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A Study of the Impact of Energy Management Systems – Final Report

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List of Abbreviations

AAE	Assessment of effect energy management systems
AGEB	Arbeitsgemeinschaft Energiebilanzen e.V.
Approx.	Approximately
BAFA	*Bundesamt für Wirtschaft und Ausfuhrkontrolle*, German Federal Office for Economic Affairs and Export Control
BesAR	*Besondere Ausgleichsregelung*, Special Equalisation Scheme
BfEE	*Bundesstelle für Energieeffizienz*, German Federal Agency for Energy Efficiency
BMWK	*Bundesministerium für Wirtschaft und Klimaschutz*, German Federal Ministry for Economic Affairs and Climate Action
cf.	Compare
CO_2	Carbon dioxide
DIN	*Deutsches Institut für Normung*, German Institute for Standardisation
e.g.	For example
E1, E2 and E3	Energy intensity groups in the manufacturing industry sector defined in the study (in ascending order)
EE	Energy efficiency
EEffG	*Bundes-Energieeffizienzgesetz (*EEffG), German Federal Energy Efficiency Law
EI	Energy intensity
EN	European standard
EDL-G	*Gesetz über Energiedienstleistungen und andere Energieeffizienzmaßnahmen* (EDL-G), German Federal Energy Services Law
EED	EU Energy Efficiency Directive
ELAN-K2	*Elektronische Antragserfassung und -kommunikation*, online application logging and communication portal operated by the German Federal Office for Economic Affairs and Export Control
EMAS	Eco-Management and Audit Scheme
EnM system	Energy management system
EnPI	Energy performance indicator
etc.	et cetera
GWh	Gigawatt hour
incl.	including
ISO	International Organization for Standardization
SME	Small and medium-sized enterprise
KPI	Key performance indicator

Log.	Logarithm
MWh	Megawatt hour
Mt	Mega tonne
PAE	*Programm zur Auswirkungsanalyse von Energiemanagmentsystemen*, energy management system impact assessment software
p.a.	Per annum
PDCA	Plan-Do-Check-Act
PLS	Partial least squares
SpaEfV	German Regulations on Systems for Improving Energy Efficiency (*Verordnung über Systeme zur Verbesserung der Energieeffizienz, SpaEfV*).
TJ	Terajoule
ValERI	Valuation of energy related investments
Vs.	versus

1 Introduction

1.1 Background

The efficient use of available resources plays a key role in achieving **European climate, energy and environmental targets**. Against this backdrop, corporate governance models geared towards environmental awareness and sustainability and designed to improve energy efficiency are increasingly coming to the fore. As well as reducing CO_2 emissions and achieving cost savings, improvements in energy efficiency can also reduce energy imports. The changes in energy supply associated with the energy revolution and the related emissions and costs also present a specific challenge for businesses. If they are to meet this challenge they must be armed with the right tools.

The implementation and operation of **energy and environmental management systems** (EnM systems) offers a tangible **means of increasing energy efficiency** in companies and other private, public and not-for-profit organisations. These EnM systems can help reduce energy consumption through sustainable management and thus avoid greenhouse gas emissions. As well as helping to improve energy efficiency, they can also be used to provide an improved information base and so enable forward-looking management practices including identifying potential for improvement, determining the right measures to be taken and achieving cost savings.

The study described in this report sets out to examine the **impact of EnM systems on corporate energy efficiency and consumption**, to gain **insight into how they are used** and to consider the extent to which German companies operating EnM systems can assist in achieving national and European goals. In addition, it investigates the potential costs of implementing EnM systems and the barriers faced by companies in so doing.

1.2 Organisation of the report

The report is divided into nine sections, which are in turn organised into **three topic-based modules**. The first, Context and approach, comprises Sections 1 to 4. Following an introduction in **Section 1** and a summary of the context and findings of the study in **Section 2**, **Section 3** goes on to provide an overview of the basis for the study and the associated research brief. **Section 4** completes the first topic block with information on the study methodology.

The second module, Survey findings, contains **Sections 5 and 6**, which describe and discuss the findings of the online survey and the expert interviews.

The third topic module, In-depth analysis and interpretation of collected data, consists of Sections 7 to 9. **Section 7** outlines the process of setting up and using a new tool for estimating the economic impact of EnM systems in Germany. **Section 8** describes the subsequent findings on the added value of EnM systems, while **Section 9** provides an aggregated summary and interpretation of the findings alongside a set of action recommendations drawn from these findings.

2 Executive summary

Current situation and objectives

Energy management systems (EnM systems) play a significant role in many areas of **European and national regulations**. With the ‘Green Deal’, the European Commission is aiming for a climate-neutral economy by 2050. EnM systems, such as those based on ISO 50001, are key instruments for achieving this goal[1]. The objective of an EnM system that complies with the international standard ISO 50001 is to enable organisations to establish the systems and processes necessary to **continuously improve energy performance**, including energy efficiency, energy use and energy consumption[2].

The effectiveness of EnM systems in improving energy efficiency is widely acknowledged. However, studies on the detailed effects and impacts of EnM systems on companies and the national economy are rather diffuse. Therefore, this study seeks to address this matter and examines the extent to which the operation of an **EnM system by a substantial number of companies can contribute to the achievement of energy and climate policy goals** at the macroeconomic as well as the company level. It provides a differentiated analysis of which particular companies and sectors use EnM systems, what savings are achieved, and what other positive quantitative and qualitative effects are brought about by operating such a system. To estimate the effects of EnM systems and calculate savings at a macro level, an MS Excel-based tool has been designed (AAE tool) and further developed in accordance with current requirements.

Approach

To evaluate the efficiency and effectiveness of EnM systems, this study uses a **theory-based empirical approach**. The goal of the study is to:

- Present information regarding the use of such systems at German companies,
- Analyse the operation of EnM systems, including questions such as: “Why is the EnM system effective?”, “How does it function?” as well as “To what extent do the EnM systems achieve their goals (improving energy performance)?”,
- Estimate and evaluate the macroeconomic effects of using different EnM systems.

An anonymous online survey was used to collect primary data. The questionnaire developed for this purpose is based on an analysis of the literature encompassing studies from the energy and environmental management

[1] cf. Harfst, N. (2021). Controlling als Treiber der Energieeffizienz – Integration von Energiemanagement in vorhandene Controllingstrukturen, Springer-Gabler-Verlag.

[2] cf. Introduction to ISO 50001:2018.

sector. In accordance with the focus topics of the survey, the questionnaire was divided into different topic-based modules.

In addition to the standardised online survey, structured expert interviews were conducted to validate the findings. The interviews, which lasted 45-60 minutes, were conducted via digital platforms such as Microsoft Teams and Cisco Webex. For the evaluation of the interviews, the answers were anonymised and clustered, and this was followed by an analysis of the transcripts of the interviews and an elaboration of core statements.

The **findings obtained from the online survey and the expert interviews** are used for three different purposes:

1. Descriptive presentation and interpretation of the use of EnM systems at German companies,
2. Statistical analysis of the relevant elements within EnM systems that comply with ISO 50001 (structural equation modelling),
3. Development and use of a tool for estimating the economic effect of the different EnM systems and their penetration of the German corporate landscape.

Findings of the online survey and the expert interviews

The **key findings** of the survey are:

- A large proportion of the companies surveyed would (continue to) operate their EnM systems even without governmental regulations.
    - The systems in and of themselves generate relevant benefits for companies.
- The level of the energy efficiency improvements remains almost constant, even if companies have been dealing with the topic for an extended period of time.
    - Potential energy performance improvements of relevance continue to exist even among experienced companies.
- The improvements in energy performance achieved through the implementation and operation of an EnM system that complies with ISO 50001 are even high in percentage terms in the tertiary sector.
    - Energy management is not an issue solely for the manufacturing sector; rather, all sectors can benefit from systematic approaches.
- The use of systematic approaches (ISO 50001 or Eco-Management and Audit Scheme [EMAS]) offers significant business and economic benefits.
    - The more intensively companies deal with energy efficiency opportunities, the more successfully they achieve their energy efficiency goals.
    - The introduction of EnM systems is worthwhile for a large number of companies. This varies depending on the energy intensity and size of the company. In addition, current developments such as energy and CO_2 prices can influence profitability.
- The large-scale introduction and implementation of EnM systems in accordance with ISO 50001 can make a significant contribution to the achievement of climate targets.

    - The potential large-scale introduction of EnM systems according to ISO 50001 at companies with an annual energy consumption of more than 10 GWh would reduce CO_2 consumption by approximately 158 megatons over the next 23 years (by 2045).

Conclusion and recommendations for action

To analyse possible threshold values for potential savings and economic effects, the AAE (Assessment of the Effects of EnM systems) tool, which was developed as part of the study, should be used.

- It provides detailed mapping of the different use cases of EnM systems in practice.
- Thanks to its dynamic adjustment options, the AAE tool provides a very useful foundation for estimating the effort for compliance with statutory obligations and for estimating the need for subsidies.

An assessment of the impact and criteria for the mandatory implementation of energy efficiency measures, e.g., based on the action plans of ISO 50001 or the action plans from energy audits according to DIN EN 16247-1, is recommended. This can be supplemented by an analysis of the impact of various threshold values for the cost-effectiveness of measures (e.g. positive net present value after X% of the utilisation period) using the BAFA database on findings from energy audits.

We recommend that the environmental law, constitutional law and European law aspects of such a possible obligation be examined at an early stage with regard to its legal feasibility. In addition, it could be useful to establish a platform for information, data collection and verification in order to minimise administrative costs in particular, but also with a view to the resource consumption for company compliance. In addition, a stakeholder-related communication concept seems to be extremely important, e.g., by presenting ‘success stories’.

A phased-in obligation could be devised in order to avoid burdening companies ‘at the threshold of economic viability’ too early. The time-related effects of energy price increases on profitability can be analysed with the AAE tool. The early involvement of stakeholders (e.g. associations, certifiers) is recommended.

3 The research brief

3.1 Current situation

IS0 50001-compliant EnM systems are designed to enable businesses to establish the systems and processes required to ensure the **continuous improvement of energy-related performance**, including energy efficiency, use and consumption. As management systems, they aim to minimise energy consumption and, thereby, energy costs and environmental emissions in a systematic and sustainable manner. This requires the development of instruments and structures that help plan, monitor, measure, analyse and ultimately control energy consumption. The implementation of an EnM system embeds the continuous improvement of energy efficiency performance in a company by applying a series of clear processes, strategies, goals and measures. In addition to IS0 50001-compliant EnM systems, a number of other approaches are currently being used to increase energy efficiency in Germany. These include other systematic regimes such as the European Commission's Eco-Management and Audit Scheme (EMAS), and more static systems such as DIN EN 16247-1 energy audits and so-called 'alternative systems' introduced under the German Regulations on Systems for Improving Energy Efficiency (*Verordnung über Systeme zur Verbesserung der Energieeffizienz, SpaEfV*).

EnM systems already play a role in many areas of the European and national regulatory framework. In its Green Deal, the European Commission has drawn up a plan of action designed to achieve a climate-neutral economy by 2050. The Green Deal's mechanism for greenhouse gas emission reduction is increasing energy efficiency. In addition, the current proposed amendment to the Energy Efficiency Directive (EED) envisages the **mandatory** implementation of a certified, IS0 50001-compliant EnM system for companies with an **energy consumption of 100 TJ p.a. or above (approx. 28 GWh)**.

German federal legislation also stipulates the use of IS0 50001-compliant EnM systems and other energy-related systems as a prerequisite for tax relief and as an alternative to a mandatory energy audit, for example. As early as 2018, the German Federal Ministry for Economic Affairs and Climate Action (*Bundesministerium für Wirtschaft und Klimaschutz*, *BMWK*) invited tenders for a research project to examine the impact of DIN EN IS0 50001-compliant EnM systems, SpaEfV 'alternative systems' and EMAS. This project went on to produce initial findings on the use, sector distribution and impact of EnM systems.

However, data on the actual impact and effects of EnM systems is diffuse. Böttcher and Müller (2016), for example, point to a positive impact of ISO 50001 on carbon and corporate performance, but without providing any detail on the quantitative improvement of energy efficiency or indicating which mechanisms are effective.[3] In contrast, both Harfst (2021) and Schulze and Heidenreich (2017) examine the elements and structures that influence the effectiveness of EnM systems and quantify certain improvements in energy efficiency.[4] However, these studies fail to consider an appropriate comparison group and as such shed no light on the advantages to be gained from using EnM systems as compared to the status quo.

3.2 Overview of energy and environmental management under ISO 50001, EMAS and other energy-related systems

An **ISO 50001-compliant energy management system** is a voluntary system that can be used by businesses of all sizes and from all sectors of the economy. The objective of ISO 50001 is to reduce energy consumption and the associated energy costs and to achieve continuous improvement in a company's energy-related performance. It enables companies and other organisations to develop their own systems and processes that can be used to improve energy-related performance. ISO 50001 forms the basis of a certifiable EnM system. It follows the Plan-Do-Check-Act cycle designed to ensure the continuous improvement of processes and systems.

International standard ISO 50001 was first published in 2011, when it replaced European Standard EN 16001 and adopted some of its themes. To ensure credible certification, the continuous optimisation of and compliance with the requirements of ISO 50001 are audited annually by independent external certification bodies. Companies that meet ISO 50001 enjoy a certain number of advantages including, amongst others, tax relief and exemption from the mandatory energy audit imposed by the German Energy Services Law (*Gesetz über Energiedienstleistungen und andere Energieeffizienzmaßnahmen, EDL-G*).

The **Eco-Management and Audit Scheme (EMAS)** is an environmental management instrument designed for companies that wish to improve their environmental performance on a voluntary basis. Developed in 1993 by the European Commission, it is now both an ambitious environmental management system and the highest European award for operational environmental management. EMAS has evolved into a significant environmental protection instrument that measures corporate environmental performance and helps companies use raw materials and other resources more efficiently. EMAS is designed for businesses in all sectors and of all sizes. As a general rule, compliance with the relevant requirements is monitored annually by a government-approved independent external environmental expert. Companies that use EMAS also enjoy certain advantages, including benefits in

[3] cf. Böttcher, C., & Müller, M. (2016). Insights on the impact of energy management systems on carbon and corporate performance. An empirical analysis with data from German automotive suppliers. Journal of Cleaner Production, 137, 1449-1457.

[4] cf. Harfst, N. (2021). Controlling als Treiber der Energieeffizienz – Integration von Energiemanagement in vorhandene Controllingstrukturen, Springer-Gabler-Verlag and Schulze, M. and Heidenreich, S. (2017). Linking energy-related strategic flexibility and energy efficiency – The mediating role of management control systems choice. Journal of Cleaner Production, 140 (Part 3), 1504-1513.

relation to environmental enforcement regulations and exemption from the mandatory energy audit imposed by the German Energy Services Law.

'Other' energy-related systems include the **DIN EN 16247-1 energy audit** and the **'alternative system' set out in Appendix 2 of the German Regulations on Systems for Improving Energy Efficiency**. DIN EN 16247-1 describes the process and content of an energy audit, including how to establish appropriate measures for improving the energy efficiency of a site or company, while the so-called 'alternative system' in Appendix 2 of the German Regulations on Systems for Improving Energy Efficiency offers a basic framework for measuring energy consumption and identifying areas for improvement. Both approaches seek to create transparency in energy consumption and to identify actions to be taken. In contrast to ISO 50001 and EMAS, however, they go no further. They are more static approaches that make no provision for an internal or external control cycle involving a concrete plan for implementing measures and countermeasures where targets are missed.

3.3 Study objectives and approach

The study sets out to examine how EnM systems can contribute to **achieving energy (efficiency) and climate change policy objectives** (primary energy savings and the reduction of CO_2 emissions). As a result, it aims to examine the impact of EnM systems on energy efficiency and consumption in companies, to gain insight into how they are used use and to consider the extent to which German companies operating EnM systems can assist in achieving national and European goals. Alongside effectiveness at company level, a further objective is to assess their savings potential and impact on the national economy by examining the contribution that a greater number of companies actively operating EnM systems would make to achieving energy (efficiency) and climate change policy objectives (primary energy savings and the reduction of CO_2 emissions). It can be assumed that, unlike other statutory energy management requirements – energy audits under DIN EN 16247-1 or the German Regulations on Systems for Improving Energy Efficiency, for example – both IS0 50001-compliant EnM systems and EMAS systems offer the advantage of a systematic and continuous approach, and that this should lead to increased savings. The study sets out to support this thesis with the appropriate data.

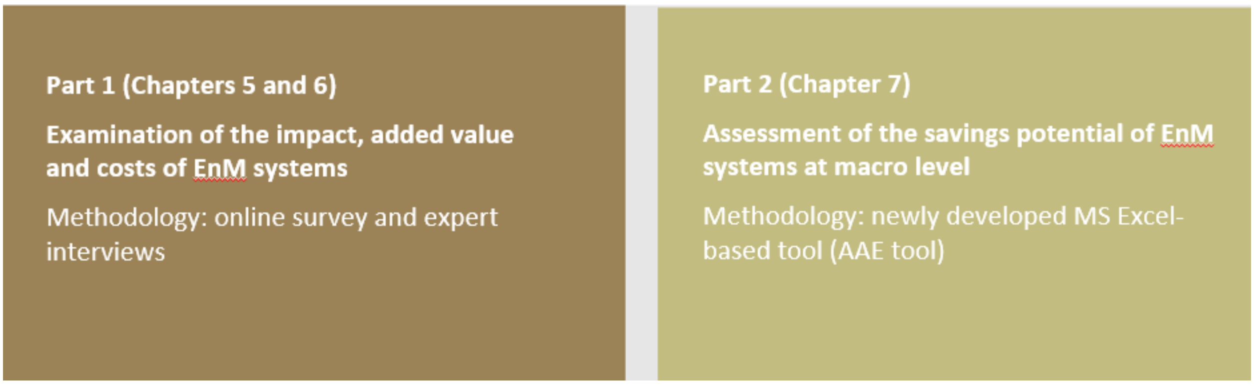
A detailed and differentiated analysis of:

- the companies and sectors that use EnM systems,
- the savings they achieve, and
- any other positive quantitative, but also qualitative effects associated with their use

can not only improve the way in which they are **implemented and used** in companies, but can also help to assess their impact on European and national climate and energy goals. Once more is known about the barriers to and potential for improvement, it will be possible to specifically develop the structure of EnM systems to reinforce their positive impact.

The study is divided into two basic strands of analysis (cf. **Fehler! Verweisquelle konnte nicht gefunden werden.**). The first part concentrates on examining **how EnM systems work and the added value they bring** by investigating, amongst other factors, the parameters and the potential benefits of EnM systems, company motivation, and the internal and external costs connected with setting up and operating the systems. These include the cost of the metrics concept and of obtaining detailed measurements, of the personnel input required for implementation, of the annual certification process and of defining relevant and meaningful key performance indicators (KPI). The second part of the study assesses the savings potential of EnM systems at the macroeconomic level thanks to the use of a newly developed tool for gauging the effect of energy efficiency systems. In addition to the data collected as part of the study, the tool also uses other secondary sources (e.g. data from the German Federal Office of Statistics [*Statistisches Bundesamt*], for example), allowing the figures to be extrapolated to the German national economy as a whole.

Figure 1: Structure of the study as a whole



Source: Original graphic

4 Methodological approach

4.1 Concept development methodology

The methodology centred on designing the analysis and the effects model in response to the research brief (Section 3) and the data collection and evaluation methods used. It was also based on the research questions set out in the research brief (cf. Appendix 3: Research questions addressed). A detailed data collection concept was developed to ensure that the study was conducted systematically and efficiently.

- The **content component of the data collection concept (design)** defines two analysis models. The first is the model for evaluating and quantifying the potential advantages of ISO 50001 over other approaches. This model primarily serves as the basis for the newly developed AAE tool and for the descriptive comparison of the systems. The second is the effects model used to determine the impact of individual components of ISO 50001 and on which the research-goal-based target and indicator system is built. The effects model indicators (questions in the online questionnaire and expert interviews, see appendix) serve to operationalise the content framework for addressing the central issues specified in the research brief.
- The **methodological component of the data collection concept (method)** defines the methodological approach chosen for the collection and evaluation of data. It first outlines how the relevant target groups were contacted and encouraged to take part in the study and, second, the data collection methods used.

4.2 Analysis and effects model design

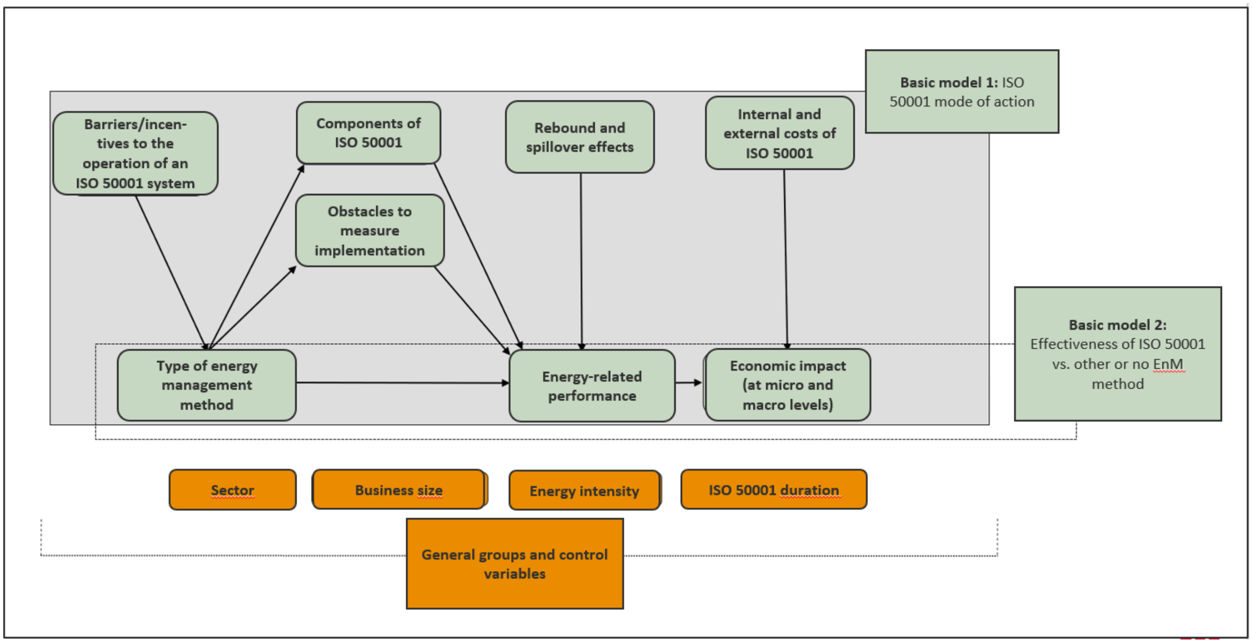
In this study a **theory-based empirical approach** was chosen to assess the efficiency and effectiveness of EnM systems. The aim of this theory-based investigation is to examine how EnM systems operate, addressing the issues of why and how they work as well as asking whether they achieve their goals (to improve energy efficiency).

The investigations are based on an effects model that is both **ISO 50001-specific and comprehensive** (cf. Figure 2). The effects model describes the intended effects of ISO 50001, starting with its requirements and policy aims. It creates a logical connection between the activities and membership of potential subgroups (e.g. companies with greater or lesser experience of exploiting potential energy efficiencies), one on hand, and intended improvements in energy efficiency and economic performance, on the other. Additional assumptions regarding mechanisms of action and external influencing factors are used to build up the most complete picture possible. The advantage of using a theoretical effects model as the starting point is that it provides a comprehensive description and ensures transparency in relation both to the target system and intended and unintended effects.

The inputs for the EnM-specific effects model and its indicators were ISO 50001, the research questions and models from other EnM-specific studies, such as Harfst (2021), on the impact of individual components of ISO 50001 on the improvement of energy-related and economic performance.[5]

The **effects model in** Figure 2 shows possible mechanisms of action of EnM systems at both the company and macroeconomic level, while also illustrating internal influencing factors.

Figure 2: Possible basic study model



Source: Original graphic based on the research brief and earlier studies on the impact of EnM systems

The **internal influencing factors (barriers and incentives)** affecting the impact of considered EnM systems include issues such as relevant experience and management support. The **external influencing factors** include, amongst others, the legal framework, funding programmes and energy prices. These factors are taken into account both in describing the findings of the impact analysis of the various components of ISO 50001 and in constructing and using the AAE tool.

4.3 Online survey methodology

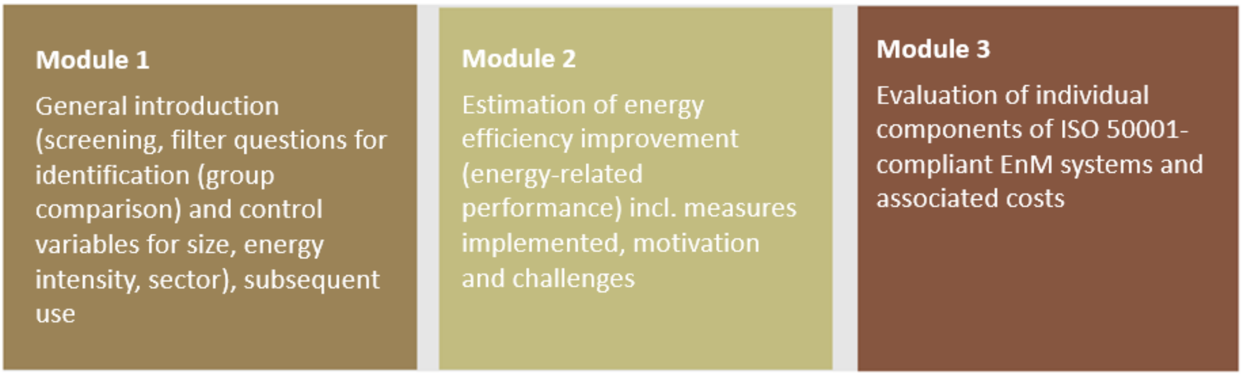
Primary data collection was carried out by means of an **online survey using the Qualtrics market research software**. The online survey method was used due to the high degree of standardisation of the survey content. The

[5] cf. Harfst, N. (2021). Controlling als Treiber der Energieeffizienz – Integration von Energiemanagement in vorhandene Controllingstrukturen, Springer-Gabler-Verlag

online format also enabled survey participants to pause the survey and continue it at a later stage. This was particularly helpful where participants required additional information from other sources in order to answer a question. The survey questionnaire was developed on the basis of a literature review covering studies from the fields of energy and environmental management, the questions to be addressed in the study and the information required to provide these answers[6]. Both open and closed questions were used, and information was elicited in bandwidths and at specific data points depending on the data to be collected.

The questionnaire was divided into a number of topic-based modules according to the focus topics of the survey.

Figure 3: Questionnaire focus topics



Source: Original graphic

Some of the questions asked were only designed to be answered by companies using a specific system (ISO 50001, EMAS, SpaEfV, other). Filter questions were used to ensure that survey participants were asked to only answer those questions that were relevant to them.

A pre-test was carried out with ten companies to test the comprehensibility and length of the survey. The **anonymised survey link** was then distributed from March 2022 by email and via the homepages of multipliers. A reminder was subsequently sent out in May 2022. The total duration of the survey period was **13 weeks**.

4.4 Guided expert interview methodology

The research findings of the online survey were validated and supplemented by **structured expert interviews** in which the knowledge of selected experts on the impact and effectiveness of EnM systems offered further perspectives on the research subject. The interviews were guided to ensure comparability of results. The pre-set questions were based on assessments previously carried out in similar subject areas (e.g. energy and

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[6] The full questionnaire is provided in the Appendices.

environmental management, energy industry) and were geared towards research questions on the impact of EnM systems that lent themselves to qualitative rather than quantitative illustration.

The interviews followed a **semi-structured scheme** with the addition of supplementary focus areas depending on the experience, expertise and institutional background of the interviewees. The order of the questions asked during the interviews was also varied at the interviewer's discretion.

The interviewees contributed expertise from the fields of certification and energy consulting. They represented companies from different economic sectors, including the food and pharmaceutical industries and metal fabrication, and used both a variety of energy efficiency improvement systems (ISO 50001, the 'alternative system' outlined in Appendix 2 of the German Regulations on Systems for Improving Energy Efficiency, etc.) and other systematic approaches (ISO 9001, ISO 14001, EMAS).

The interviews were carried out remotely via digital platforms and lasted for 45 to 60 minutes per interview to keep the time commitment manageable for the interviewees, while also allowing time for detailed discussion on certain topics as required.

To evaluate the interviews the answers were anonymised and clustered, and the interview transcripts were subsequently analysed to identify core statements. They were assessed in relation to the following topics:

- Requirements for and barriers to the implementation and operation of EnM,
- A comparison of EnM systems,
- The impact of EnM systems.

The key findings of the expert and practitioner interviews are outlined in Section 6.

5 Descriptive results of the survey on EnM systems

5.1 Representativeness and robustness

In advance of the survey, reference values were defined for each EnM method used in order to ensure **robust results**. These reference values were obtained by analysing the population and the various company characteristics in the population. Assumptions are based on a confidence interval of 90%, a margin of error of 10% and a standard deviation of 0.5 (sample). At the end of the survey, the number of returns was compared with the reference values determined before the start of the survey (cf. next section).

Table 1: Theoretical considerations for setting a suitable sample size

EnM method	Population	Sample
ISO 50001-compliant EnM system	~ 5.500	~ 70
EMAS (Eco-Management and Audit Scheme) system	~ 1.200	~ 65
SpaEfV "alternative system"	~ 2.500	~ 65
Other	~ 21.000	~ 70

Source: Original graphic

5.2 Distribution of survey participants

This chapter addresses the following questions from the research brief:

Which companies decide to implement and/or certify an ISO 50001-compliant EnM system?

5.2.1 Classification of survey returns by EnM method

The companies contacted as part of the survey were German. They were surveyed between March and June 2022.

Once the dataset had been cleaned, there were **250 exploitable returns** available for further analysis.[7] Table 2 shows the exact distribution of survey returns.

[7] In certain individual cases, the consortium prepared the data provided by the companies according to the research questions to make it exploitable for analysis.

Table 2: Overview of survey participants

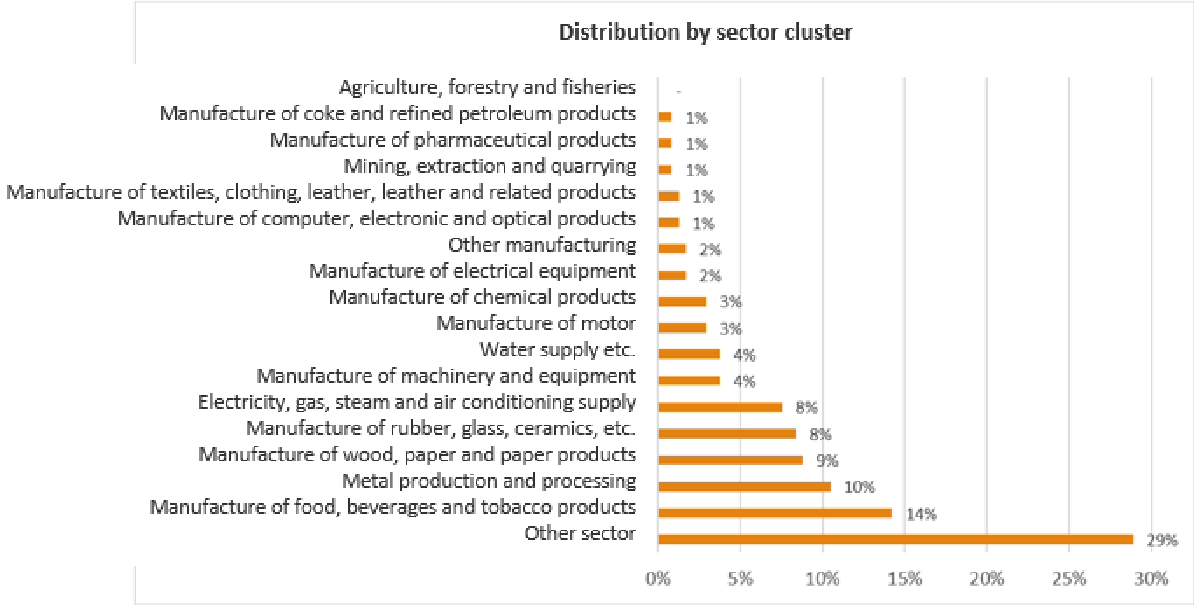
Number of responses per EnM system	
ISO 50001-compliant EnM system	95
EMAS (Eco-Management and Audit Scheme) system	74
DIN 16247-1-compliant energy audit (EDL-G)	49
SpaEfV “alternative system”	26
None of the systems listed	5
Others (e.g. energy consultancy)	1
Total	**250**

Source: Original graphic

The comparison groups (treatment and control group) listed below were formed to ensure the comparable group sizes required for the planned analyses and to enable a comparison of systematic and non-systematic EnM systems. ISO 50001-compliant EnM systems and EMAS systems were assigned to the **treatment group**. The **control group** contained energy audits under DIN 16247-1 (German Energy Services Law), the SpaEfV ‘alternative system’, other systems (e.g. energy consultancy) and none of the systems named. This produced three groups of comparable size (control group: 81 returns, ISO 50001: 95 returns, EMAS: 74 returns) that would ensure a robust analysis. The fact that the control group contained various different systems meant that the extent to which differentiated statements could be made about the groups within the control group was limited.

5.2.2 Business size and sector

Figure 4: Analysis of companies by economic sector, n = 239



Source: Original graphic

The distribution of participating companies by economic sector shows that a large proportion of the companies come from the manufacturing sector (cf. Figure 4 and Table 3). Some 29% of participants were unable to assign their company to one of the sectors specified in the survey (Other economic sectors). These included seven companies operating an ISO 50001 system. At the next stage, the participating companies were divided into two groups, 'industry' and 'tertiary'. The companies in the industry group were also clustered according to energy intensity (cf. Table 3). Energy intensity was calculated by determining energy consumption in relation to turnover. The individual categories comprise the following sector clusters: E1 corresponds to low energy intensity (economic sectors 13-15, 26-33), E2 to medium energy intensity (economic sectors 5-12, 20-21) and E3 to high energy intensity (economic sectors 16-18, 22-25).

Table 3: Analysis of companies by energy intensity, n = 219

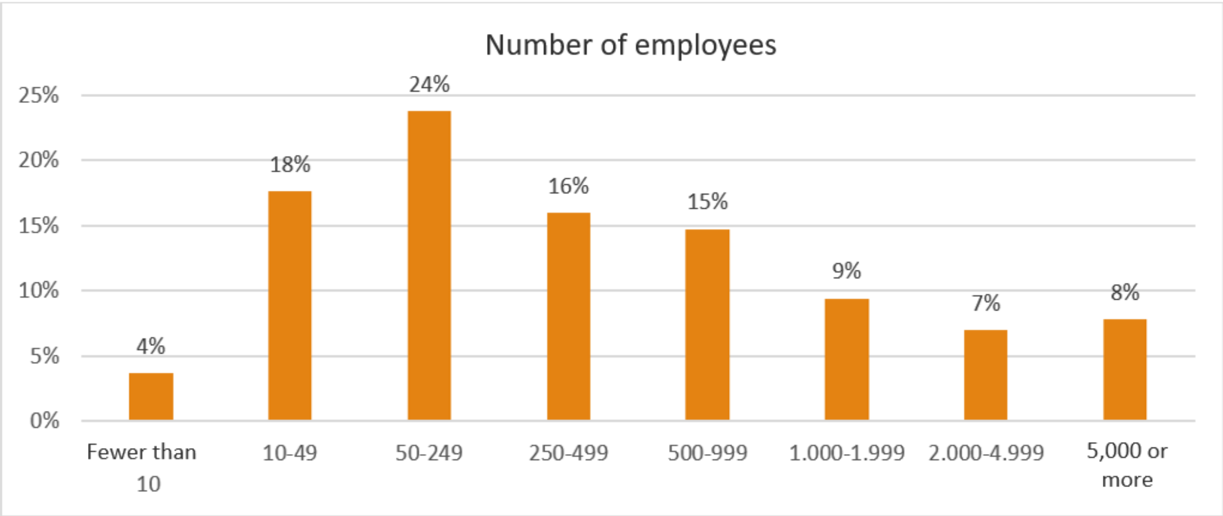
Energy intensity (EI)	E1 (low EI)	E2 (medium EI)	E3 (high EI)	Tertiary
Companies	14 %	21 %	30 %	36 %

Source: Original graphic

In order to differentiate between the types and sizes of participating companies, the online survey elicited the number of employees per company. The survey companies were evenly distributed across all size categories. Just under one in five of the surveyed companies had between 10 and 49 employees, while one quarter had between

50 and 249 employees. Small and medium-sized businesses were therefore faithfully represented in the sample (cf. Figure 5).

Figure 5: Analysis of companies by number of employees, n = 244



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5.2.3 Organisation of energy management and energy efficiency

Some 40% of the companies have **specific staff members or teams** that are (completely or partially) responsible for energy management. In 11% of cases responsibility falls to management or to board members. Frequently, however, energy management is seen as a **cross-company task** that is dealt with by various departments including management, energy management and technical departments.

5.3 Spread and implementation of EnM systems

This chapter addresses the following question from the research brief:

What is the role played by incentive schemes/mandatory systems such as the Special Equalisation Scheme (BesAR), peak balancing and mandatory audits? Differentiation according to business size, energy intensity, sector, EnM system duration (short vs. long) and motivation (voluntary, mandatory, prerequisite for obtaining certain advantages).

The online survey examined the spread and implementation of EnM in order to examine the external factors that promote the implementation of EnM systems. Study of the implementation and certification regimes showed that most companies become involved with EnM systems as a **reaction to regulatory requirements**. One such example is the requirement to carry out mandatory energy audits. In April 2015, the German Energy Services Law required all non-SME's either to carry out an energy audit under DIN EN 16247-1 by 15 December 2015 or to demonstrate that they had put an IS0 50001-compliant EnM system in place.

Although the companies' awareness of the usefulness of EnM systems was positive (cf. Section 5.7 Goal attainment and satisfaction), it **contrasts with** the fall-off in the implementation of new systems. Overall, the survey shows that the **number of EnM systems implemented fell** in **previous years** (2017-2022) (cf. Figure 6 and Figure 6). However, the results of the online survey also reveal that those companies that have implemented an EnM system (irrespective of the reason) appreciate the added value it brings and that over **50% of them would continue to operate it even if it were not mandatory** (cf. Figure 8). This leads us to assert that measures designed to promote the **implementation** of EnM systems, in particular, might well prove productive. It is the motivation of the companies in question that appears to guarantee their continued operation.

Figure 6: Implementation and certification under ISO 50001 and EMAS

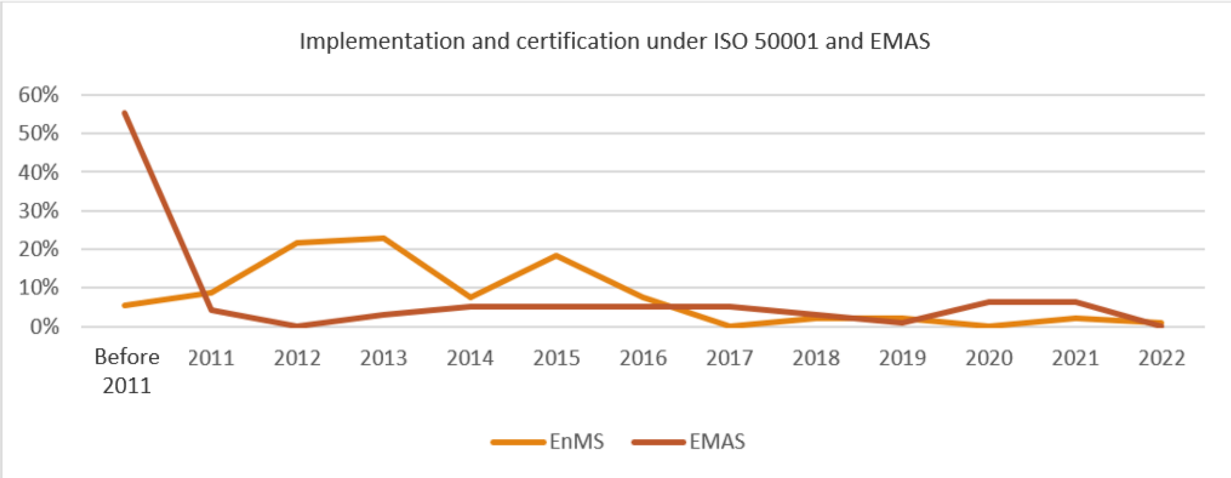

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Figure 7: Implementation and certification under SpaEfV and energy audits

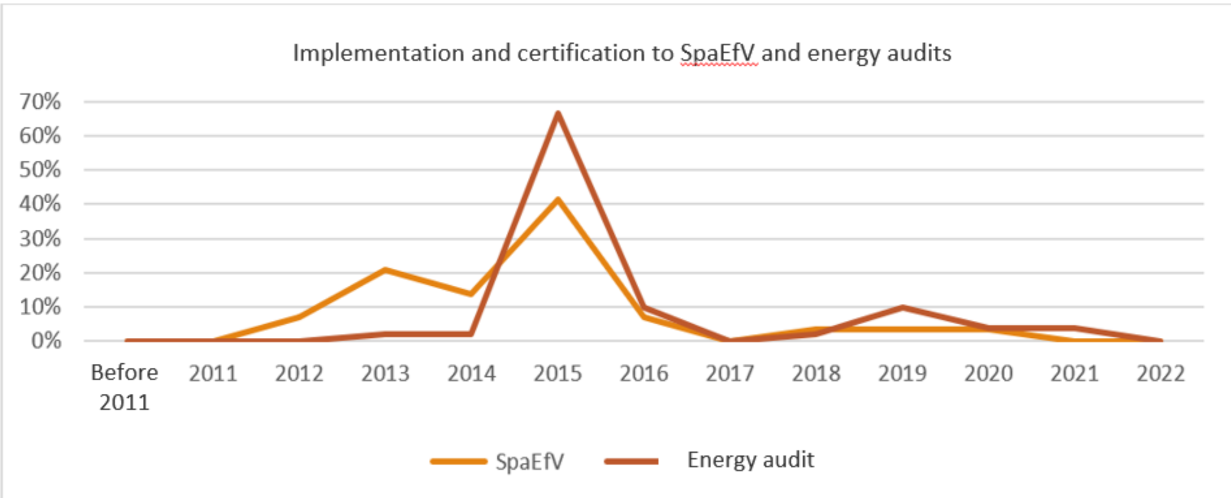

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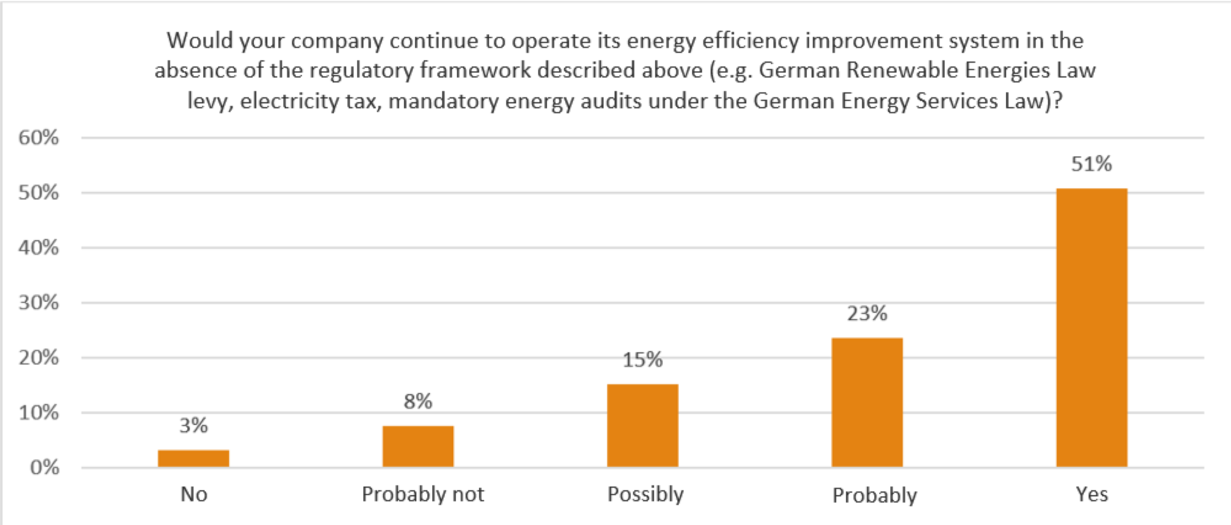
Figure 8: Companies would continue to operate energy efficiency systems without government regulation



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This chapter addresses the following questions from the research brief:

What internal costs are incurred in operating an ISO 50001-compliant system? How high are the costs of external services (certification, re-certification, review audits)?

5.4 Cost and profitability of EnM systems

A particular focus of the study was the profitability and savings potential of IS0 50001-compliant EnM systems. The online survey contained several questions designed to gain insight for the companies as to the cost of the systems.

To obtain a detailed overview of the cost structures involved, both the **internal** and **external costs of implementation** and **operation** were examined. The study also investigated the cost of the regular **audits** that have to be carried out on ISO 50001-compliant systems.

On average, the companies estimated the **internal costs** of **implementation** of ISO 50001 at approx. EUR 27,600, with subsequent annual internal operating costs at an average of approx. EUR 26,800. The study did not, however, seek to quantify the level of internal costs incurred for an energy management officer specifically for the operation of an ISO 50001 system. In addition, the firms surveyed assumed **external costs** averaging EUR 30,400 for the implementation of an ISO 50001-compliant system, with the annual external costs of operating the system being an average of approx. EUR 17,500. The cost of monitoring and certification audits under ISO 50001 amounted to an average of EUR 8,900.

Exkurs

Operating and certification costs from an empirical investigation of the market for energy services, energy audits and other energy efficiency measures (Final Report 2021 – BfEE 20/04)

The current German Federal Office for Economic Affairs and Export Control (BAFA) market study cites the following external system certification costs to suppliers:

1. approx. EUR 10,676 for initial certification of an ISO 50001-compliant EnM system,
2. approx. EUR 8,800 for re-certification,
3. approx. EUR 2,785 for certification of an "alternative system".

Public budgets (at both state and local level) show the total annual costs of an energy/environmental management system (internal costs and third-party maintenance, etc.) averaging approx. EUR 101,000 (unadjusted average based on 35 returns).

IT system costs

IT system costs vary widely depending on the specific system requirements. Annual licences for EnM software start at approx. EUR 2,000, to which are added provider-dependent set-up costs of approx. EUR 1,000. At the other end of the price range, control systems for entire districts/neighbourhoods may have set-up costs in the region of EUR 50,000. As a general rule, price models are based on the number of users and licences and on the number of data points and items. The number of locations is largely irrelevant, though it does have an indirect impact due to the higher number of data points.

Internal costs for energy managers

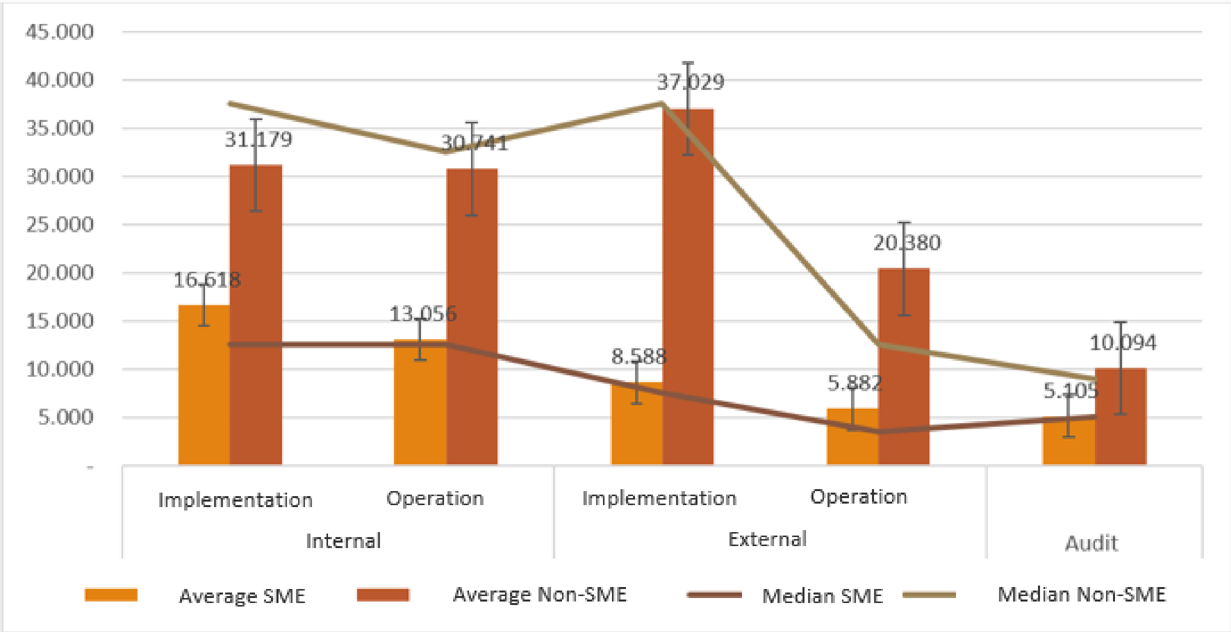
According to current research, salaries for energy managers vary between EUR 50,000 and 60,000 per annum. In terms of how organisationally embedded EnM systems are, the findings of the online survey show that most companies allocate between half a post and several full-time posts to energy management.

Sources: Consortium's own project results and BAFA market study[8]

The study reveals that **the larger the company, the higher the cost** of implementing and operating an ISO 50001-compliant system. Figure 9 illustrates the allocation of average implementation costs (one-off) and operating costs (annual). It also shows the standard deviation, which indicates the average difference between the individual values and the mean. It emerges that non-SMEs have clearly higher costs in all areas of the cost distribution. This is also reflected when considering the cost medians for non-SMEs. Median implementation costs in non-SMEs are EUR 37,500 for both internal and external costs. These companies estimated their median annual operating costs at EUR 32,500 for internal and EUR 12,500 for external costs. According to the data provided by the companies, median audit costs were EUR 9,000 (rounded values).

[8] Bundesstelle für Energieeffizienz (BfEE) (Publ.) (2022). "Empirische Untersuchung des Marktes für Energiedienstleistungen, Energieaudits und andere Energieeffizienzmaßnahmen im Jahr 2021", Endbericht 2021 – BfEE 20/04, Eschborn.

Figure 9: Cost distribution for an ISO 50001-compliant system by SME/non-SME, n = 70



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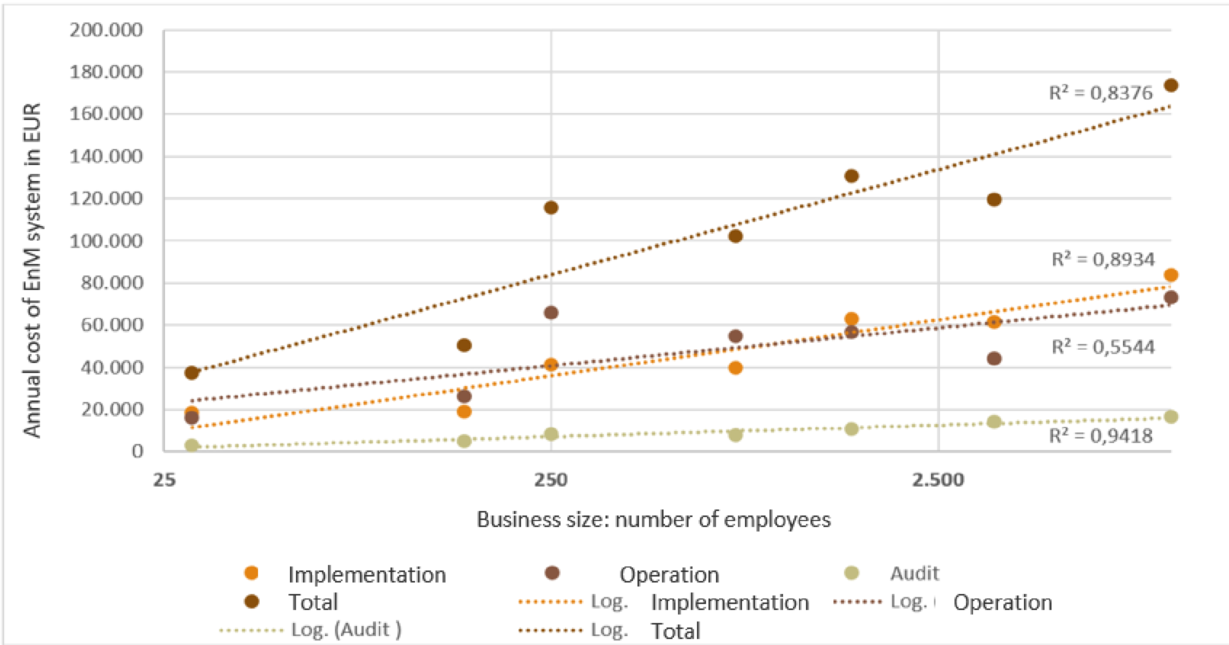
A look at the number of employees per company reveals the same situation. The average annual total cost (internal and external) of implementing and operating an ISO 50001-compliant system rises as the number of employees grows (cf. Figure 10). It should also be noted that large companies report higher costs for the implementation and operation of an ISO 50001-compliant system.

Figure 10: Average costs in EUR of an ISO 50001-compliant system by number of employees, n = 70



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Increases in efficiency can reduce product and service costs, which can in turn lead to a rise in product sales. As a result, the 'savings effect' may be swallowed up wholly or in part by an increase in output. At the same time, increases in efficiency can also change the behaviour of a company's employees, once again leading to a reduction in potential savings. In both cases, the phenomenon is referred to as the rebound effect. This study investigated the extent to which behaviour-related rebound effects occurred in companies operating an EnM system. The results of the online survey show that the majority of companies observed few (47.6%) to no (24.8%) behavioural changes and therefore that **rebound effects were low**.

A small number of businesses (11.2%) observed rebound effects. They noticed that countereffects occurred in the same or different areas due to changes in behaviour brought about by the measures implemented (i.e. additional energy consumption). Most of these answers (65.2%) indicated changes in behaviour relating to lighting, e.g., lights being left on for longer. The second most frequent behavioural change was in regard to heating (8.7%), where the installation of programmable thermostatic valves led to higher room temperatures when rooms were being used.

Figure 12: Do behavioural changes offset savings?, n = 250

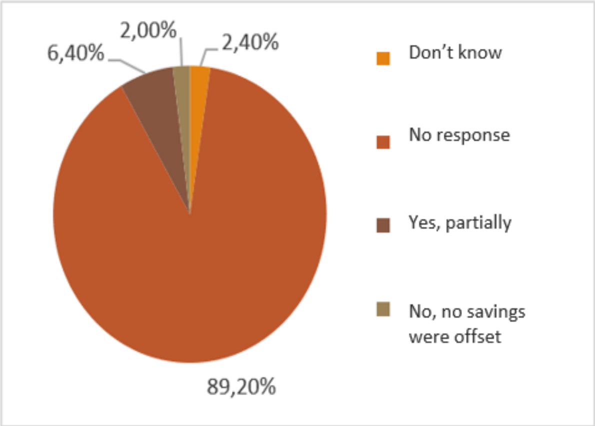

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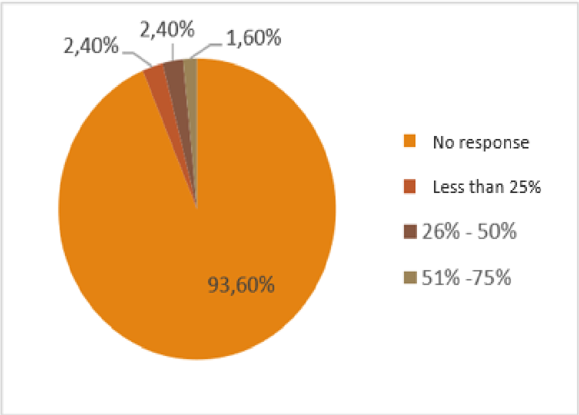
Figure 11: What is the percentage of residual energy savings?, n = 250



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Very few companies were able to put a figure on how much these behavioural changes completely or partially offset the savings previously achieved by the implementation of an EnM system (cf. Figure 12). Of these companies, only 2.4% estimated the residual energy savings at less than 25% or 26-50% (cf. Figure 11). When considering these figures, it is important to keep in mind that the rebound effect is a complex phenomenon that is difficult to evaluate with simple indicators. For this reason, these results were further examined in the expert interviews for validation.

5.5 Evolution of energy efficiency over time

This chapter addresses the following questions from the research brief:

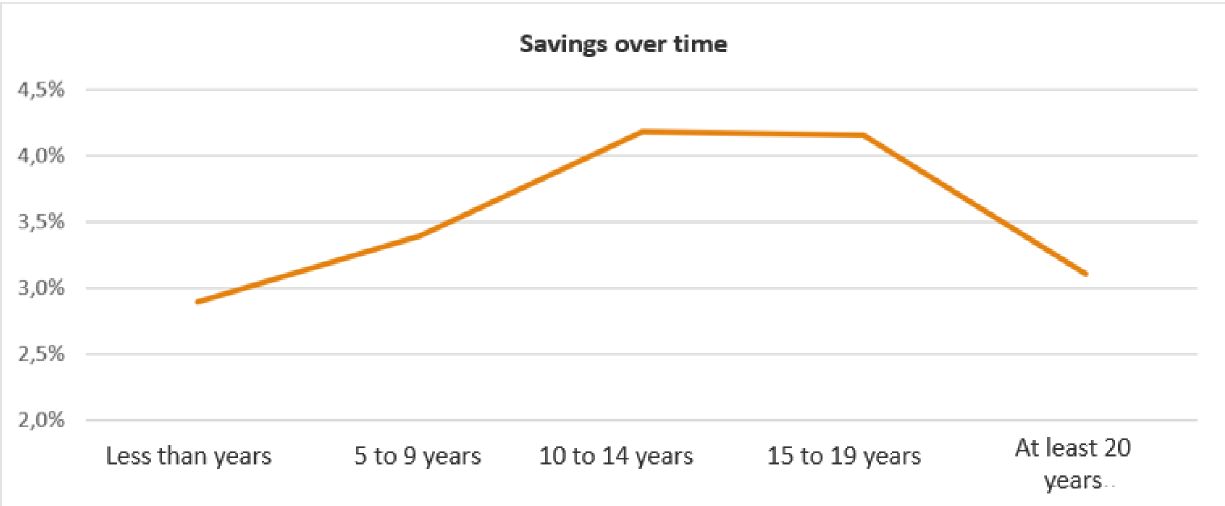
What savings (energy, CO2 emissions, costs) are made? How does implementation evolve over time?

As part of the study, the participating companies were asked how long they had already been addressing the problem of increasing energy efficiency in a targeted manner. They were also asked what energy savings they had achieved in the last two years.

An examination of efficiency increases over time shows that when a **systematic approach** (such as ISO 50001) is adopted, there is **no drop in the level of energy efficiency increases over time**. In fact, it remains constant and it is possible to achieve lasting savings by accumulating a range of energy efficiency measures. Looking at a time period from less than five years to over 20 years, it becomes clear that in percentage terms the reported savings of 3% to 4% are almost identical to those noted at the start (cf. Figure 13). This means that even after 20 years of measures designed to address the issue in a targeted way, for example, potential continues to exist and be exploited.

Systematic energy management can therefore both deliver continuous improvements in energy efficiency in companies and organisations and reduce energy consumption and associated greenhouse gas emissions. This stands in stark contrast to non-systematic systems such as energy audits, which offer potential savings for shorter periods and thereby reduced system profitability.

Figure 13: Efficiency savings over time, n = 175



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This analysis also shows that those companies that exploit opportunities to increase energy efficiency in an intensive and systematic manner, in particular, achieve their goals (cf. Table 4). A large proportion of companies reported having **reached their energy efficiency targets in the last two years**. At 36%, companies operating an ISO 50001-compliant system, in particular, indicated that they had achieved their goals.

Table 4: Achievement of energy efficiency targets in the last two years, n EMAS = 65, n ISO 50001 = 88, n Other = 49

	1 – Strongly disagree	2	3	4	5 – Strongly agree	Sum
EMAS	6%	11%	26%	35%	22%	100%
ISO 50001	0%	7%	23%	34%	36%	100%
Other	20%	14%	29%	18%	18%	100%
Total	**7%**	**10%**	**25%**	**31%**	**27%**	**100%**

Source: Original graphic

5.6 Implementation of energy efficiency measures

This chapter addresses the following questions from the research brief:

Does the use of an EnM system increase the likelihood of energy efficiency measures being implemented? What measures are implemented and on what scale?

Are ISO 50001-compliant systems as instruments for increasing energy efficiency in competition with other tools?

In terms of the implementation of energy efficiency measures, the study clearly shows that companies actively implement **economic** energy efficiency measures. This particularly relates to companies that operate an ISO 50001-compliant EnM system or EMAS system (cf. Table 5) and underlines that the companies are aware of the benefits of identifying potential savings and implementing tangible measures designed to save energy and costs. It is, however, important to note that it was the participating companies themselves that assessed their profitability (e.g. net present value vs. amortisation period).

Table 5: Companies' own assessment of the extent to which they had carried out the economic energy efficiency measures of which they were aware (e.g. from audit reports) in the last two years (n EMAS = 65, n ISO 50001 = 87, n Other =53

	1 – Strongly disagree	2	3	4	5 – Strongly agree	Sum
EMAS	2%	12%	15%	31%	40%	100%
ISO 50001	1%	7%	16%	41%	34%	100%
Other	8%	13%	30%	36%	13%	100%
Total	**3 %**	**10 %**	**20 %**	**37 %**	**31 %**	**100 %**

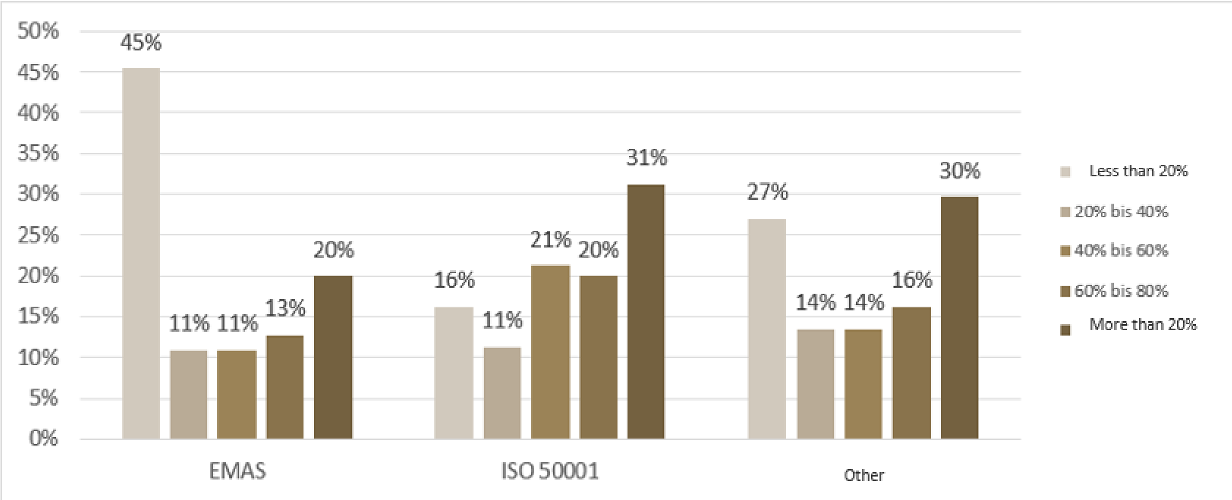
Source: Original graphic

5.6.1 Differentiation by investment and non-investment measures

In considering the implementation of energy saving measures, two groups of measures were distinguished: investment-based measures and behaviour-related measures such as increasing awareness of the issue of energy savings amongst employees, for example.

Almost half of the companies operating an EMAS system (45%) indicated that **behavioural measures formed the focus** of their energy savings, while investment measures took a subordinate role (cf. Figure 14). The situation with regard to ISO 50001-compliant systems was different. Approx. 70% of companies indicated that between 40% and 80% of their savings were made thanks to investment-based energy efficiency measures. This shows that the energy efficiency improvements achieved using ISO 50001-compliant systems are more reliant on investment. measures. Both groups of measures are equally represented in the control group.

Figure 14: Improvements in energy efficiency attributed to investments, n EMAS = 55, n ISO 50001 = 80, n Other = 37



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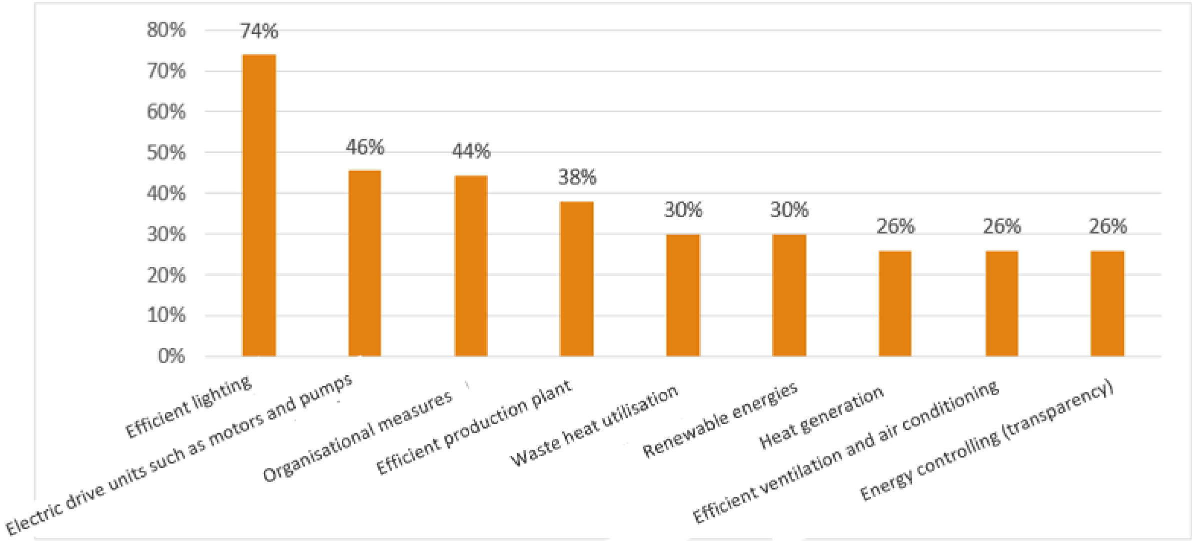
5.6.2 Differentiation by measure type and technology

A detailed evaluation of energy efficiency improvements by measure type shows that a variety of economic measures result in improvements in energy efficiency. The most frequently encountered improvement measure was efficient lighting. Just under three quarters of the participating companies reported having installed efficient lighting in their company in the last two years (cf. Figure 15).

Figure 15: Energy efficiency measures implemented in the last two years, n = 248, multiple answers possible



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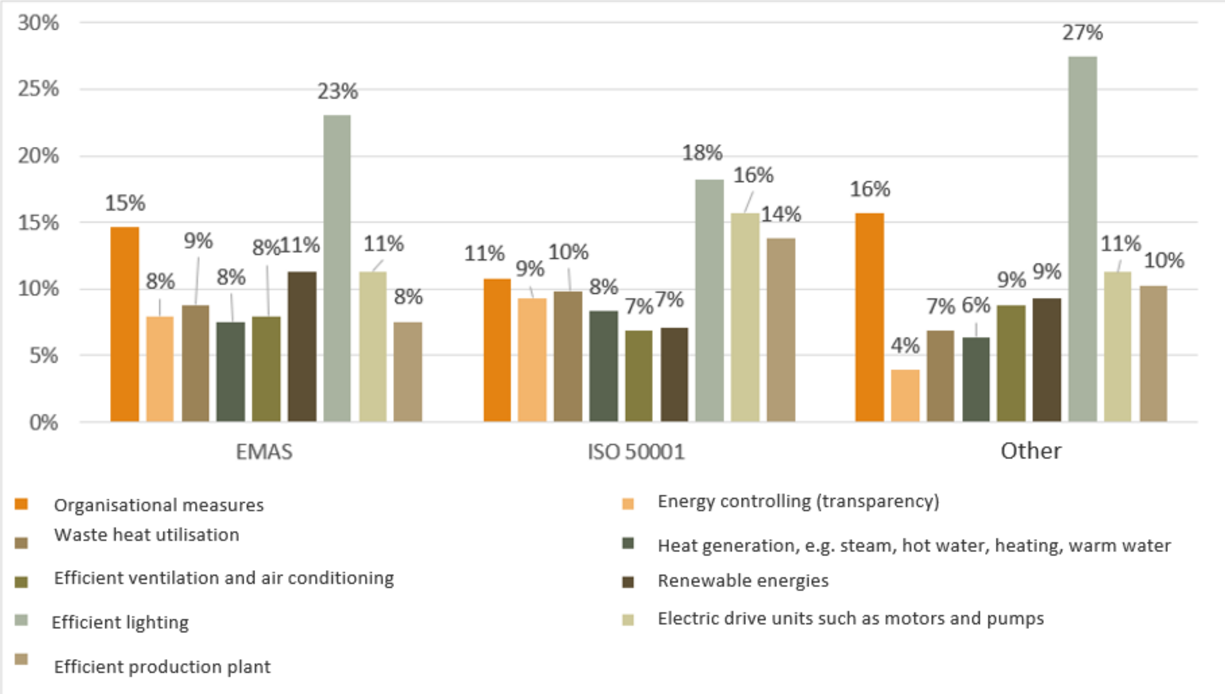
A comparison of the various EnM systems reveals that **measures designed to improve the efficiency of lighting** were the main focus in all groups. However, while measures such as the utilisation of waste heat (heat recovery) and efficient production plant operation were found where ISO 50001-compliant systems were implemented, it became clear that organisational measures took priority in the case of EMAS (15%) and other systems (16%) (cf. Figure 16). In these last two groups the focus tended to be on low-investment measures alongside efficient lighting and organisational measures.

Figure 16: Frequency of implemented energy efficiency measures, EMAS n = 74, ISO 50001 n = 95, Other n = 81, Multiple answers possible



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5.7 Motivation, goal attainment and satisfaction

This chapter addresses the following questions from the research brief:

Which companies decide to implement and/or certify of EnM systems? What is the role played by incentive/mandatory systems such as the Special Equalisation Scheme (BesAR), peak balancing and mandatory audits?

What are the barriers to certification?

Does the use of an EnM system increase the likelihood of energy efficiency measures being implemented?

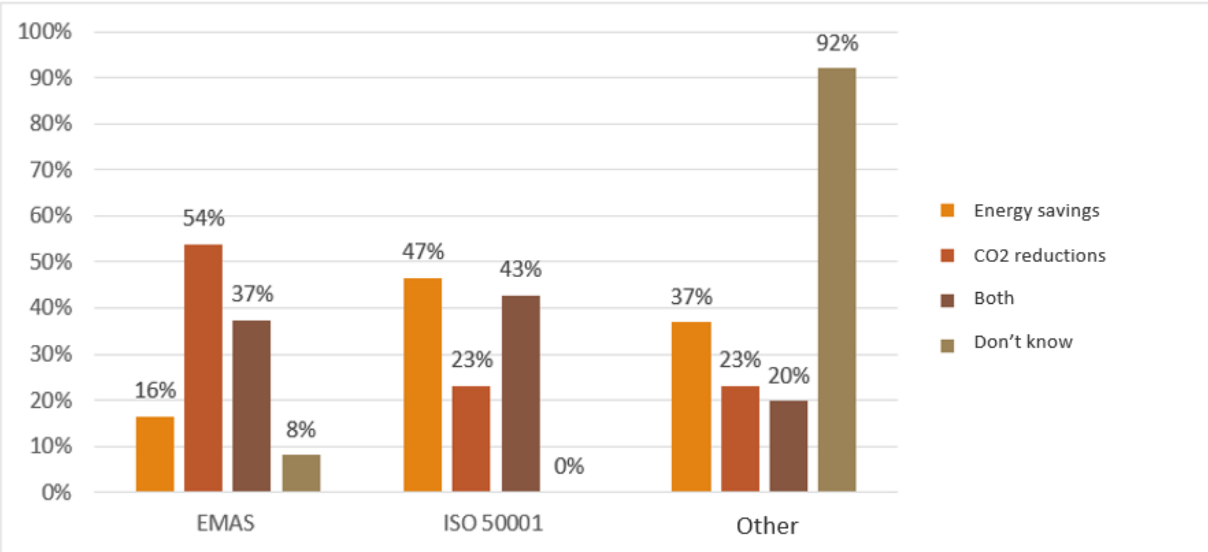
Are ISO 50001-compliant systems as instruments for increasing energy efficiency in competition with other tools?

In terms of motivation and goal attainment, the survey was geared towards investigating the significance of energy savings, CO_2 savings and other motivators for the operation of the various EnM systems. Against the backdrop of the growing importance of climate protection, it started by considering whether the companies primarily targeted energy savings or CO_2 savings. Here, **energy savings** appear to be the **prime motive** for the implementation and operation of EnM systems. **47%** of companies operating an **ISO 50001-compliant system** are aiming to reduce their energy consumption and save the associated energy costs. Companies operating an ISO 50001-compliant system regard CO_2 savings as a ‘by-product’, with 43% reporting that they targeted energy savings and CO_2 savings equally (cf. Figure 17).

In contrast, companies operating an **EMAS system see CO_2 savings as the priority**. Some 54% of companies indicated that they were operating an EMAS in order to generate CO_2 savings, while energy savings at 16% appear to be somewhat subordinate (cf. ibid.). This reflects EMAS' strong focus on environmental management and audits.

It is particularly interesting to note that 92% of companies **without a systematic approach** report not knowing why they are operating their particular system or **what their motivation for doing it is**. This highlights the disparity in knowledge about the purpose of energy efficiency initiatives and the planned/implemented measures between users of the two system types. None of the surveyed companies operating an ISO 50001-compliant system indicated that they did not know their motivation for operating the system.

Figure 17: Motivation for operating an EnM system; n EMAS = 70, n ISO 50001 = 93, n Other = 79



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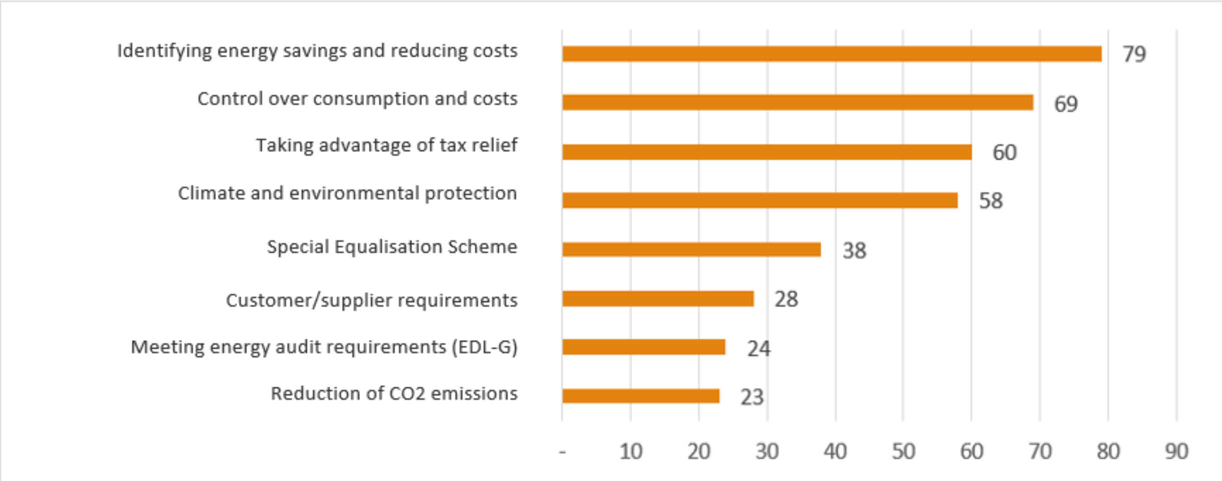
Alongside a company's fundamental motivation, the study also analysed other reasons for operating an EnM system. The central factor here was **energy costs** (cf. Figure 18), including both identifying potential savings and regular monitoring and analysis of energy use. Regulatory issues are another significant factor, with companies citing the benefits obtained under the Special Equalisation Scheme (*Besondere Ausgleichsregelung, BeSAR*) introduced by Germany's Federal Renewable Energies Law (*Erneuerbare-Energie-Gesetz, EEG*) (including a reduction in the levy for energy-intensive industrial companies) and in relation to mandatory energy audits (exemption from the four-yearly mandatory energy audit for companies with ISO 50001 or EMAS certification). In addition, issues such as climate protection and supplier requirements also affect motivation. Multiple answers were possible for these questions.

Figure 18: Reasons for operating an EnM system, n = 230, multiple answers possible



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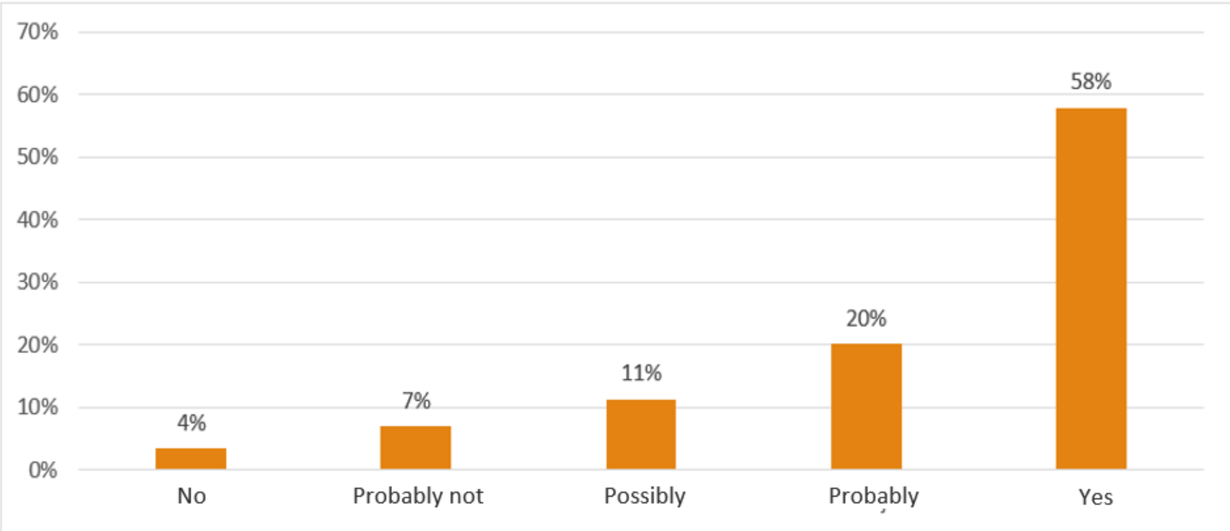
A large proportion of the companies surveyed would continue to operate an EnM system **even if there were no government regulation**. More than three quarters of the respondents agreed to the statement with 'Yes' or 'Probably' (cf. Figure 19).

Figure 19: Continued company EnM system operation without government regulation, n = 114



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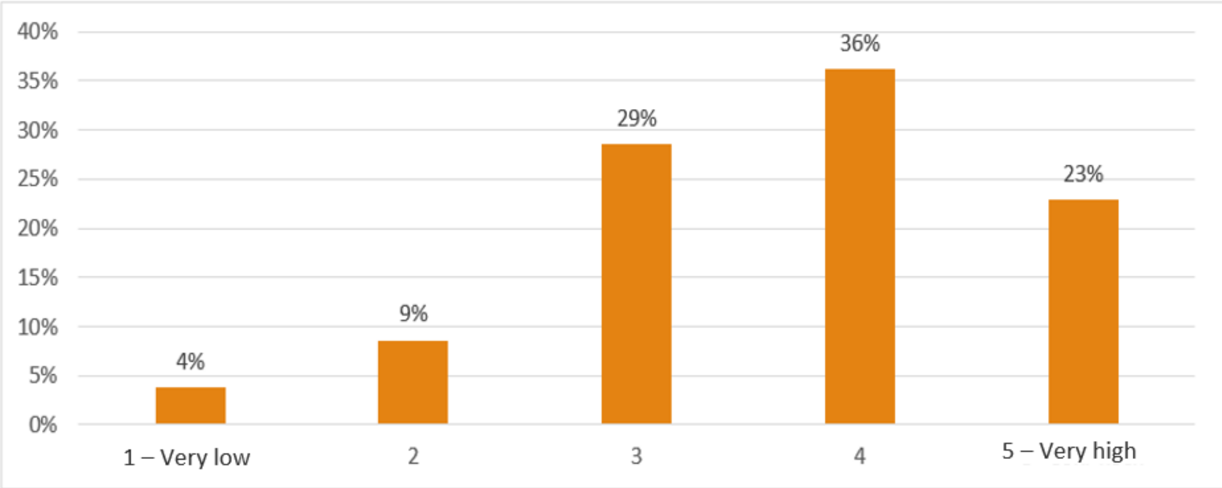
Our analysis of motivation and goal achievement was followed by a question on company satisfaction levels, to which the companies answered that they were **satisfied with the effectiveness of their EnM system**. More than half of the companies rated their system's effectiveness in improving energy efficiency as high or very high (cf. Figure 20). This is true of all the systematic approaches investigated as part of the study.

Figure 20: Estimated effectiveness of an EnM system (ISO 50001 und EMAS), n = 105



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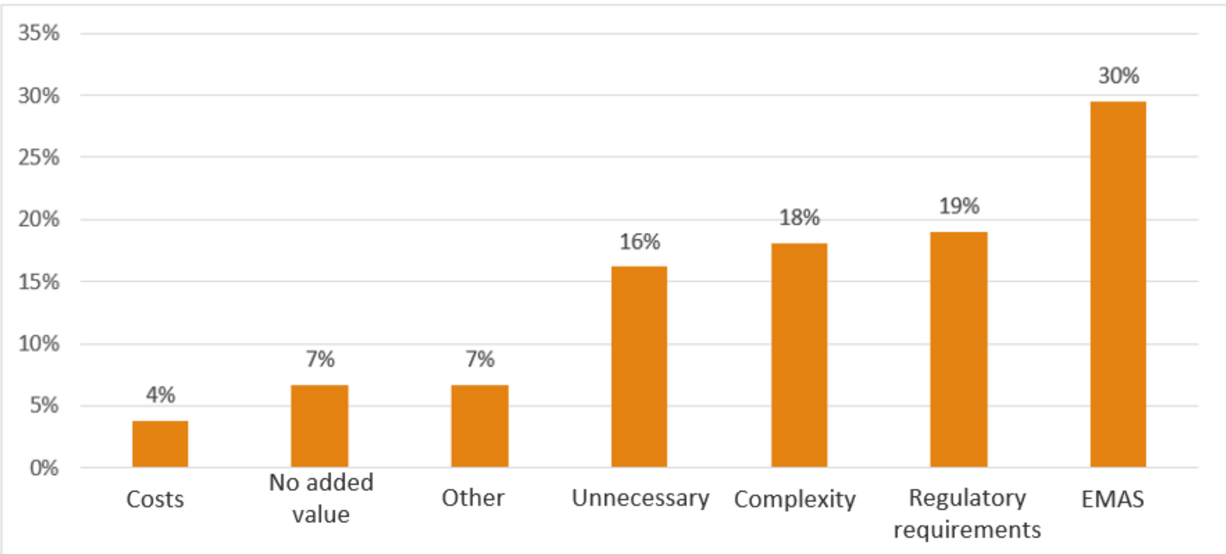
In this context the study also identified the factors and circumstances acting as barriers to the implementation and certification of IS0 50001-compliant EnM systems (open survey question). A large percentage of the answers related to companies with an existing EMAS system and as such there was no perceived added value in the implementation and certification of an additional ISO 50001-compliant system. In addition, some companies opted not to certify their ISO 50001-compliant system due to the anticipated **complexity** (cf. Figure 21). In other cases, companies saw certification as unnecessary or having **no further added value**. Factors such as the mandatory performance of energy audits were aggregated under 'Regulatory requirements' (cited particularly in this group).

Figure 21: Reasons for not implementing and certifying an IS0 50001-compliant EnM system, n = 105



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5.8 Findings on the drivers of effectiveness of ISO 50001 systems

This chapter addresses the following questions from the research brief:

Does the use of an ISO 50001-compliant management system increase the likelihood of energy efficiency measures being implemented? If so, which components of ISO 50001 play a key part in increasing this likelihood?

The part of the study described here looks in detail at which components of ISO 50001 have a particular impact on energy efficiency and energy consumption. The aim is to gain insight into the structure and effectiveness of the system within companies. The contextual examination took a statistical approach to the analysis of structural equation models. The effectiveness of IS0 50001-compliant EnM systems target value was tied to three indicators:

1. Improvement in energy efficiency,
2. The extent to which known measures are implemented,
3. The extent to which targets are reached.

As part of the online survey the **quality of individual components** of an IS0 50001-compliant EnM system was also assessed (e.g. the quality of support from top management, the quality of planning and monitoring)[9].

The impact of the following components of ISO 50001 on the effectiveness of the system were examined:

- The extent of support from top management,
- The availability of resources,
- The activities of the energy management team,
- The motivation of individual employees within the EnM team,
- The quality of energy-related
    - planning,
    - auditing,
    - feedback from top management,
    - follow-up of corrective measures,
    - variance analyses.

In addition to these components, a further variable relating to the quality of capital budgeting was collected since, according to Harfst (2021), this at least appears to be a relevant driver for sub-groups, and stipulations on the type

[9] The design of the structural equation models and the operationalisation of the individual constructs was based on the work of Harfst (2021). The data collected was analysed systematically using Partial Least Squares (PLS) as part of a variance-based structural equation analysis.

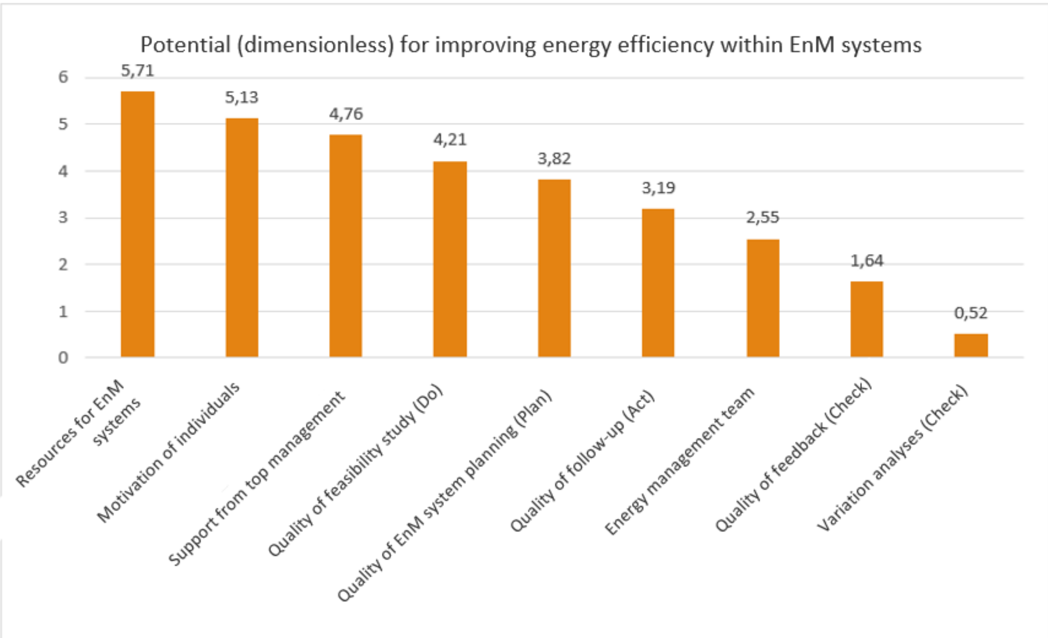
of capital budgeting – above all the preference of the net present value method over the use of the amortisation period – are increasingly featuring in current energy-related laws and regulations (cf., for instance, the German Carbon Leakage Regulations (Verordnung über Maßnahmen zur Vermeidung von Carbon-Leakage durch den nationalen Brennstoffemissionshandel, BECV), the German Regulations on Securing Medium-term Energy Supply (Verordnung zur Sicherung der Energieversorgung über mittelfristig wirksame Maßnahmen, EnSimiMaV), peak balancing for 2023, the draft German Federal Energy Efficiency Law (Bundes-Energieeffizienzgesetz, EEffG), etc.).

The results of the 'entire group' of 88 companies operating ISO 50001-compliant systems show that all the components set out in ISO 50001 and, in addition, the quality of capital budgeting have a significant positive impact on the level of effectiveness of the system and, thereby, on any increase in energy efficiency. This means that ISO 50001 offers a highly effective framework for increasing energy efficiency.

This is a key finding in that many of the relevant and effective components of ISO 50001 are not to be found in the more static systems such as the energy audit or the SpaEfV 'alternative system'. As a systematic approach, ISO 50001 shows clear advantages over alternative, more static systems.

As well as analysing individual effects, Partial Least Squares (PLS) also offers the possibility of determining the remaining potential for increasing the dependent variable (in this case the effectiveness of the system in relation to an increase in energy efficiency) in the effects model. Figure 22 shows the potential of the individual components in descending order.

Figure 22: Potential of individual EnM system components to increase energy efficiency, n = 88



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Based on this analysis, the most important driver of effectiveness of IS0 50001-compliant EnM systems is the **provision of the resources required** to implement and operate the system, followed by the motivation of individuals and the general support provided by top management. Interestingly, the quality of capital budgeting also shows great potential for improving energy efficiency. As carrying out complete, i.e., over the entire life cycle, and transparent capital budgeting is not stipulated in ISO 50001, the legislator might consider adding it to the relevant energy-rated regulations.

6 Descriptive findings of the expert interviews

This chapter addresses the following questions from the research brief:

What are the barriers to certification?

What internal costs are incurred in operating an ISO 50001-compliant EnM system?

Do rebound effects play a significant role? For instance, does additional energy consumption occur in the same or different areas due to changes in behaviour brought about by the measures implemented, thereby offsetting the resulting energy savings?

Are there any spillover effects? For instance, are there energy and cost savings that cannot be attributed directly to a measure but are achieved due to a radiating effect inside and outside the company? E.g. word-of-mouth recommendations, greater awareness of energy efficiency. Are there other economic effects above and beyond the savings, and how are they gauged? E.g. increased productivity, better access to capital market, image and advertising?

To what extent would the mandatory introduction of an ISO 50001-compliant EnM system for companies with an annual energy consumption of over 100 TJ influence the spread and so the effect of ISO 50001?

Are ISO 50001-compliant systems as instruments for increasing energy efficiency in competition with other tools?

In addition to the standardised online survey examining the mode of action and effectiveness of EnM systems, **three expert and five practitioner interviews** were carried out to consider complex issues and validate the findings. The practitioner interviews involved employees from businesses and organisations in a range of sectors who had implemented different (energy) management systems and tools for promoting energy efficiency in their company or organisation. The experts came from the fields of certification and consultation. Evaluation was qualitative with distinctions being made between the following topic areas: requirements for and barriers to the implementation and operation of EnM systems, a comparison of EnM systems and the impact of EnM systems.

6.1 Requirements for and barriers to the implementation and (continued) operation of energy management systems

Companies implementing and operating energy management systems are influenced by external societal and economic factors such as industrial decarbonisation, rising energy prices and changing customer demands and supplier requirements, for example.

Internally, the interviewees cited:

- the necessary intrinsic motivation combined with **support, motivation** and **delegation of duties** by **company directors and management,**
- the **availability** of personnel and financial **resources**, particularly in small- and medium-sized businesses, and
- staff **expertise, experience** and **awareness**

as relevant factors in the successful implementation and operation of an EnM system. The absence of these elements was, in turn, considered a barrier to the implementation and operation of EnM systems. This is particularly evident in the extrinsically motivated implementation of an EnM system as the result of a statutory requirement, for example. In addition, the interviewees reported that certification costs, in particular, were an obstacle to implementation, particularly in SMEs, especially where there was insufficient information to carry out a comprehensive cost-benefit analysis of the implementation of an EnM system.

From initial planning to the final evaluation of the improvements in energy-related performance that have been achieved, the implementation of **energy-related measures** is subject to a multitude of influences that can complicate the process. The interviewees reported that It was difficult to estimate future benefits due to lack of data on influence values, for example. In some economic sectors material costs took priority over energy costs, thereby reducing the motivation to implement energy-related measures. According to interviewees working in companies, production-driven measures were frequently regarded as paramount. Personnel resources and employee knowledge were also seen as indispensable in implementing measures; in their absence it became difficult or impossible to carry out these measures.

The interviewees described the final **evaluation of measures** as difficult, often due to insufficient pre-implementation data (‘before’ measurements) because the necessary metrics were missing, for example, making it impossible to map the improvement achieved by a measure in quantitative terms. When compared to ISO 50001, the ‘alternative system’ stipulated in Appendix 2 of the German Regulations on Systems for Improving Energy Efficiency (SpaEfV) lacks components such as the internal audit and management review, which together form the Plan-Do-Check-Act (PDCA) cycle[10]. These components were seen to facilitate the implementation of measures and drive improvements forward.

When **determining profitability**, the interviewees voiced a wide range of views on options and practical implementation. The experts believed that measures should be evaluated in advance using the net present value method or the amortisation period, with DIN EN 17463 (ValERI) providing a useful supporting tool. When it came to actual implementation, however, company respondents reported difficulties in making assessments due to a lack of information (variables, etc.) or to internal rules such as fixed in-house amortisation periods, for example, which could complicate the process. It was also reported that, in practice, costs were frequently considered at project rather than company level, particularly in the case of higher-value investments. In addition, not all of the employees responsible for EnM systems in the surveyed companies were involved in the profitability evaluation process.

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[10] The PDCA cycle is an approach used in the continuous improvement process. The PDCA cycle consists of four iterative phases: Plan-Do-Check-Act.

According to the company respondents, in practice follow-up evaluation measures, like ‘before and after measurements’ and EnPI evaluations (variance analyses), are not carried out across the board due to lack of information. In the view of the experts, the **evaluation and prioritisation of measures** should be carried out in a multi-dimensional manner to include energy savings, CO_2 savings, economic values, practicability and the total service life.

Internal costs are primarily incurred in relation to personnel and the acquisition and installation of measuring technology. However, the weighting of costs differs according to business size. In SMEs, personnel costs were paramount. In the surveyed companies, an energy team as defined in ISO 50001 frequently comprised employees from the engineering and maintenance, production, purchasing and controlling departments.

The interviewees considered the government-initiated nationwide implementation of EnM systems, in particular ISO 50001-compliant EnM systems, as positive in view of increasing levels of acceptance amongst company management. However, they also expressed misgivings about the circle of users and the complexity of the standard. They took the view that the smaller the business, the more difficult the implementation of ISO 50001 would be and suggested ISO 50005 as an alternative. The company interviewees believed that the mandatory implementation of ISO 50001 would encourage a focus on selected sections of the standard (e.g. Section 6). The majority of respondents cited the availability of resources and (intrinsic) motivation in conjunction with statutory imposition as critical variables, irrespective of the size of the business.

6.2 A comparison of energy management systems

EnM systems as instruments for increasing energy efficiency **are in competition with other tools to some extent**. According to the experts, this is in part due to the fact that the legislation refers to various alternatives. Respondents representing certifying organisations and energy consultants, in particular, emphasised that ad hoc approaches promoting energy efficiency should be contrasted with the systematic approach. When applied systematically, the latter can be expected to produce sustainable savings due to the continuity of ISO 50001, while the ad hoc approach of the energy audit does not as yet contain any obligation to implement concrete measures.

Respondents representing certifying organisations and energy consultants viewed the combination of an internal structure that fixes knowledge within a company and external stimuli such as audits, for example, as productive. When looked at in this way, an energy audit under DIN EN 16247-1 could provide an additional incentive for evaluating energy efficiency. According to company interviewees, there was no evidence of **competition with other instruments** for increasing energy efficiency. There was, however, internal competition with other divisions and areas of business (e.g. production, quality assurance, environment). Energy efficiency activities were also used in companies to promote climate neutrality.

Both company employees and certifying body staff and consultants believed that ‘low-hanging-fruits’ were exploited at the start of the use of an EnM system. Companies implementing ISO 50001 systems took the view that although the number of projects and measures create a constant over time, savings tend to decrease (no evidence of this was provided). The majority of the interviewees regularly saw jumps in savings (a ‘wave-like pattern’) due to technical innovations and other external factors (e.g. energy prices, changes in legislation, etc.). According to the certifiers, various **effects and new features** such as the creation of metrics and regression analyses, for example, provided the possibility of making more valid decisions in relation to the implementation of measures.

The experts believed that with energy audits under DIN EN 16247-1 it would be possible to achieve early partial successes, but that there would be no systematic change with continuous improvement. The ‘alternative system’ stipulated in Appendix 2 of the SpaEfV, in contrast, provided neither continuity nor a systematic approach to continuous improvement through the implementation of measures.

6.3 The impact of energy management systems

Rebound and spill-over effects were examined in the expert and practitioner interviews and were also apparent in the implementation of EnM systems. The interviewees had no further information for their quantification and further evaluation. EnM system users believed that data collection could conceivably be expanded in order to make such effects quantifiable and take appropriate measures.

The company interviewees reported that the direct rebound effect did appear in practice, when using self-generated electricity, for example. Initially, there was a decrease in efforts by staff to save energy and use it efficiently. The experts believed that to counter this phenomenon it was necessary to **inform and raise awareness amongst staff on a regular basis**. In addition, though the resource savings achieved in a company were frequently used in the same department, it was often in the form of financing for further (efficiency) measures.

The survey showed that many users assume there are no indirect rebound effects in their company. However, the respondents had no clear facts or data on this issue and thus could not draw any clear conclusions.

In the view of the experts, rebound effects should be looked at separately from other effects such as economic growth, for example. CO_2 emissions should also be measured in parallel. Some interviewees expressed the opinion that it was acceptable for energy consumption to increase as long as CO_2 emissions continued to fall.

The survey revealed that the spill-over effect particularly manifested itself in the **continued development of staff awareness** of energy issues within their companies. This was reflected across the board in the transfer of knowledge and exchange of best practice between staff members, for example.

According to the majority of interviewees, the incentives came from the system, but also from changes in society. It also improved the **public perception/image of their company** and, in some cases, resulted in measures being implemented more quickly. Overall, many processes were re-evaluated and optimised as a result of the incentives provided by EnM systems.

The interviewees took the view that it was impossible to quantify the spill-over effect due to its complexity and because it is a general development process.

7 Approach to determining energy and GHG savings

7.1 Operating principle and use of the tool-based approach

The ‘Energy Management System Impact Assessment Software’ (PAE tool[11], 2018) serves as the data-based foundation for calculating the economic impact of EnM systems at both the micro and macro level. The tool is able to evaluate the energy consumption, costs and CO_2 emissions of German industrial and tertiary sector companies using variable parameters (e.g. economic sector). The tool is based on the Impact Estimator Tool (IET) developed by the Berkeley National Laboratory in 2015.

Several years after its release, the tool is now in need of revision in terms of the underlying research topic. In a first step, the framework data of the tool (in particular energy consumption by sector) was analysed (7.1.1). In step two, the use of the tool was evaluated and its limitations highlighted (7.1.2). A third step determined the PAE tool data that was suitable for continued use, and a tool capable of answering the research questions (AAE tool) was developed (7.1.3).

7.1.1 Description of the original PAE tool

The PAE tool calculates the impact of EnM systems on the corporate energy consumption in Germany. In so doing, it provides savings data both sector by sector and cross-sector. The energy savings it determines are then used to ascertain energy cost savings and impact on greenhouse gas emissions in the form of CO_2 equivalents.

The PAE tool is able to make the following distinctions as standard:

- EnM system: differentiation by ISO50001 or alternative (EMAS, SpaEfV) system,
- Economic sector: all sectors together or differentiated by energy intensity or sector cluster.

For the calculation itself, the tool has options to vary the following parameters, in particular:

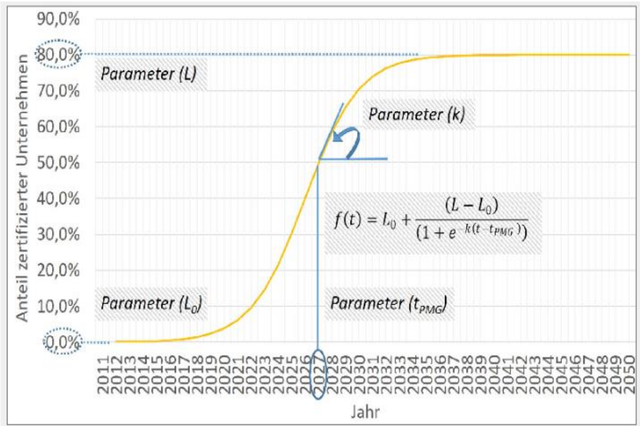
- Percentage input for the result scatter (deviation from “best case” and “worst case” scenarios),
- Percentage input for energy efficiency gain (annual and one-off due to the implementation of an ISO 50001-compliant system),
- Percentage input for the proportion of investment measures,
- Input of S-curve parameters for the development of the spread of ISO 50001 within the group studied,
- Input of electricity and fuel prices and price trends.

[11] Studie zur Wirkung von Energiemanagementsystemen Referenznummer der Bekanntmachung: BfEE 08/2021. Available at: https://ausschreibungen-deutschland.de/849244_Studie_zur_Wirkung_von_EnergiemanagementsystemenReferenznummer_der_Bekanntmachung_BfEE_2021_Eschborn last retrieved on 11/08/2022

7.1.2 Evaluation of the application and limitations of the original PAE tool

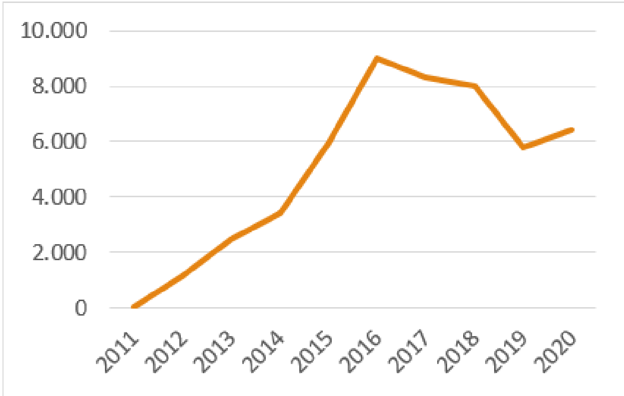
The PAE tool offers a very good overview of the impact of EnM systems on the German national economy, supposing an increasing level of saturation due to the voluntary implementation of EnM systems in the country. It is therefore assumed that the number of German companies operating an EnM system is increasing according to an inverse sigmoid function and that saturation will eventually occur.

Figure 23: Original PAE tool start-up curve



Source: PAE tool

Figure 24: ISO 50001 certificates in Germany



Source: Original graphic des ISO-Survey

The original PAE tool represents macroeconomic energy savings differentiated according to EnM system and sector cluster using user-based calculation parameter inputs. However, its calculations are based on the 'rigid' assumption of a saturation-type EnM system spread pattern (cf. Figure 23). The original 'start-up curve' was an appropriate assumption at the time the tool was developed, but had to be reconsidered in light of certificate and regulatory developments in Germany. According to an ISO survey, the number of ISO 50001 certificates initially dropped after 2017-2020 and then increased slightly (cf. Figure 23 and Figure 24).

Mapping the framework of evolving national and European climate protection measures and targets requires an approach that is able to react in a flexible manner to the number of companies operating EnM systems and the resulting reduction in energy consumption.

This is particularly true against the backdrop of European legislative initiatives such as the revision of the EED with its planned mandatory implementation of IS0 50001-compliant EnM systems depending on company energy consumption (the first draft of the revised EED sets the threshold value at 100 TJ). It is unlikely that a slowly increasing curve would suffice for regulatory initiatives of this kind. On the contrary, it would be more appropriate to assess the business and economic impact of this type of mandatory regime as a function of the threshold value set. As a result, part of the study involved deciding to fundamentally redesign the PAE tool. This resulted in the production of a new tool for assessing the impact of EnM systems (AAE tool).

7.1.3 Function and components of the new AAE tool

The AAE tool determines the macroeconomic consequences of the use of a mandatory EnM regime for companies with energy consumption above a certain level (threshold value for the mandatory implementation of an EnM system). Thanks to the ability to select the threshold value, the tool provides its users with a scenario-based simulation of the potential consequences of a mandatory EnM regime. In the process, the tool integrates variable user inputs via a dashboard, primary data from the survey and secondary data on general and cluster-specific calculation parameters.

The following parameters can be personalised on the dashboard:

- Selection options for the group studied
    - threshold value
    - sector cluster
    - EnM system
- Input options
    - reduction in energy consumption through increases in efficiency (for the tertiary and industrial sectors)
    - electricity and fuel prices and price growth rates
    - CO_2 equivalence values for electricity and fuels

Alongside these inputs, the AAE tool also collects the following information from the survey and supplements the scenarios with macroeconomic projections and assumptions based on secondary data, as follows:

- Survey data (average values by EnM system and sector cluster)
    - Increase in efficiency p.a. due to implementation and operation of EnM systems
    - Contribution of investment measures to the increase in efficiency
    - ISO 50001 implementation and operating costs (by cluster only)
- Macroeconomic projections using government databases
    - Destatis, AGEB (*Arbeitsgemeinschaft Energiebilanzen e.V.*) and information provided by the German Federal Office for Economic Affairs and Export Control (BAFA) on the distribution of all German companies and businesses in the tertiary and industrial sectors
    - BAFA database of energy audit results and STABU database on the distribution of companies by energy consumption
        - BAFA database based on past verification of energy audits for the macroeconomic extrapolation of all tertiary sector companies
        - Data from the German Federal Office of Statistics (*Statistisches Bundesamt*) on the energy consumption of businesses in the manufacturing industries for extrapolation to all industrial companies
            - Assumptions/methodology: companies with fewer than 10 employees were assigned an energy consumption of less than 1 GWh

    - AGEB reviews on the percentage distribution of electricity and fuel consumption for industrial and tertiary sector companies (from the Fraunhofer Institute for Systems and Innovation Research)
    - ISO 50001 database and official EMAS data on distribution by sector cluster[12]
        - Percentage distribution after extrapolation of all businesses by energy consumption
- Other fixed assumptions made, in particular, on the basis of the survey findings:
    - Energy savings assumed to be constant over time (time horizon: 2045)
    - 35% energy cost savings required to cover investment costs
    - The ~6000 existing ISO 50001 certificates reported in the ISO survey were distributed over the group of companies with a consumption in excess of 5 GWh based on data from a certification body even though there are also companies with lower energy consumptions operating an ISO 50001 system. For the analysis, this changes the one-off implementation costs in a given group. It is nevertheless also possible to analyse mandatory implementation from a lower threshold value.
    - The cost of implementing and operating EMAS is the same as the cost of an IS0 50001-compliant EnM system

7.2 Example evaluation parameter settings and evaluation using the AAE tool

This section provides an example of an evaluation carried out using the AAE tool and the resulting findings. Appendix 4 provides a more technical overview of the calculation model ('calculation flow'). As an example, it considers the effects of the mandatory implementation of an IS0 50001-compliant EnM system in all German companies with an energy consumption >10 GWh. To this end the selection options were set as follows:

- Threshold value: 10 GWh
- Cluster: total
- EnM system: ISO 50001

as indicated in Figure 2625 'Example AAE tool evaluation settings'. The default options were maintained for all other inputs. Since some absolute final energy savings achieved through efficiency measures are 'offset' to a certain extent by increases in production, the also tool offers the possibility of setting a percentage at which savings result in a reduction in absolute final energy consumption. By default, the tool assumes that 100% of efficiency measures in the tertiary sector 100% result in final energy savings as energy consumption in this sector is

[12] cf. ISO Survey (online: https://www.iso.org/the-iso-survey.html) and EMAS register (online: www.emas-register.de)

less dependent on ‘output’. In the industrial sector, on the other hand, the default setting assumes that 50% of efficiency gains result in final energy savings while the rest are offset by increases in production.

Figure 25: Example AAE tool evaluation settings

Options		
Threshold value (GWh)	10,00	
Sector cluster	Total	
EnM system	ISO 50001	
Input options	**Tertiary**	**Industrial**
Percentage reduction in energy consumption reduction due to efficiency gains	100,00%	50,00%
Input options	**Electricity**	**Fuels**
Basic costs (ct./kWh) (values must be above 0!)	18,0	12,0
Cost growth (%/a) (values must be over -100%!)	2,0%	3,0%
CO2 equivalents (tCO2/GWh)	366	224

Source: Original graphic

The first results are generated based on these settings (cf. Figure 26). This example shows that approx. 9,000 companies in Germany have an energy consumption of >10 GWh. Although they only correspond to 0.3% of the more than 3 million companies operating in Germany, these 9,000 companies account for approx. 86.3% of the energy consumption in the German economy. Based on the threshold values, some 40% of companies with an energy consumption >10 GWh already operate an ISO 50001-compliant EnM system. At the same time, approximately half of the total energy consumption of the studied companies is not yet being systematically managed as part of an ISO 50001-compliant EnM system.

Figure 26: First output of example AAE tool evaluation

Outputs	**Absolut**	**Prozentual**
How many companies have an energy consumption higher than the threshold value?	9 074	0,3%
What is the energy consumption of these companies (GWh)?	879 340	86,3%
What is the total energy consumption observed (GWh)?	1 018 999	100,0%
How many of the companies above are already ISO 50001 certified?	3 773	41,58%
What level of energy consumption do the certified companies account for?	477 598	54,31%

Source: Original graphic

Based on:

- the energy consumption of the selected group and the corresponding prices and CO_2 equivalents (see Figure 25: Example AAE tool evaluation settings) and
- the number of studied companies (see Figure 26) the potential savings due to the use of an EnM system and the associated costs (data from survey)

the tool calculates

- energy savings, energy cost savings and GHG savings,
- the cost of operating the system and investments in energy efficiency measures and
- the net costs and savings for each year (starting in 2022) up to 2045

and then cumulates the effects over the studied period (cf. Figure 27).

The example results show that at the selected threshold value and the other setting parameters indicated above the implementation and operation of an EnM system will result in an economic benefit of EUR 72,490 million by 2045. This benefit is the result of the advantages reaped by the individual companies in the selected group. In this scenario the cumulated emission savings amount to approx. 158 Mt CO_2.

Figure 27: Example AAE tool evaluation of changes in energy, cost and GHG

Impact on energy savings	Year 1	Year 2	....	Year 23
Potential savings potential of energy consumption observed (%/a)	3,30%	3,30%	....	3,30%
Variable energy consumption (regression)		867.839,49	....	658.229,41
Total energy savings – Electricity (GWh/a)	10.007	9.876	....	7.491
Total energy savings – Fuels (GWh/a)	19.012	18.763	....	14.231
Savings potential – Electricity (EURm/a)	1.837	1.850	....	2.126
Savings potential – Fuels (EURm/a)	2.350	2.389	....	3.370
Cumulative savings (€m)	4.187	8.425	....	110.615
Cumulative savings: newly implemented systems (€m)	1.913	3.849	....	50.536
Cumulative savings: existing systems (€m)	2.274	4.576	....	60.079
			....	
Cost analysis	Year 1	Year 2	....	Year 23
Implementation costs (€m)	342		....	
Operating costs (€m/a)	272	655	....	655
Investment costs	875	886	....	1.148
Cumulative costs (€m)	1.489	3.029	....	38.125
Cumulative costs (€m) – newly implemented systems only	742	1.529	....	19.313
			....	
Cost/savings balance (€m)	2.698	5.396	....	72.490
Cost/savings balance – newly implemented systems only (€m)	1.171	2.321	....	31.223
			....	
Environmental improvements	Year 1	Year 2	....	Year 23
CO2 savings – electricity ktCO2	3.663	3.615	....	2.742
CO2 savings – fuels ktCO2	4.259	4.203	....	3.188
Cumulative total	7.921	15.739	....	158.230

Source: Original graphic

Via the evaluations shown here, the tool also offers the possibility of generating matrices in which the results can be represented in differentiated and summarised form using setting parameters such as threshold value and increases in energy price. A description and interpretation of these findings is provided in Section 7.3.

7.3 Impact in future scenarios

By using different inputs, the **AAE tool** is able to differentiate between the consequences of the widespread implementation of ISO 50001 systems on the economy as whole. As a result, it is possible to determine an **optimum threshold value for mandatory ISO 50001 system implementation** by selecting or inputting different variable parameters. As the optimum threshold value is heavily dependent on both increases in fuel and electricity prices and on potential savings and implementation and operating costs, Figure 28 uses different scenarios (in relation to annual energy price rises and threshold values) to illustrate cumulative net costs and net savings. It distinguishes between three sectors or sector clusters: *Total* (corresponding to the tertiary and industrial sectors), *tertiary* and *industrial* (corresponding to clusters E1, E2 and E3).

In addition, Figure 28 'Impact in future scenarios' shows the cumulative net macroeconomic figures (in EUR millions) resulting from the implementation and operation of an EnM system for the aforementioned clusters and for the German economy as a whole until 2045. The results are given as a function of the threshold value and potential energy price growth rates. The optimum (greatest economic benefit) shifts towards a lower threshold value as a function of expected increases in energy prices as the financial return increases in relation to expenditure on the implementation and operation of the system due to higher energy prices. At an expected price growth rate of 3%, for example, the optimum threshold value for the industrial sector (E1, E2, E3) is therefore approx. 14 GWh and a macroeconomic benefit of EUR 47,883 million by 2045. With an expected price growth of 6%, on the other hand, the optimum for the industrial cluster (E1, E2, E3) would be 10 GWh with a macro economic benefit of EUR 63,068 million.

Using this matrix provided in the tool, it is therefore possible to analyse the **macroeconomic impact of various scenarios** in a flexible manner. As the cost of implementing and operating EnM systems and the cost of investing in energy efficiency measures is also mapped, the tool also offers a solid foundation for estimating the compliance costs of the companies in question by sector.

Figure 28: Impact in future scenarios

Scenario 1: "Total" selected
Cumulative costs/savings after 23 years

Threshold value in GWh: Total

Annual cost growth - fuels		0	1	2,8	5	10	14	28	50	100	250	1000
	1,00%	-6.503.297	25.571	45.468	54.640	61.460	62.911	62.217	59.426	54.656	46.382	34.516
	2,00%	-6.497.329	31.281	51.039	60.050	66.574	67.850	66.762	63.625	58.439	49.552	36.863
	3,00%	-6.490.426	37.887	57.483	66.309	72.490	73.565	72.020	68.485	62.817	53.222	39.579
	4,00%	-6.482.432	45.538	64.948	73.560	79.344	80.186	78.114	74.117	67.892	57.476	42.729
	5,00%	-6.473.161	54.411	73.605	81.969	87.294	87.866	85.183	80.652	73.781	62.414	46.385
	6,00%	-6.462.399	64.714	83.656	91.732	96.525	96.785	93.393	88.242	80.621	68.150	50.633
	7,00%	-6.449.893	76.686	95.337	103.079	107.254	107.152	102.937	97.066	88.575	74.822	55.575
	8,00%	-6.435.349	90.611	108.924	116.277	119.735	119.211	114.041	107.332	97.830	82.586	61.326
	9,00%	-6.418.422	106.819	124.737	131.639	134.263	133.250	126.968	119.286	108.607	91.629	68.025
	10,00%	-6.398.712	125.693	143.153	149.530	151.185	149.601	142.027	133.212	121.163	102.166	75.832

Scenario 1: "Tertiary" selected
Cumulative costs/savings after 23 Jahren

Threshold value in GWh: Tertiary

Annual cost growth - fuels		0	1	2,8	5	10	14	28	50	100	250	1000
	1,00%	-6.297.393	-13.816	-1.049	5.892	11.720	13.249	13.728	12.752	10.854	7.588	4.695
	2,00%	-6.295.881	-12.447	271	7.142	12.835	14.287	14.601	13.492	11.451	7.990	4.941
	3,00%	-6.294.148	-10.878	1.782	8.575	14.113	15.476	15.601	14.341	12.135	8.451	5.223
	4,00%	-6.292.158	-9.077	3.518	10.220	15.580	16.841	16.748	15.316	12.920	8.980	5.547
	5,00%	-6.289.870	-7.007	5.513	12.111	17.267	18.410	18.068	16.436	13.823	9.589	5.919
	6,00%	-6.287.236	-4.623	7.810	14.289	19.209	20.217	19.587	17.726	14.863	10.289	6.348
	7,00%	-6.284.200	-1.874	10.459	16.799	21.449	22.300	21.338	19.213	16.061	11.097	6.842
	8,00%	-6.280.695	1.299	13.516	19.697	24.033	24.704	23.360	20.930	17.445	12.029	7.412
	9,00%	-6.276.644	4.965	17.049	23.045	27.020	27.483	25.696	22.913	19.043	13.106	8.071
	10,00%	-6.271.960	9.205	21.135	26.918	30.474	30.697	28.398	25.207	20.892	14.352	8.833

Scenario 1: "E1, E2, E3" selected
Cumulative costs/savings after 23 Jahren

Threshold value in GWh: E1, E2, E3

Annual cost growth - fuels		0	1	2,8	5	10	14	28	50	100	250	1000
	1,00%	-216.803	29.042	36.453	39.023	40.651	40.947	40.614	39.521	37.498	33.724	26.192
	2,00%	-213.280	32.523	39.871	42.385	43.922	44.163	43.690	42.457	40.244	36.169	28.077
	3,00%	-209.205	36.547	43.824	46.275	47.706	47.883	47.248	45.853	43.421	38.995	30.258
	4,00%	-204.486	41.208	48.402	50.779	52.088	52.191	51.368	49.786	47.099	42.269	32.783
	5,00%	-199.015	46.613	53.710	56.001	57.170	57.187	56.146	54.347	51.365	46.065	35.712
	6,00%	-192.664	52.886	59.872	62.063	63.068	62.985	61.692	59.640	56.316	50.472	39.111
	7,00%	-185.284	60.176	67.031	69.107	69.921	69.723	68.136	65.791	62.069	55.592	43.061
	8,00%	-176.702	68.652	75.357	77.298	77.891	77.558	75.630	72.944	68.760	61.546	47.654
	9,00%	-166.716	78.517	85.045	86.831	87.166	86.675	84.350	81.268	76.546	68.476	52.999
	10,00%	-155.087	90.003	96.327	97.930	97.965	97.292	94.504	90.961	85.612	76.544	59.223

Source: Original graphic

In addition to the financial aspects of this examination, the potential energy savings also result in corresponding **GHG savings** that vary according to the selected threshold value and sector. Figure 29 shows the cumulative potential savings resulting from the use of an ISO 50001 system by 2045 by threshold value and sector. Selecting a threshold value of 10 GWh for the implementation and operation of an ISO 50001-compliant EnM system in all German companies would result in GHG savings of 158 Mt CO_2.

Figure 29: Macroeconomic GHG savings by 2045 by threshold value and sector

GHG savings by 2045 in ktCo2

		Threshold value in GWh: Total										
		0	1	3	5	10	14	28	50	100	250	1.000
Sector cluster	Total	185.735	177.313	172.905	167.770	158.230	152.639	140.030	129.076	115.924	96.659	71.314
	E1, E2 & E3	100.761	99.535	97.769	96.198	93.605	92.028	88.026	84.028	78.591	69.930	53.951
	E2 & E3	89.511	88.848	87.723	86.682	84.937	83.789	80.836	77.830	73.324	66.158	51.119
	E3	56.326	55.878	55.093	54.396	53.266	52.512	50.741	49.001	46.538	42.840	32.924
	GHD	63.796	57.745	55.645	52.740	47.043	43.764	36.797	31.243	25.179	16.966	10.378
	E2	33.167	32.952	32.613	32.268	31.654	31.260	30.079	28.813	26.771	23.305	18.184
	E1	11.247	10.684	10.042	9.513	8.666	8.236	7.187	6.196	5.265	3.770	2.832

Source: Original graphic

Overall, the analysis shows that the increased implementation and operation of EnM systems in German industry can result in extensive financial and environmental benefits.

8 Conclusion and recommended actions

This chapter addresses the following questions from the research brief:

What savings (energy, CO2 emissions and costs) are made? How does implementation evolve over time? Which proposed measures are not implemented? Why are they not implemented?

What levels of savings are achieved at company level by sector, business size and energy intensity when EnM systems are implemented?

What savings (energy, CO2) can be expected in the short, medium and long term as a function of the spread of EnM systems in Germany? What level of EnM system penetration is economically viable and what is the potential for the spread of EnM systems in Germany? Appropriate scenarios should be selected for illustration purposes.

To what extent would the introduction of a mandatory ISO 50001-compliant EnM regime for companies with an annual energy consumption of 100 TJ influence the spread and so the impact of ISO 50001-compliant systems?

Is ISO 50001 as an instrument for increasing energy efficiency in competition with other tools?

8.1 Summary benefits and costs of an EnM system

This section summarises the potential that ISO 50001 offers to companies. The results of the study show that **reducing both energy consumption and emissions is very important** for many companies operating an ISO 50001, and that both act as drivers for the use of an EnM system. An active EnM system plays a decisive role in achieving their objectives. Table 6 shows the level of first-year savings potential for companies with average energy consumption for their sector operating an ISO 50001-compatible system based on the survey results. Companies with medium and high energy intensity (E2 and E3), in particular, benefit from the implementation of an EnM system, with potential savings of approx. 125 to 179 MWh in the first year. In GHG equivalents, this corresponds to approx. 46 t for medium-energy-intensity businesses and 32 t for high-energy-intensity businesses.

Table 6: Average company savings potential by energy intensity

	E1 (low EI)	E2 (medium EI)	E3 (high EI)	Tertiary
Energy savings per company in GHG equivalents	29,3	178,8	124,9	4,9
Energy savings per company in GHG equivalents	7,6	46,2	32,3	1,3

Source: Original graphic

In terms of business size, the study findings show that **the larger the business, the more costly** the operation of an ISO 50001-compliant system, but also that the **higher its energy consumption, the greater the absolute savings potential** the system offers. Most of the surveyed businesses attribute their savings potential to investments, which represent between 40% and 80% of their savings. The study also reveals that the level of increase in energy efficiency remains more or less constant even if the issue is addressed over a long period. An initial investment with higher implementation costs therefore pays off. Alongside the necessary investment, organisational issues also appear to be an important prerequisite for the successful implementation of an ISO 50001-compliant system.

The expert interviews also suggest that **rebound effects are very small** and can be easily offset by appropriate staff training. The holistic approach of an ISO 50001-compliant system that incorporates all of a company's processes and staff compares favourably with the one-off analyses characteristic of similar EnM systems and non-systematic approaches. Ultimately, this is a key factor in implementing a successful ISO 50001 strategy. Most energy savings can be achieved if everyone from senior management to technical and commercial employees are involved and drive the issue of energy efficiency forward. The survey underlines the fact that an intensive commitment to energy efficiency increases the success with which concrete measures can be implemented. Another factor is the continuous development of monitoring and control measures provided for in ISO 50001, which increases transparency.

Positive effects of an ISO 50001-compliant system for companies

- Increase in energy efficiency
- Reduction in energy consumption and emissions
- Increased implementation of efficiency measures
- Basis for a long-term, sustainable energy purchasing strategy
- Option of using tax/levy relief (e.g. under EEG, BEHG)G
- Greater awareness at all levels and savings with few countereffects (rebound)

The decision-making process leading to the implementation of an ISO 50001 system should involve the consideration of **cost factors**, in particular those relating to the setting up and operation of the system, as well as its positive effects. The companies surveyed in this study were asked to estimate their initial and ongoing costs. Implementation costs were on average EUR 27,600 internally and EUR 30,400 externally. On average, the companies estimated their annual operating costs at EUR 26,800 for internal and EUR 17,500 for external costs. The audit costs reported by the companies were on average EUR 8,900 (rounded values).

The issue of **time and resources** represents a further challenge. Not all business have a dedicated department or designated member of staff to operate an ISO 50001-compliant system in-house. Building up the skills required for the initial set-up (in the form of knowledge and expertise in the relevant post/department) can prove to be the first hurdle. Keeping this knowledge up do date can also generate further costs.

The staff responsible for the ISO 50001-compliant system cite the availability of resources, expertise, support, motivation and the delegation of duties by management as major challenges. It is, however, precisely these factors that offer major potential for systematic and continuous improvement. This is also shown by the quantitative analysis of the relevant drivers in Section 5.8.

In addition, the complexity of ISO 50001 presents challenges, in particular for SMEs. Although awareness of energy efficiency measures is growing and the economic advantages of an ISO 50001-compliant system are known, it may prove impossible for smaller companies with energy consumption below 10 GWh, in particular, to refinance such a system directly from energy savings. The implementation of an ISO 50001-compliant system may fail in small- and medium-sized businesses due to a lack of staff and financial resources (cf. section on the PAE tool, interviews).

The challenges of operating an ISO 50001-compliant system

- Implementation costs
- Personnel resources and skills building
- Involvement of management, lack of information and internal communication
- Profitability tends to be dependent on business size

Finally, it should be noted that the proactive use of the knowledge obtained from ISO 50001 handling (planning and implementation of measures) represents another important area of activity in a company and enables expertise gained to flow into the **implementation of concrete savings measures**. The implementation and operation of an ISO50001-compliant EnM system can generally be seen as effective. However, the scale of the specific benefit to any given company depends on the sector in which it is operating, the size of the business and other company-specific factors.

8.2 Recommended actions

This section uses the key findings of the study to propose recommended actions designed to broaden the distribution of systematic EnM approaches and optimise their use.

It has been shown that companies would continue to operate their EnM systems even in the absence of government regulation. This suggests that a mandatory EnM **implementation** regime would represent a reasonable measure for ensuring that companies benefit from such systems. The fact that energy efficiency potential remains almost constant (although varying from sector to sector), even when a company continues to address the issue over a long period, appears to confirm the estimated long-term benefits of such systems.

In the future it will be possible to use these findings to set sector-specific energy consumption threshold values, depending on expected variations in energy costs, from which the implementation of an EnM system is guaranteed to provide savings in terms of both energy consumption and cost reductions. This takes both implementation and operating costs into account. The comparison of systematic approaches (ISO 50001 or EMAS) and other approaches such as the performance of energy audits, for example, shows that continuous attention to energy and savings potential is advantageous for companies above a certain threshold value (which changes from sector to sector). We can draw a number of lessons from this fact.

Firstly, it would appear that there is no business argument for the **implementation of a mandatory energy management regime** for all companies, particularly for those **with low consumption**, even if it increased potential for reducing consumption. This is primarily due to the comparatively high implementation and operating costs of such systems. **Neither does it appear to be expedient in macroeconomic terms** because of the cost-benefit argument and the high administrative costs involved. This thesis is supported by the structure of companies in Germany. Of its approx. 3.4 million businesses, some 2.9 million employ fewer than 10 members of staff. By contrast, there are only 314 companies in Germany with more than 5,000 employees.

Secondly, it should be noted that, depending on the sector, the introduction of a threshold value of between 2.8 and 50 GWh for the implementation of EnM systems promises macroeconomic effects. When determining potential **threshold values**, however, both the **sector and the associated potential savings need to be taken into account**. In percentage terms, the tertiary sector offers the greatest potential. This is because investment is particularly focussed on measures in the fields of lighting, ICT, space heating and crossover technologies, which have considerably lower consumption than measures relating to process heat for industry, for example. However, the energy consumption of an average company or per employee is considerably lower than in industry. It is, therefore, clear that the **cost** of implementation **is aligned closely to business size** and, to a lesser extent, energy consumption, and that a higher threshold value in the tertiary sector might, generally speaking, make sense from both a macroeconomic and a business point of view.

Thirdly, **rising energy prices** are a further significant factor influencing the optimum threshold value in the new AAE tool. The higher a company's energy costs, the more quickly it will be able to recoup the initial costs of implementing and operating an EnM system. As a result, when rising energy prices (in particular fuel prices) are expected, a lower threshold value would generally appear advantageous from an economic and business point of view. The results matrices shown in Section 8 support this thesis.

Finally, the AAE tool can be used to determine potential CO_2 savings as well as potential energy savings. Imposing a mandatory regime on all businesses with an energy consumption of more than 10 GWh will mean CO_2 savings of approx. 158 megatons over the next 23 years. With regard to the design of a possible mandatory regime, the AAE tool is able to provide an indicative estimate of the potential effect of the implementation of ISO 50001 systems.

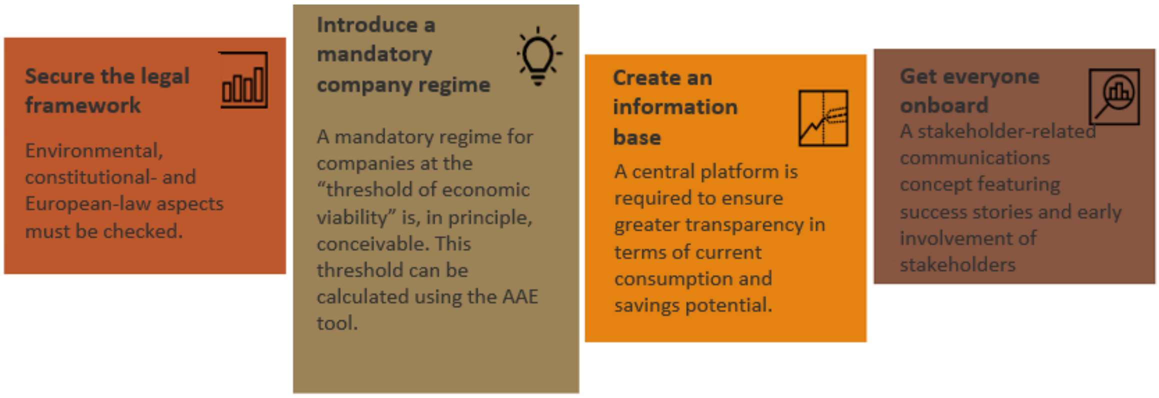
On the basis of the study findings, a more in-depth analysis of the mandatory extension of ISO 50001-compatible system would appear useful since the **implementation of EnM systems has been shown to be worthwhile**. The associated profitability is influenced by internal factors such as energy intensity and business size, and by external factors such as current developments in energy and CO_2 prices.

The widespread introduction and implementation of an ISO 5000-compliant system can make a **significant contribution to achieving climate goals** while also permitting companies to reduce their individual energy costs going forward. The necessary investment will additionally create business incentives for technology providers, tradesmen and solutions providers.

In addition to economic factors, we also recommend the **early examination of the environmental, constitutional and European law aspects** of a mandatory regime in terms of its legal feasibility. It would also be useful to involve the stakeholders (e.g. trade and industry associations, certifying organisations) at an early stage. This could be supported by a stakeholder-oriented communications strategy on EnM systems involving the publication of 'success stories', for example. The **phased-in introduction of such a mandatory regime** might also be considered in order to avoid overburdening companies 'at the threshold of economic viability' too early.

We recommend setting up a central platform for information, data collection and verification (certificates, feasibility studies under DIN EN 17643 (ValERI), proof of implementation, etc.) to further support this line of argument and to minimise administrative costs. The BAFA databases available until now – ELAN-K2 for the Special Equalisation Scheme and OREA for energy audit measures – could serve as a basis or model for such a platform.

Figure 230: The route to large-scale EnM system implementation



Source: Original graphic

9 Bibliography

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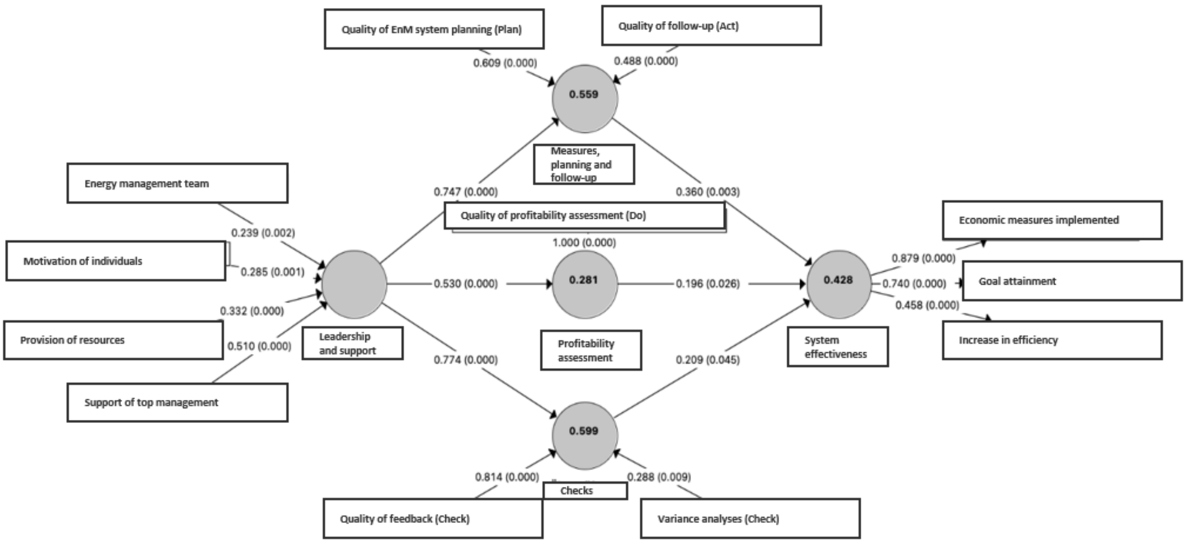
10 Appendices

Appendix 1: Structural equation model

Figure 31: Structural equation model for determining the effect of individual ISO 50001 components



The values on the arrows between the constructs marked in grey indicate the standardised effects. In the brackets between the elements are the p-values of the coefficients generated using bootstrapping with 5,000 subsamples. The values on the arrows running to and from the circular grey constructs show the loading and weighting values of the individual indicators in relation to the relevant construct. The p-values obtained from the bootstrapping are also given in these brackets.

Quality of EnM system planning (Plan)

Quality of follow-up (Act)

Measures, planning and follow-up

Energy management team

Motivation of individuals

Provision of resources

Appendix 2: Structured questionnaire

A Study of the Impact of Energy Management Systems

Introduction

The German Federal Agency for Energy Efficiency (*Bundesstelle für Energieeffizienz, BFEE*), part of the German Federal Office for Economic Affairs and Export Control (*Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA*), commissioned a consortium comprising PricewaterhouseCoopers GmbH WPG (PwC), Arqum GmbH and Dr Nathanael Harfst to carry out a study of the impact of energy management systems.

As part of this study we are surveying a number of companies on their use of energy management systems. We need your input to help us better evaluate the impact and advantages of the various approaches to improving energy efficiency. We would be delighted if you were prepared to complete our questionnaire on your energy consumption and costs and provide some information about the efficiency measures you are implementing.

It will take only 15 minutes of your time.

To say thank you, we will send you an exclusive report on the findings of the study and a voucher entitling you or another member of staff to attend a free 2-hour workshop on “Business transition to climate neutrality: a range of systems for improving energy efficiency”.

If you have selected the “Turn on cookies ” function in your browser you will be able to pause the survey at any time and then continue it at a later stage.

Your data will be collected and analysed anonymously and cannot be linked to your company. If you have any questions, please do not hesitate to contact us. If you would like further information about the content or technical aspects of the survey or the study, please contact Josephine Neuhaus at PwC (josephine.neuhaus@pwc.com) or the project manager at the German Federal Office for Economic Affairs and Export Control, Martina Erler (martina.erler@bafa.bund.de).

The German Federal Agency for Energy Efficiency would like you to thank you for your support.

Part 1

The questionnaire starts with a few general questions about your company and the energy efficiency improvement systems it uses.

N.B. This questionnaire relates to your company's sites in Germany.

Question 1

In your company, who has primary responsibility for energy efficiency and energy savings?

NB: Please do not include personal information about yourself or others.

Managing director / Owner / Board (1)

A named officer / a team (e.g. energy manager or energy team) (2)

Accounts or controlling department (3)

Another business department (e.g. purchasing, accounts, controlling) (4)

A technical department (e.g. maintenance, production) (5)

Contractor (6)

Cross-company function (7)

Other, i.e.: (8)

No one (9)

Don't know / No data provided (10)

Question 2

What economic sector does your company belong to?

Agriculture, forestry and fisheries (sectors 01-03) (1)

Mining, extraction and quarrying (sectors 05-09) (2)

Manufacture of food products, beverages and tobacco products (sectors 10-12) (3)

Manufacture of textiles, clothing, leather, leather and related products (sectors 13-15) (4)

Manufacture of wood and wood products, paper and paper products and printed materials (sectors 16-18) (5)

Manufacture of coke and refined petroleum products (sector 19) (6)

Manufacture of chemical products (sector 20) (7)

Manufacture of pharmaceutical products (sector 21) (8)

Manufacture of rubber and plastic products, glass and glass products, ceramics, processing of quarried materials (sectors 22, 23) (9)

Metal production and processing, manufacture of metal products (sectors 24, 25) (10)

Manufacture of computer, electronic and optical products (sector 26) (11)

Manufacture of electrical equipment (sector 27) (12)

Manufacture of machinery and equipment (sector 28) (13)

Manufacture of motor vehicles and other transport equipment (sectors 29, 30) (14)

Other manufacturing, repair and installation of machinery and equipment (sectors 31 - 33) (15)

Electricity, gas, steam and air conditioning supply (sector 35) (16)

Water supply; sewerage, waste management and remediation activities (sectors 36-39) (17)

Other sector (sectors 41-99) (18)

Don’t know / No data provided (19)

Question 3

How many people does your company currently employ?

Fewer than 10 (1)

10-49 (2)

50- 249 (3)

250-499 (4)

500-999 (5)

-1999 (6)

2000-4999 (7)

5,000 or more (8)

Don’t know / No data provided (9)

Question 4

What was your turnover in 2021?

Less than EUR 2 million (1)

EUR 2-9 million (2)

EUR 10-49 million (3)

EUR 50-99 million (4)

EUR 100-249 million (5)

EUR 250-499 million (6)

EUR 500-999 million (7)

More than EUR 1,000 million (8)

Don’t know / No data provided (9)

Question 5

Does your company own or lease/rent the buildings it operates?

Predominantly owns (1)

Predominantly leases/rents (2)

Question 6

What was your total energy consumption in 2021? (MWh)

Electricity (1) ____

Gas (2) ____

District heat (3) ____

Fuel oil (4) ____

Diesel (5) ____

Petrol (6) ____

Biomass (7) ____

Other (8) ____

Don’t know / No data provided (9)

Question 6a

What was your estimated energy savings potential in 2021? Please indicate your savings potential either in MWh (box 1) or as a percentage (box 2), as you prefer.

Savings potential in MWh: (1)

Savings potential as a percentage: (2)

Don’t know / No data provided (3)

Question 7

Which energy efficiency improvement system is your company currently using?

ISO 50001-compliant energy management system (1)

SpaEfV "alternative system" (2)

EMAS (Eco-Management and Audit Scheme) system (3)

DIN 16247-1-compliant energy audit (German Energy Services Law, *EDL-G*) (4)

Other (e.g. energy consultancy), i.e.: (6) ______________________

None of the systems listed above (7)

Question 7a

In what year was your ISO 50001-compliant energy management system first certified?

Before 2011 (1) … 2022 (13)

Question 7b

In what year was your SpaEfV alternative system first tested?

Before 2011 (1) … 2022 (13)

Question 7c

In what year was your EMAS (Eco-Management and Audit Scheme) system first validated?

Before 2011 (1) … 2022 (13)

Question 7c

In what year was your first DIN 16247-1-compliant energy audit carried out?

Before 2011 (1) … 2022 (13)

Question 8

Does your company operate other or additional ISO-compliant management system?

ISO 9001 Quality management (1)

ISO 14001 Environmental management (2)

ISO 27001 Information security management (3)

ISO 45001 Occupational health and safety management (6)

Other, i.e.: (4) ______________________

Don’t know / No data provided (5)

Question 9

For how long have your company’s sites in Germany been addressing energy efficiency (in a targeted manner)? How long is it since your company designated an energy efficiency officer or retained an energy consultancy firm, for example?

Fewer than 5 years (1)

5 to 9 years (2)

10 to 14 years (3)

15 to 19 years (4)

At least 20 years (5)

Don’t know / No data provided (6)

Question 10

What motivated your company to implement and operate a system for improving energy efficiency?

Identifying energy savings / Reducing energy costs (1)

Controlling energy consumption and energy costs (2)

Climate and environmental protection (3)

Taking advantage of special compensation regime, i.e. reduced German Federal Renewable Energies Law (EEG) levy (4)

Obtaining tax relief: “peak balancing” for electricity tax or energy tax (5)

Reducing CO_2 emissions (e.g. German Carbon Leakage Regulations) (6)

Mandatory energy audit under the German Federal Energy Services Law (EDL-G) (7)

Customer/supplier requirements (8)

Other, i.e.: (9) _________________________

Don’t know / No data provided (10)

Question 10a

Would your company continue to operate its energy efficiency improvement system even if the regulations listed mentioned (e.g. German Federal Renewable Energies Law levy, electricity tax, mandatory energy audit under the German Federal Energy Services Law) did not apply?

No (1)

Probably not (2)

Possibly (3)

Probably (4)

Yes (5)

Don’t know / No data provided (6)

Part 2

These questions look at the increases in efficiency that your company has been able to achieve in recent years and the energy efficiency measures that it has implemented.

Question 11

Is your company targeting predominantly energy savings (i.e. MWh) or CO_2 reduction with its energy management system?

Energy savings (1)

CO_2 reduction (2)

Both (3)

Don’t know / No data provided (4)

Question 12

On average, to what extent has your company been able to increase its energy efficiency in the last two years?

Less than 2% (1)

2% to 4% (2)

4% to 6% (3)

6% to 8% (4)

8% to 10% (5)

10% to 12% (6)

12% to 14% (7)

More than 14% (8)

Don’t know / No data provided (9)

Question 13

How much energy in MWh has your company saved thanks to efficiency efforts in the last two years?

____

Question 14

In general terms, what percentage of your energy efficiency improvements can be attributed to investments rather than behaviour-related measures?

Less than 20% (1)

20% to 40% (2)

40% to 60% (3)

60% to 80% (4)

More than 80% (5)

Don’t know / No data provided (6)

Question 15

How would you estimate the economically viable energy savings potential in your company over the next five years?

Less than 5% (1)

5% to 10% (2)

10% to 15% (3)

15% to 20% (4)

20% to 25% (5)

25% to 30% (6)

More than 30% (7)

Don’t know / No data provided (8)

Question 16

With regard to your company, do you agree or disagree with the following statements?

Our company has reached its energy efficiency targets in the last two years. (1)

Our company has carried out the economic energy efficiency measures that it was aware of (e.g. from audit reports) in the last two years. (2)

Strongly disagree (1)

(2)

(3)

(4)

Strongly agree (5)

Don’t know (6)

Question 17

In what areas has your company carried out measures as part of its energy efficiency improvement system in the last two years?

Efficient lighting (1)

Electric drive units such as motors and pumps (2)

Efficient production plant (3)

Waste heat utilisation, i.e. heat recovery (4)

Heat generation, e.g. steam, hot water, heating, warm water (5)

Building envelope, e.g. insulation (6)

Efficient ventilation and air conditioning (7)

Demand management, e.g. load management, storage (8)

Efficiency refrigeration (9)

Renewable energies (10)

Other investments in energy efficiency measures (11)

Combined heat and power generation (12)

Energy services (e.g. contracting) (13)

Information and communication technology (14)

Organisational measures (15)

Transport (16)

Energy controlling (transparency) (17)

None of these areas (18)

Don’t know / No data provided (19)

Question 18

How many euros has your company invested in energy-related measures in the last two years?

Question 19

Have you noticed any counter effects in the same or different places as a result of the measures implemented (e.g. additional energy consumption) due to behavioural changes? Example: switching lights off less frequently due to the use of LEDs.

Yes (1)

Yes, some (3)

Not really (4)

No (2)

Question 19a

You have indicated that you noticed counter effects (e.g. additional energy consumption) as a result of changes in behaviour when measures were implemented. Can you give us an example of this?

____

Question 19b

Does this change in behaviour completely or partially offset the saving?

Yes, completely (1)

Yes, partially (2)

No, it doesn't offset the saving (3)

Don't know / No data provided (4)

Question 19c

You have indicated that energy savings in your company were full or partially offset by a change in behaviour. What does your company estimate to be the percentage energy saving remaining?

Less than 25% (1)

26% - 50% (2)

51% - 75% (3)

76% - 100% (4)

Part 3

The third section of our questionnaire deals with the evaluation of individual components of energy management systems and looks at the costs associated with energy management systems.

Question 20

How would you rate the following statements in relation to your company?

In our company

the quality of energy management system-related planning (e.g. setting targets and measures) (1)

the quality of feedback from top management (e.g. as part of the management review system) (2)

the quality of follow-up in relation to corrective measures (3)

the motivation of individuals to identify and implement energy-related measures (4)

is

1 – very low (1)

2

3

4

5 – very high (5)

Don't know / No data provided (6)

Question 21

How would you rate the following statements in relation to your company?

In our company

top management gives its full support to energy-related efforts. (1)

regular variance analyses of key performance indicators are carried out and variations are acted on.(2)

energy performance indicators are standardised based on relevant influencing factors (e.g. tonnes produced, external temperature, etc). (3)

an energy management team works actively to achieve energy-related goals. (4)

the profitability of energy related measures is evaluated over its entire life cycle (e.g. using net present value rather than amortisation period). (5)

the energy management system is integrated into existing company processes, e.g. controlling. (6)

energy management system data is used to make CO_2 assessments. (7)

comprehensive personnel and financial resources are available for operating the energy management system and implementing measures. (8)

1- Does not apply at all (1)

2

3

4

5 – Applies fully (5)

Don't know / No data provided (6)

Question 22

What would you estimate were the **internal** costs of **<u>implementing</u>** the energy management system operating in your company (e.g. personnel costs)?

Less than EUR 5,000 (1)

EUR 5,000 to EUR 10,000 (2)

EUR 10,000 to EUR 15,000 (3)

EUR 15,000 to EUR 20,000 (4)

EUR 20,000 to EUR 25,000 (5)

EUR 25,000 to EUR 30,000 (6)

EUR 30,000 to EUR 35,000 (7)

EUR 35,000 to EUR 40,000 (8)

More than EUR 40,000 (9)

Don’t known / No data provided (10)

Question 23

What would you estimate were the approximate **external** costs (e.g. consultants, IT hardware and software) of **<u>implementing</u>** the energy management system operating in your company?

Less than EUR 2,000 Euro (1)

EUR 2,000 – EUR 5,000 (2)

EUR 5,000 to EUR 10,000 (2)

EUR 10,000 to EUR 15,000 (3)

EUR 15,000 to EUR 20,000 (4)

EUR 20,000 to EUR 25,000 (5)

EUR 25,000 to EUR 50,000 (6)

More than EUR 50,000 (7)

Don’t know / No data provided (8)

Question 24

What would you estimate were the **annual internal** costs of **<u>operating</u>** the energy management system (e.g. personnel and IT hardware and software) implemented in your company?

Less than EUR 5,000 (1)

EUR 5,000 - EUR 10,000 (2)

EUR 10,000 to EUR 15,000 (3)

EUR 15,000 to EUR 20,000 (4)

EUR 20,000 to EUR 25,000 (5)

EUR 25,000 to EUR 30,000 (6)

EUR 30,000 to EUR 35,000 (7)

EUR 35,000 to EUR 40,000 (8)

More than EUR 40,000 (9)

Don’t know / No data provided (10)

Question 25

What would you estimate were the annual external costs (e.g. consultancy, IT hardware and software) associated with the energy management system operating in your company?

Less than EUR 2,000 (1)

EUR 2,000 – EUR 5,000 (2)

EUR 5,000 to EUR 10,000 (2)

EUR 10,000 to EUR 15,000 (3)

EUR 15,000 to EUR 20,000 (4)

EUR 20,000 to EUR 25,000 (5)

EUR 25,000 to EUR 50,000 (6)

More than EUR 50,000 (7)

Don’t know / No data provided (8)

Question 26

What would you estimate were the **annual audit** costs (certification and monitoring audits) for the energy management system operating in your company?

Less than EUR 2,000 (1)

EUR 2,000 – EUR 4,000 (2)

EUR 4,000 to EUR 6,000 (3)

EUR 6,000 to EUR 8,000 (4)

EUR 8,000 to EUR 10,000 (5)

EUR 10,000 to EUR 12,000 (6)

EUR 12,000 to EUR 14,000 (7)

EUR 14,000 to EUR 16,000 (8)

EUR 16,000 to EUR 18,000 (9)

More than EUR 18,000 (10)

Don’t know / No data provided (11)

Question 27

Why did your company decide not to implement and certify an ISO 50001-compliant energy management system?

Question 27a

Under what circumstances would your company implement an energy efficiency improvement system?

CO_2 price of: (1)

Energy cost increase of: (2)

Increased energy consumption (3)

Integration and certification capability of climate management in ISO 50001 (4)

Question 28

How does your company evaluate the effectiveness of its energy efficiency improvement system?

1 – Very low (19)

2

3

4

5 – Very high (5)

Don’t know / No data provided (6)

Question 29

Would your company be interested in receiving an exclusive report on the findings of the study and a voucher for a free 2-hour workshop?

Yes / No

Question 29a

“I hereby consent to PwC PricewaterhouseCoopers GmbH of Friedrich- Ebert-Anlage 35-37, 60327 Frankfurt am Main (PwC) using my personal data (company name, first name, surname, email address) to email me an exclusive report on the findings of the study and a voucher for a free 2-hour workshop once the survey has been carried out and the results have been evaluated.

Right of revocation – I may revoke my consent in full or in part with effect for the future at any time as against PwC without incurring any costs other than standard transmission costs at basic rates. I may revoke my consent simply by sending an email to josephine.neuhaus@pwc.com or writing to PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft, for the attention of Ms Josephine Neuhaus, Moskauer Str. 19, 40227 Düsseldorf, Germany. Such revocation will not affect the lawfulness of the processing of my personal data between the time of giving and revoking my consent. I am giving consent freely. I will suffer no adverse consequences as a result either of my refusal to give consent or my subsequent revocation of consent. If I do not revoke my consent it will apply for an unlimited period. This informed consent statement applies together with the associated data protection notice, which contains information on Articles 13 and 14 of the General Data Protection Regulation."

Company name (1)

First name (2)

Surname (3)

Email address (4)

End

You have now reached the end of the survey. Thank you for taking part! Do you have any final questions or comments about the survey?

NB: NB: Please do not include personal information about yourself or others.

Appendix 3: Addressed research questions

1. Which companies decide to implement and/or certify EnM systems? What is the role played by incentive/mandatory systems such as the Special Equalisation Scheme (BesAR), peak balancing and mandatory audits? Answers should be differentiated according to business size, energy intensity, economic sector, EnM

system duration (short vs. long) and motivation (voluntary, mandatory, prerequisite for obtaining certain advantages).

2. What are the barriers to certification?
3. Does the use of an EnM system increase the likelihood of energy efficiency measures being implemented? If so, which components of the EnM system play a key part in increasing this likelihood? What measures are implemented and on what scale? What are the barriers to implementing measures? What savings (energy, CO_2 emissions, costs) are made? How does implementation evolve over time? Which proposed measures are not implemented? Why are they not implemented?
4. What levels of savings are achieved at company level by sector, business size and energy intensity when EnM systems are implemented? What internal costs are incurred in operating an EnM system? How high are the costs of external services (certification, re-certification, review audits)?
5. What savings (energy, CO_2) can be expected in the short, medium and long term as a function of the spread of EnM systems in Germany? What level of EnM system penetration is economically viable and what is the potential for the spread of EnM systems in Germany?
6. Do rebound effects play a significant role? For instance, does additional energy consumption occur in the same or different areas due to changes in behaviour brought about by the measures implemented, thereby offsetting the resulting energy savings?
7. Are there any spill-over effects? For instance, are there energy and cost savings that cannot be directly attributed to a measure but are achieved due to a radiating effect inside and outside the company? E.g. word-of-mouth recommendations, greater awareness of energy efficiency. Are there other economic effects above and beyond the savings, and how are they gauged? Example: increased productivity, better access to capital market, image and advertising?
8. To what extent would the introduction of a mandatory EnM regime for companies with an annual energy consumption of over 100 TJ influence the spread and so the impact of EnM systems?
9. Are EnM systems, as instruments for increasing energy efficiency, in competition with other tools?

Appendix 4: Determining quantitative impact using the AAE tool

The AAE tool calculates the long-term energy, cost and CO_2 savings achieved by companies that exceed the set threshold value using the inputs and data listed in Section 7.1.3. The example below provides a detailed outline of the calculation flow of the various inputs, information bases and the resulting outputs generated by the tool (see Figure 32).

Figure 24: AAE tool outputs

Options		
Threshold value (GWh)		10,00
Sector cluster	**Tertiary**	
EnM system	ISO 50001	
Input options	**Tertiary**	**Industrial**
Percentage reduction in energy consumption reduction due to efficiency gains	100,00%	50,00%
Input options	**Electricity**	**Fuels**
Basic costs (ct./kWh) (values must be above 0!)	18,0	12,0
Cost growth (%/a) (values must be over -100%!)	2,0%	3,0%
CO2 equivalents (tCO2/GWh)	366	224

Source: Original graphic

1) **Companies and their energy consumption by selected threshold value, EnM system and sector cluster (see example outputs)**
    a) Number of firms with an energy consumption higher than the threshold value, the energy consumption of these companies and the energy consumption of all companies in the selected sector cluster
    b) Number of companies with ISO 50001 certification and energy consumption of certified firms covered

Figure 33: First AAE tool outputs – Number of companies and their energy consumption

Outputs	**Absolut**	**Prozentual**
How many companies have an energy consumption higher than the threshold value?	4.968	0,2%
What is the energy consumption of these companies (GWh)?	260.637	73,7%
What is the total energy consumption observed (GWh)?	353.454	100,0%
How many of the companies above are already ISO 50001 certified?	1.225	24,66%
What level of energy consumption do the certified companies account for?	63.869	24,50%

Source: Original graphic

2) **Determination of energy savings over a 23-year horizon** (first five years only shown due to space restrictions) according to 1) company and user inputs on percentage energy consumption reduction due to efficiency gains for the tertiary and industrial sectors and basic electricity and fuel costs, cost growth and CO2 equivalents
   a) Possible savings potential by EnM system, sector cluster (and where more than one cluster has been selected, e.g., ‘Total’, by threshold value)
      i) Data source: survey data
      ii) Calculation: for multiple sector cluster selections (e.g. ‘Total’), using the total energy consumption above the threshold value per sector cluster weighted averages
   b) Total energy savings for electricity and fuels
      i) Data source: distribution of consumption by sector input according to ISI review
      ii) Calculation 1: regression in energy consumption of the businesses studied using weighted percentages of tertiary and industrial sectors and associated energy consumption reduction due to efficiency gain factors
      iii) Calculation 2: product of regressed energy consumption of companies studied, possible savings potential and percentage consumption per energy type
   c) Cost savings potential for electricity and fuels using electricity and fuel savings
      i) Calculation: product of savings, price and annual price growth rates by energy source
   d) Cumulative savings and cumulative savings broken down according to newly implemented and existing systems
      i) Calculation: Cumulation of cost savings for electricity and fuels; distribution of these cost savings using the percentage energy consumptions of already certified businesses per company

Figure 34: Potential energy savings in the first five years

Impact on energy savings	Year 1	Year	Year 3	Year 4	Year 5
Potential savings potential of energy consumption observed (%/a)	4,33%	4,33%	4,33%	4,33%	4,33%
Total energy savings – Electricity (GWh/a)	4.650	4.448	4.255	4.071	3.895
Total energy savings – Fuels (GWh/a)	6.645	6.357	6.081	5.818	5.566
Savings potential – Electricity (EURm/a)	854	833	813	793	774
Savings potential – Fuels (EURm/a)	821	809	797	786	774
Cumulative savings (€m)	1.675	3.317	4.927	6.506	8.055
Cumulative savings: newly implemented systems (€m)	1.264	2.504	3.720	4.912	6.081
Cumulative savings: existing systems (€m)	410	813	1.207	1.594	1.974

Source: Original graphic

3) **Cost analysis of an EnM system over a 23-year horizon (first five years illustrated) based on 1) the business studied, and 2) energy savings**
   a) One-off implementation costs for EnM systems and selected sector
      i) Data source: survey data, assumed costs of EMAS and ‘non-structured or no systems’

ii) Calculation: product of the number of non-certified companies studied and sector- and EnM system-specific implementation costs

b) Operating costs by EnM system and selected sector

i) Data source: survey data, assumed costs of EMAS and 'non-structured or no systems'

ii) Calculation: product of the number of certified companies studied and sector- and EnM system-specific operating costs

c) Investment costs by EnM system and selected sector

i) Data source: survey data, assumption of 35% investment cost in savings

ii) Calculation: product of total savings potential, percentage of investment measures and assumed percentage of investment costs in savings

d) Cumulative costs, cumulative costs of newly implemented systems

i) Calculation: cumulation of all costs; cumulation of costs in respect of the operation and implementation of new systems using the percentage distribution of already certified companies and their energy consumption

e) Cost/savings balance and cost/savings balance specifically for new implementations / newly implemented EnM systems

i) Calculation: difference between cumulative costs and cumulative savings; difference between cumulative costs and cumulative savings for new systems only

f) Comparison with threshold value above

i) Calculation: difference between cost/savings balance for selected threshold value and cost/savings balance for one threshold value

Figure 35: Cost analysis of an ISO0001-compliant system for the next five years

Cost analysis	Jahr 1	Year 2	Year 3	Year 4	Year 5
Implementation costs (€m)	284				
Operating costs (€m/a)	107	436	436	436	436
Investment costs	387	379	372	365	358
Cumulative costs (€m)	779	1.594	2.402	3.203	3.996
Cumulative costs (€m) – newly implemented systems only	577	1.191	1.801	2.404	3.003
Cost/savings balance (€m)	896	1.723	2.525	3.304	4.058
Cost/savings balance – newly implemented systems only (€m)	688	1.313	1.919	2.508	3.078

Source: Original graphic

4) Environmental improvement due to energy savings and selected CO_2 equivalence values

a) CO_2 savings for electricity and fuels

i) Calculation path: products of total energy savings and CO_2 equivalence values by energy source

b) Cumulative sum

i) Calculation path: cumulated sum of total CO_2 savings

Figure 36: Environmental improvement due to energy savings

Environmental improvements	Year 1	Year 2	Year 3	Year 4	Year 5
CO2 savings – electricity ktCO2	1.702	1.628	1.557	1.490	1.425
CO2 savings – fuels ktCO2	1.488	1.424	1.362	1.303	1.247
Cumulative total	3.190	6.242	9.162	11.955	14.627

Source: Original graphic