Information

IT-for-Green: Next Generation CEMIS for Environmental, Energy and Resource Management

Barbara Rapp, Andreas Solsbach, Tariq Mahmoud, Ammar Memari, Jörg Bremer[1]

Abstract

Contemporary CEMIS do not cope with requirements from the sustainability discussion. At the time of reporting environmental performance, it is too late to set the right course. Without an early identification of cause and effect to anticipate environmental impacts of decisions for timely intervention, potentials for acting precautious remain unemployed. A resource-friendly design of processes and their controlling demands for sustainability oriented organizational structures. The methodical view is often neglected. Innovative solutions are in demand. This versatile task may not be accomplished by science alone. Thus, the ertemis network (http://www.ertemis.eu) supports a new project to further the development of next generation CEMIS. Integrated modules will map the whole product life cycle from input (energy efficiency), transformation processes (production and green logistics) up to the output side (communication and reporting). In this paper, we introduce the IT-for-Green project (http://www.it-for-green.eu) and give an overview of the modules and the objectives we want to achieve.

1. Introduction

Political parameters and guiding principles for environmental protection, sustainability and energy efficiency demand for assistance by environmental management systems. Indeed, a high-capacity environmental management system has a need for multiple diverse and heterogeneous data in order to meet the requirements of planning, controlling and assessing versatile environmental tasks within an organization and beyond organizational boundaries. This data has to be provided by so called corporate environmental management information systems (CEMIS) for a goal oriented processing. But, looking into business practice shows (Marx Gómez et. al 2010) that currently implemented CEMIS do not cope with the requirements from the sustainability debate.

In our assessment, ICT (information and communication technology) and its ability for efficient controlling plays a decisive role for sustainable business development, if ICT is applied already at the product design stage as the first step within environmental conscious production and if it is part of the strategic decision making processes. CEMIS must not be mere end-of-pipe solutions for documenting environmental performance or for complying with legal requirements (cf. Teuteberg/Freundlieb 2009). The reason is, that at the time of reporting it is too late to set the right course. The application of intelligently cross-linked systems and processes supports the ICT on the strategic enterprise level. At this level, strategically relevant environmental information and decision processes are supplied (e.g. by an active environmental data warehouse) in order to support a better rating of different paths of sustainable development, mission critical resource costs or volatile energy markets. In this way, associated risks and strategically relevant and dynamic cause-and-effect relationships between economical, ecological and social indicators become visible.

Hence, next generation CEMIS will aim at integrating the IT of a company to a resource controlling entity (service-oriented approach) in order to realize a strategic corporate environmental management for an increased company value. In this way, a chance and risk efficient, strategic environmental management will be realized and added value by sustainability will be generated for the companies (cf. Funk et al.

[1] Department of Computing Science, C.v.O. University of Oldenburg, Germany

2007). Moreover, new CEMIS must be able to document cause-and-effect relations of different indicators for different development scenarios in a transparent way.

This versatile task of implementing sustainability supporting ICT concepts may not be accomplished by science alone. For this reason, the European research and transfer network for environmental management information systems (ertemis) has been set up in order to bring together experts from all necessary fields as an innovative community (http://www.ertemis.eu). This innovative community is supporting the newly initiated project "IT-for-Green: environment, energy and resource management with next generation CEMIS". For the rest of the paper we will refer to the project simply as IT-for-Green (http://www.it-for-green.eu). Within the project, the ertemis community will further the development of next generation CEMIS. The system will integrate three modules which map the whole product life cycle starting out from input (measuring energy efficiency), going on with transformation processes (production and green logistics) and ranging up to the output side (company communication and sustainability reporting). A previously accomplished feasibility study (cf. Teuteberg/Marx Gómez 2010) has already come up with a list of requirements.

Therefore, we currently have two main targets:

1) Expanding and improving the ertemis network, to build-up a cutting-edge community.
2) Developing a next generation CEMIS and demonstrate its advantages by reference implementations.

Moreover, the project incorporates pivotal questions from applied computing sciences, environmental management, ecology and from business administration in order to open up all resources of knowledge about next generation CEMIS. In this way, enterprises – especially SME (small and medium-sized enterprise) – will be supported (cf. Fettke 2004) – as a project result – by utilizable products (e.g. maturity models, reference models, software, outsourcing of new businesses, on-the-job training courses, new university degree programs, etc.).

From this point of view and in contrast to past habits, the scientific discipline of corporate environmental informatics faces the challenge to make the term sustainability the origin of their topic. Virtually, this postulates a change of paradigms that results in strategic environmental information management and the definition of holistic sustainability supporting information systems.

In future, such information systems will gain a significant operational relevance. In this way, these systems will find their way back to the realms of perception of the management level. Companies will – as a result – gain additional potential for cost reduction (e.g. by energy and material efficiency) if corporate environmental informatics shifts its focus towards the results of the sustainability debate. The often heard phrase "Environmental protection is to cost-intensive" might then – finally – become obsolete.

2. Related Work

An analysis of third-party funded projects in the field of corporate environmental management from the last decade has shown a need for action and research in the interest of society, politics, business and science. None of the scrutinized projects aimed at supporting all parts of environmental management cycle starting out from input (energy and material efficiency), going on with transformation processes (production integrated environmental protection) and ranging up to the output side (sustainability reporting and strategic decision support) in a holistic and integrated way. However, a cross-corporate inspection on the sustainability of whole supply chains (sustainable supply chains) has been a casual topic in scientific literature but has – as yet – not found its way to business practice.

The research network ertemis and the project IT-for-Green will, in contrast to the other projects, put exactly these aspects (integration of the strategic level and sustainability needs) of next generation CEMIS to the front. The new CEMIS systems will bring advantages to business users by bringing them into the position to:

- Develop environmental production and reverse logistics processes.
- Develop hybrid products (integrated services of kind and associated services) with sustainability ideas in the front in order to open up new markets for sustainable products.
- Realize an interactive exchange of information between different stakeholders in the field of sustainability reporting based on new internet technologies (blogs, wiki, semantic web, podcasts, etc.).
- Realize synergy effects, cost cutting effects, strategic advantages etc. by offering or using green services from the cloud (green clouds / green service mall) or based on service-oriented architectures.
- Pinpoint complementary cause-effect-relations and their effects on different targets from a strategic perspective. Complementary in this case means, that, say, heading for ecological targets concurrently supports ecological targets at the same time.

Whereas traditional CEMIS might be regarded rather as isolated, functional oriented information systems (cf. El-Gayar/Fritz 2006), new CEMIS will take a holistic approach that guides organizations to a strategic orientation. In this way, next generation CEMIS are - from our perspective – information systems that deal with material and energy efficiency, emission and waste minimization, reverse logistics, stakeholder support, legal compliance and especially with strategic environmental management. As yet, such systems only exist as concepts within scientific discussions. As yet, they have not found their way into business practice. Therefore, a need for research and knowledge transfer especially into SME can be identified as an important prerequisite for putting such systems into action.

A ubiquitous ICT and continuously integration of digital and physical systems allow for a fundamental renewal of business processes regarding sustainable business development, for an increased transparency as well as for a better control of material and energy usage.

In order to map the whole life cycle of a product, we see a need (cf. Isenmann/Marx Gómez 2008) for three respective modules that in sum interact as a reference implementation and proof of concept for a next generation CEMIS.

3. A modular concept for CEMIS

One result of the project will be a proof-of-concept implementation. The core system that will finally make up the next generation in the CEMIS will be a service-oriented platform that allows for loose coupling and bundling of necessary methods. A green service mall will provide a semantically enriched procurement of CEMIS-functionality for individual embedding into workflows. Embedding environmental considerations into arbitrary (business) processes this way, allows for an intermixed usage of specific functions from self-hosted services, external service providers and non-environmental services. Such architecture allows for a highly flexible integration of environmental tasks into traditional (already installed) information infrastructure with the new CEMIS as the integrating system.

For our prototype we will have to short-list the functions that will be actually implemented. The choice will be made with the help of example use cases and process chains that are taken from the topics Green IT, Green Logistics and Sustainability Reporting. In general, the actual functionality of the system will be grouped into three modules after these topics.

3.1 Green-IT: (partly) automatically measuring ICT's energy efficiency, illustrated by data centers

Energy demand of information and communication technologies (ICT) in Germany was in 2007 at 55 TWh, and showed in the years 1998 - 2008 an annual growth rate of 17%. The resulting CO_2 emissions exceed that of the entire air transport.

Causes behind this high energy demand are various; they range from poor efficiency, inefficient air-conditioning, and oversized infrastructure and computing resources to a non-optimized load management or outdated hardware. For this reason, the efficiency of data centers varies; this efficiency could be described in terms of PUE (power usage effectiveness).

Calculating energy demand of a data center is not a straight forward issue; it rather requires comprehensive analysis of the characteristics of the data center, infrastructure, installed hardware and software as well as the different operation profiles of the data center.

This data about the data center is to be fed into a software model which can calculate the energy demand and compare it to a reference data center or to a future planned state of the data center. Simulation results will help the owner of the data center to optimize energy costs or decide upon a reinvestment.

The progress in this module could be divided into two distinctive phases: requirements analysis and conception.

Extensive measurements are to be carried out and recorded in this first phase; these could be aggregated and then fed into BUIS and Corporate Social Responsibility Records. These data could also help the data center to obtain certain certification such as the Energy Star of TÜV Saarland.

There already exist some important procedural models for acquisition and improvement of IT energy requirements, such as "Code of Conduct on Data Centres Energy Efficiency" of the EU, the guide "Energieeffizient im Rechenzentrum" of Bitkom and the guidelines "Durchführung von Energieverbrauchsmessungen in der Bundesverwaltung". They will be a starting point for our own developments.

In the second phase the above mentioned guidelines in addition to experience of the consulting firms participating in this project, are to be used for creating a systematic concept. This concept is to be used for the (semi-) automatic acquisition of energy demand for the whole supply chain of the data center starting from the UPS (uninterruptible power supply) through the energy distribution and air conditioning equipment to the servers and network equipment. Moreover, the concept is to determine the energy needs by analysis of a database that contains data on consumption of not directly measurable components. The analysis results are directly exported to the reporting module. They are also used by a simplified simulation model of the first data center to identify potential improvements. These are the approaches from which we want to achieve energy savings with methods that are to be developed.

3.2 Green Logistics and sustainable product development: automatic determination of CO_2-emissions along the supply chain

3.2.1 Motivation and problem background

Climate change affects current and future generations and poses new challenges on them. Especially greenhouse gas reduction (primarily CO_2 from energy conversion) plays an important role. The number of enquiries for a proper illustration of transport related emissions (and the relation to a specific product) from different classes of stakeholders is constantly rising. An increased demand for methods on determination and comparative illustration of emissions on different paths of transport and different means of conveyance emerges. A problem arises for example in connection with defining and fixing basic data regarding vehicle type, pre- and post-carriage, capacity utilization and so forth. Even if transport related

emissions are determined, they have to be mapped to the different batches or freight weights. Currently, it is in fact possible – at least semi-automatically – to come to a calculated result; but only with high time requirements or personnel costs and without any tested and generally accepted method. First and foremost the question for integrating the scopes from ISO 14064 (direct, energy indirect and other indirect emissions) into calculations is still unanswered. Moreover, mostly averaged values for CO_2-emissions are used in calculating as yet. Of course, such averages are available only with a considerable delay. Basically, it is possible to capture relevant data with significantly lower delay by using for example mobile data terminals or RFID techniques.

A better resource and energy efficiency on the one hand side contributes to climate protection, but also has a significant share in improving a company's cost effectiveness, on the other. With the help of CEMIS, preconditions and consequences of energy using devices, appliances or transport means can be determined and documented. However, the interaction and co-operation of different facilities or between different companies may currently not be mapped satisfactorily. Particular attention is paid to the logistics part, because logistics plays an important role as an economic factor within Lower Saxony as a coastal and transit region with many important traffic arteries that adjoins many neighboring countries. In this way, the task is to improve material and energy efficiency of inter-corporate transformation processes, production and logistics by new CEMIS concepts. One challenge will be the handling of data defects and uncertainties due to variable material qualities and limited sensor abilities. Reliability of data from partners within the supply chain will also be addressed. Especially this holds true for the case of perishable goods (cold chains). In this context, the new field of perishable logistics summarizes approaches for this problem.

3.2.2 Solution

In order to improve resource and energy efficiency as sketched above, the proper allocation of individual shares to products, product life cycle stages and specific companies will make the difference in the first instance. Besides, an analysis of energy usage and innovative developments in the field of production and logistics will be necessary. The first step – capture of energy consumption – will be part of module one (Green IT). As a second step, models for material and energy flow will be considered or developed in order to determine proper actions as well as reference models for handling them. In the next step, methods from production planning and many-criteria decision support will be applied for determining the best combination of actions. In order to achieve this, current concepts for CEMIS have to be improved for continuous use of data and data structures from data capture procedures, data analysis methods and optimization algorithms up to needs for reporting the data and the generated results. Concurrently, concepts for supporting new business cases (e.g. chemical leasing or life cycle costing) with these CEMIS are scrutinized.

On the long term, this will lead to a substitution of the traditional selling of a product with well-defined performance features by a business relationship where function or benefit of product features are based on concepts like pay-on-production or pay-per-use as a basis of service exchange. Fair contracts will demand for proper information exchange. New CEMIS might serve as the information platform for quantifying and documenting contractually guaranteed environmental features like avoided CO_2-emmisions or generally warranted improved eco efficiency.

3.2.3 Concept

Using the example of an industry solution regarding perishable logistics, a survey will be conducted in order to determine the potential of CEMIS to realize and further green logistics concepts. Missing functionality will be identified. Methods from production planning, data quality management and many criteria decision support will be implemented as proof of concept and evaluated by our industry partners.

The main objective is the integration of emission calculation into a CEMIS based and relying on an accepted calculation procedure. This emission calculation must be able to map the proper share onto the respective batch or at least onto the fraction of transported mass, it must allow for a more detailed calculation as today and it must allow different stakeholders to distinguish emissions along the supply chain, between transport means, transport nodes and the life cycle of a product. The latter will demand for new ways of preparing sustainability reports in order to deliver discriminating views of the data on demand and probably in near real time.

As a further goal and in addition to CO_2-emission values, other logistics related environmental performance indicators are to be included for pro-actively spread them to all employees and stakeholders in order to further the sustainability culture of a company. All indicators will be accompanied by concrete advice for decision support and improvement actions. A later adaption of the concepts to intra-enterprise logistics is aspired.

3.3 Sustainability reporting and communication

3.3.1 Motivation and problem background

The sustainable development and the sustainable impact of companies' processing nowadays is not only discussed by internal stakeholders, like workers, managers or analysts. Social, ecological and environmental impacts and relations between these three aspects in the so called "triple bottom line" from (Elkington 1997) are in the focus of public interest. The public demand for information, supported by information and communication technologies development in the last decade, induced an increased number of social and environmental reports. Companies are addressing to this arising issue by using sustainability reports (Grünwald/Marx Gómez 2007).

The European Coalition for Corporate Justice, the European Trade Union Confederation and the Global Reporting Initiative (GRI) released a joint call towards the European Commission for mandatory company reporting including sustainability reporting on February 3, 2011. "Companies' stakeholders, including directly affected communities and the public at large, need comprehensive and credible information on corporate social and environmental impacts to identify problems with and monitor progress of the companies they deal with." (ECCJ 2011).

To reply from a companies' side to this development, the system landscape has to be adopted to be able to handle environmental, social and economy related information. Companies, especially SMEs, require expert support to handle the width range of sustainability guidelines such as GRI G3, Sustainability Accounting 8000 or United Nations Global Compact with their different kind of indicators or topics mentioned in the guidelines. The required support is not only focused towards the guidelines - companies also demand software solutions to support the generation and distribution of reports. Currently, reports are often generated manually using office solutions.

Interviews with companies have shown that (commonly) no reporting software is used and second, that companies have no overview of existing software solutions, which support the report generation process. Current sustainability reports distributed in the web lacks the dialog orientation, personalization and different kind of formats supporting the demands of stakeholders.

3.3.2 Solution

The third module "sustainability reporting and communication" in the "IT-for-Green" project aims at generating an open source software module, which is able to handle current stakeholder demands and is flexible and adaptable for future demands of stakeholders. The underlying idea is to develop web-based software situated in a service-oriented architecture, able to handle the generation process of structured reports and supporting the required processes in the software. Companies will be supported by using schemas to identify necessary indicators. At the same time, content guidelines and other aspects will be transformed into a schema that may be used by the companies. This procedure has to be done only once. Afterwards, it can be shared (with XML as exchange format) with all participating companies. Companies using this module will overcome the use of spreadsheets or Access™ solutions, which - from our point of view - are not able to meet the requirements of current environmental management issues. On the other hand, a second stakeholder group has implemented first environmental management tools, but without considering generally accepted (theoretical) concepts, due to the low priority of environmental management in the management sections of companies in the last decade.

The proposed system will be able to handle structured reports, such as sustainability reports following guidelines like GRI's G3, but also any other kind of reports, that can be transformed into a schema.

3.3.3 Concept

As a first step towards ICT support for sustainability reporting and communication, module 3 will establish a web based reporting solution, which is suited on top of the service-oriented architecture. Reporting will be varied, what means different required internal and external reports can be generated, like reports to economy analyst or management summaries (for internal use).

The module will support the access and distribution of environmental, economy related and social information and their relations, what is an obstacle, especially for first reporting companies. First reporting companies normally don't have the financial background to establish a group of experts that are familiar with the topic of sustainability reporting and communication. The non-existence or not fully integrated IT-infrastructure is another drawback. The required information is not prepared for automatic access, this leads to a need for human interaction, what is a major cost factor.

4. Architectural considerations

In this section, we will highlight the main architectural considerations that are going to be taken into account during the project lifecycle. It has been agreed upon between the project members that the core architecture that constitutes the heart of the IT-For-Green project is a service-oriented infrastructure. A conceptual service-oriented infrastructure will be designed and implemented as an runtime environment, where different application scenarios can be integrated.

From a technical perspective, all the services are going to be published in the so-called "service mall". This mall is representing the project's main service repository that has connections to the three modules and main workflow management system. The latter contains the main system's workflows that are translated from the use cases. These workflows are composed of activities, where most of them are realized using the Web Services that are published in the service mall.

The realization of the service-oriented infrastructure takes place in two phases, namely the conception phase and the realization phase.

During the phase of conceptualization, the most important architectural requirements of the service-oriented infrastructure will be determined. Some of these requirements are: reusability, efficient development, integration of applications and data in conjunction with the achievement of agility, flexibility and

alignment between business and IT. Another milestone is to establish the project's conceptual architecture, which must define all the project-relevant terms, concepts, processes, etc.

The second phase includes the detailed design of the system platform, the implementation of its services and the integration of the project's modules.

The detailed design of the core system introduces a formal architectural definition that can be utilized for objective validation of applications and services. The platform is going to support the project concepts, specify hierarchy of services and provide service types, define how services fit in the project modules, and finally, provide a separation of concerns.

The effective implementation of a service-oriented infrastructure is a complex undertaking. Various technical and economic aspects must be considered. This requires the cooperation of all parties that are involved in the project and covers management, economics, software architecture, development, organization, operation, ecology and so on. In this implementation process, the use cases' relevant services are going to be implemented to be available to the project's three modules.

5. Conclusions and further work

As research has just started out, all concepts are still in their infancy. The next steps will be to finalize the concept for the service platform that binds together all the functional modules and start implementing. The functional modules that will make up the next generation of CEMIS will subsequently be developed.

The main goal of this project is to ensure operational relevance of the new CEMIS concepts. In the past CEMIS concepts often did not made their way into daily business. For this reason, corporate partners are involved right from the beginning in developing the new CEMIS concepts. Even more important, it will be the task of our corporate partners to evaluate the feasibility and suitability for daily use of our research results and solutions. With their participation in this project, our partners from business contribute significantly to a proper injection of all conceptual results into business practice.

Frequent internal workshops will ensure a constant information and knowledge exchange in both directions in order to enable a proper know-how transfer.

All project results that are not product related, vendor-specific or proprietary (e.g. reference architecture, reference models, maturity models, methods, concepts, business cases, proof-of-concept implementation) will be frequently released to the public domain and published or presented on conferences, exhibitions and workshops. Integrating the idea of IT-for-Green into teaching at several universities will contribute to establishing new CEMIS concepts as state-of-the-art for young academics.

Acknowledgement

This work is part of the project IT-for-Green (Next Generation CEMIS for Environmental, Energy and Resource Management). The IT-for-Green project is funded by the European regional development fund (grant number W/A III 80119242). The authors thank for the support.

Bibliography

ECCJ (2011): United call for mandatory company reporting, press release, online available: http://www.corporatejustice.org/press-release-united-call-for.html, last access: 7/21/11, Brussels, February 2011.

El-Gayar, O. & Fritz, B. (2006): Environmental Management Information Systems for Sustainable Development: A Conceptual Overview, in Communication of the AIS 17.

Elkington, J. (1997): Cannibals With Forks: The Triple Bottom Line of 21st Century Business. Capstone, Oxford.

Fettke, P. (2004): Referenzmodellierungsforschung, in: Wirtschaftsinformatik. Bd. 46 (2004), Nr. 5, S. 331-340.

Funk, B.; Möller, A.; Niemeyer, P. (2007): Integration of Risk-Oriented Environmental Management Information Systems and Resource Planning Systems, In: Hryniewicz,O., Studzinski, J. (Eds.): Environmental Informatics and Systems Research, Warsaw.

Grünwald, C., Marx Gómez, J. (2007): Conception of System Supported Generation of Sustainability Reports in a Large Scale Enterprise; in: Marx Gómez, J., Sonnenschein, M., Müller, M., Welsch, H., Rautenstrauch, C. (Eds.): Proceedings of the 3nd Conference on Information Technologies in Environmental Engineering (ITEE '2007), Oldenburg, (Germany), p. 61-68.

Isenmann, R., Marx Gómez, J. (2008): Internetbasierte Nachhaltigkeitsberichterstattung: Maßgeschneiderte Stakeholder-Kommunikation mit IT. Berlin: ESV, 2008.

Marx Gómez, J., Teuteberg, F.: Corporate Environmental Management Information Systems: Advancements and Trends. IGI Global, 2010.

Marx Gómez, J., Teuteberg, F., Funk, B., Niemeyer, P. (2010): Betriebliches Umwelt- und Nachhaltigkeitsmanagement; in: Schumann, M., Kolbe, L., Breitner, M., Frerichs, A. (Eds.): Multikonferenz Wirtschaftsinformatik 2010.

Teuteberg, F., Freundlieb, M. (2009): Betriebliche Umweltinformationssysteme zum Compliance Management; in: WISU – Das Wirtschaftsstudium, 4, 2009.

Teuteberg, F.; Marx Gomez, J.: Green Computing & Sustainability − Status Quo und Herausforderungen für BUIS der nächsten Generation; in: HMD – Praxis der Wirtschaftsinformatik, 47 (2010) 274.