AN INTEGRATION PLATFORM FOR IT-FOR-GREEN
Integrating Energy Awareness in Daily Business Decisions and Business Systems

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Abstract: Political parameters and guiding principles for environmental protection, sustainability and energy efficiency demand for assistance from 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 that currently implemented CEMIS do not cope with the requirements from the sustainability debate. Current software is mostly used to manage the damage done, hence an energy efficient behaviour can not come to daily business. Knowledge about the energy footprint of a product throughout its life-cycle is currently not properly made accessible to business people, stakeholders or customers. For this reason, we plan a new CEMIS that is able to take into account e.g. ICT for designing, building or selling, product related transport and production processes, as well as web store energy costs for the whole product life.

1 INTRODUCTION

An organizational, technical system for systematically capturing, processing and publishing environmentally relevant data within an organization is called corporate environmental management information system (CEMIS). The main idea of sustainability is in the public eye and forces companies to report on ecological, economical and social aspects. At this point, the traditional concepts of CEMIS could have been used, but this did not happen.

From today's perspective, traditional systems failed for any number of reasons. Mainly, current CEMIS focus just on achieving legal compliance or realizing standardized environmental management systems like ISO 14001. In business terms, such systems are at an operational management level. All in all, present CEMIS aim at avoiding or lowering the costs of environmental impacts, which are already caused by organizations. These systems are merely output oriented. But, according to the current situations for companies and the requirements from different stakeholders a proactive approach is required.

Energy has become a major cost impact for most companies. Raising energy awareness, enabling energy efficiency and saving money in this way will be one of the most important duties for newly implemented CEMIS. When a system like the one proposed in this paper is in action within a company, energy awareness becomes part of daily business decisions and helps saving energy in a proactive way.

In this position paper we present our thoughts on how energy awareness will be integrated into next generation CEMIS.

2 THE IT-FOR-GREEN APPROACH

Besides satisfying stakeholder interests, it is the prime objective of sustainable development to establish a harmonic balance of economy and ecology, for example by lowering costs through material and energy efficiency. The reduction of material and energy consumption in companies has a direct positive impact on both the environment and the economy. However, such beneficial effects can only be achieved by imple-

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menting a new generation of more strategic CEMIS.

The term IT-for-Green aims at increasing the environmental friendliness of companies and their processes by means of IT. In this context, CEMIS are to be regarded essential for supporting the sustainability integration. Conventional CEMIS are not sufficient to achieve this objective, for they mostly serve the purpose of ensuring legal compliance with relevant environmental laws and regulations, mainly in order to avoid financial sanctions from state authorities. With such a strong operational focus, the requirements entailed by the concept of sustainable development can only be fulfilled to a very limited degree. On the other hand, companies may achieve profits by applying sustainable development measures: they reduce costs through material savings and – becoming more and more important – by implementing energy efficiency and increase their turnovers through sustainable products and services, corporate image improvement and advantages in competition.

Besides giving guidelines, the IT-for-Green project aims at implementing a second generation CEMIS. We are planning a system, that is based on three building blocks. These modules correspond to the life-cycle of products from input (measuring energy efficiency of the ICT used) to transformation (logistics and sustainable product development) to output (corporate communication and sustainability reports). The underlying architecture enables a collection of green web services. In future, they will provide a basis for a service platform (called green service mall). To succeed in implementing a second generation CEMIS the expertise of different scientific and industry partners is combined.

2.1 Goals

Second generation CEMIS will be located at the strategic level of a company and provide relevant environmental information and algorithms for decision support. Also, it will enable the evaluation of sustainable development lines, of mission critical prices of resources or of volatile energy markets. For this reason related risks and system dynamical cause and effects between economic, ecologic and social indicators can be made visible.

Future CEMIS aim at using the company's IT as resource guiding, integrative system for intelligent and strategic supervision. In this way a chance and risk efficient, strategic environmental management can be realized and sustainable shareholder value can be generated. Such information systems will gain broad importance for companies.

2.2 Planned Implementation

One result of the project will be a proof-of-concept implementation. As mentioned above, three software modules with corresponding services and process models will be developed. The building blocks will cover the complete product life-cycle from input to transformation to output. The module ”Green IT” (section 3) will provide services that deal with energy efficiency of the ICT infrastructure. They can be used stand-alone or as data source for other services and modules. Section 4 focusses on ”Green Production and Logistics”. This module provides services that enable the reduction of energy and material flows. The third module deals with sustainability reporting and dialog-based communication. It provides services, that for example enhance (external) data (e.g. from module 1 or 2) and based on this, build reports for different stakeholders.

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 infrastructures with the new CEMIS as the integrating system. For our prototype we will have to short-list the functions that will be actually implemented.

With high priority, we will focus on energy awareness and reduction as one of the most important use cases for our first prototype. These services are currently implemented and tested with our industry partners.

3 CAPTURING AND REPORTING ICT ENERGY CONSUMPTION

The energy demand of ICT infrastructure is rising continuously (Koomey, 2007). Looking at a typical data center today, consumption has reached a point, were the running costs of the ICT equipment is as much an important factor as the investment costs in the first place (Barroso, 2005).

Yet, many businesses do not have much information about the energy requirements and consumption

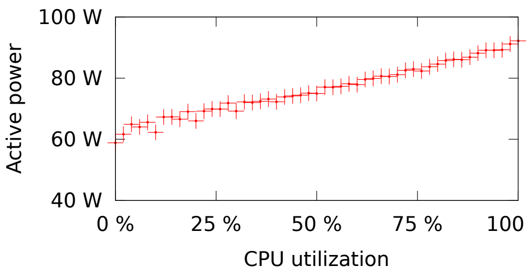

Figure 1: Energy usage of a server in different load situations.

of their ICT equipment (BITKOM, 2008). It is therefore an important aspect of future CEMIS to support companies in monitoring energy usage and attribute it to the relevant business processes.

To tackle this problem, it is necessary to introduce measuring hardware into the data center. A large number of measuring points are required to reach a high degree of detail in the reporting. To lessen the burden of implementing this measuring infrastructure, our project will also look into ways to reduce the number of measuring points needed.

One such approach consists of merely estimating energy usage on the basis of equipment utilization levels. Looking at the example of servers, this kind of data – for example CPU utilization or network activity – is often readily available through software alone. If this data can be used to accurately estimate power usage, the implementation of a monitoring infrastructure can be simplified.

It will be a goal of the project to facilitate such an approach by providing relevant services as part of the green service mall. Preliminary work has started to build reliable models that predict energy usage based on server utilization. We validate these models through measurements performed in our lab server environments as well as in larger data centers. Consistent with other work in this area (Rivoire et al., 2008) we see a strong influence of CPU activity on power usage in our measurements (figure 1).

Even with a simple linear module based on CPU utilization levels it is possible to attempt a power usage estimation. Figure 2 shows a screenshot of a software module – which will be part of our prototype – as it is estimating the power usage of a server. For comparison, the actual measurements are tracked as well and in our experiments this model achieves correct predictions with an average error of 6 %.

Of course there are many more components than servers in a data center. Measuring points are also required for the cooling infrastructure, for network equipment and for the uninterruptible power supply. Once all of these measurement points are in place, the data can be fed into a model of the data center. Such a model-based approach is helpful in two ways: Firstly, it can be the basis for various reports and metrics (like PUE, power usage effectiveness) regarding the current situation. Secondly, it becomes possible to simulate the effect of changes to the data center and thereby helps in the process of identifying power saving potentials.

Furthermore, a detailed understanding of the energy situation of the data center also helps in mapping business processes to the computing resources they require and in turn the energy usage they cause. Making this connection is a crucial part in making informed decisions about the structure of these business processes.

4 CAPTURING AND REPORTING PRODUCTION AND LOGISTICS PROCESSES

The "Green Production and Logistics" module aims at developing services, that allow small and medium-sized enterprises (SMEs) for better analyzing the environmental impact of their production and/or logistics processes. In both areas, international standardized methodologies such as the Eco-Management and Audit Scheme (EMAS), parts of the ISO 14000 series and the DIN EN 16258 are applied, in order to ensure the comparability of results and long term usability. However, one major obstacle is the difference in those two process types. On the one hand, production processes describe the physical transformation of goods and can be very versatile depending on the industrial sector the enterprise is operating in. Logistic processes, on the other hand, cover the transportation of goods over space and time and are less industry-specific, which means they require less customization efforts after the installation of our tool.

4.1 Green Production

The module enables a SME to measure the environmental performance of production processes. Therefore, the first important step is to break down main processes into subprocesses and further into single activities. In this sense, it is not suitable to treat the enterprise as a whole (black-box) and just quantify its in- and outputs, because thereby, potential improvements can not be identified.

Each identified activity, specified by its core (e.g. technical plant specification) and dynamic data (e.g. material input), is used to create a basic material and

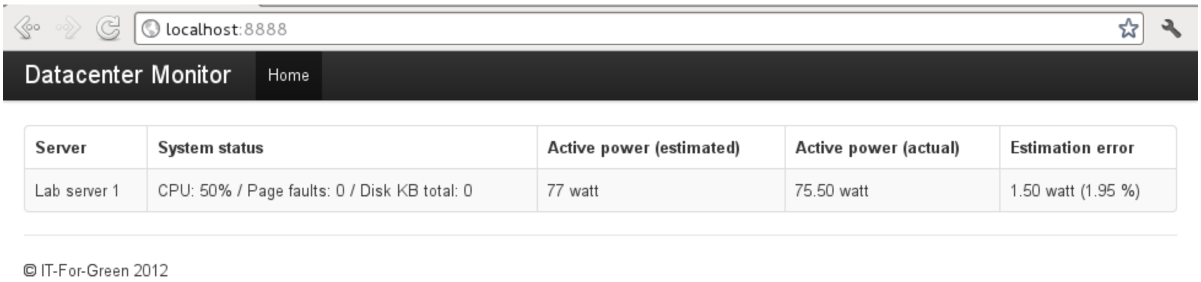

Figure 2: Software tool to estimate power usage based on server utilization.

energy flow model. In order to ease data assessment and to reduce manual user input, links to repositories which contain this specific informations, are established. It is necessary to obtain information covering the following aspects: energy efficiency, material efficiency, water, waste, biodiversity and emissions, as these are the six core environmental indicators stated by the EMAS (European Parliament and Council, 2009). On top of that, it is advised to publish additional branch specific indicators.

However, for the management it might be hard to interpret the gathered data, due to missing comparative values and metrics that allow for an evaluation of the environmental performance. To solve this and to give the management the possibility of a quick evaluation, several impact assessment methods exist. Methods like CML 2001 (Guine et al., 2002) and IMPACT2002+ (Jolliet et al., 2003) can be used to aggregate the environmental performance into a few total values.

Besides the ability to evaluate the performance in a short amount of time and to validate the results against target values, enterprises are enabled to spot economic and/or ecologic weaknesses in their production processes. For instance, processes with the highest energy consumption could be highlighted in the material and energy flow model, which could lead to a further investigation. In that sense, the identification of ecological improvements could also lead to monetary benefits.

Unfortunately, several feasible improvements may contradict each other. In these situations, the management is supported by certain multi-criteria decision aiding methods. Our tool allows the decision maker to set up different alternatives (the possible improvements), which will be ranked according to the identified criteria and the decision makers preferences.

4.2 Green Logistics

Besides the evaluation of the production processes, a SME might be interested in an assessment of their transportation processes as well. For the purpose of publication, it should not matter whether they perform the transportation on their own or assign them to a forwarding agency. The second part of module 2 helps enterprises with that task and is based on the DIN EN 16258 norm (Deutsches Institut für Normung, 2011). The norm incorporates two major advantages. Firstly, the evaluation of the transportation processes is independent of the various means of transport (e.g. trucks, trains, aircrafts, etc.). Secondly, there is no set requirement for the data source, which is used in the calculations (although, the more accurate the data, the better the result).

The assessment of the transportation processes has to cover two different areas, which are to some extend in relation to scope 1 and scope 3 emissions mentioned in the green house gas (GHG) protocol (WRI and WBCSD, 2004). Scope 1 emissions refer to direct emissions that arise from enterprise controlled sources, like the combustion of fuel in company owned vehicles. Scope 3 emissions contain indirect emissions, which do not originate from the enterprise itself, like the provision of fuel, but which are needed to execute their business processes. The tool is translating those scopes into Well-to-Tank (WTT) and Tank-to-Wheel (TTW) processes, which stand for scope 3 and scope 1 respectively. In order to ensure that results are comparable over various means of transportation, two different units are calculated. Energy consumption (e.g. consumption of gasoline, diesel, kerosene, electricity) will be measured in megajoule (MJ) while GHG emissions will be denoted in carbon-dioxide equivalents (CO_2e).

Calculation methods will vary depending on the desired output format and the data source. Four different sources are possible: 1. specific measurements for each vehicle used during the transport, 2. typical mean measurements based on vehicle type and/or route, 3. measurement of the annual mean fleet consumption, 4. default values found in scientific or governmental publications. The first option is only viable for enterprises, which have direct control over the vehicles and can track their distances, load and fuel consumption. The other three options can also be used by enterprises, which assign forwarding agencies with the transportation of their goods and will depend on the level of cooperation, because option two and three may require access to external data.

After it is clear, which data is available, the calculation itself is pretty straightforward. The transport route needs to be divided into single parts which are determined by the vehicles that were used. If a good-specific assessment is desired and a vehicle did carry other goods next to the one under investigation, an allocation is required. Such an allocation can be done in three different ways: 1. weight-dependent, 2. volume-dependent or 3. a mixture of both. In that fashion, TTW and Well-to-Wheel (WTW), which is WTT plus TTW, can be calculated for each single part of the route and then be aggregated into a total value for the investigated good.

At the end, the results of both parts are submitted to module 3, which may then lead to a publication in a sustainability report.

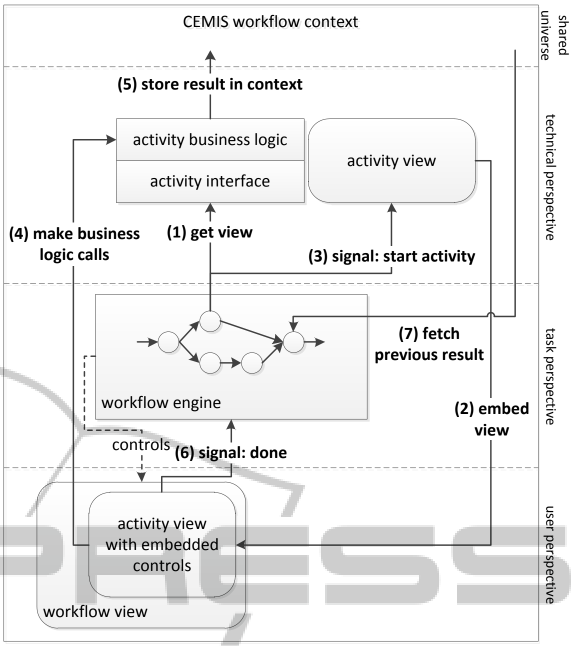

Figure 3: Integration scheme for energy aware product development.

5 INTEGRATION

We will now discuss the advantages of the integrating character of our planned platform approach in the context of a possible use case. Every task, an end user will be able to fulfill with the help of our new CEMIS, is organized as a workflow and controlled by a new workflow system. Let's assume, we want to develop a new product: A small portable device in need of frequently downloading information from an online store (like an e-book reader, portable media player).

Figure 3 shows the information and control flow during the execution of a single activity within a CEMIS workflow. There are several perspectives on such activities. We will start with a more generic look on the whole system and then discuss it in the light of raising energy awareness and efficiency.

From the user perspective there will be a client application (planned as browser application) that visualizes the processing of a workflow, allows user input and control flow interaction, presents intermediate results, etc.

The technical perspective reflects the realization of the services needed for fulfilling an activity. This is so to speak the business logic of the whole system. For the sake of an individually composed software system that serves exactly the individual needs of different business and companies, we will have a set of interoperable services for individual tasks. With this modular design principle each company may compass its own tailor made CEMIS. A high priority will be given to the supply of energy related services.

In the task perspective, a workflow represents an executable arrangement of different activities that guides an user during his work with the system. It will be possible to define (or rather program) complex relations and control flows within a workflow.

A workflow may comprise activities from several (maybe external) sources and also from different users. On a time scale, a workflow might be executed in several phases (during product life-cycle) and be saved to disc in the mean time. In order to share information among all these services and phases, a specialized context for information exchange is shared.

In the context of the mentioned new product, one necessary activity might be to estimate later energy consumption of the servers that host the web store. In this case, the workflow engine will fetch all necessary view information from the service and put it into the user perspective for choosing an appropriate server model and for parameterizing it.

Due to the design of our workflows, the engine will continue with the appropriate activity based on the model choice of the user and carry on with a view that lets him use the model. All calculated results on estimated energy consumption are stored to the context for usage by further activities.

Necessary information about all entailed server loads, when using the product, might be taken from previously executed design activities and thus from the CEMIS context. In this way, results from market research on estimated product using profiles may be fed directly into the server model for transferring product usage into an estimate of the energy load it will entail on the server. In a similar way, energy consumption for logistics related to the product can be utilized. This might comprise upstream chains for procurement of product parts as well as distribution logistics.

Integrated in a workflow all these energy consumption and estimation related activities may be executed multiple times with different parameters and product configurations in order to take into account production and product life-cycle energy costs for the product design. The energy estimation data from the design phase is stored in the CEMIS context, so it will be still readily available when the workflow is suspended and resumed later for a product redesign phase. The context is part of the workflow and will be stored to disk together with the workflow and its execution state, if necessary.

Nevertheless, the energy data (as any other environmental data in the platform) may also be saved to an environmental data store and be used in any other workflow that might accompany the product life-cycle. All data will be transfered into an standardized CEMIS data format (development will start soon) in order to ensure interoperability.

A frequent use case will be communication and reporting. Communicating energy information in this context refers to activities like including achieved savings in product advertisements, fair and source-related cost allocation or raising awareness for the impacts of one's own daily business decisions. Reporting on the other hand refers to an integration of energy data into annual, official sustainability reports that may be generated and published with our system as well. New and interactive graph and gauge elements in this report will enable stakeholders to experience a versatile offer of energy information that is exactly tailored to their specific needs.

6 CONCLUSIONS AND NEXT STEPS

The development of the core integration platform has just started out. The business concepts are developed in close collaboration with our scientific and industry partners, especially to confirm that they can benefit from these concepts in daily business. Currently, we are also facing the specification of a common, XML-based data exchange format. The definition of services, that implement different workflow activities is yet another next step.

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REFERENCES

Barroso, L. A. (2005). The price of performance. *ACM Queue*, 3:48–53.

BITKOM (2008). Energy Efficiency in the Data Center: A Guide to the Planning, Modernization and Operation of Data Centers. Retrieved February 16, 2012, from http://www.bitkom.org/files/documents/energy_efficiency_in_the_data_center_volume_2.pdf.

Deutsches Institut für Normung (2011). Methode zur Berechnung und Deklaration des Energieverbrauchs und der Treibhausgasemissionen bei Transportdienstleistungen (Güter- und Personenverkehr). DIN EN 16258, Deutsches Institut für Normung e. V.

European Parliament and Council (2009). Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 november 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), repealing Regulation (EC) No 761/2001 and Commission Decisions 2001/681/EC and 2006/193/EC. Technical report, European Community.

Guine, J., Gorre, M., Heijungs, R., Huppes, G., Kleijn, R., Koning, A. d., Oers, L. v., Wegener Sleeswijk, A., Suh, S., Udo de Haes, H., Bruijn, H. d., Duin, R. v., and Huijbregts, M., editors (2002). *Handbook on life cycle assessment. Operational guide to the ISO standards. Part IIa: Guide.* Kluwer Academic Publishers, Dordrecht.

Jolliet, O., Margni, M., Charles, R., Humbert, S., Payet, J., Rebitzer, G., and Rosenbaum, R. (2003). Impact 2002+: A new life cycle impact assessment methodology. *International Journal of Life Cycle Assessment*, 8(6):324–330.

Koomey, J. (2007). Estimating total power consumption by servers in the U.S. and the world. Retrieved February 16, 2012, from http://sites.amd.com/de/Documents/svrpwrusecompletefinal.pdf.

Rivoire, S., Ranganathan, P., and Kozyrakis, C. (2008). A comparison of high-level full-system power models. In *Proceedings of the 2008 conference on Power aware computing and systems*, HotPower'08, pages 3–3, Berkeley, CA, USA. USENIX Association.

WRI and WBCSD (2004). The greenhouse gas protocol. Technical report, World Resources Institute and World Business Council for Sustainable Development.