# Comparison of International and European Standards in the Field of Energy Management

CARINA BEERMANN

Faculty of electrical engineering and communication (FEEC)

Brno University of Technology

Antonínská 548/1, 601 90 Brno-střed
CZECH REPUBLIC

*Abstract:* The European Union (EU) has set ambitious targets to increase energy efficiency by 32.5 % by 2030 compared to a development without further efficiency efforts [1]. According to the EU, sustainable efficiency improvements can be achieved, among other things, through mandatory energy audits and management systems in the companies concerned. Today, a large part of society is dependent on resources such as electricity, gas, oil and water. Without these resources, daily life would be unimaginable, but awareness is needed. It is important that we humans use resources responsibly. For everyday life, suggestions and legal regulations have been created for dealing with the scarcity of resources and sustainability. In industry, too, guidelines and laws regulate the use of resources such as electrical energy. However, these regulations do not only apply in Germany, but - usually initiated by the European Union (EU) - for all member states of the EU. Do the companies concerned only have the choice between an energy audit and an energy management system or can sustainable synergy effects be achieved by linking them with other management systems?

*Key-Words:* Energy, Energy Management, Economics, Sustainability

## 1 Introduction

The European Union has committed itself to climate and energy policy goals in accordance with the Framework Convention on Climate Change and various decisions of its own.

Within the framework of the Climate and Energy Pact, the interim target for energy efficiency for the year 2030 is an increase in energy efficiency of 32.5% compared to a development without further efficiency efforts [2]. To achieve this goal, Directive (EU) 2012/27 of the European Parliament and of the Council of 25 October 2012 [1] and Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 [3] were adopted. The EU sees one way - among others - to increase energy efficiency in the introduction of energy audits and energy management systems. This applies primarily to companies that are not SMEs (small and medium-sized enterprises).

However, the EU recommends that the Member States also create programmes for SMEs in order to ensure that SMEs also undergo energy audits and implement the recommendations of these audits.

For companies that are not SMEs, the Member States shall ensure that these companies are subject to a mandatory energy audit or introduce an energy management system - ISO EN DIN 50001 - or an environmental management system - ISO EN DIN 14001 or EMAS - certified according to the relevant European or international standards [4].

Therefore, this paper will examine the differences between an energy audit according to EN DIN 16247-1 and an energy management system according to ISO EN DIN 50001, which advantages arise for SMEs as well as for non-SMEs and to what extent synergy effects can be achieved by linking with the environmental management system ISI EN DIN 140001 and EMAS (Eco Management and Audit Scheme).

The transformation into national law remains unconsidered.

## 2 Comparison of international and European Standards Definition

Brief description of the contents of the international and European standards

## 2.1 DIN EN ISO 50001

In June 2011, the standard ISO 50001 Energy Management Systems (ISO 50001:2011 Energy management systems - Requirements with guidance for use) and in December 2011 the German version DIN EN ISO 50001 were published [5]. The structure of the standard corresponds to that of DIN ISO 9001 (quality management systems) and DIN ISO 14001 (environmental management systems). An energy management system (EnMS) according to ISO1 50001 can be implemented independently of existing management systems or integrated into already existing management systems.

DIN EN ISO 5001 specifies requirements and instructions for the introduction, implementation, maintenance and improvement with the aim of enabling an organisation to achieve energy savings potentials through continuous improvement of energy-related performance and thus help to reduce energy costs, greenhouse gases and other environmental risks.

With the increasing international importance of the topic of energy efficiency, the standards organisation ISO has published further standards in the 50000 series. ISO 50002:2014 describes the requirements for an energy audit and will probably replace DIN EN 16247 in the future. With ISO 50003:2014 "Energy management systems - Requirements for bodies providing audit and certification of energy management systems", an international set of rules for certification bodies was published. ISO 50003 specifies how and to what extent energy management systems are to be certified. In future, the duration of an audit will be determined by the energy sources used, the energy consumption and the complexity of a company. A certificate is only to be issued upon proof of continuous improvement of energy-related performance. One support for an energy audit is the guideline of ISO 50006 [6].

The German version of ISO 50003:2014 was published in November 2016. It also stipulates that all accreditations must be converted to ISO 50003:2014 by 14 October 2017 [7].

In the current ISO 50001:2018, there are no fundamental changes compared to ISO 50001:2011, but terms such as energy assessment, energy performance indicators and energy baseline are clarified [8].

---

1 ISO= International Organization for Standardization (Internationale Organisation für Normung)

The basis of the energy management system (EnMS) according to DIN EN ISO 50001 is the Plan-Do-Check-Act cycle (PDCA cycle): plan, implement, control and act.

In summary:
- all relevant energy consumption areas of the company should be recorded and an organisation-specific structure for the presentation should be developed.
- all values are measured and monitored, and
- regularly determine the current energy-related performance.

In addition, it is necessary to:
- review the performance of the EnMS and its processes and systems
- compare the results with the energy targets
- provide information for benchmarking
- investigate problems, and
- identify causes of weaknesses and opportunities for continuous improvement.

Top management is required to provide the resources for the implementation of energy management. Furthermore, the company management should appoint a responsible person, such as an energy or environmental manager, as well as initiate sensitisation and awareness-raising of the employees for the process. Suggestions for improvement and innovative ideas should be considered and reviewed by the employees.

## 2.1 DIN EN 16247-1

In October 2012, the standard DIN EN 16247-1 Energy audits - Part 1: General requirements- was published. DIN EN 16247-1 specifies requirements, methods and results for an energy audit. In the actual sense, the standard describes the process of a qualified energy analysis. An energy audit usually includes an analysis of energy consumption and an analysis of potential. In this way, potentials can be identified and corresponding reductions in consumption can be implemented [9].

According to DIN EN 16247-1, an energy audit is a systematic inspection and analysis of the energy use and consumption of a plant, a building, a system or an organisation with the aim of identifying and reporting on energy flows and the potential for energy efficiency improvements.

An energy audit requires relatively little financial and personnel effort. However, DIN EN 16247-1 is not a management system standard, as management system structures such as those in ISO 50001 are omitted; therefore, the audit does not represent certification. An energy audit is suitable for

systematically uncovering and evaluating potential energy savings. It therefore shows the company the current state of the energy situation, but does not support the continuous improvement process.

The benefits of an energy audit include transparency of energy use, elimination of weak points (identification of potentials), cost reduction through energy savings and the basis for energy management.

An energy audit documents the current state of your company in terms of energy efficiency. The audit determines the energy flows, centrally measures the energy consumption of individual units and develops concrete recommendations for action. According to legal requirements, an audit must cover at least 90 percent of the company's total energy consumption. The analysis concerns all areas of the company: Buildings, equipment, transport routes and production processes.

In fact, the energy audit is a basic component of the introduction of an energy management system according to DIN EN ISO 50001 and helps to evaluate the ACTUAL state of your energy consumption. It thus represents the optimal entry into the introduction process for an energy management system according to DIN EN ISO 50001.

## 2.1 ISO 14001

The standard was first published in 1996. In June 2000, the first revision of the standard was decided. The main goals were to achieve greater compatibility with the ISO 9001 quality management standard and to eliminate ambiguities.

In February 2012, international negotiations began on the second revision of ISO 14001, which was published in September 2015. The German version DIN EN ISO 14001:2015 followed in November. This standard covers the design and implementation of an environmental management system (EMS). The international standard specifies requirements for an environmental management system with which an organisation can improve its environmental performance, fulfil legal and other obligations and achieve environmental goals. It can be applied to both manufacturing and service-providing companies. However, it does not set absolute requirements for environmental performance. ISO 14001 focuses on a continuous improvement process as a means to achieve the defined environmental performance objectives of an organisation. The continuous improvement process is based on the method Plan-Do-Check-Act (PDCA) as in DIN EN ISO 50001 [10] Seite 3. A significant innovation in the current version of 2015 is the introduction of a uniform basic structure for ISO management system standards (so-called "high-level structure"), in order to be able to fall back on what is already known when introducing further management systems.

The main innovations in the current version of ISO 14001 are:

- Introduction of the uniform basic structure for ISO management system standards, (so-called "high-level structure").
- Strengthening of management responsibility for environmental management and integration into the organisation's business processes
- Greater emphasis on environmental performance improvement and its measurement through appropriate indicators
- Conduct a context analysis to identify cross-cutting issues and developments relevant to the organisation and its environmental management system, including how the environment may impact the organisation (e.g. as a result of climate change or overexploitation of natural resources).
- Analysis of stakeholder groups to determine and take into account their expectations and requirements.
- Identify and consider the risks and opportunities that may be associated with significant environmental aspects, binding commitments and other issues and requirements.
- Increased consideration of the life cycle, i.e. upstream and downstream environmental impacts, whereby the preparation of comprehensive life cycle assessments is not a requirement.

The amended standard has been in force since its publication on 15.09.2015. Certified companies and other organisations have been granted a transition period of three years to change over to the new standard [11].

## 2.1 Eco Management and Audit Scheme (EMAS)

EMAS is the English abbreviation for an environmental management and audit system according to the European EMAS Regulation, which was introduced in 1995. It is aimed at companies and, since 2001, also at public authorities and other organisations that want to improve their environmental performance systematically and transparently. The current legal basis is Regulation (EC) No 1221/2009, as amended by Regulation (EU) No 2017/1505 (Annexes I to III) [12] and Regulation (EU) No 2018/2026(Annex IV) [13]. EMAS organisations simultaneously fulfil all requirements of the environmental management standard ISO 14001, but go beyond it in essential

points. EMAS also includes energy use as a significant environmental aspect. Therefore, only a few adjustments and concretisations are necessary for EMAS users to implement the international energy management system standard ISO 50001, which was published in 2011 and amended in 2018. Conversely, an energy management system can also be an entry point to an environmental management system according to EMAS that covers all environmental aspects.

EMAS is a link between quality and environmental management, in which part of the energy management is also taken into account.

# 3 Comparsion of international and European standards relation to energy management

### 3.1 DIN EN ISO 50001 – DIN EN 16247-1

While environmental management systems according to EMAS and energy management systems according to DIN EN ISO 50001 are "real" management systems based on a complete PDCA cycle, energy audits according to DIN EN 16247-1 are actually only inventories. The legislator in Germany, for example, hopes that knowledge of economic savings potentials will also lead to their realisation.

DIN EN 16247-1 defines an energy audit as a "systematic inspection and analysis of the energy use and energy consumption of a plant, building, system or organisation with the aim of identifying and reporting on energy flows and the potential for energy efficiency improvements". This distinguishes it from the audit of an energy management system, which checks whether the requirements of an (already existing) energy management system are fulfilled, e.g. whether the company's own requirements for energy efficiency are met, whether its own requirements are implemented, whether it complies with standards and whether it improves energy-related performance. It corresponds more to the energy assessment, a central planning step of ISO 50001.

One difference between an energy audit and an energy management system is that an energy audit is usually repeated every four years and technical energy efficiency measures are identified.

The energy assessment to be carried out within the framework of DIN EN 50001 corresponds in principle to a detailed energy analysis, as also required by DIN EN 16247-1. In this respect, the energy audit can also be understood as a preliminary stage or first basis for an energy management system.

See the following table for an illustration of significant differences:

**DIN EN ISO 50001 and energy audit according to DIN EN 16247-1 in comparison**

Table 1: Comparsion DIN EN ISO 50001, DIN EN 16247-1 and EMAS

|  | DIN EN ISO 50001 | DIN EN 16247-1 | EMAS |
|---|---|---|---|
| *Remark* | Globally recognized standard | European-wide recognized standard | |
| *Content* | Holistic consideration of the interacting elements | Analysis of energy use and consumption | valid EU standard for environmental management systems<br><br>Suitable for companies of all sizes and sectors |
| *Deadline* | 31.12.2016<br><br>Until 5.12.2015 only proof to BAFA of introduction of ISO 50001 system | Carried out until 5.12.2015 | voluntary |
| *Target group* | Suitable for all organisations and company sizes | Suitable for all organisations as a starting point: For non-SMEs as proof of mandatory energy audits according to EDL-G | Companies that must comply with ISO14001.<br><br>EMAS substitutes ISO14001 |
| *Managementsystem* | Holistic management system with a continuous improvement process | no management system with a continuous improvement process | no management system with a continuous improvement process |
| *Efficiency* | Continuous improvement of | Indication of savings potentials with | |

|  |  |  |  |
|---|---|---|---|
|  | energy efficiency possible

Energy savings possible | details of which investments pay off over which period of time

One-off effect through snapshots

No compulsion to act |  |
| *Effort* | medium | low | High |
| *Additional effect* | Image effect through certificate

Considerable savings are possible

The topic of energy management systems according to ISO 50001 was positively assessed in supplier evaluations.

Linking to existing management systems is possible, because responsibilities, systems and processes already exist | A report is produced, not a certificate that can be used for advertising. | Image effect through certificate

No compulsion to take action after recording savings potentials |
| *Prospect of success* | Strengthens corporate identity through employee involvement

Strong external impact | Strongly dependent on individual commitment |  |
| *Cost* | Introduction of energy management in accordance with | Consultancy expenses for regular repeat audits can |  |

|  |  |  |  |
|---|---|---|---|
|  | ISO 50001 can be more cost-effective than carrying out energy audits | generate costs similar to the introduction and maintenance of an energy management system in accordance with ISO50001 in the long term. |  |
| *Benefit* | Energy management system can be combined with existing ISO 14001 certification<br><br>Detection of savings potentials<br><br>Low documentation requirement and therefore simple and effective to implement | Identification of energy influences and potentials for energy efficiency improvements<br><br>Summary of energy potentials and measures in an energy report | EMAS participants are entered in a public register.<br><br>Receipt of a certificate from the responsible registration body |
| *Recommendation* | EnMS certification is suitable for all companies and organisations with high energy consumption that want to sustainably improve their energy efficiency using the systematic approaches of the "Plan-Do-Check-Act" cycle (PDCA) and the continuous improvement process (CIP). | Energy audits enable the systematic identification of energy-saving potential. However, energy audits in accordance with DIN EN 16247-1 are also a suitable preparation for the introduction of an EnMS in accordance with DIN EN ISO 50001. | EMAS validation is suitable for all companies that, in addition to exploiting energy savings potential, are also striving for a comprehensive improvement of their environmental performance. |

This leads to the following conclusions:

Energy-intensive companies are well advised to implement an energy management system according to DIN EN ISO 50001 and not only an energy audit according to DIN EN 14247-1, because in addition to the continuous reduction of energy consumption, energy efficiency can be sustainably improved at the same time. Furthermore, new technical developments can be effectively integrated into the existing internal energy supply system. In contrast, the energy audit according to DIN EN 14247-1 only provides a snapshot of the current situation, but does not guarantee a continuous process. However, the energy audit can be used as a basis for an energy management system.

If energy-intensive companies also have a connection to environmentally relevant risks, because they may be subject to the Industrial Emissions Directive (Directive 2010/75/EU on industrial emissions), an environmental management system is often unavoidable. If a management system according to ISO 14001 or DIN EN ISO 50001 or EMAS already exists in these cases, a combination with another management system is efficiently possible due to the so-called "high-level structure", as duplication of work can be avoided and costs saved. However, an energy audit according to DIN EN 14247-1 does not offer these advantages.

Energy audits should be seen as an opportunity, as they also offer advantages and can be used as a preliminary stage to a more complex energy management system. The data obtained provides the "technical" basis for the further development of an energy management system according to ISO 50001.

## 3.2 DIN EN ISO 50001 – ISO 14001

ISO 50001 is based on the common elements of ISO management system standards to ensure a high degree of compatibility, especially with ISO 9001 and ISO 14001. It is also based on the continuous improvement process known as the PDCA cycle. Thus, the relationship to ISO 14001 in particular is clearly evident. However, ISO 50001 is not a mere copy of ISO 14001.

The main differences between ISO 50001 and ISO 14001 are:

ISO 50001 refers to energy performance, i.e. energy use, energy consumption, energy efficiency and energy intensity.ISO 14001, on the other hand, refers to overall environmental performance. In addition to energy aspects, other environmental aspects such as water,waste and auxiliary and operating materials are also taken into account. In addition to the top manager, ISO 50001 requires the appointment of an "operational energy manager" and the approval of the formation of an energy management team. Furthermore, the responsibility of the top management and the tasks of the representative are set out very specifically.

According to ISO50001, the energy policy does not have to be made available to the public, nor does it have to be communicated to the contractors, as required by ISO 14001. Another difference is that according to ISO 50001, energy-efficient purchasing of products and services must already be emphasised in the energy policy. ISO 50001 makes it mandatory to regularly check that the policy is up to date and to change it if necessary. The organisation must implement and document an energy planning process.

ISO 14001 refers to environmental impacts, where an environmental impact is any change in the environment, whether adverse or beneficial, resulting in whole or in part from the environmental aspects of an organisation. ISO 50001 only refers to the concept of environmental impact in the introductory part. Another new feature of ISO 50001 is that an energy assessment must be carried out and an energy baseline (energy season for energy consumption) must be defined, from which energy performance indicators must be calculated. In ISO 14001, objectives and targets are required. ISO 50001, on the other hand, refers to strategic and operational goals. According to ISO 14001, the organisation must introduce action plans to achieve the strategic and operational goals. The action plans must include responsibilities, means and timeframes for achieving the operational objectives, a statement of the method by which improvement in energy performance will be verified, and a statement of the meta-method by which the results will be verified.

ISO14001 requires a mandatory emergency preparedness process, but ISO 50001 does not.

The energy-efficient or ecological procurement of products and services is equally required in both standards. In the case of ISO 50001, however, there is an additional obligation to identify and plan those processes and maintenance activities that are related to the main areas of energy use. Furthermore, sequencing is intended to ensure that facilities/sites, processes, systems and equipment are operated and maintained in accordance with operational criteria. When designing new, modified or renovated facilities/sites, equipment, systems and processes that have a significant impact on energy-related performance, ISO 50001 requires the organisation to consider ways to improve energy-related performance and sequencing. The results of the design shall then be recorded. ISO 14001 also refers

to product-related aspects (the product as an environmental aspect); the product as well as the service do not play a role in ISO 50001.

## 3.3 ISO 14001 – EMAS

DIN EN ISO 14001 is a standard that applies to organisations of all shapes and sizes. But even in smaller companies or in the service industry, 14001 certification demonstrates an organisational commitment to the environment and the more effective use of the world's resources.

The European EMAS Regulation incorporates the contents of ISO 14001 in a central location. For this reason, the majority of EMAS organisations are also certified to ISO 14001 - at no extra cost. On the other hand, organisations with an environmental management system according to ISO 14001 have a good starting point for participating in EMAS.

The structure of the environmental management system under EMAS corresponds to the environmental management standard ISO 14001, but EMAS goes beyond a pure management system and is performance-oriented: The organisation should improve beyond the requirements of environmental legislation. Employees are to be involved in the process of continuous improvement of environmental performance. This helps employees identify with the company's environmental protection interests and ensures that environmental management is "lived" and does not gather dust in the form of unread manuals in the cupboard.

The introduction of an environmental management system is voluntary, there is no legal obligation. An EMAS-certified environmental management system is a combination of environmental management and environmental audit and releases the company from the obligation to conduct regular energy audits.

EMAS (Eco-Management and Audit Scheme) goes a few steps further than the ISO 14001 standard. Certified companies are obliged to publish an annual environmental statement in which they report on the direct and indirect environmental impacts of their business operations and compare them with their self-imposed environmental targets. These statements must be verified by a state-supervised environmental verifier. In addition, the entire environmental management system must be recertified every 3 years. The ISO 14001 standard and the European EMAS standard are substitutes for each other. EMAS is not recognised internationally, although the requirements are significantly higher.

## 3.4 DIN EN ISO 50001 – EMAS

According to the German Energy Services Act (EDL-G), companies and organisations that do not fall under the European SME regulation are obliged to carry out an energy audit according to DIN EN ISO 14247-1. An existing certification according to DIN EN ISO 50001 or registration according to EMAS fully fulfils this obligation.

EMAS registration therefore satisfies the energy audit obligation; parallel certification of an energy management system is therefore not necessary.

The structure of ISO 50001 is based on the common elements of ISO management systems, in particular DIN EN ISO 9001 and DIN EN ISO 14001. An energy management system according to this standard (ISO 50001) is intended to enable organisations to establish systems and processes that are necessary to improve their energy-related performance (for more information on ISO 50001, see also sections 3.2.1 and 3.2.2).

The EMAS Regulation, in turn, includes the management system structures of DIN EN ISO 14001 and expands on these contents, particularly with regard to improving environmental performance. EMAS does not fulfil all the requirements of ISO 50001, so that a corresponding certificate cannot be issued automatically. However, if energy use as a significant environmental aspect is already part of the environmental management system - which can be assumed for organisations for which ISO 50001 is relevant - only a few adjustments and concretisations, e.g. with regard to energy-related performance, will be necessary.

ISO 50001 summarises the responsibilities of top management and the energy management representative in a separate section. In the EMAS Regulation, these are found in various places and are partly only formulated within the framework of the requirements for the organisation. Since the EMAS Regulation essentially contains the management system structures of ISO 14001, reference can be made to Sections 3.2.2 and 3.2.3 for further points of comparison.

In addition to the EMAS regulation, the systematic introduction of an energy management system according to ISO 50001 enables a sustainable and continuous improvement of energy efficiency in the company. Potential savings are not only recognised, as is the case with the energy audit, but are implemented step by step.

## 4 Discussion

The energy saving potential causes an increase in the competitiveness of the companies, as investments can be made in other areas.

The reasons for an energy management system include: Cost reduction, environmental protection, sustainability, climate policy - future-oriented

action, image enhancement and use of legal facilitations (e.g. in Germany).

Energy management should be SMART: specific, measurable, appropriate, realistic and ter-minated.

From a business point of view, it is worthwhile to focus on energy in the course of the recurring energy audits, as this already lays the foundations for a later EnMS. It is also possible that the direct introduction of an EnMS will be considered in order to achieve a structured continuous improvement process with regard to energy. Nevertheless, it cannot be said across the board that the introduction of an energy management system is the optimal recommendation for action in every respect.

# 5 Conclusion

An energy audit in accordance with DIN EN 16247-1 already lays the foundation for the introduction of an energy management system (EnMS). With the data recorded, the energy audit provides an inventory of the energy situation and indicates opportunities for improvement. In summer 2018, a new edition of DIN EN ISO 50001 was published. The central change is based on a simplification of the combination of several management systems, which means that companies that already operate an environmental management system according to ISO 14001, for example, will find it easier to introduce an EnMS.

However, the audit according to DIN EN 16247-1 is not (yet) a management system standard. Therefore, it is only comparable with DIN EN ISO 50001 to a limited extent, nor does it replace certification. It evaluates the actual state of energy consumption, but does not yet provide any indications for continuous energy savings, as is intended in a management system. Nevertheless, the energy audit according to DIN EN 16247-1 is a good basis for a successful certification of the energy management system according to DIN EN ISO 50001. The decision for an energy audit or an energy management system should be made individually by each company, taking into account the respective initial situation and objectives. ISO 50001 defines an EnMS as a set of interrelated or interacting elements for the introduction of an energy policy and strategic energy goals, as well as processes and procedures for achieving these strategic goals.

In the future, auditors will continue to certify on the basis of ISO 50001. However, it can be assumed that more emphasis will be placed on the aspects of measuring consumption and significant variables, maintaining key figures and improving energy performance. ISO 50003, which will be valid from autumn 2017, will not have a significant impact on companies for the time being. However, companies must be aware that in the future they will have to prove the improvement of energy-related performance in the form of meaningful key figures.

Energy audits should be seen as an opportunity, as they also offer advantages and can be used as a preliminary stage to the more complex energy management system. The data obtained provide the "technical" basis for the further development of an energy management system according to ISO 50001.

An environmental management system certified according to EMAS combines the fulfilment of the obligation to conduct an energy audit with the requirements of an environmental management system valid throughout Europe. Companies and organisations with locations outside Europe are better off with a combination of an energy management system according to ISO 50001 and an environmental management system according to ISO 14001 if they consider the goals of climate change to be relevant. With regard to potential energy savings, EMAS does not replace the development of an own energy efficiency roadmap.

In conclusion, it can be said that management systems and audits should not be considered in isolation, as they contribute to a more energy-efficient handling of resources across the board. The international standards are primarily voluntary; only when laws or legal regulations such as EU directives refer to them are they legally binding. DIN EN ISO 50001 provides guidance on energy management, which, in conjunction with DIN EN ISO 14001, is an ideal management system overall for protecting the environment and conserving resources.

The saying "You cannot manage what you do not measure" is of central importance here.

*References:*

[1] European Union, "DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC," 25 October 2012. [Online]. Available: DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. [Accessed 23 February 2021].

[2] European Commission, "2030 climate & energy framework," 31th November 2016. [Online]. Available: https://ec.europa.eu/clima/policies/strategies/2030_en. [Accessed 23th February 2021].

[3] European Commission, „DIRECTIVE (EU) 2018/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 amending Directive 2012/27/EU on energy efficiency," 11 December 2018. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2002&rid=7. [Accessed 23 February 2021].

[4] European Commission, "DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC," 25 October 2012. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32012L0027. [Accessed 23 February 2021].

[5] A. Barckhausen, J. Becker, P. Malodobry, N. Harfst and U. Nissen, *Energiemanagement-systeme in der Praxis Vom Energieaudit zum Managementsystem nach ISO 50001: Leitfaden für Unternehmen und Organisationen,* Dessau-Roßlau, 2020, p. 6.

[6] ITC AG Samrt Energy Solution, „ISO 50000er Normen," [Online]. Available: https://www.itc-ag.com/ISO_50000er_Normen.html. [Accessed 23 February 2021].

[7] VOREST AG, „Umweltmanagement& Energiemanagement," [Online]. Available: https://umweltmanagement.me/energiemanagement_iso_50001/iso_50003_aenderungen_auswirkungen/. [Accessed 23 February 2021].

[8] DNV-GL, "Wesentliche Änderungen von der ISO 50001:2011 zur ISO 50001:2018," [Online].Available: https://www.dnvgl.de/assurance/Management-Systems/neue-iso/transition/Wesentliche-Aenderungen-iso-50001-2018.html. [Accessed 23 February 2021].

[9] Bundesamt für Wirtschaft und Ausfuhrkontrollen, "Leitfaden zur Erstellung von Energieauditberichten nach den Vorgaben der DIN EN 16247-1 und den Festlegungen des Bundesamtes für Wirtschaft und Ausfuhrkontrolle (BAFA)," 30 November 2020. [Online]. Available: https://www.bafa.de/SharedDocs/Downloads/DE/Energie/ea_leitfaden.pdf?__blob=publicationFile&v=26. [Accessed 23 February 2021].

[10] VOREST AG, „Umweltmanagement & Energiemanagement Leitfaden zur Erstellung von Energieauditberichten nach den Vorgaben der DIN EN 16247-1 und den Festlegungen des Bundesamtes für Wirtschaft und Ausfuhrkontrolle (BAFA)," [Online]. Available: https://umweltmanagement.me/umweltmanagement_iso_14001/. [Zugriff am 23 February 2021].

[11] TÜV Rheinland Cert GmbH, „MANAGEMENTSYSTEME - DIN EN ISO 14001 Revision der DIN EN ISO 14001 – Änderungen und Auswirkungen," [Online]. Available: Revision der DIN EN ISO 14001 – Änderungen und Auswirkungen. [Accessed 23 February 2021].

[12] European Union, „REGULATIONS COMMISSION REGULATION (EU) 2017/1505 of 28 August 2017 amending Annexes I, II and III to Regulation (EC) No 1221/2009 of the European Parliament and of the Council on the voluntary participation by organisations in a Community eco-management a," 29 August 2017. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R1505&from=DE. [Accessed 23 February 2021].

[13] European Union, „COMMISSION
REGULATION (EU) 2018/2026 of 19
December 2018 amending Annex IV to
Regulation (EC) No 1221/2009 of the
European Parliament and of the Council on the
voluntary participation by organisations in a
Community eco-management and audit scheme
(EMAS)," 20 December 2018. [Online].
Available: https://eur-lex.europa.eu/legal-
content/EN/TXT/PDF/?uri=CELEX:32018R20
26&from=DE.