OBJECTIVES AND BARRIERS FOR THE IMPLEMENTATION OF ENERGY MANAGEMENT SYSTEMS IN MANUFACTURING ENTERPRISES IN GERMANY: RESULTS OF AN EMPIRICAL INVESTIGATION

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Abstract: *This paper introduces and examines objectives and barriers that occur during the implementation of an energy management system (EnMS). It thereby presents the results of an empirical investigation regarding manufacturing enterprises in Germany conducted by the Fraunhofer Institute for Production Systems and Design Technology IPK. It further focuses on the context of German legislature and public facilitation made to promote energy efficiency. The results shall give recommendations where promotions made to energy efficiency should be aimed at and what potentials for improvement exist.*

Key words*: energy management system, ISO 50001, energy efficiency, barriers, small and medium-sized enterprises*

1. INTRODUCTION

The increasing significance of sustainable use and deployment of energy is a central challenge of today's industrial nations. Rising energy costs, scarcity on fossil energy sources and higher customer requirements regarding sustainability assert that energy efficiency is a topic yet essential to be shed light upon.

Indeed the EU's 20-20-20-target of reducing the emissions of greenhouse gases while increasing energy efficiency and the share of renewable energies by the year 2020 by 20 % each seems to be very hard to reach [1]. This is emphasized by the fact, that despite satisfactory results in German industry and the high political relevance, industrial energy management has not had an equivalent impact in research work [2][3].

1.1. Energy Management Systems

The purpose of EnMSs according to ISO 50001 is to enable organizations to build systems and processes, which are to improve the energy related performance, to depict and to value energy flows and to create a basis on which existing potentials can be identified and thus measures to be derived from, resulting in a more efficient energy deployment [4]. It further demands for a distinct statement regarding an organization's energy policy and energy related targets with the overall intention, that due to the realized measures, a certain level of output performance requires minimal energy input.

The systematic identification and enhancement of energy potentials primarily involves the manufacturing processes, behavioral aspects, and the innovative process development.

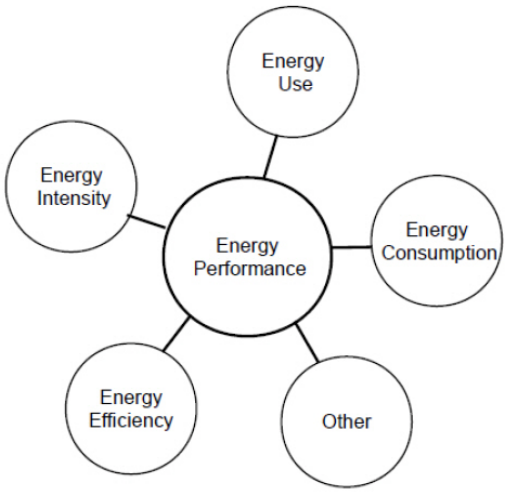

Figure 1. Energy Related Performance According to ISO 50001

The possible industrial parameters that underlie optimization are e.g. electrical power, heat, and energy related environmental emissions. These are measured and regarded in the context of the energy related performance by the characteristics energy use, energy consumption, energy intensity, and energy efficiency (Figure 1).

As any other management system, EnMS according to ISO 50001 shares its derivation from the standard for quality management systems ISO 9001. Since management systems are distinguished by a high level of integration in the strategic procedures of an organization, EnMSs require the commitment of an organization's top management and the continuous engagement with the energy topic. This becomes clear when considering the requirements for establishing an energy team and the continuous improvement process (CIP).

1.1.1. The Challenge of Promoting Energy Efficiency

As market-based instruments for a European energy policy, EnMS standards are currently well acknowledged. The internationally widely established environmental management systems according to ISO 14001 and the eco-management and audit scheme (EMAS) have paved the way for further developments in the field. Experiences of international companies have shown, however, that the dedicated management of energy is critical to long-term and continuous energy saving. This notion has been seized in a variety of national energy efficiency action plans (NEEAPs) that reflect the EU's 20-20-20-target. These NEEAPs are intended to promote energy efficiency and differ among the EU member states [5].

By the legislature, EnMSs are considered suitable instruments for companies to encourage energy efficiency [6]. Therefore policy makers grant the introduction of EnMS in the industry a high priority. It is also a goal to involve small and medium-sized enterprises (SMEs) in energy management more extensively [1]. The German federal government, however, promotes this energy concept by granting companies reductions on their energy and electricity taxes and the renewable energy act levy (REA levy, *in German: EEG-Umlage*) if a contribution to energy savings is made. The REA levy distributes the costs arising from the promotion of renewable energy sources among the consumers [7]. This contribution can be performed by operating an appropriate certified EnMS according to ISO 50001 (or the previous standard EN 16001) or equivalent measures.

Despite these promotional factors and an achievable energy saving potential of 15 % for manufacturing enterprises by basic measures, organizations are often reluctant to implement EnMSs [8]. This fact relates to immanent barriers organizations face implementing an EnMS. Further, with the implementation of EnMSs certain objectives may be pursued. These objectives and barriers apply in varying degrees depending on different factors inside an organization.

This paper shall subsume the results of an empirical investigation made by the Fraunhofer-Institute for Production Systems and Design Technology IPK, examining the progress made regarding the implementation of industrial EnMSs in manufacturing enterprises in Germany [9]. The following part depicts the insights that were gained concerning objectives and barriers to theSub implementation of EnMSs with regards to the special situation in German legislature.

Section 2 gives a brief overview about the taxonomy adopted in this paper, and what contributions have been made so far concerning this topic. It defines the terminology used on objectives and barriers and reflects the context in which this paper is to be set. In Section 3 the methodology of the empirical investigation is described and how the data of the relevant objectives and barriers is gathered.

In section 4 and 5 the results will be presented and discussed.

2. THEORETICAL BACKGROUND

There have been quite a few contributions made on objectives respectively barriers for the implementation on energy efficiency measures.

Objectives for the implementation of EnMSs are described by Hirzel et al. as points of motivation that generate cost effective and competitive advantages for the relevant enterprises [10].

The definition of barriers to energy efficiency in this paper relies on Sorrel et al. who see barriers as factors that comprise all influences that hinder the adoption of cost-effective energy efficient technologies or slow down their diffusion [11]. Their definition also proposes a categorization of barriers into scopes of, an economic, behavioral, and organizational nature.

The most helpful contribution regarding this paper's taxonomy on barriers came from Cagno et al. who distinguish between origins and further scopes of barriers that influence enterprises [12]. They stipulate the origins to be either internal or external and the scope to informational, economic, organizational, competence related, and behavioral.

As described, the above summarized taxonomy refers to barriers that account for energy efficiency measures. Thus, the methodology represented in this paper had to be modified to adapt to the survey as immanent issues of an EnMS. Selected objectives and barriers from the literature were revised and set in the relevant context to suit the empirical investigation made, concerning management systems and the particular distinction of the German NEEAP.

Table 1gives an overview about the examined objectives and barriers used for the empirical investigation.

Table 1. Examined Objectives and Barriers (issues).

	No.	Objective or Barrier	Scope
Objectives	O1	Save energy costs	
	O2	Reduce exposure to volatile energy prices	
	O3	Secure energy supply and independence	
	O4	Optimize energy procurement	
	O5	Make energy flows transparent	
	O6	Improve image	
	O7	Fulfill customer requirements	
	O8	Benefit from limiting the REA levy	
	O9	Reduce on energy and electricity tax	
	O10	Exercise social responsibility	
	O11	Prevent possible future regulation	
Barriers	B1	Missing information on costs and benefits	Informational
	B2	Missing information on public facilitation	
	B3	Missing information on energy efficient equipment	
	B4	Missing references to other companies	
	B5	Investment costs too high	Economic
	B6	Risk of hidden costs too high	
	B7	Expected return on invest too little	
	B8	Risk of intervention in business processes too high	Organizational
	B9	Integration in existing business processes too costly	
	B10	Identification of saving potential too complicated	Competence related
	B11	Effort for composition of internal competence too high	
	B12	Enterprise's personnel resp. time capacities insufficient	
	B13	Acquisition of external competence too complex	
	B14	Interest in energy management and energy efficiency too little	Behavioral
	B15	There are other priorities	

3. METHODOLOGY OF THE SURVEY

The questionnaire the investigation is based on was carried out with the help of an internet open source application. Initially over 84,000 managing directors of manufacturing enterprises throughout Germany were requested per email to participate in the survey that was conducted from November 28th 2012 to January 15th 2013. With a response of 3,908 answers the return rate was fairly at 5 %. At an adequate pace, it took around 15 minutes to complete the questionnaire, in German. The participants were asked to give information with regard to their enterprise.

In the first section the respondents provided details about facts related to energy and energy efficiency, the second section examined the topics management systems and energy management in particular. The third section questioned the details concerning the relevant enterprise and ended the questionnaire.

The results of the investigation presented in this paper were gathered in the second part of the questionnaire. The questions aimed at obtaining the degree to which certain objectives apply in general for a composition of an EnMS and to which barriers apply during the implementation of an EnMS. Furthermore, to what degree these barriers hinder the implementation. Participants were asked to assess on a five level Likert scale on how much objectives and barriers applied to the situation of enterprise. From level one, "does not apply at all" to level five, "fully applies". A decision for level three, the middle level, can be interpreted as a neutral position to the questioned issue.

To bring the questioned objectives and barriers in an adequate order they were rated after their arithmetic mean ($\bar{x}$).

4. RESULTS AND DISCUSSION

Before presenting the results concerning objectives and barriers some relevant details about the participating enterprises shall be provided.

Of the participants who finished the whole questionnaire 93 % can be considered SMEs (relying on the number of employees, an enterprise is considered a SME if the number of employees is less

than 250 [13]). See Figure 2 for a breakdown of the size of the participating enterprises.

Approximately 20 % of the participants declared that they have an EnMS operating in their enterprise without regard to the way it is run or any kind of certification. While 77 % of the respondents have no kind of EnMS in operation, 3 % did not specify.

Of the participants who have an EnMS in place, 20 % are operating a certified EnMS according to ISO 50001 and 4 % according to the previous certification EN 16001 (resp. 4 % and 1 % of the whole sample).

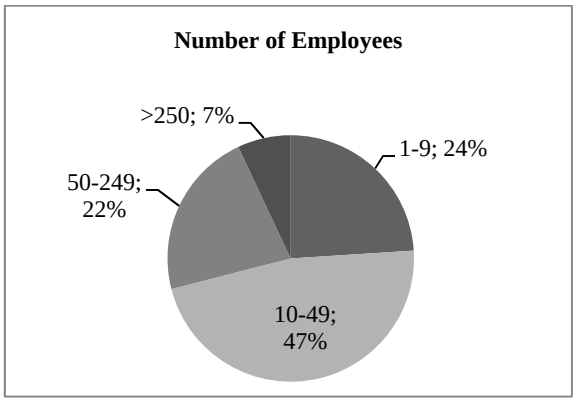

Figure 2. Break Down of the Size of the Participating Enterprises.

In total 12 % of the participants are planning to implement an EnMS in the future (1/4 of these plan an ISO 50001 certification, which represents 6 % of the whole sample).

4.1. Energy Management Representatives and Teams

An energy management representative (usually an employee) has practical knowledge about energy related statutory regulations and the relevant national legislation. He or she is acquainted with the operating principles of EnMSs and its integration into existing management systems and provides qualification in project management.

In the survey 21 % of the participants declared that they have an energy management representative assigned, while 78 % did not (1 % did not specify).

Energy management representatives can be employed individually or as a team which can be involved either full time or part time with the energy topic.

About 30 % of the participating enterprises that have an energy representative assigned stated that they employ it as a team of which 1/5 are involved full time again (6 % of the whole sample).

Comparing this overall numbers with enterprises holding a certificate (either ISO 50001 or EN 16001) 56 % of the certified enterprises employ an energy management team (of which almost 1/3 are involved full time).

4.2. Objectives for Energy Management Systems

The top priority objective for EnMSs is to “save energy costs”. Approximately 75 % of the participants decided that this is an objective that fully or almost fully applies (see Figure 3). Hence, this not surprising fact is due to the extensive increase of energy costs in total and share of overall costs over the last decade. Without taxes and fees however, the energy prices rose more than 50 % for German industrial enterprises [14].

Enterprises in Germany and Europe that offer their goods on the world market are pressured by the competition with enterprises from emerging markets of e.g. Asia and South America. To keep a cost-effective competitive advantage they have to reduce their energy costs in total and share, which also explains the second strongest objective: “reduce on energy and electricity tax”. Since these taxes take a share up to 20 % of an enterprise’s energy costs [15], reducing the taxes is another measure of lowering the energy related costs as a whole.

Even though this paper’s taxonomy does not stipulate a scope for the objectives to energy management systems it becomes obvious that both the first two objectives and objective number three (“reduce exposure to volatile energy prices”) are somehow economic related, which emphasizes the statements made above.

The last four objectives (“improve image”, “benefit from the REA levy”, “fulfill customer requirements”, and “prevent possible regulation”) are seen as a rather neutral influence to EnMSs.

The low score of the objective “benefit from limiting the REA levy” is probably due to the fact that the majority of enterprises that participated in the survey are SMEs. Since only enterprises that pass the threshold of energy consumption of 1 GWh p.a. may benefit of this facilitation.

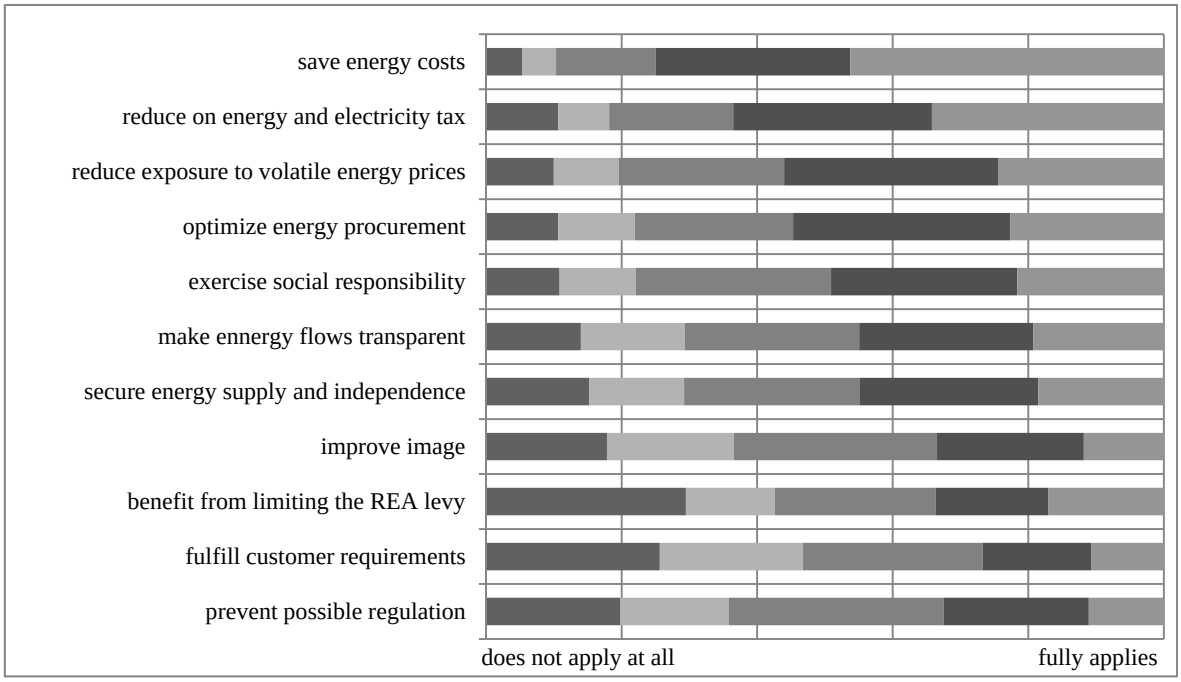

Figure 3. Examined Objectives for EnMSs Rated on a 5-Level Likert Scale

4.3. Barriers for the Implementation of Energy Management Systems

Ranking the scopes of the relevant barriers, results in the economic barriers being the most relevant for manufacturing enterprises, followed by the informational and competence related barriers. Behavioral and organizational barriers seem not to affect enterprises as much in implementing an EnMS; these two are ranked lowest concerning the five scopes (see Figure 4).

These results correspond to the investigation regarding barriers in energy efficiency made by Trianni et al. to which economical, informational barriers contributed most and organizational, behavioral least [16].

The reason for economic barriers being so highly relevant may be due to the fact that enterprises are not sure that a payoff of EnMS is guaranteed. They may neither be certain of a short-term amortization to the investment they made. An economic related barrier also raises the question if enterprises have sufficient access to capital. The scope of informational barriers represents the top single issue: “missing reference to other enterprises”. The most relevant barrier that fully or almost fully applied to more than half of the participants can be aimed both at not knowing what measures other enterprises perform or have performed and the lack of information what other enterprises have accomplished yet in energy efficiency. Nevertheless, this barrier could be a call for more transparency about energy related performance amongst manufacturing enterprises and a need for energy consulting, too.

The barrier “missing information on public facilitation” fully or almost fully applies to half of the participants. This shows a crucial lack of transparency, although it is the intention of the German legislature to promote energy efficiency and to support the implementation of EnMSs.

With an average arithmetic mean the other informational barriers “missing information on costs and benefits” and “missing information on energy equipment” indicate that at least half of the enterprises perceive they are aware of the benefits that EnMSs offer and that they know these technologies can be realized.

The competence related barriers are located in the middle regarding the whole sample. “Enterprise's personnel resp. time capacities insufficient” is valued with a relatively high arithmetic mean and is overall considered the third barrier in rank.

In the investigation this barrier was accounted to the scope of competence related barrier, although it could be added to the scope of organizational barriers as well. This depends on the point of view. Nevertheless, it was considered to be competence related, due to the fact that this barrier relies on how enterprises are deployed regarding EnMSs and how they cope with integrating EnMSs into other management systems and the relevant ISO standards.

The complex issues that may occur when acquiring external competence for implementing an EnMS fully or almost fully apply to 50 % of the participating enterprises. This again can rely to the above made statement that yet better proposals regarding energy consulting and transparency are to be made.

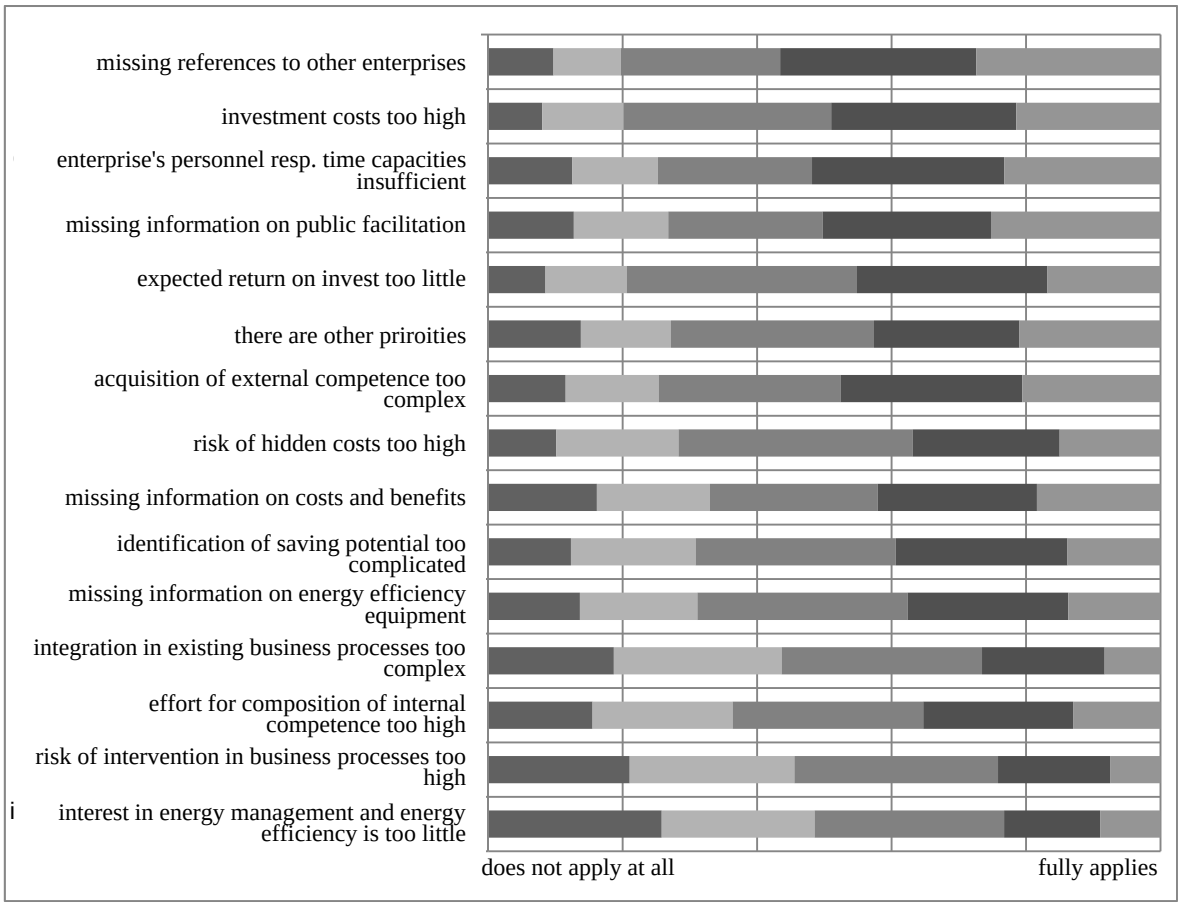

Figure 4. Examined Barriers for the Implementation of EnMSs Rated on a 5-Level Likert Scale

Very notable however is the behavioral barrier “there are other priorities” which falls out of frame regarding the other organizational and behavioral barriers. After all, more than 40 % of the participants considered that other priorities fully or almost fully apply as a barrier to the implementation of EnMSs.

As mentioned above organizational and behavioral barriers seem not to affect enterprises highly in relation to the other scopes mentioned. A possible explanation may be that enterprises overrate their behavioral and organizational abilities as asserted in Trianni et al. [16].

4.3.1. Barriers with Regard to the Size of the Enterprise

Since more than 90 % of the participating enterprises can be considered SMEs it seems appropriate to break down barriers with regard to the size of the enterprise.

With $\bar{x}$=3.13 being the arithmetic mean for all barriers of the whole sample, it can be observed that $\bar{x}$ decreases with increasing size of an enterprise. A decrease in $\bar{x}$ implies that barriers apply less (see Table 2 for a comparison).

This observation indicates that SMEs have indeed a higher avoidance concerning the implementation of energy management systems.

Table 2. Arithmetic mean of all barriers in the investigation with regard to the size of the enterprise

No. of Employees	Arithmetic Mean ($\bar{x}$)
1-9	3.23
10-49	3.17
50-250	3.07
>250	2.65
Overall	*3.13*

5. CONCLUSION

This brief extract of the empirical investigation of the Fraunhofer Institute for Production Systems and Design Technology IPK concludes the objectives that may be pursued and the relevant barriers that may hinder the implementation of an EnMS. It further depicts to what degree these issues apply to manufacturing enterprises in Germany.

The insights that were gained by this empirical investigation show a clearer picture of the relevance of the issues and rank them. The investigation has been conducted with a regard to the size of the enterprises and their acquaintance with EnMS, its possible certifications, and features.

Considering the whole sample it can be stated that the major objectives that motivate and the major barriers that hinder the implementation of an EnMS are of economical scope. Regarding the barriers, the informational issues complete the composition of major influences added by barriers from the competence related scope. Behavioral and organizational barriers do not apply to a high degree, which leads to the assumption that enterprises perceive themselves being ahead concerning these aggregations.

The analysis of the barriers applying to the highest degree yield a demand for more transparency on the energy performance of all manufacturing enterprises, giving less experienced and especially SMEs insights into best practice methods and public facilitation methods. This notion needs to be conveyed by better proposals of energy consulting and energy networks [17].

As mentioned, SMEs apply to the examined barriers to a higher degree. Since SMEs are the majority of manufacturing enterprises policy makers should show additional efforts on promoting the implementation of EnMSs in SMEs more intense. Apart from tax-based incentives, the implementation of EnMSs enterprises of all sizes have an energy saving potential of 15 %, which is left idle by SMEs. This calls upon German legislature and researchers to develop appropriate incentive schemes for SMEs to overcome these barriers.

For decision makers especially of SMEs informational and economical barriers (e.g. intransparent public facilitation and lack of capacities for energy efficiency projects) play a crucial role in deciding whether the implementation of EnMSs should be pursued or not. Energy management projects can be more thoroughly conducted by transdisciplinary teams since not only technical expertise and project management skills are relevant. Moreover, the frequently changing legislature confronts enterprises with challenges. In traditional management systems most of the tasks of implementing and operating can often be handled by a single management system representative. ISO 50001 is the first standard to advice enterprises to put the responsibility for the EnMS as a whole in the hands of a team. How these teams are to be set up and what competences are needed for a successful implementation of EnMSs is not sufficiently addressed in current scientific literature. Especially since the acquisition of external consultants appears to apply as a barrier to most enterprises, competence diagnostic and competence enhancement fields are worthwhile further research.

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