Findings of an Action Research on implementing an Integrated Energy Management in a German SME

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Abstract

The responsible and sustainable use of energy in private, public and business environments is one of the major societal challenges of our time. An essential part of this challenge is to increase the energy efficiency of (high energy) companies and implementing a sustainable energy management. In this paper we demonstrate that this is a complex socio-technical problem that asks for a holistic view and the need of integrated energy management systems without neglecting the difference between the needs and roles of the various stakeholders in a company. These findings are based on an ongoing action research where we conduct interviews with 15 groups of interest in the company that is operational in the area of fastening technology and has more than 2300 employees in 30 subsidiaries.

1. Introduction

The responsible and sustainable use of energy in private, public and business environments is one of the major societal challenges of our time. One of the key factors of a successful implementation of the energy turnaround is the energy efficiency of (high energy) companies. In Germany, for instance, government acknowledges this need e.g. with the introduction of the "Erneuerbare-Energien-Gesetz" (EEG) law.

In later versions of the EEG incentives were added for manufacturing companies that implement an energy management system conform to DIN EN ISO 50001 [1] or conduct an energy audit based on the ISO 16247 [2]. The key concept of the ISO 50001 is to establish a continuous improvement process (CIP) increasing the organizational energy efficiency. This process is split into four iterative phases: Plan, Do, Check and Act [3]. On completion of each iteration, a new revision of energy management processes should be implemented. This CIP method is analogue to common methods of business process management (BPM). Since the main goal of the CIP (introduced according to ISO 50001) is to increase the sustainability of a company there is a great affinity to Green BPM [4] concerning the optimization of the energy consumption.

In organization, energy efficient tasks play a major role for energy conservation. For example Schröter et al. [5] estimate that about 15% of all consumption could be saved by efficient task, according to Meyer [6] it is up to "25% . While energy efficiency tackles both, ecologic and economic dimensions, the latter is rather important. Especially small and medium enterprises need to increase their efficiency, for the simple reasons that energy costs are one of the main cost drivers in production processes and especially smaller companies may struggle due to increasing costs (ibid.).

In the following sections we will survey the state of the art of a socio-technical scope on energy management, afterwards we describe our research approach and present our findings. We conclude by discussing our findings and give an outlook on our next research activities.

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2. State of the Art

Most organizations lack proper information on energy consumption, demand and pricing, which is necessary to improve sustainability. This has proven to be substantial to instantiate suitable measures on various organizational levels. For example, Schwartz et al. [7] and Jakobi et al. [8] showed that individual feedback on the employees' energy consumption is a valid instrument to lower energy consumption in office environments. On a more strategic level a study conducted by the IHK Siegen-Wittgenstein, the regional chamber of Industry and Commerce, for instance, pointed out that enterprises with an active energy procurement policy, buying directly on the energy exchange market, can save up to 34% of their energy costs [9]. These examples show that IT-supported organizational information management about energy consumption, procurement and production is vital to succeed. But in order to achieve that kind of economization, the company needs accurate energy consumption forecasts based on historical consumption, which is not necessarily given in organizations.

In principle energy management could rely on the manual collection of consumption data (and conform to ISO 50001). Yet an effective and holistic eco-controlling could only be carried out by IT support [10] as information technology enables the company to schedule and control energy consumption during the manufacturing and production. Hence, one key component for a modern energy management is the implementation of a computational energy management system, since it allows the involved stakeholders to gather the needed information on, e.g. the current load, energy peaks and the energy efficiency of a certain product. Sangmeister et al. stated companies now save about 10% of their energy in the first year through the introduction of such energy management systems [11]. IT-systems itself, however, are dead capital, if they are not effectively used in practice. Hence we must understand the integration of an energy management as an integrated organization and technology development process [12] with the "green business" as a guiding principle [13]. To achieve a this goal, Süpke and Heil [14] have identified three core elements: Involvement of all relevant stakeholders, expansion of the business strategy by including a sustainability dimension, and the implementation of new processes derived directly from the new strategy.

A holistic approach resting on the three-pillar model of social, ecological and economical sustainability [15] is one of the modern corporate objectives. Nevertheless, there are still too few companies with clear strategies and management concepts, from which sustainability management can be derived [16]. In addition, energy management cannot be equated with energy efficiency [17]. The management of energy has to be aligned with the corporate strategy (ibid.). Concerning this, the adoption of "green" business processes is an essential part in the successful implementation of energy management and sustainable corporate strategies. The alignment of the sustainability strategy with the corporate strategy as well as the alignment of the intended sustainable processes and the real processes must be regularly monitored. Well-known instruments to assess the adoption of business processes are maturity models, which should also be used during and after the implementation of energy management [18] in order to secure the success of the corporate strategy.

This brief survey on energy management shows that energy management is a complex task that must be perceived as a socio-technical challenge.

3. Field of Application and Method

This work covers the empirical, analyze phase of an ongoing action research [19] where we participate with a SME in South Westphalia.

The company is operational in the area of fastening technology, has more than 2300 employees in 30 subsidiaries, and thus can be characterized as decentralized. In contrast the company has a cen-

tralized energy management department, which is part of a shared service center and is responsible for managing all subsidiaries in this matter.

Our research activities addressed the holding company and three subsidiaries, while a second more focused empirical study addresses only the holding and two subsidiaries.

3.1. The First Study

Our status quo analysis was carried out in September 2013, when we conducted ten semi-structured interviews over the course of two days with various stakeholders in the company (Management, Maintenance, Controlling, IT Department, Energy Management, Energy Procurement, and Production Management). The questions focused on the general organizational energy management activities and the existing infrastructure, the individual need of information and their individual assessment of the importance of the internal energy management. On average, the interviews lasted 45 minutes and were transcribed and analyzed with qualitative methods.

3.2. The Second Study

While the first study was conducted in order to assess the status quo of the energy management and unveil the untapped potential for an action-centered visualization approach, the second study is more focused on action taken and is still ongoing. The study takes place in a joint research project, which was established about 3 months after completion the first study. In this research project, the following goals are to be achieved:

- Design and implementation of a holistic and modular energy management system
- Design and implementation of a strategic and an operative indicator system for an energy controlling as part of the energy management system
- Integration of the energy data into the business processes of the company, especially the integration into the ERP-System in order to allow e.g. the calculation of the direct costs of the products and a production scheduling under consideration of the, energy consumption of particular process steps

As part of the second study (which will be concluded in September of this year) we identified 15 groups of interest which are part of the requirements engineering, the research and the design process. Additionally, to the first interviewees, the groups of interest consist of a production manager of a new subsidiary, two project managers (the two projects are the implementation of a factory data collection module and a maintenance module of the ERP-System), the factory manager of one subsidiary, three managers of the most energy consuming organizational units (electroplating, hardening, production) and the local controller. The groups of interests are likely to be expanded while the project goes on.

4. Findings

4.1. First Study

In the following section we will outline the results of the study, ordered by the groups of interest.

- Maintenance
  The maintenance department is responsible for the servicing and maintenance of production facilities. This includes both tools and materials, as well as energy and building technology, including gas and compressed air facilities.
  The manager of the maintenance department is also responsible for the cost centers associated with energy, water, gas, and compressed air consumption. The necessary information is gath-

ered manually at the end of each month and is transferred to the central environmental management department.
From the perspective of the maintenance department the importance of integrated energy data management is rather high, since it could possibly enable them to avoid load peaks during the production cycles. Furthermore, they could implement a base load optimization process, focusing especially on the auxiliary process time, e.g. between shifts or during the night.

- Controlling
  The controlling department at the cooperation is divided into central, international and business division controlling. It consists of 14 members. Our interviewee is part of the business division controlling, which deals primarily with the value chain and manufacturing costs controlling.
  In regard to energy data management their main task is to enable the different production departments the allocation of direct expenses of their product. Due to the state of the energy data management (manual data collection, monthly polling of the consumption data, no IT support) precise cost allocation is impossible and they need to rely on the distribution of overhead costs (such as energy costs). Another request of the controlling department is the possibility to identify the major energy drivers (e.g. electroplating, hardening) and support in the process of calculating machine hour rates.

- IT-Department
  The IT-Department consists of 20 employees and is a central service unit for the holding and all the subsidiaries. The requirements identified in the discussions on energy data management in the field of IT are to be classified with low priority for the business and have a strong operational focus. However, they are aware of their importance in the implementation of an integrated energy management system, since an information system is one key element of environmental and energy management.

- Energy Procurement
  The department is part of the general procurement department and is responsible for the purchase of electricity and gas and is supported by an external consulting company. Their procurement structure is organized into ten tranches a year, which are ordered at different points of time, in order to minimize the price risk. The main requirements for this department are the support of aggregated views on the consumption of electricity and gas (weekly, monthly, and yearly). Furthermore, they need a breakdown of the energy costs into the dimensions working price, "KWK"[6]-apportionment, "EEG"[7]-apportionment, offshore apportionment and energy tax.

- Business Division Building Fasteners
  For the business division building fasteners the consumption data of the energy carriers, water, waste, compressed air, electricity and gas are important. Due to the unique production process water consumption especially is relevant to the manager. The consumption data is read once a month from the corresponding meters. In addition to the manager, all the foremen and employees need to be informed about the consumption, since the change of consumption is discussed in the regular meetings among the foremen. A critical requirement for this business division is the task-oriented visualization of energy data, since overall consumption is not that useful for

[6] The "Kraft-Wärme-Kopplungsgesetz" subsidizes the contruction of cogeneration plants and technologies

[7] The "Erneuerbare-Energien-Gesetz" is a German law that regulates the priorization of the feed-in of electricity from renewable sources into the power grid and guarantees their producers fixed feed-in prices.

the foremen and employees. Furthermore they need support in their foremen meetings, in order to monitor and benchmark process changes both in the subsidiary and as well as between subsidiaries.

- Business Division Electroplating
  As part of the initial study, one manager of an electroplating department was also interviewed. From his perspective, when it comes to energy data, the main concern is water consumption. Compressed air is the second most important resource, whereas electricity and gas are not as important. From his point of view, the biggest improvement would be a batch-oriented analysis of energy consumption. Moreover he needs continuous monitoring of the compressed air, since bottlenecks can decrease efficiency drastically.

- Business Division Screw
  The division manager's opinion is that energy data management is not really important for him. The only interesting scenarios he could think of were a comparison of energy consumption in the procurement process of new machinery and in support of the audit process.

- Business Division Environmentalism – Industrial Safety – Facility Management (ESM)
  The ESM division is the central division when it comes to energy and environmental (data) management. In addition, they are responsible for the implementation of the ISO 50001 in German Subsidiaries. Their main concern with the current state of energy data management is the manual collection of the consumption data. Not only does it delay the monthly reporting, but it is also the main source of errors in the current environmental controlling. Their main demands on energy management are the automation of the data collection, an alert system which informs the energy manager of relevant incidents, the support for strategic environmental controlling and the integration of an information exchange between energy contractors and the company.

The status quo analysis revealed four major weak spots of the existing energy management:

1. Although the company implemented certified energy management (ISO 50001) in 2012 and an environmental reporting system based on the Global Reporting Initiative[8], the data collection is still done manually and only down to subsidiary level. Hence real time collection, analysis and visualization are not possible, which means the managers and employees cannot use the information for their day-to-day activities
2. The performance measurement and controlling system is too general and only fits the requirements of the environmental manager
3. The implemented energy management is fragmented and does not follow a holistic approach. As a result there is insufficient provision of information and inconsistencies occur
4. Although energy management is a major concern for both the ESM division and the management, most production divisions regard it as being less significant. Even so, most of the interviewees could think of at least some scenarios where they could benefit from integrated energy management. Nevertheless there is a gap between the management and the employees that are part of the operational business.

[8] https://www.globalreporting.org

On the basis of the first study, we developed (coordinated with the company) an integrated energy management concept that consisted of the major areas: hardware, software and processes.

The discussion of this concept and how to implement it started in February 2014 and is still ongoing. The key of the concept includes a measuring sensor system which allows the energy consumption of the e.g. machinery to be monitored. This is partially realized in practice (e.g. one subsidiary was equipped with sensor technology). The data will be stored in a central real-time database system to allow precise evaluation of the energy consumed in the production process. At the moment, an operating and machine data logging software has been selected and will be installed, thus connecting the measure points by the end of July. In addition, two value-added services have been selected and will be implemented. The former is a web application for both strategic and operative eco-controlling and the latter is a web-application which allows the forecasting of energy consumption based on historical data.

The energy management solution is the core element of the project which we started with the company. Nonetheless the implementation of both new and altered business processes are also a major part of the project, and will be addressed in the second study.

4.2. Second and ongoing Study

Whereas the first study aimed at the analysis of the state of the energy data management in the company, the second study is more action focused in order to implement an energy management system and engage in the change of the corresponding business processes.

In this study we focused on two production business divisions and the holding. Yet we started with a requirements analysis of one subsidiary first, which is the pilot enterprise for both, the company and ourselves. And was not covered in the initial study.

- Energy Procurement
  As part of the research project, we will develop a module that enables the company to forecast their energy consumption based on the collected energy data. The energy procurer needs an algorithm, which helps him with his procurement process (when to buy) and supports his reporting.

- Maintenance:
  Although we interviewed one maintenance department in our first study, we also interviewed the local maintenance at the chosen subsidiary. Additionally to the requests of the other maintenance department, they need an integration of the implemented energy management system into the maintenance module of their ERP-software. Furthermore they requested a feature, which detects electrical interferences.

- Production:
  From the point of view of the local production assistant the energy management system needs to be integrated with the operating data module of their ERP-software. This would allow them to evaluate, whether there is an upcoming assignment for a machine and if it could be e.g. disconnected from the compressed air grid. In addition, he thinks that through the connection between the consumption and operating data one can finally analyse the direct costs of the products. Moreover, it should be integrated into the efficiency overview, which now only consists of the number of items per hour.

Additionally to the conducted interviews, we informed all participants about our research project and our next steps. In the aftermath most of the stakeholders engaged in a discussion and pointed out, that they need support for their project team, which tries to increase energy efficiency of processes and the subsidiary in general. They envisioned a tool, which allows them to benchmark processes and supports the evaluation of their measures. Generally they are really interested in the comparison with other subsidiaries and hope that the implemented energy management system will help them with energy audits and reports.

5. Conclusion

As seen in the state of the art and based on our first study, the implementation of an energy management present a socio-technical challenge where different stakeholders and their roles have to take into account. Further a holistic energy management system needs to be integrated in both the existing infrastructure and the business processes of the company. Moreover a strategic and operational environmental controlling must be implemented in order to qualify for the tax benefits and to unfold the full potential of an energy management system. A process integration is imperative for a modern approach on environmental (data) management. Furthermore, the different attribution of importance of the energy (data) management by the subsidiaries and the holding must be addressed, since at the current state of the project, the needed infrastructure for the measurement of the consumption data is about to be rolled out, but the subsidiary lacks proper use cases and business processes to incorporate the data into their processes. Right now we are about to finish the requirements analysis with the subsidiary, and are working on both operational and strategic concepts for an environmental controlling. Besides we are working on a concept for the integration of our energy management system into the existing infrastructure (ERP-system).

As part of the ongoing research activities in the research, we will analyze the implementation of our energy management solution in three different companies and will work on the concept of the holistic energy management.

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