Energy Management in German Small and Medium-Sized Enterprises

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Abstract

The aim of this work is to assess the current status of energy management in small and medium-sized enterprises (SMEs) in order to better understand the motivating factors and the main obstacles. An empirical study of SMEs in Germany was performed by sending a short online survey to 7745 German companies and quantitatively analyzing the results. In order to better highlight the benefits of energy and environmental management systems, a model of environmental and energy management has been developed which clearly illustrates the potential returns for the company as a function of effort and outlay. An analysis of the distribution of survey participants within the model is presented in this paper. The majority of survey participants claim a high awareness of energy efficiency matters, so it seems there is a high chance of unlocking the large energy-saving potential offered by more energy-efficient SMEs, provided the necessary support is made available.

Keywords: QuiXel, SMEs, survey, energy management

1 Introduction

Energy management plays an increasingly important role in recent times. Energy production and usage have a huge economic, ecologic, and social impact that also affects SMEs either directly, through energy usage costs, or indirectly, through follow-up costs associated with climate change or environmental degradation. Energy management provides the possibility to monitor and evaluate energy usage and serves as the foundation from which to derive and implement measures for the improved, more efficient use of resources. Despite the high relevance of this theme to today's society, commercial/industrial energy management is only partly developed from a research standpoint (Hrustic, Sommarin, Thollander, &Sönderström, 2011).

The QuiXel project aims to develop an integrated data and information platform for collaborative and evolving environmental and energy management in SMEs. In this context, a general model (from here on referred to as the "shell model") of environmental and energy management systems was developed, clearly outlining the benefits of the system as a function of the amount of effort invested by the company. In the analysis phase of the project, a survey was sent to several thousand German companies to evaluate the current status of energy management in SMEs. Although the project also deals with environmental management, the survey was limited to questions on energy management for the sake of simplicity and to keep the completion time under approximately 15 minutes. A primary goal of the survey was to pinpoint companies' current and target positions within the shell model.This paper is structured as follows: the background to the work is presented in Section 2, including a brief discussion of energy management in SMEs followed by a description of the shell model. The methodology employed in the preparation of the survey is outlined in Section 3, and the results of the survey are presented in Section 4. The implications of the results are addressed in Section 5, followed by a short summary and conclusion in Section 6.

2 Background

Increasing energy efficiency is key for addressing future challenges. This is reflected in the climate change and energy targets of the Europe 2020 strategy, which call for a 20% increase in energy efficiency and a 20% increase in the share of renewable energy sources as well as a 20% (or 30% if the conditions are right) reduction in greenhouse gas emissions (European Commission, 2010). New legislation, such as the German Energy Act (EnWG) (Bundestag, 2005) or the ISO 50001 norm (Deutsches Institutfür Normung, 2011), as well as increasing awareness and rising energy prices provide a strong motivation for companies to seriously address the theme of energy management.

2.1 Energy management and energy management systems in SMEs

SMEs make up more than 99% of German companies (Statistisches Bundesamt (Destatis), 2014), with an estimated 3.64 million businesses across the country as of 2016 (Statista, 2017). Tapping into the energy-saving potential in SMEs would therefore make a significant contribution to energy efficiency across Germany as a whole. According to a study conducted in 2014, 79% of German SMEs rate their awareness of energy efficiency as high or very high (Meyer, 2014). The same study showed that the main reasons for the adoption of energy management in SMEs are primarily economic (cost saving 81%, legal standards 80%) rather than social (environmental protection 13%). A study from 2013 showed that 33% of SMEs implemented measures for improving energy efficiency and a further 10% had measures planned in the period 2011–2013 (Schwartz & Braun, 2013).

Given the limited resources (time, money, and personnel) in SMEs, full, in-house energy management solutions are generally not justifiable (Thollande r& Dotzauer, 2010). On the other hand, it has also been found that a uniform, one-size-fits-all approach to energy management is not necessarily effective due to the many differences in the broad range of business types spanning different sectors (Christoffersen, Larsen, &Togeby, 2006). In order to be successful, an energy management system must be tailored to the specific conditions at the company in which it will be used. The efficient implementation of energy management is very often dependent on the company size. Specifically, it has been found that:

- smaller companies have a more unstructured approach to energy management (Meyer, 2014).
- SMEs lack important frameworks for energy management (Hrustic et al., 2011).
- larger companies have more problems with coordination and collaborative work (definition of performance indicators and data acquisition) (Oehler, Schalkowski, & Wendt, 2013).
- strategic objectives (aside from cost saving) play more of a role for the introduction of energy management in larger companies than in smaller ones (Posch, 2011).
- there is no software or tool that performs all the required tasks for energy management in SMEs (EnergieAgentur.NRW, 2013).

Two different approaches can be taken in an attempt to provide a tailored but general solution to energy management: the use of a simplified energy management system (Hrustic et al., 2011) or the implementation of certain energy management components that address the key issues without placing too much burden (either financial or temporal) on the companies (Thollander & Dotzauer, 2010).

2.2 The shell model

A major goal of the current project is to supply users of the platform (SMEs) with a tailored plan to achieve their energy management goals based on their current and target levels of energy management. In order to provide a solid foundation for the different possible levels of energy management, the shell model was derived to describe the relationships between the amount of effort invested by the company and the potential effects and outcomes. (It should be noted that the model describes environmental management systems equally well.) A schematic illustration of the model is shown in Figure 1, with the shells on the left and the associated effects and outcomes in the center and on the right, respectively.

The shell model incorporates the important aspects of the European norms ISO 50001 (DeutschesInstitutfür Normung, 2011) and ISO 14001 (Deutsches Institutfür Normung, 2015). At the core of the model are the nested levels or shells describing the different aspects of a management system. The first (smallest) shell *implementation of improvements* represents the first step in energy management and the last (largest) shell *certification* represents a full implementation.

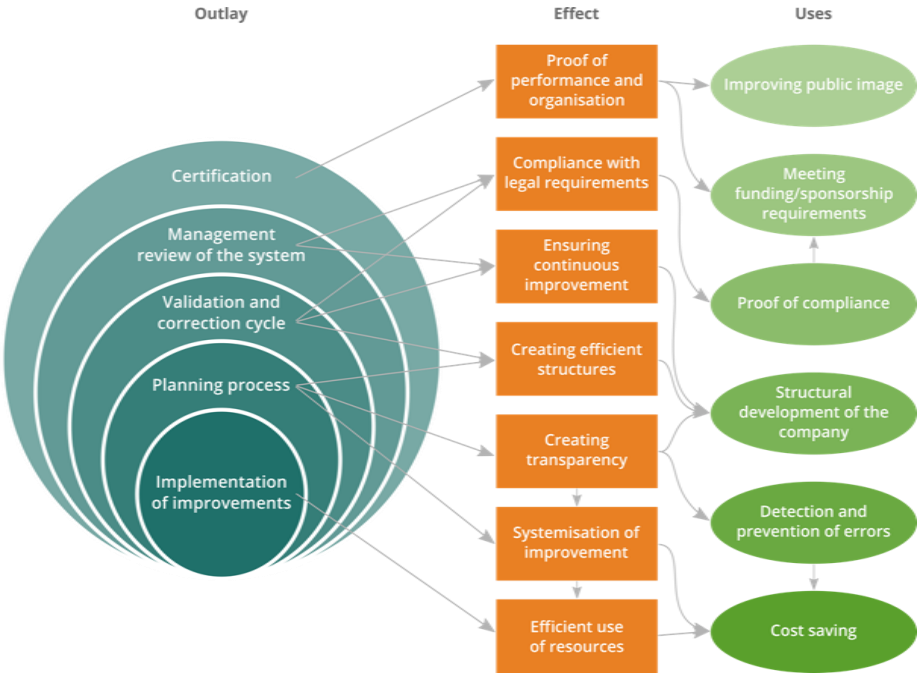

Figure 1: Illustration of the shell model showing the outlay, effects, and outcomes for different levels of energy management.

The shells in between represent intermediate levels of energy management in order of increasing complexity and outlay. The model is designed as a nested system, meaning that each shell includes and relies on the smaller shells it contains. For example, the *planning process* requires implementation of improvements, or in the most extreme case, *certification* requires the conditions of all other shells to be fulfilled.

Each shell is linked with one or more effects and outcomes, with more efficient use of resources and cost saving associated with the first shell and compliance with legal requirements as well as improved public image associated with the upper shells. It should be noted that the effects and outcomes are focused on the returns for the company itself rather than the more abstract benefits such as advances in social responsibility or environmental protection.

3 Methodology

The methodology employed in the preparation, running, and evaluation of the survey is briefly outlined in this section.

3.1 Preparation of content

In addition to ranking companies' current and target levels of energy management using the shell model, the five statements presented earlier in Section 2.1 were also tested as part of the survey. These statements, or hypotheses, concentrate mainly on the structure, organization, and complexity of energy management as a function of company size. Questions relating to the shell model and each hypothesis were carefully formulated to be as clear and unbiased as possible. Once the questions were finalized, they were grouped into self-consistent categories and put in a logical and sequential order from the point of view of a participant.

3.2 Structure of the questionnaire

By the end of the preparation phase, the questionnaire consisted of three distinct blocks:

1. general questions for the classification of companies,
2. questions for pinpointing companies' current and target levels of energy management in the shell model,
3. questions relevant to the core processes of energy management – key performance indicators (KPIs), data acquisition, as well as software and tools.

In particular, Block 2 (relating to the shell model) consisted of 11 questions with yes/no answers. The yes answers determined the companies' current position in the model. The no answers were further subdivided into three categories ("no, but we have a concrete idea of how to do that in the future"; "no, but we could imagine that in the

future"; and "no, and this is not desired") in order to estimate the companies' target position in the model.A background logic for the order of the questions was devised for the entire questionnaire, as certain questions (or sets of questions) were only asked given a yes answer to a previous question. In Block 2, for example, questions relating to the third shell of the model were only asked if the participant fulfilled all criteria of the second shell, or similarly, questions relating to KPIs were only asked in Block 3 if the companies indicated they had experience with them in Block 2.

3.3 Data collection

The survey was implemented with the online survey tool SurveyMonkey (de.surveymonkey.com). The final version of the survey was tested by multiple team members to ensure the completion time was less than 15 minutes and also to verify the question logic throughout the questionnaire. Once testing was complete, the survey was active for three weeks in September 2016. A system was set up to automatically send emails to companies with fewer than 250 employees from the Hoppenstedt company database (www.hoppenstedt-firmendatenbank.de), inviting them to participate in the survey. Of the 7745 SMEs contacted about the survey, 69 companies participated, with 57 completing the survey to the end.

3.4 Data evaluation

Once the survey was finished and deactivated, all responses were exported from SurveyMonkey as a csv file. A comprehensive, in-house analysis of the data was performed using the python statistics library "scypy". The answers to the individual questions were first evaluated, and these figures were then used to test the degree of correlation between different parameters, e.g., the number of companies that document their KPIs as a function of company size (number of employees).

4 Results

By the end of the survey period, 69 companies had answered the questionnaire, 90% of which were active in the manufacturing sector. The small number of responses resulted in a margin of error of about ±10% on the results quoted given a 90% confidence interval.

Although companies with fewer than 250 employees were specifically targeted, eight of the companies had significantly grown since the creation of the database, having between 250 and 500 employees at the time of the survey. The participating companies were distributed all around Germany (see Figure 2), with the highest concentrations in North Rhine-Westphalia (18), Baden-Württemberg (14), Bavaria (14), and Lower Saxony (11).

Figure 2: Distribution of participating companies around Germany

In order to test each of the five statements presented in Section 2.1, the relationship between the response to relevant questions in the survey and the size of the company was tested. The correlations were evaluated using the Kendall tau rank correlation coefficient. Due to the small number of participants, only four correlations were found to be significant at (or above) the 90% confidence level:

- Larger companies have more complex KPIs.
- Larger companies provide more documentation on their KPIs.
- KPI definition is more collaborative in larger companies.
- Data acquisition is more collaborative in larger companies.

The result of ordering companies in the shell model is shown in Figure 3. The left panel of the figure shows the current distribution of companies in the shell model (out of a total of 61). A high proportion of the participants (49%) already have certified energy management systems and all companies aim to implement at least some level of energy management. The right panel shows the target shells for the 51% of participants that are not yet certified. While most companies are striving for a higher level of energy management in the future, some are content to remain at their current level (denoted by the blocks on Level 1 and Level 4).

The participants were also asked to rank the importance of the different outcomes of implementing an energy management system for their company. The responses were given on a 4-point Likert scale ("very important", "important", "unimportant", and "irrelevant"). A weighted average of the responses for each outcome was then calculated, the results of which are shown in Figure 4. The results here confirm the findings of (Meyer, 2014), with cost saving being the number one motivating factor.

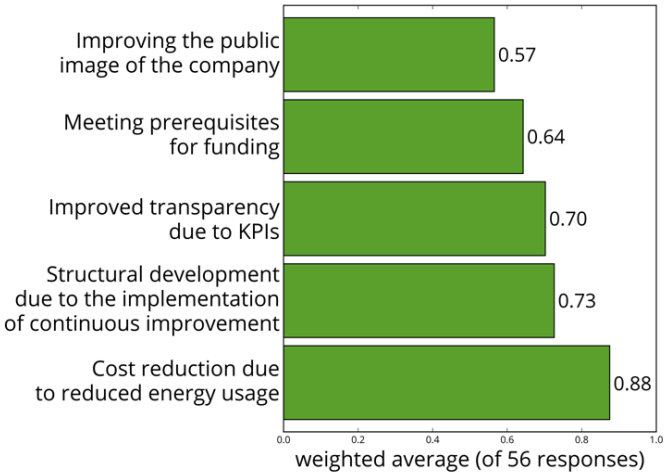

Figure 4: Importance of the different outcomes of implementing an energy management system according to the survey participants. On this graph, 1 corresponds to "extremely important" and 0 represents "completely irrelevant".

Questions relating to KPIs revealed that the number of companies using top-down (first choosing the KPIs and then creating the necessary data sources to calculate them) and bottom-up (using the existing data sources to define KPIs) approaches are approximately evenly split. In addition, a collaborative element to the definition of KPIs was identified, with about 80% of companies involving more than one person in this process.

With regards to data acquisition, it was found that 75% of companies utilize a central acquisition method, i.e., the necessary data are collected from all locations and processed by a central office. The majority of companies (about 80%) employ some form of data quality monitoring checking data plausibility and completeness. It was also discovered that 75% of companies have some form of automatic data acquisition for energy usage, energy costs, or auxiliary parameters such as working hours, production volume, etc.

At the end of the survey, participants were asked to rate the usefulness of software and management tools in six different areas: management instructions/guidelines, KPI definition, data acquisition, data analysis, documentation, and reporting. A weighted average of all responses was calculated in order to rank the areas in terms of the usefulness of software support.

The difference between the highest (data analysis) and lowest (KPI definition) ranks did not much exceed the statistical error on the values, suggesting the software support is approximately equally useful across all areas of the management process. Participants were also asked to rate the helpfulness of support for collaborative work (multiuser and collaborative tools) in the same six areas. Again, no area significantly outranked any of the others, suggesting a general interest in being able to work collaboratively throughout the entire management process.

5 Discussion

It is interesting to note that companies from economically strong German states dominate the participation in this survey. On the one hand, it is natural that states with a higher absolute number of companies are more represented in the survey. However, it could also indicate that companies seated in weaker German states require more support and assistance to get started with energy management. It is noteworthy that all companies that completed the questions related to the shell model aim to implement at least some level of energy management. Of the 69 companies that began the questionnaire, 61 responded fully this section. It can be assumed that non-completion of this section implies a lack of interest in the subject. In this case, it can be said that 88% of participants are aware of energy efficiency matters and are willing to take action. However, care must be taken when extrapolating these results to include all German SMEs – there is presumably a non-negligible bias introduced by the fact that companies already interested in energy management are more likely to participate in and complete the survey. The four significant correlations relating to energy management as a function of company size support the natural assumption that larger companies require more manpower to successfully implement an energy management system, and go towards corroborating the third statement in Section 2.1: larger companies have more problems with coordination and collaborative work. However, it could not be unambiguously confirmed as two more correlations tested with respect to this statement were found to be statistically insignificant. The other four statements could neither be confirmed nor rejected as all other correlations were found to be insignificant.

6 Summary and outlook

The results of an empirical survey of energy management in German SMEs have been presented. In agreement with previous studies on the subject, it was found that cost saving due to reduced energy consumption is the top motivating factor for companies. Half of the survey participants already had a certified energy management system and a further third were aiming for certification in the future. The remaining companies (15%) indicated a desire to implement at least some energy management measures. Care must be taken when extrapolating these results to include all German SMEs there is presumably a non-negligible bias introduced by the fact that companies already interested in energy management are more likely to participate in and complete the survey. However, given that the majority of German SMEs claim a high awareness of energy efficiency matters (Meyer, 2014, also supported by the results of this work), it would seem there is a high chance of unlocking the large energy-saving potential offered by more energy-efficient SMEs in the near future, provided the necessary support is made available.

References

Bundestag (2005).Gesetzüber die Elektrizitäts- und Gasversorgung. Berlin.

Christoffersen, L. B., Larsen, A., &Togeby, M. (2006).Empirical analysis of energy management in Danish industry.Journal of Cleaner Production, 14 (5):516-526.

DeutschesInstitutfürNormung. (2011). DIN EN ISO 50001:2011-12. Energiemanagementsysteme–AnforderungenmitAnleitungzurAnwendung.

DeutschesInstitutfürNormung. (2015). DIN EN ISO 14001:2015-11. Umweltmanagementsysteme–AnforderungenmitAnleitungzurAnwendung.

EnergieAgentur.NRW. (2013).EMS.marktspiegel. Retrieved from http://www.energieagentur.nrw/ energiee ffizienz/ ems. marktspiegel

European Commission.(2010). Europe 2020.A strategy for smart, sustainable and inclusive growth.

Hrustic, A., Sommarin, P., Thollander, P., &Sönderström, M. (2011).A simplified energy management system towards increased energy efficiency in SMEs.World Renewable Energy Congress. Linköping, Sweden: Linköping Electronic Conference Proceedings. Linköping University Electronic Press.

Meyer, J. A. (2014). Energie- und Umweltmanagement in kleinen und mittlerenUnternehmen.Jahrbuch der KMU-Forschung und -Praxis 2014 (pp. 3-12). Euler Verlag.

Oehler, A., Schalkowski, H., & Wendt, S. (2013). Persönliche und automatisierteKommunikation in KMU: Ein Ansatz zum Management gestiegenerKomplexität von Kommunikationsprozessen. Jahrbuch der KMU-Forschung und -Praxis 2013 (pp. 105-112). Euler Verlag.

Posch, W. (2011).GanzheitlichesEnergiemanagementfürIndustriebetriebe.Springer Gabler.

Schwartz, M., & Braun, M. (2013).Energiekosten und EnergieeffizienzimMittelstand.FokusVolkswirtschaft, 40.

Statista.(2017). Anzahl der kleinen und mittlerenUnternehmen in Deutschland bis 2016. Retrieved from https://de.statista.com/statistik/daten/studie/321958/umfrage/anzahl-der-kleinen-und-mittleren-unternehmen-in-deutschland

StatistischesBundesamt (Destatis). (2014). Anteilekleiner und mittlererUnternehmen an ausgewähltenMerkmalen 2014. Retrieved from https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/ Unternehmen Handwerk/KleineMittlereUnternehmenMittelstand/Tabellen/Insgesamt.html

Thollander, P., &Dotzauer, E. (2010).An energy efficiency program for Swedish industrial small- and medium-sized enterprises.Journal of Cleaner Production, 18 (13):1339-1346.