Practical Guide for Sustainability in Computing Centers

High-Performance Computing Center of the University of Stuttgart

The contents of the guide have been developed as part of the “Sustainability in HPC Centers II” project. They were funded by the Ministry of Science, Research and the Arts of Baden-Württemberg and were carried out in cooperation with the Baden-Württemberg Academy for Nature and Environmental Protection.

Baden-Württemberg

MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST

Akademie für Natur- und Umweltschutz
Baden-Württemberg

Cover photo: Cray XC40 (Hazel Hen)
Boris Lehner for HLRS

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Welcome

Dear Readers,

We are pleased to present the “Sustainability in Computing Centers” guide that we have developed as part of the “Sustainability in HPC Centers II” project. The primary content of the project was to implement a sustainability concept for the High-Performance Computing Center of the University of Stuttgart (HLRS). To this end, an environmental management system according to the EMAS regulation and an energy management system according to DIN EN ISO 50001 were established and certified.

With this practical guide, we want to make the experience we gained in our efforts to improve HLRS's sustainability accessible to other computing centers. The practical examples come from the fields of public service and high-performance computing (HPC), but much of it can also be applied to commercial computing centers. In our guide we have also included many useful tips that can be helpful for you in implementing such a project.

We wish you much success in the development and implementation of your sustainability concept.

Your HLRS Sustainability Team

Preface

Dear Readers,

As a high-performance computing center, we have a special responsibility to the environment and to society. This concerns the large requirement for energy and other resources to operate our computers as well as the possibilities of predicting and improving systems that offer the use of these computers. In order to fulfill this responsibility, HLRS has developed and implemented a sustainability strategy involving all our employees, and has established an environment and energy management system based on it. They were certified at the end of 2019 by an independent, government-approved environmental verifier according to the Eco-Management and Audit Scheme (EMAS), ISO 14001 and ISO 50001. These environmental certifications are an important milestone on our way to the future.

Considering climate change and other threats to our livelihoods, it is imperative that the IT sector do everything possible to minimize its effects on the environment. The knowledge that we have acquired along the way has been recorded in this "Practical Guide for Sustainability in Computing Centers". We hope that you will be able to benefit from this guide if you are also working to establish a sustainable computing center.

Best regards,

Prof. Dr.-Ing. Dr. h.c. Dr. h.c. Prof. E.h. Michael Resch, Director of the HLRS

Photo: Boris Lehner for HLRS

About the guide

Origins of the guide

In May 2014, the "Sustainability in HPC[1] Centers" project was launched at the High-Performance Computing Center (HLRS) to develop a sustainability concept. The project was funded by the Ministry of Science, Research and the Arts of Baden-Württemberg for a period of almost three years. The Academy for Nature and Environmental Protection of Baden-Württemberg was also a key partner in this project.

This first sustainability project laid the foundation for sustainability at HLRS. The first steps included determining the most important fields of action in the area of sustainability and formulating the first sustainability goals as part of departmental and employee workshops. Then, sustainability and energy guidelines were formulated with the involvement of all employees. In addition, a sustainability concept was developed and its implementation was started. In order to continue implementing this concept and to anchor the subject of sustainability permanently in the HLRS, the follow-up project "Sustainability in HPC Centers II", also funded by the Ministry of Science, Research and the Arts of Baden-Württemberg, was conducted. The following goals were pursued in this project:

1. Introduction and maintenance of an environmental management system and its certification according to EMAS: Regulation (EC) No. 1221/2009.
2. Introduction and maintenance of an energy management system and its certification according to ISO 50001.
3. Determination of whether it is possible for the HLRS to obtain the Blauer Engel (Blue Angel) ecolabel for "energy-efficient data center operation" (DE-UZ-161).
4. Publication or dissemination of the results (including the creation of the this practical guide).
5. Target group-specific motivation and training of employees.

The most important findings that the HLRS has acquired from these two sustainability projects have been recorded in this "Practical Guide for Sustainability in Computing Centers". Because the Institute for High-Performance Computing (IHR) of the University of

[1] HPC: High-Performance Computing

Stuttgart is closely linked with the HLRS – the director of the HLRS is also the institute director of the IHR and his employees have their offices at the HLRS – the IHR was included in the sustainability efforts. This is not always explicitly mentioned in the practical tips.

Contents of the guide

In this practical guide you will learn how to develop and implement a sustainability concept in your computing center based on an environmental management system according to EMAS regulations and an energy management system according to DIN EN ISO 50001. We explain the steps from the introduction of the management systems to the certification and show you what you need to pay attention to along the way. Here, we give you **many helpful tips** and experiences **from practice:**

Helpful tips

are provided in blocks with medium green shading

Practical examples from our experience

have a light green shading and are identified by our HLRS sustainability logo

Sustainability in Computing Centers

Definition of sustainability

Nowadays, the terms “sustainability” and “sustainable development” are on everyone's lips and have become an integral part of our vocabulary. The most well-known and fundamental definition of “sustainable development” comes from the Brundtland Report[2] of 1987:

“Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs.” (Weltkommission für Umwelt und Entwicklung, 1987)

In its definition of “Sustainable Development”, the German Council for Sustainable Development[3], which was appointed by the Federal Government in April 2001, explains what it means to do business in a sustainable manner and addresses the **three dimensions of sustainability**: **ecological, social, and economic**. All three dimensions are regarded as equal.

“Sustainable development means considering environmental aspects equally with social and economic aspects. Hence, doing business in a sustainable manner means: We must leave an ecological, social, and economic structure intact for our children and grandchildren. You can’t have one without the other.” (Rat für Nachhaltige Entwicklung, 2019).

Thus, sustainability in computing centers is much more than a purely technical matter (e.g. energy optimization).

[2] Brundtland Report: Report by the World Commission on Environment and Development (1987), named after the chairperson of the commission, former Prime Minister of Norway, Gro Harlem Brundtland.

[3] “The German Council for Sustainable Development (RNE) was appointed by the Federal Government for the first time in April 2001. The council is composed of 15 public figures. Werner Schnappauf, lawyer and consultant, former State Minister, and former CEO of the Federation of German Industries, has been the Chairman of the Council since 2020.“ (See: https://www.nachhaltigkeitsrat.de/en/the-council/ (January 22, 2020).

There are three important aspects to sustainability: ecology, economics, and social:

Ecology

- Examples include:
  - Environmental protection in order to maintain an intact livelihood
  - Climate protection by economical and sensible use of energy and sustainable mobility

Social

- Examples include:
  - Assuming social responsibility
  - Creating a healthy and safe working and living environment

Economy

- Examples include:
  - Economic security
  - Positive reputation among all stakeholders

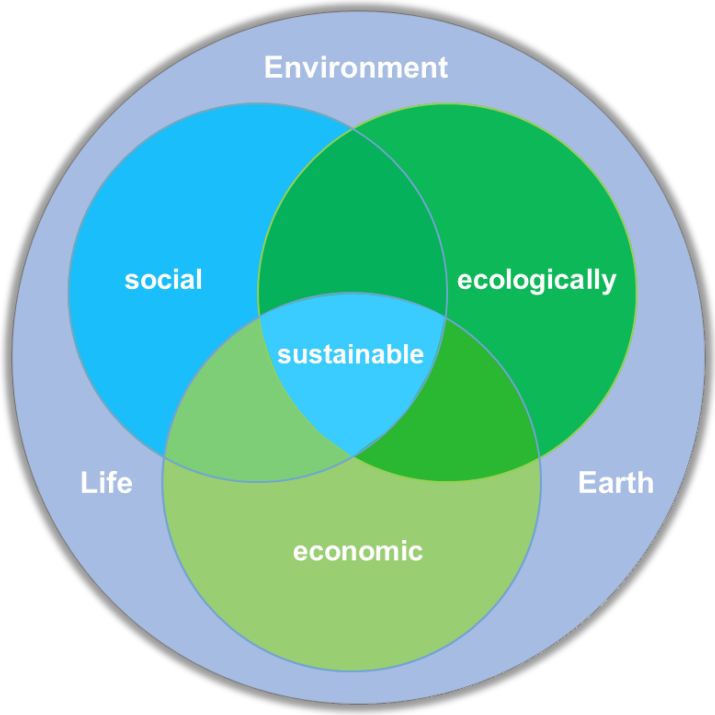


Figure 1: "Three overlapping circles" sustainability model based on (Pufé, 2014)

There are different sustainability models. The “three overlapping circles” model is shown in Figure 1. In this model, the overlapping of the “economy”, “ecology”, and “social” circles demonstrates that there is a close connection between the respective areas (see also Pufé, 2014). In addition to this model, there is also the “three-pillar” model, in which sustainability rests on the three pillars of “economy”, “ecology”, and “social”. In this model, the pillars stand side by side as equals, but in contrast to the three overlapping circles, they are considered only in isolation from each other, which is why we prefer the “three overlapping circles” model.

Reasons for sustainability in computing centers

Climate, energy, and resources play an important role in information and communications technology (ICT) and it is becoming increasingly critical for computing centers to deal with these major sustainability issues. Thus, *"the energy requirements of computing centers [...] continue to increase – in recent years even with increasing growth rates. In 2017, computing centers in Germany required 13.2 billion kWh of electricity. That is approximately the annual power consumption of Berlin."* (Hintemann, 2018a).

From Our Experience

Sustainability challenges based on examples at HLRS:

- High energy consumption, resulting in high costs and significant environmental impacts
- Prevention of emissions
- Cost savings due to more efficient use of energy
- Waste heat utilization, e.g. for building heating
- Cooling systems:
  - Evaporation cooling systems: the 42nd Federal Emission Control Act Ordinance on Evaporation Cooling Systems, Cooling Towers and Wet Separators (42nd BImSchV) must be complied with
  - Dry cooler with glycol coolant: Compliance with the requirements of the Water Resources Act (WHG) and the AwSV (Ordinance on Installations for the Handling of Substances Hazardous to Water)
- Increasing the regenerative share of the energy supply, e.g. through the university's own photovoltaic system

Establishing sustainability on a permanent basis

As you learned in the previous section, sustainability is quite varied and more than "just" environmental protection. Both economic aspects (cost efficiency and cost savings) and ecological aspects (energy efficiency and climate protection) play a significant role in computing centers.

Therefore, the following main fields of action are important in a computing center:

- Energy- and cost-efficient operation of the computer
- Energy- and cost-efficient cooling
- Energy-efficient programming

Official opening of Hawk at the HLRS; from left to right: State Secretary Gisela Splett, Member of State Parliament Sabine Kurtz, Parliamentary State Secretary Michael Meister, Minister Theresia Bauer, Prime Minister Winfried Kretschmann, HLRS Director Michael Resch, and HPE Chief Sales Officer Heiko Meyer.

If you want to have a sustainable computing center, you should start by defining the main fields of action that are most important for your computing center and determine the goals to be pursued.

In order to introduce sustainability and establish it on a permanent basis in the computing center, it makes sense to implement and maintain a suitable management system. In this way, *"a management system [...] can ensure that defined corporate objectives are implemented systematically and can be controlled in every phase"* (Bundesministerium für Umwelt, Juni 2012). Quality, occupational safety, and environmental management systems are examples of management systems. The differences between these individual management systems consist primarily of the subject matter and the requirements to be coordinated *(see* (Landesanstalt für Umwelt, Messungen und Naturschutz BW (Hrsg.), 2000)*).*

From Our Experience

The most important fields of action at the HLRS

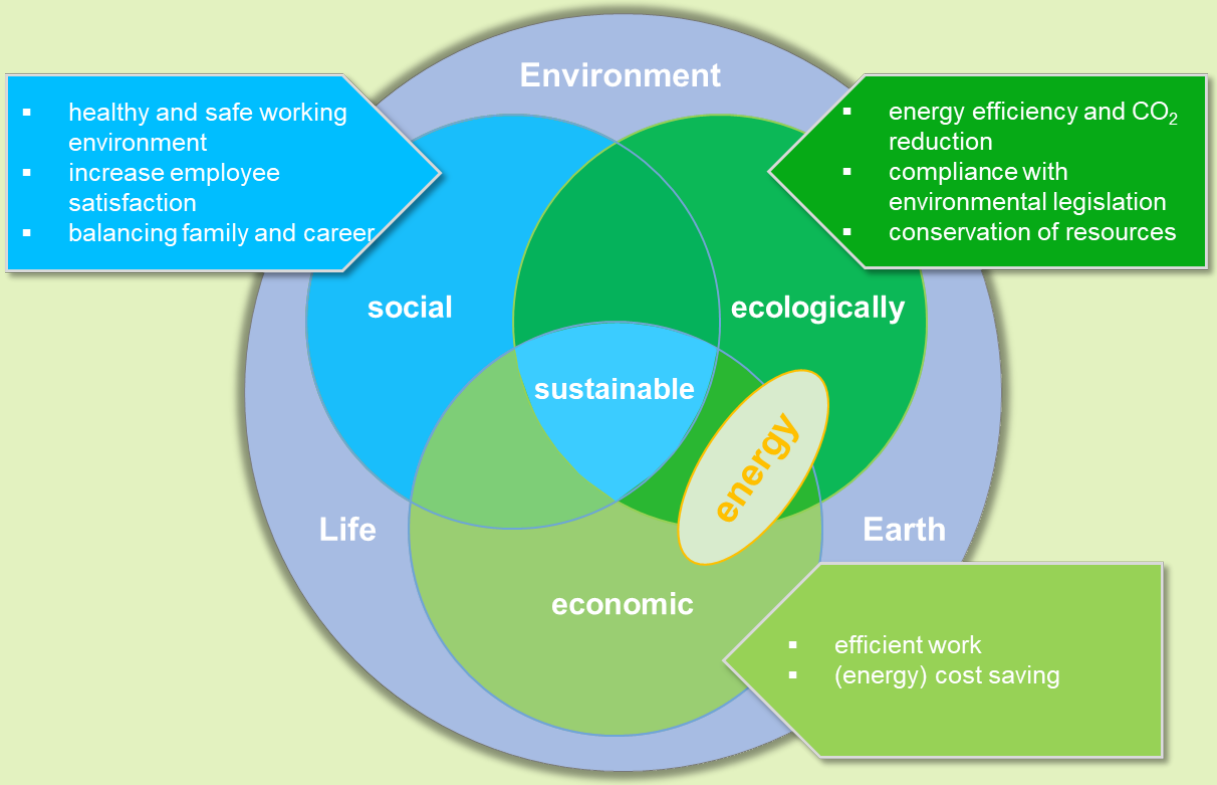


Figure 2: Important fields of action of the HLRS in environmental protection and in the area of sustainability

Based on the "three overlapping circles" sustainability model[4], Figure 2 shows that the subject of energy in computing centers plays a significant role from both an ecological and an economic standpoint. In addition to the fields of action shown in the figure, employee integration, training, and the cultivation of awareness are important building blocks for the successful implementation of the sustainability concept at HLRS.

Important building blocks of management systems are:

[4] The "three overlapping circles" model is also referred to as an intersection model. *"The overlapping of the circles demonstrates that there can be a close connection between any two areas, and that the boundaries are fluid."* (Pufé, 2014)

- Establishment of a strategy
- Clear definition of measurable goals
- Definition and documentation of internal process flows
- Recording of deviations and corrective and preventive measures derived from them
- Training and motivation of employees
- Internal monitoring and evaluation of the entire system

An environmental management system is especially suitable as a basis for a sustainability concept, because *"Environmental management is a significant pillar of sustainability management. Because environmental management includes the same business components (organization, processes, products, etc.) as CSR[5], it is also suitable as a basis for developing operational sustainability management"* (Geschäftsstelle des Umweltgutachterausschusses (Hrsg.), Dez., 2011).

It is useful to structure an environmental management system according to the requirements of the EMAS regulation (EC) No. 1221/2009, because EMAS offers many advantages:

- "EMAS is the most sophisticated system for sustainable environmental management worldwide" (Umweltgutachterausschuss, 2019).
- EMAS is a valuable guide (in terms of method and content) for developing a management system for sustainability.
- EMAS leads to a process of continuous improvement.
- "EMAS ensures compliance with the legal requirements and transparency" (Geschäftsstelle des Umweltgutachterausschusses (Hrsg.), April 2017).
- In addition, EMAS also forms a good basis for an energy management system according to DIN ISO 50001.

Energy consumption and energy efficiency are the most important sustainability issues in computing centers, so it is a good idea to expand the environmental management system to include an energy management system.

[5] CSR: Corporate Social Responsibility

The environmental and energy management system can be expanded to include social issues based on the respective requirements.

Tip:

Guide to social responsibility

DIN ISO 26000:2011 (Guidance on social responsibility) is a good guide for integrating additional sustainability issues usefully in an environmental and energy management system.

"By addressing key issues of organizational governance, human rights, work practices, the environment, fair operating and business practices, consumer concerns, as well as the integration and development of the community, DIN ISO 26000 has a comprehensive substantive claim. […] In addition, this guide shows in a coherent and structured manner the contribution that an organization can and should make to sustainable development worldwide. DIN ISO 26000 is not certifiable." (Bundesministerium für Arbeit und Soziales (Hrsg.), 2011).

However, your computing center cannot be certified according to ISO 26000. If certification is your goal, you have the option of developing an environmental management system according to EMAS or ISO 14001 and/or an energy management system according to DIN EN ISO 50001 and having it certified.

From Our Experience

HLRS's sustainability concept

The basis for HLRS's sustainability concept is an environmental management system based on EMAS that has been expanded further to a sustainability management system. In order to account for the great significance of the environmental aspect of energy in the HLRS, an energy management system was also developed according to DIN EN ISO 50001.

An important building block for sustainability management at HLRS is the involvement of employees as well as their training and the cultivation of awareness of the subject of sustainability.

The EMAS regulation

"The community system for the voluntary Eco-Management and Audit Scheme (EMAS) is an instrument developed by the European Communities in 1993 for companies wishing to improve their environmental performance. The current legal basis is ***Regulation (EC) No. 1221/2009****. This amendment became effective on January 11, 2010. For EMAS, the structure of an EMS (environmental management system) and the processes have also complied with ISO 14001 since 2001"* (Umweltgutachterausschuss, 2019).

EMAS is an important instrument of the EU action plan for sustainability: *"The objective of EMAS, as an important instrument of the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, is to promote continuous improvements in the environmental performance of organizations by the establishment and implementation of environmental management systems by organizations, the systematic, objective and periodic evaluation of the performance of such systems, the provision of information on environmental performance, an open dialog with the public and other interested parties and the active involvement of employees in organizations and appropriate training." (Article 1 of the EMAS regulation of 2009,* (Europäische Kommission, Nov. 2009)*).*

Important elements of EMAS

The central component of EMAS is the international environmental management standard DIN EN ISO 14001 (short: ISO 14001). But EMAS goes beyond the requirements of ISO 14001. For example, EMAS requires the regular publication of environmental statements for public information. In the environmental statement, the most important environmental information, data, and facts, as well as the environmental policy and a self-imposed environmental program are made available to the public. *"EMAS environmental verifiers verify and confirm that the information in the environmental statement is correct and credible."*
(Geschäftsstelle des Umweltgutachterausschusses (Hrsg.), Juni 2018)
In addition, EMAS organizations are also committed to continually improving their environmental performance beyond the legal requirements. ISO 14001, on the other hand, concentrates on improving the management system and *"unlike ISO 14001, proof of compliance with the legal requirements is an essential prerequisite for participation in EMAS." Therefore EMAS contributes substantially to the legal and liability security of those responsible in the company"* (Geschäftsstelle des Umweltgutachterausschusses (Hrsg.), Juni 2018).

In addition to the key issue of "developing an environmental management system", EMAS focuses primarily on the following points:

- Continual improvement
- Development of environmental goals to improve the environmental performance
- Involvement of employees, e.g. by introducing a suggestion system
- Employee training and the cultivation of awareness, e.g. through workshops and "environment days"

- Public relations:
  - Publication of environmental statements
  - Press relations
  - Internally: regular employee information
- Compliance with legal requirements:
  - Conducting and maintaining a legal register
  - Carrying out a legal check

Advantages of EMAS

The introduction of an environmental management system creates advantages for a computing center, such as:

- Transparency of resource consumption, especially in terms of energy consumption, making it easier to identify savings potential
- Positive image in politics, among customers, and in public through active public relations (e.g. by regular publication of an environmental statement)
- Employee motivation
- Legal security by maintaining a legal register and by conducting regular compliance audits

Energy management system according to ISO 50001

The standard for energy management systems (EnMS) DIN EN ISO 50001 helps companies and organizations of all sizes and industries develop systematic energy management plans. According to *VDI guideline 4602: 2018*, the definition of energy management is:

"...forward-looking, organized, and systematized coordination of procurement, conversion, storage, distribution, and use of energy to cover utilization requirements, taking into account ecological and economic objectives."

The main goals of an energy management system are the:

- Improvement of energy efficiency
- Improvement of energy use
- Reduction in energy consumption
- Compliance with legal requirements

An energy management system systematically records all energy flows and in this manner constitutes an instrument for deciding on investments and measures to improve energy performance. Thus, saving energy becomes part of the organizational culture.

ISO 50001 focuses primarily on the following points:

- Continual improvement
  - Development of energy goals to improve energy performance
  - Creation of a culture of improvement with regard to energy performance (change in culture)
- Involvement of employees, e.g. by introducing a suggestion system
- Training and the cultivation of awareness, e.g. through workshops for employees
- Compliance with legal requirements by keeping and maintaining a legal register

Advantages of an EnMS according to ISO 50001

- Greater competitiveness by reducing energy costs
- Protection of the environment through more sustainable management
- Supporting national climate protection goals by reducing energy-related greenhouse gas emissions
- Improvement in public image and credibility
- As an energy-intensive, non-public business, the opportunity to benefit from tax refunds and exemption from levies[6] (note: this also applies to EMAS-certified companies)
- Legal compliance according to the EU Energy Efficiency Directive or the Energy Services Act (EDL-G)

Relationship between EMAS, ISO 14001, and ISO 50001

In recent years, ISO standards 14001 and 50001 have been adapted to a common basic structure (High-Level Structure – HLS) consisting of ten sections with uniform definitions of terms. This also applies to ISO 9001 for quality management systems.

The HLS can be used to find the requirement of certain subjects in the same section of the respective standard in question, which simplifies the combining of different management systems. It is the mandatory basis for all new and revised standards. This also applies to EMAS: regulation (EC) No. 1221/2009, which contains the ISO 14001 standard as a central component.

There are many similarities between the management systems according to EMAS, ISO 14001, and ISO 50001. Figure 3 models overlapping requirements of the management systems: EMAS includes ISO 14001 completely. Many of the requirements made according to ISO 50001 are met by EMAS and ISO 14001.

6 https://www.bafa.de/EN/Home/home_node.html;jsessionid=5A1E250FAD2362816FFE01DE13F6FAD9.1_cid387

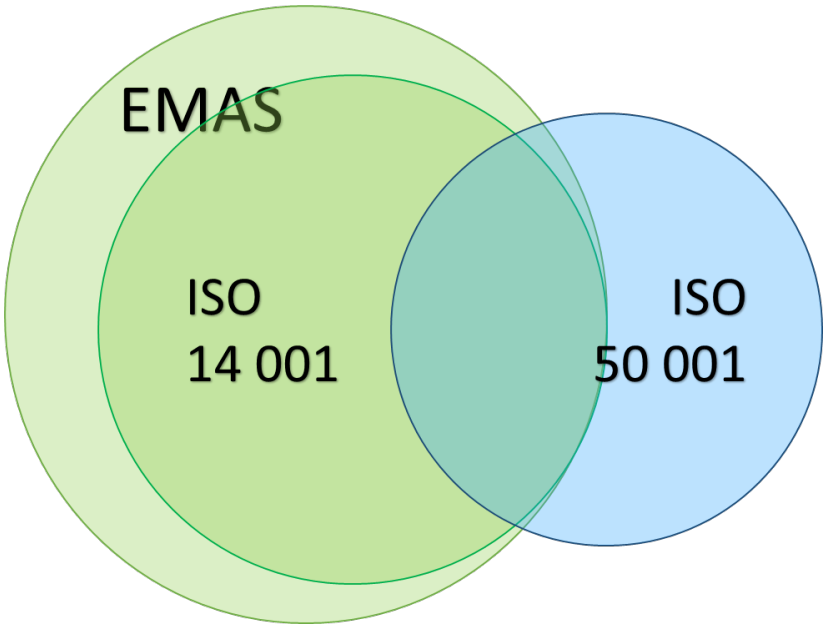


Figure 3: EMAS, ISO 14001, and ISO 50001

Comparison between EMAS and ISO 50001

EMAS can also be supplemented by an energy management system according to ISO 50001, which makes sense in computing centers, with their high energy consumption, because energy use is a very significant environmental consideration. Since EMAS already contains many requirements of ISO 50001, any additional effort is limited. Your environmental verifier can check your management system according to both EMAS and ISO 50001. Because: *"According to § 9 (3) of the Environmental Audit Act, accredited EMAS environmental verifiers are authorized to issue certificates according to DIN EN ISO 50001."* (Geschäftsstelle des Umweltgutachterausschusses (Hrsg.), Juli 2015).

Tip:

Meeting the requirements of ISO 50001 by EMAS

In the brochure "EMAS and Energy Management" from the European union 2013 (https://ec.europa.eu/environment/emas/pdf/factsheets/EMAS_Energy_Management.pdf) you will find a table that demonstrates the extent to which EMAS already meets the requirements of ISO 50001.

Tip:

Joint audit according to EMAS, ISO 14001, and ISO 50001

If your business is international, it makes sense to have your environmental management system certified according to the international standard ISO 14 001 in addition to EMAS. Since EMAS contains all the requirements of ISO 14001, this requires no additional effort. There are only minor extra charges to have the additional certificate issued by the environmental verifier.

Since the operation of computing centers is very energy-intensive, you should consider whether you want to have ISO 50001 certification for energy management from the beginning. A joint audit according to EMAS, ISO 14001, and 50001 by an environmental verifier would be cheaper than an individual certification of your environmental and energy management system.

Data center standard DIN EN 50600

The "Data center standard" DIN EN 50600 describes the general principles for the construction and design of computing centers. In addition to operational safety, energy efficiency also plays a significant role. Thus it provides a valuable basis for energy and environmental management systems to build upon in computing centers.

From Our Experience

Management systems for environment and energy at the HLRS

HLRS made the decision to establish an environmental management system according to EMAS (regulation (EC) No. 1221/2009) and to have it audited by an accredited environmental verifier. In addition, HLRS also requested a certificate according to ISO 14001.

By introducing a management system according to EMAS, our intention is to permanently anchor sustainability at HLRS. Recognizing the importance of the subject of “energy” at the High-Performance Computing Center, the environmental management system (EMS) developed in accordance with EMAS was supplemented by an energy management system based on ISO 50001 requirements.

To expand our environmental management system into a more comprehensive sustainability management system, social issues — such as a better balance of family and career and health at work — were also taken into account. The HLRS sustainability team works closely with the Uni & Family Service and the health management office at the University of Stuttgart.

Introduction of an environmental management system

Organizational requirements

In order to establish and maintain a management system, you need people to take care of the system. According to EMAS, an environmental management representative must be appointed for this purpose. Since the tasks of the representative are diverse and extensive, it is also a good idea to put together an environmental team to support him or her (see the section *Structure of the environmental management system)*.

Employee involvement

Experience has shown that it is a good idea to get the employees involved in the EMAS process as soon as possible. According to EMAS, employee involvement is explicitly required: *"Employee involvement is a basic requirement […] in the EMAS process: all employees must be included in the EMS."* (Zell, Carina et al.; Umweltgutachterausschuss (Hrsg.), 2015). In addition, employee involvement is a very important part of the ongoing improvement process.

HLRS sustainability workshop

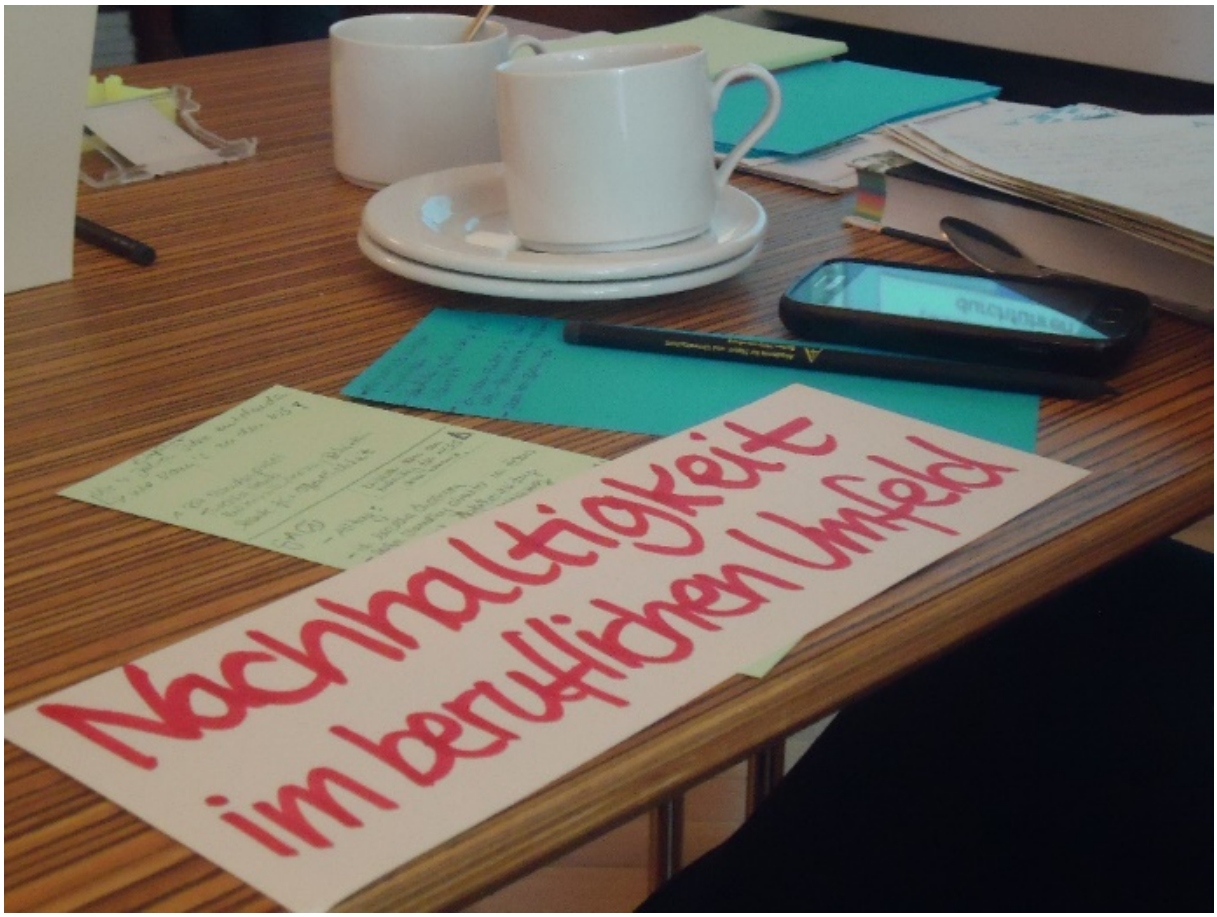
Tip: Employee involvement

The subjects of "sustainability" and "environmental protection" concern all employees, which is why they should be involved and also trained from the beginning when a management system is established.

Good suggestions for improvement often come from employees, because they are most familiar with the ways in which sustainability intersects with their daily work.

You can find good tips for employee involvement and motivation in the following guides:

- European Union, 2018: "CASE STUDY – Involving employees in implementing EMASBACKGROUND", May 2018 (https://ec.europa.eu/environment/emas/pdf/other/Case%20study_Involving%20employees.pdf)
- DIHK Service GmbH (publisher): "Praxisleitfaden Ideen für (noch) mehr Energieeffizienz & Klimaschutz. Mitarbeitende einbinden und motivieren" (Practical guide to ideas for (even) greater energy efficiency & climate protection. Involve and motivate employees), January 2019.
- Bavarian State Office for the Environment (publisher): "Mitarbeitermotivation für umweltbewusstes Verhalten, Ein Leitfaden für Umweltbeauftragte in Unternehmen" (Employee motivation for environmentally conscious conduct, a guide for environmental representatives in companies), November 2018.



Impression from an HLRS sustainability workshop "sustainability in the work environment"

From Our Experience

Employee involvement at the HLRS

At HLRS, all employees have been involved in the EMAS and ISO 50001 processes from the very beginning. An important part of the sustainability concept at the HLRS is training and cultivating awareness, motivation, and consciousness surrounding the subject of sustainability for all employees. Sustainability workshops have been held together with the Academy for Nature Preservation and Environmental Protection of Baden-Württemberg annually since 2014. Sustainability workshops have been held for department heads every year since 2011.

In addition, a series of lectures on "sustainability" was introduced at the HLRS. In this context, lectures on various sustainability issues have been offered regularly.

Important documents for management systems have been prepared and developed together with the employees as part of the sustainability workshops.

The chemist Linus Carl Pauling once said: "The best way to get a good idea is to have a lot of ideas."

Together with as many interested employees as possible, the HLRS sustainability team collected ideas on sustainability goals and concrete measures for their implementation, areas of responsibility and competence, and necessary resources. These ideas were recorded in a list of suggestions. Together with the department heads, the list of suggestions was developed into a sustainability program (see also *Determining the environmental program*). The workshops also addressed issues such as resource efficiency and future responsibility, and options for sustainable procurement, among others. The employees received training on the subjects, but were also expressly expected to provide their own expertise and ideas.

Plan-do-check-act cycle

An important aspect of management systems is the continual improvement process (CIP). This is based on the plan-do-check-act cycle (PDCA cycle), which also applies to EMAS.

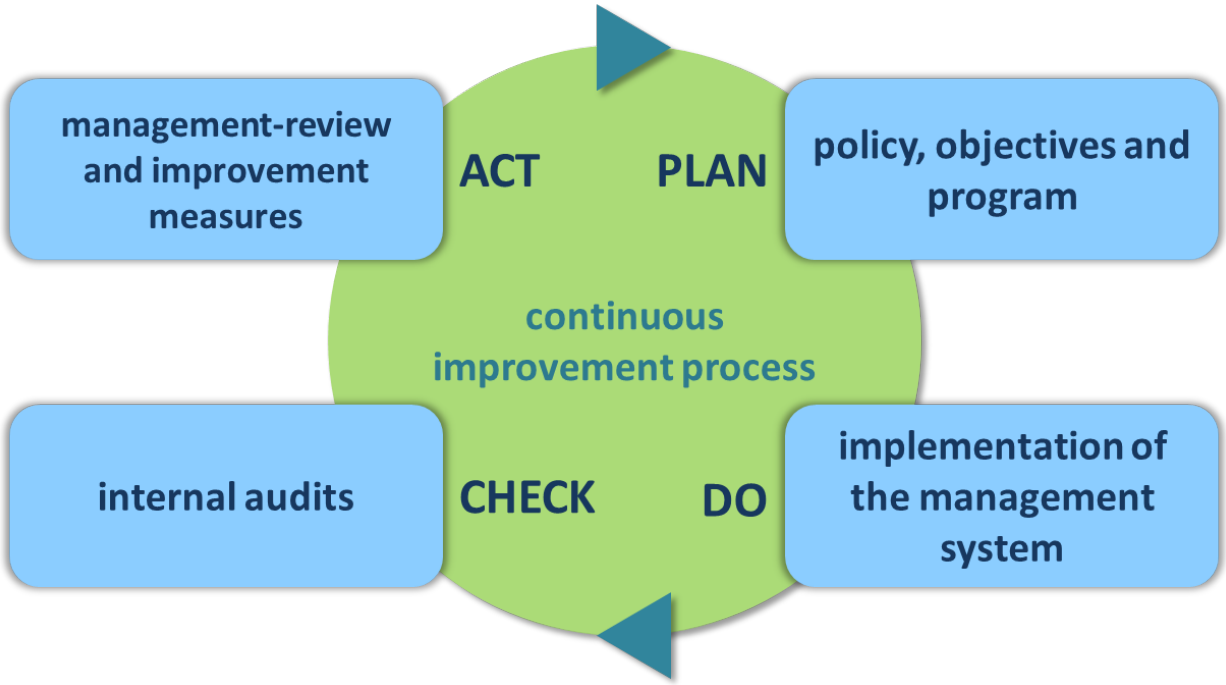


Figure 4: PDCA cycle

Explanation of the PDCA cycle (see Figure 4)

Plan – This includes establishing guidelines, goals, and a program.

Do – A management system is established and implemented.

Check – The functionality of the management system is checked by internal audits.

Act – The management of the business conducts an evaluation of the management system in a management review. Improvement and corrective measures are introduced. This sets a continual improvement process in motion.

Conducting the environmental review

According to the EMAS regulation, an environmental review must be conducted. This review is *"an initial comprehensive analysis of environmental aspects, environmental impacts, and environmental performance related to an organization's activities, products, and services* (regulation (EG) No. 1221/2009). Compliance with environmental law is also reviewed. A determination is made as to which environmental law requirements must be met by the computing center and a check is made to determine whether they are being met.

In 2017, an amendment to the EMAS regulation added further requirements for the environmental review (see Annex I to the regulation (EU) 2017/1505). These new subjects involve determining the context, the interested parties (stakeholders), and opportunities and risks, as well as strengthening the assessment of product lifecycles.

In addition, the environmental review also includes the identification of the applicable environmental legislation. To do this, you must create a list of the legal requirements that apply to your organization and indicate how you can provide evidence that the organization is in compliance.

You must also identify which direct and indirect environmental aspects have a significant impact on the environment. This includes both qualitative and quantitative assessment as appropriate. In addition, a register of the aspects identified as significant is to be compiled.

According to EMAS, the following issues are considered in assessing the significance of an environmental aspect:

- The potential to cause environmental harm
- The fragility of the local, regional, or global environment
- The size, number, frequency, and reversibility of the aspects or impacts
- The existence and requirements of relevant environmental legislation
- The significance to the stakeholders and employees of the organization

EMAS distinguishes between direct and indirect environmental aspects:

"Direct environmental aspects are associated with activities, products, and services of the organization itself over which it has direct management control."

"Indirect environmental aspects can result from the interaction of an organization with third parties which can to a reasonable degree be influenced by the organization seeking EMAS registration. For non-industrial organizations, such as local authorities or financial institutions, it is essential that they also consider the environmental aspects associated with their core business" (Europäische Kommission, Nov. 2009).

Direct environmental aspects relate to, but are not limited to:

- Legal requirements and permit limits
- Emissions to air
- Use of natural resources and raw materials (including energy)
- Releases to water
- Production, recycling, reuse, transportation and disposal of solid and other wastes, particularly hazardous wastes
- Use and contamination of land
- Transport issues (both for goods and services)
- Risks of environmental accidents and impacts
- Effects on biodiversity

Indirect environmental aspects relate to, but are not limited to:

- Product lifecycle related issues (design, development, packaging, transportation, use and reuse/disposal)
- Choice and composition of services

- Administrative and planning decisions
- The environmental performance and practices of contractors, subcontractors, and suppliers

For the direct environmental aspects, you must consider key areas such as energy efficiency, material efficiency, water, waste, biodiversity and emissions.

For the areas that you have deemed to be significant for your computing center, you must define key figures (so-called core indicators). These key figures must be published in the environmental statement. If you believe that one or more of the core indicators listed in Fig. 5 is/are not critical to your computing center, you must justify this view.

Since the environmental aspect of "energy" is very significant for computing centers, you should indicate further key figures specific to the computing center in addition to the key figures shown in Fig. 5. For example, you can find useful key figures for computing centers, in the award criteria for the Blue Angel ecolabel for "Energy-efficient data center operation" (DE-UZ-161) or in the Bitkom guidelines "Energy efficiency in data centers" (Bitkom e.V. , 2015).

Key areas	Core indicators
Energy efficiency	Total annual energy consumption expressed in MWh or GJ, total consumption of renewable energies with indication of the percentage of energy from renewable energy sources in the total annual consumption (electricity and heat)
Material efficiency	Annual mass-flow of different materials used (excluding energy carriers and water) expressed in tons
Water	Total annual water consumption expressed in m^3
Waste	Total annual generation of waste broken down by type, expressed in tons, total annual generation of hazardous waste expressed in kilograms or tons
Biodiversity	Use of land expressed in m^2 of built-up area
Emissions	Total annual emission of greenhouse gases, including at least emissions of CO2, methane (CH4), nitrous oxide (N2O), perfluorocarbon, hydrofluorocarbon, and sulfur hexafluoride (SF6), expressed in tons of CO2 equivalent Total annual air emission expressed in kilograms or tons, including at least emissions of sulfur dioxide (SO2), nitrogen oxide (NOx) and particulate matter (PM)

Figure 5: Key areas and core indicators for environmental reporting,

according to: (Geschäftsstelle des Umweltgutachterausschusses, Okt. 2012)

Determining the context of the organization

According to EMAS and ISO 14001, the context of the organization must be determined. "Context" is understood to be subjects related to the organization, such as limited human resources and technological capacities within the organization, an increasingly critical public, as well as increasing regulatory pressure or extreme weather events (see also: EMAS Novelle 2017/2019, Die Änderungen im Überblick (EMAS amendment 2017/2019, The changes at a glance) (Umweltgutachterausschuss beim Bundesumweltministerium, Januar 2019)).

Examples of internal and external subjects according to ISO 14001 are:

- Environmental conditions related to climate, air quality, water quality, land use
- Availability of natural resources
- Competitive circumstances (e.g. political, legal, financial, and technological)
- Features of the organization (e.g. activities, products, and services)

From Our Experience: Organizational context of HLRS

At HLRS and IHR, the subjects that constitute the HLRS environment were determined first. In addition, the dependencies and the relevance of the subjects were also determined.

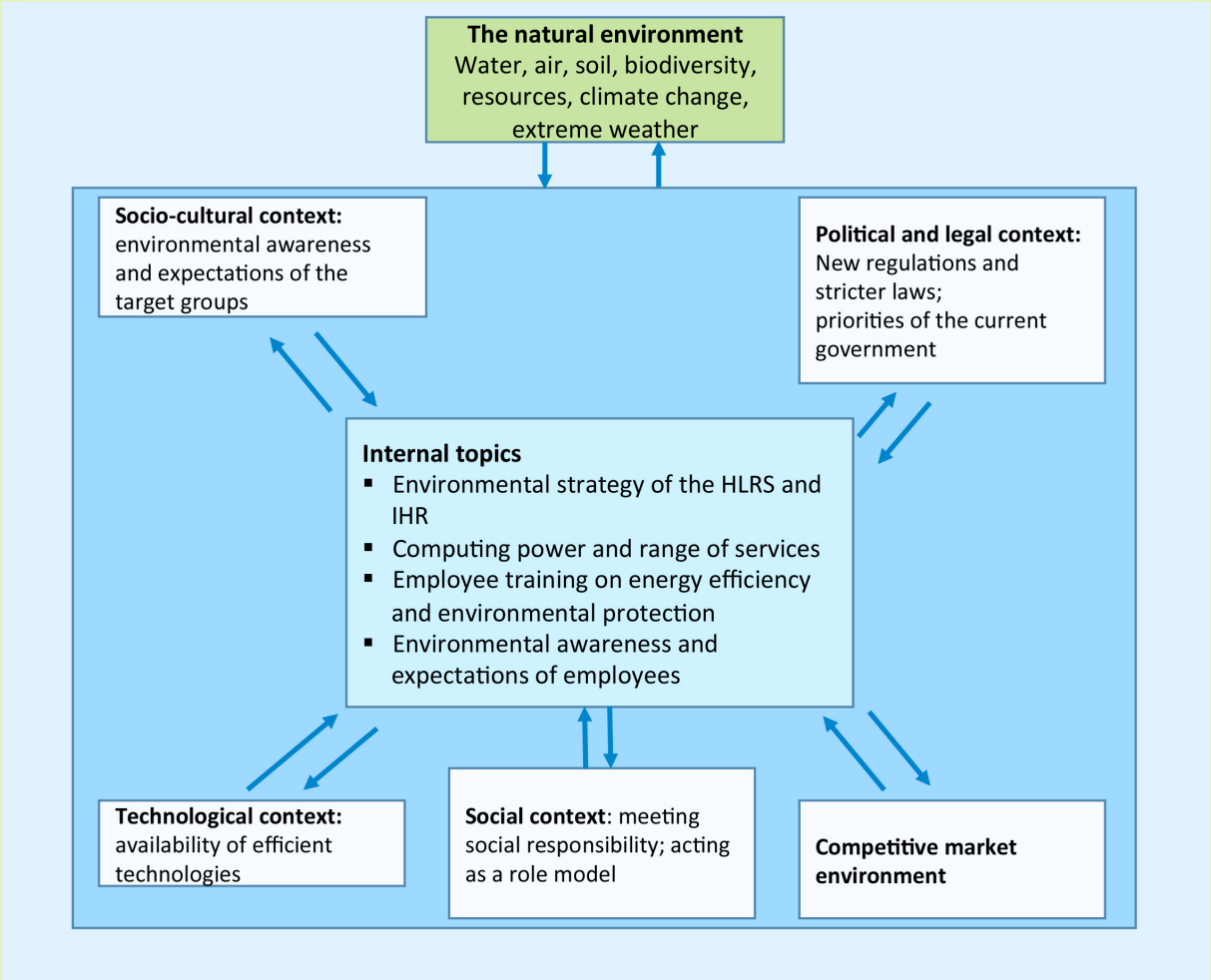


Figure 6: Organizational context at the HLRS

Stakeholder determination in an organizational context

The internal and external stakeholders must be determined in an organizational context. Their expectations and requirements in connection with environmental concerns are recorded here.

From Our Experience: Stakeholder determination in an organizational context at the HLRS

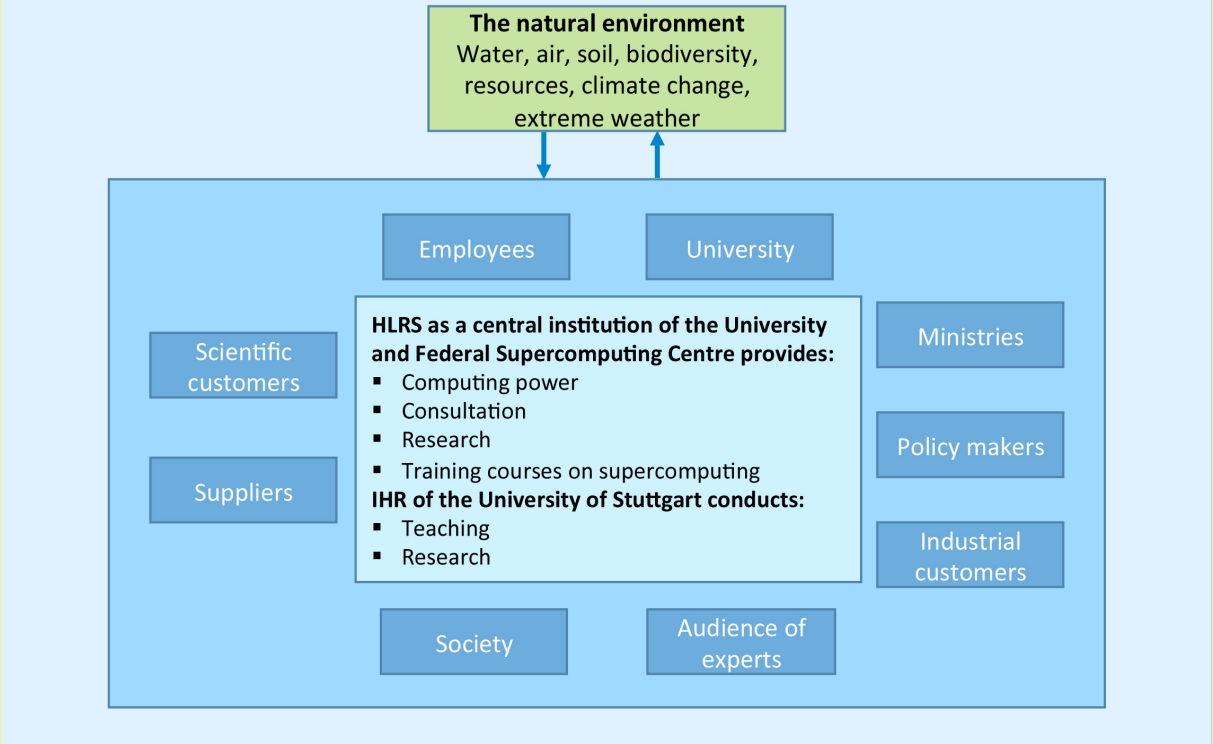


Figure 7: The most important internal and external stakeholders of the HLRS

From Our Experience

Stakeholders and their requirements and expectations

At the HLRS and IHR, the stakeholders and their requirements and expectations were determined in workshops for department heads. An excerpt of the results can be found in Fig. 8:

Stakeholder	Requirements and expectations	Consideration / possible activities
Customers (scientific and industrial customers)	Computing time for scientific customers is allocated by the steering committee; cooperation with local industry	Taking sustainability criteria into account when allocating computing time
University	Compliance with the guidelines of the University of Stuttgart, e.g. guidelines for waste and handling of substances hazardous to water	Ensure compliance with university guidelines, inclusion of the guidelines in the legal register
Employees	In workshops, employees participate actively in the sustainability initiative sharing their ideas; employees influence the environmental impact of the HLRS 1. directly through their own actions and 2. indirectly through customer training and motivation	Ideas competition for sustainability is in progress (note: a formal suggestion system already exists through the university); a plan for employee/staff development is in progress; motivational activities, regular training sessions, environmental awareness activities
Suppliers	There are very few providers for high-performance computers worldwide; It is not easy to take sustainability criteria into account in procurement (especially with regard to core ILO labor standards, resource conservation)	Ask providers if they have certifications in the field of environmental or energy management or a sustainability concept; if possible, include sustainability criteria in calls for bids by suppliers
Legislator / state	Environmental legislation and requirements in environmental protection	Compliance with laws and regulations, action required in the case of changes to laws and new regulations; Maintain legal register. Active participation in drafting legal requirements
Ministries	Expectation of the Ministry of Science: Achievement of the "Sustainability in HPC Centers II" project goals	Implementation of the project goals
Society / professional public	There is a sociopolitical advisory board; the professional public is important	Better involvement of the sociopolitical advisory board; regular communication with the public
Residents	HLRS and IHR strive for a good relationship with their neighbors	Engage in dialogue with others in the local community

Figure 8: Stakeholders and their requirements and expectations (excerpt)

Environmental aspects and their effects

Assessment of environmental impacts

All environmental areas relevant to the computing center, such as energy, water, waste water, and solid waste are examined within the context of an environmental review. Criteria are defined based on a determination of the essential environmental impacts produced by the computing center. It is a good idea to consider the quantitative significance of an environmental aspect, how great the hazard potential is, and how the aspect is predicted to develop in the future.

The German Environment Agency (UBA) has developed a procedure for evaluating environmental aspects (see UBA environmental statements for 2004 and 2007). The evaluation scheme for environmental relevance can be found in Fig. 9.

The evaluation is based on the ABC scheme. In terms of the quantitative significance and the hazard potential, A stands for high, B for average, and C for low. In terms of the predicted future development, A stands for increasing, B for stagnant, and C for decreasing.

Example of an evaluation: For example, if an environmental aspect has a high quantitative significance as well as a high hazard potential, and in addition, a stagnant predicted future development, its environmental relevance is evaluated as A (see Fig. 9; note: the result of the example is marked in green).

Quantitative significance	**Predicted future development**	**Hazard potential**		
		High (A)	Average (B)	Low (C)
High (A)	Increasing (A)	A	A	B
	Stagnant (B)	A	B	B
	Decreasing (C)	B	B	B
Average (B)	Increasing (A)	A	B	B
	Stagnant (B)	B	C	C
	Decreasing (C)	B	C	C
Low (C)	Increasing (A)	B	B	B
	Stagnant (B)	B	C	C
	Decreasing (C)	B	C	C

Figure 9: Environmental relevance evaluation scheme

Influence evaluation scheme

In addition to the "environmental relevance" evaluation scheme, the German Environment Agency has developed an "influence" evaluation scheme. It can be used to evaluate how great the control potential of the environmental aspect is (see Fig. 10).

Influence evaluation scheme
It is broken down into:

I There is a relatively large control potential in the short term.

II The environmental aspect is to be managed sustainably, but only in the medium to long term.

III There are no control options for this environmental aspect, only on a very long-term basis, or only depending on decisions by third parties.

Figure 10: Influence evaluation scheme

An environmental aspect, for example, that is evaluated as A and I is a significant environmental aspect of high environmental relevance for which there is also a relatively large control potential in the short term. Goals and measures for environmental aspects determined to be significant are derived based on the influence.

Determining opportunities and risks

You must determine opportunities and risks in your computing center that are associated with:

- Environmental aspects
- Compliance obligations (such as legal environmental requirements or stakeholders' requirements that you have pledged to meet),
- Internal and external subjects (see determination of the organizational context) and
- Expectations of the stakeholders

(See also: German EMAS Advisory Board at the Federal Environment Ministry, Jan. 2019)

You can find examples of possible opportunities and risks in Figure 11.

Tip: Opportunities and risks – examples

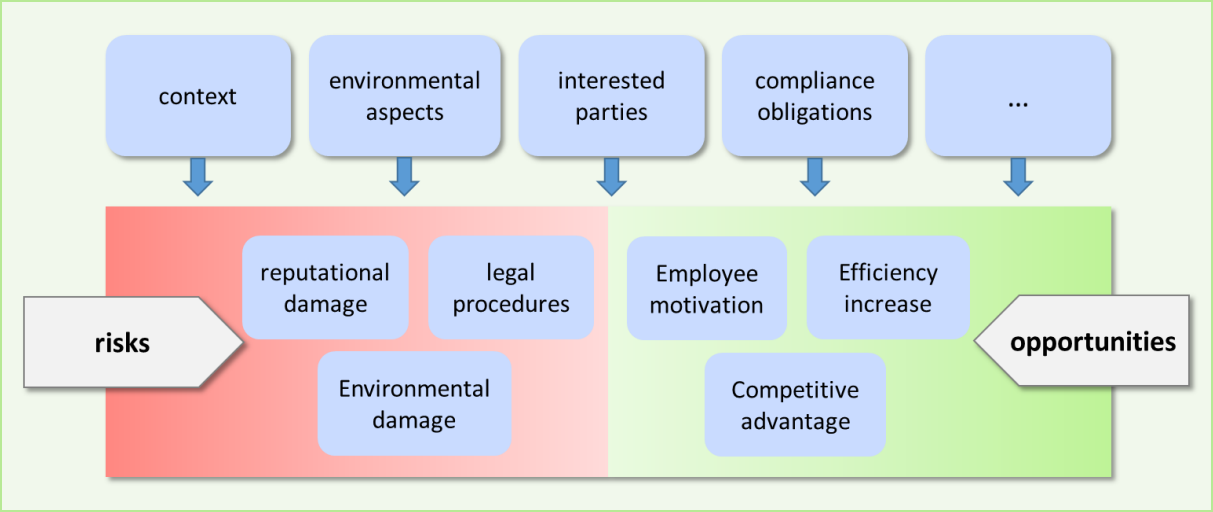


Figure 11: Examples of opportunities and risks, our presentation according to
(Umweltgutachterausschuss beim Bundesumweltministerium, Januar 2019)

Summary of the procedure:

You must determine or evaluate the following for the environmental aspects:

- Significance for the organization
- Possible activities
- Is it a compliance obligation?
- Opportunities and risks for the organization and the EMS

You must also carry out an evaluation of the environmental aspects. The evaluation is carried out based on three criteria:

- The relative quantitative significance of the environmental aspect
- The predicted future development of the environmental aspect
- The relative hazard potential of the environmental aspect

The significance of every environmental aspect results from the environmental relevance and influence (see Fig. 12).

From Our Experience

Evaluation of an environmental aspect

Note: The example below refers to the environmental aspect of *legal requirements*

Intent / requirement		42nd BImSchV (Federal Immission Control Act Ordinance on Evaporation Cooling Systems, Cooling Towers and Wet Separators)
Significance for the organization in general		Special requirements in individual legal areas
Possible activities		Comply with requirements by means of activities such as: regular laboratory tests of the industrial water, maintaining an operating log, performing a hazard assessment, employee training
Compliance obligation		Yes, because it is a legal requirement
Opportunities for the organization and the EMS		Legal and occupational safety ensured when complied with
Risks for the organization and the EMS		Health hazard for employees and residents if there is an increased number of *Legionella* and other germs; loss of image; contravention in the case of failure to comply with the 42nd BImSchV; revocation of the EMAS certificate for noncompliant operation
Evaluation of the environmental aspect	**Significance**	High
	Development	Increasing
	Hazard potential	High (if not complied with)
	Environmental relevance	**A**
	Influence	**I**
	Result	**A I**

Figure 12: Evaluation of an environmental aspect

Significant environmental aspect in computing centers: Energy

Computing centers are major consumers of energy. *"According to calculations by the Borderstep Institute, 2 percent of the total power consumption in Germany is attributed to computing centers."* (Hintemann, 2016).

Because of the large environmental impact of a computing center's energy usage, computing center operators should consider establishing an energy management system according to ISO 50001 in addition to an environmental management system according to EMAS. You can find more information on energy management systems according to ISO 50001 in the sections *Steps to an energy management system according to ISO 50001*.

Power consumption in the administration of the computing centers is rather low compared to the power consumed to operate the computers. Nevertheless, you should also make your employees aware of the significance of an efficient and economical use of energy in the office.

In addition to the key figures required by EMAS, you should also determine additional key figures specific to the computing center for the monitoring of energy efficiency.

HLRS central cooling unit

Energy indicators specific to the computing center

This section lists examples of useful key figures[7] for a computing center:

The energy indicator most commonly used in association with computing centers is the **power usage effectiveness (PUE)** or **energy usage effectiveness (EUE)**. It is used to show the relationship between the total energy consumed in the form of electricity by the computing center over a year and the power consumption of the IT systems. The smaller this value, the more efficient is the computing center.

$$\textbf{Power usage effectiveness (PUE)} = \frac{\textit{Total Electricity Consumption of the Data Center}}{\textit{Energy Consumption of IT Systems}}$$

The **carbon usage effectiveness (CUE)** figure indicates the ratio of carbon dioxide emissions from the computing center energy supply in relation to the energy requirement for IT in kilowatt hours (kWh). The unit for the CUE value is $kgCO_2/kWh$. The lower the CUE value, the less carbon dioxide is emitted by the computing center.

$$\textbf{Carbon usage effectiveness (CUE)} = \frac{\textit{CO}_2\ \textbf{Emissions from Total Energy Consumtion}}{\textit{Energy Consumption of IT Systems}}$$

Key figures for cooling and waste heat utilization

The annual coefficient of performance indicates the ratio of the cooling output over the year to the operating power consumed by a cooling system. So, larger values are better.

$$\textbf{Annual coefficient of performance (ACOP) total cooling} = \frac{\textit{Total Cooling Demand}}{\textbf{Total Electricity Demand for Cooling}}$$

[7] In ISO 50001 these key figures for energy performance are referred to as “energy performance indicators” (EnPIs). In business administration, they are also called “key performance indicators” (KPI).

If you use different systems for cooling the computers (e.g. compression cooling and free cooling), a separate ACOP can be indicated and evaluated for each.

If you use the waste heat from your computer with a heat pump, you can also enter the annual coefficient of performance of the heat pump here. This key figure indicates how efficiently the electricity is used to convert the low-energy waste heat from the computer into heating energy over a year.

Annual coefficient of performance (ACOP) for heat pump = $\frac{Output\ Thermal\ Energy}{Input\ Electrical\ Energy}$

If your computing center uses water for operation, e.g. for air humidification and, more importantly, for evaporation cooling systems, you should calculate the **water usage effectiveness (WUE)**. The WUE is the ratio of the annual water consumption to the energy consumption of the IT equipment. The lower the WUE value, the more efficiently the cooling works.

Water usage effectiveness (WUE) = $\frac{Water\ Demand}{Energy\ Demand\ for\ IT}$

From Our Experience

It is very important to make corrections in recorded measurements to account for annual weather variation so that the consumption values and the resulting key figures from different years can be compared realistically.

Additional significant environmental aspects

In this section we provide additional examples of significant environmental aspects in computing centers other than the major subject of energy consumption. It is important for you to do your own assessment of your computing center's environmental impacts. You should also evaluate the environmental impact and determine the opportunities and risks of each environmental aspect (see the section *Conducting the environmental review*).

Water and waste water

Using evaporation cooling systems to cool computers is more energy-efficient than dry cooling systems, but is also associated with high water consumption. In addition, when evaporation and hybrid cooling systems are being operated, the requirements of the 42nd BImSchV[8] must be complied with. To ensure that germs such as *Legionella* and others will not present any hazard for your employees and the population, internal tests for microbiological parameters of the industrial water must be carried out regularly (every 2 weeks) using rapid tests. The industrial water must be tested by accredited laboratories every three months. You must also keep an operations log. Additional requirements that you must meet can be found in the 42nd BImSchV.

Biocides are usually added to the cooling water to prevent contamination in evaporation cooling systems. Since these are substances that are hazardous to water, you must comply with the requirements of the Water Resources Act (WHG) and the Ordinance on Installations for the Handling of Substances Hazardous to Water (AwSV).

If you operate air conditioning systems with air humidification, they must be serviced, inspected, and cleaned regularly according to VDI 6022 to prevent contamination.

The coolant in refrigeration circuits very often contains glycol. This is a substance that is hazardous to water. The requirements of the WHG and the AwSV must be complied with.

Increasingly, modern high-performance computers contain a fluid-filled internal cooling circuit. Note that these coolants may contain hazardous substances or substances that cause water pollution. Even if the manufacturer is in charge of this circuit and the fluid used, the operator is responsible.

[8] Forty-second regulation to implement the Federal Immission Control Act (Federal Immission Control Act Ordinance on Evaporation Cooling Systems, Cooling Towers and Wet Separators - 42nd BImSchV).

From Our Experience

Water and waste water as significant environmental aspects at the HLRS

In addition to energy, the environmental areas of water and waste water also play an important role at HLRS. Much of HLRS's water consumption is due to the requirements of evaporation cooling systems. Cooling systems evaporate more than half the water required to operate the cooling towers. In addition, there is also the water required for desalination and flushing of the water filter. In order to achieve optimal operation of the cooling towers, the cooling water must be treated specially. This requires the addition of different chemicals: salt for the regeneration of the ion exchanger to decalcify the drinking water used, corrosion protection, as well as a biocide to prevent the formation of bacteria and algae.

Compliance with environmental legislation

In the description of the direct environmental aspects, we have already pointed out some important principles of environmental and labor law. But there is much more environmental legislation and other regulations relating to environmental protection (e.g. fire protection) that a computing center must comply with. EMAS stipulates that participating organizations must demonstrate compliance with the legal requirements by keeping and maintaining a legal register and by regularly carrying out a legal check, for example.

Tip: Legal register

You should involve your legal department in the creation and maintenance of a legal register.

Carrying out a legal check

In order to maintain an overview of relevant legal regulations, it is recommended that you maintain a legal register and keep it up to date.

Here is an example with possible contents of a legal register in the field of water law:

- **Legal level / legal area** (federal government: water law)
- **Name of the legal requirement** (Ordinance on Installations for the Handling of Substances Hazardous to Water (AwSV))
- **Requirement publication date** (April 18, 2017)
- **Scope** (installations for the handling of substances hazardous to water: classification of substances and mixtures, technical and organizational requirements of installations, experts, surveillance organizations, and professional auditors, specialized companies)
- **Significance for the computing center** (example: primary goal: substances that are hazardous to water must not be allowed to enter the soil or water; when handling substances that are hazardous to water, transferring them from one container to another, and transporting them, care must be taken to protect the environment and

employees; possible protective measures: collection trays, ground sealing, no drains; a facility register must be kept)

- **Most recent change to the legal requirement**
- **Legal basis for the change**
- **Source of the legal requirement** (Umwelt-online)
- **Responsibility in the computing center** (infrastructure)
- **Accountability in the computing center** (head of the computing center)

From Our Experience

Significant environmental laws and regulations for the HLRS

The following environmental laws and regulations are of special significance for the HLRS and IHR:

- 42nd regulation to implement the Federal Immission Control Act (42nd BImSchV)
- Energy Saving Ordinance
- F-Gas Regulation (compression refrigeration systems and heat pumps)
- Hazardous Substances Ordinance
- Commercial Waste Ordinance
- Circular Economy Act
- Ordinance on Installations for the Handling of Substances Hazardous to Water
- Baden-Württemberg state government administrative regulation on the awarding of public contracts

From Our Experience

Compliance with legal requirements at HLRS

Updating the HLRS legal register

At HLRS, the environmental law database of the Internet service provider “Umwelt-Online” is used to update the legal register. The attorney and the environmental management representative are automatically informed about legal changes on a regular basis with a personalized newsletter. The objective is always to be up to date to be able to comply with the applicable environmental laws and regulations at all times.

Waste

In order to conserve natural resources, the center follows principles of the circular economy. This means that waste prevention comes first, reuse second, and recycling third. If this is not possible, waste must be disposed of according to the requirements of the Closed Substance Cycle and Waste Management Act. Employees should be informed of the groups into which the waste is to be collected and separated. It is a good idea to create a waste concept for this purpose.

Disposal of hazardous waste

Old electronic devices (such as computers, laptops, printers, mainframes), used batteries, and rechargeable batteries fall under the category of hazardous waste. Refrigerants are also included in this category. The requirements of the Closed Substance Cycle and Waste Management Act, the Electrical and Electronic Equipment Act, and the Battery Act, as well as the associated regulations must be complied with when waste is disposed of. Especially the Ordinance on the European Waste List (Waste List Ordinance - AVV) must be complied with in the labeling of hazardous waste.

Greenhouse gases

If you use compression refrigeration systems or heat pumps, you must consider the damage to the climate by the refrigerants used. The F-Gas Regulation is an important legal requirement here.

Sustainable procurement

The subject of sustainable procurement is important when the lifecycle of products and services is considered. *"Under EMAS, the participants and lifecycle stages that an organization can influence directly or indirectly must be considered. A comprehensive lifecycle assessment of individual products or services is not required"* (Umweltgutachterausschuss beim Bundesumweltministerium, Jan. 2019).

Sustainable procurement of servers

Computing centers can influence environmental and sustainability criteria in the procurement and later disposal of servers. For example, during procurement you can request that providers supply information on the following points:

- Energy efficiency in terms of FLOPS per watt for HPC systems or SPEC SERT[9] values for commercial systems
- Return temperatures of the cooling system
- Provider's own activities in the area of sustainability (e.g. sustainability program, sustainability report)
- How hazardous materials are prevented in addition to the ROHS (Reduction Of Hazardous Substances) regulations
- Information on the extent to which the software offered monitors and improves the energy efficiency of the system
- Information from the provider on national or international certifications (e.g. EMAS or ISO 14001)
- Additional specific sustainability requirements of your computing center

[9] https://www.spec.org/sert/

Before you invite bids for the purchase of new computers, together with the environmental management representative, and if applicable, the environmental team, you should determine which sustainability criteria should be requested and how they are to be evaluated.

Sustainable procurement in the office

There are many guidelines that offer good tips on the subject of sustainable procurement. Here, you can also find out how sustainability aspects can be taken into account and evaluated in the procurement process. Attention should be given to energy efficiency in the procurement of office IT.

The use of recycled paper should be self-evident in EMAS businesses. Today, recycled paper is available in various degrees of whiteness according to ISO 2470 (60% to 100% whiteness). *"From an ecological standpoint, paper should be only as white as necessary, because a higher whiteness means more complex treatment steps (bleaching) and greater fiber losses due to these additional processing steps"* (Umweltbundesamt (Hrsg.), Juli 2015). The German Environment Agency provides the following information with respect to the durability of recycled paper: *"In terms of service life, recycled paper is in no way inferior to virgin fiber paper. […] Based on current knowledge, papers with the Blue Angel label have an anticipated duration of almost 100 years. But many public documents in administrative offices are required to be kept only for a few years to decades"* (Umweltbundesamt, 2019).

Tip: Guidelines for sustainable procurement

There are extensive information and guidelines on sustainable procurement, for example, from the German Environment Agency and at the Competence Center for Sustainable Procurement at the Procurement Agency of the Federal Ministry of the Interior.

See also: https://www.umweltbundesamt.de/en and

www.nachhaltige-beschaffung.info/DE/Home/home_node.html

From Our Experience

Procurement of office IT at HLRS

Much of the IT equipment for the offices at HLRS was acquired via the University of Freiburg. This is also useful for other university institutions from Baden-Württemberg. The University of Freiburg invites bids for the purchase of PCs and notebook and workstation systems on behalf of the state of Baden-Württemberg for use at the state's universities. It places particular importance on the energy efficiency of the equipment. In addition, this bundling of the order volume by all institutions of higher learning in Baden-Württemberg can also achieve a very good price-performance ratio.

For non-university computing centers, it is useful to obtain information on the sustainable procurement of office IT from the Competence Center for Sustainable Procurement at the Procurement Agency of the German Federal Ministry of the Interior. For this purpose, the Competence Center has published a special information leaflet “Information zur Nachhaltigkeit für die Produktgruppe Informationstechnik”.

Emergency preparedness and occupational safety

Safety for humans and the environment is a consideration of every environmental management system, located at the intersection of environmental protection, occupational safety, and health protection. Preventive protection has the highest priority. It is necessary to identify and eliminate potential hazards or defects that can lead to health impairments or damage to the environment. To this end, safety inspections must be carried out regularly by the occupational safety specialist, the fire prevention officer, the company doctor, and the staff council representative. These inspections focus on things like escape and emergency routes, fire protection, and first aid material. Emergency preparedness and occupational safety are also reviewed in internal audits. In addition, you must appoint a safety representative who regularly attends courses on occupational safety for your computing center.

Hazard assessments are to be carried out for each work area. Operating instructions must be created for the handling of hazardous substances and for work on systems that can pose hazards, such as evaporation cooling systems. Employee safety training based on the operating instructions, for example, must be given regularly (at least once a year). *"Instruction must be given before the employee starts work, when an employee is hired, when an employee's duties change, and when new work equipment or technology is introduced"* (https://www.bfga.de/arbeitsschutz-lexikon-von-a-bis-z/fachbegriffe-s-u/unterweisung-fachbegriff/, 19.12.2019, 09:14). These instructions are required by § 12 of the Working Conditions Act and must be documented in writing and signed by the employees.

Noise

If there are complaints by residents about noise pollution from cooling systems, for example, you should act and take measures for noise abatement.

From Our Experience

Preventive noise control at the HLRS

Noise control was installed in the evaporation cooling systems as a preventive measure, for example.

Noise control for employees

Noise is one of the most common hazards in the workplace and *"can have an impact on both physical and mental well-being"* (see: https://www.ergonomie-am-arbeitsplatz-24.de/laerm-und-laermbelaestigung/). If noise exposure levels regularly reach above 80 db(A) in your server rooms, hearing protection must be provided to the employees and a medical check-up must be offered. If daily noise exposure levels exceed 80 dB(A), additional measures, such as the labeling of the noise hazardous zones, must be taken. At values above 85 dB(A), additional measures, such as the creation of a noise reduction program and monitoring of the wearing of hearing protection, will become necessary (see also: section 3 "Action values and noise protection measures" of the Noise and Vibrations Occupational Safety and Health Ordinance of March 6, 2007, last amended on October 18, 2017).

Mobility

The state of Baden-Württemberg considers itself an innovator in the field of sustainable mobility. For example, the state subsidizes the "JobTicket BW" transit pass for employees in the public sector. *"Baden-Württemberg is the first federal state to introduce a comprehensive subsidized transit pass for its employees. 'JobTicket BW' is intended to be an important incentive for many state employees to switch from cars to buses and trains"*[10]

In addition to bus and rail transport, cycling or walking are good environmentally friendly alternatives to the car – if the distance is not too great. Carpooling is also more environmentally friendly than driving to work alone. It might be possible for you to establish a carpool exchange at your computing center.

[10] *https://vm.baden-wuerttemberg.de/de/politik-zukunft/nachhaltige-mobilitaet/mobilitaetsmanagement/jobticket-bw/; December 6, 2019, 1:43 p.m.*

From Our Experience

Mobility – promoting environmentally friendly commuting

At the University of Stuttgart, and thus also at HLRS, the employees' commute by public transport is subsidized by the state. Employees can purchase a "JobTicket BW" transit pass (see above)

Mobile on a bicycle

HLRS has a covered bicycle parking space near the entrance for cyclists. There is a shower that can be used by bicycle riders.

Biodiversity

Your computing center can make an important contribution to the protection and development of local biodiversity by designing natural outdoor landscaping. This can provide valuable refuge areas for plants and animals. The possibilities here are diverse. For example, you can create a wildflower strip or a larger wildflower meadow. Rooftops and façades can also be included in the greening efforts. A green environment is also good for the employees, because lunch breaks in the green can make an important contribution to relaxation and stress relief.

Tip: Designing natural landscapes

You can find suggestions for designing natural landscapes from the following brochures:

- *Wege zum naturnahen Firmengelände* (Paths to a natural company site close to nature) (Bundesamt für Naturschutz (Hrsg.), Juli 2015)
- *Unternehmen Natur, Naturnahe Gestaltung von Firmenflächen – Worin liegt der Mehrwert für Natur und Wirtschaft?* (Nature company, natural design of company space – what is the added value for nature and the economy?) (Bayerische Akademie für Naturschutz und Landschaftspflege (Hrsg.) , Mai 2018)
- *Moderne Unternehmen im Einklang mit der Natur – Leitfaden für ein naturnahes Betriebsgelände* (Modern companies in harmony with nature – guidelines for a natural company site) (Landesanstalt für Umwelt, Messungen und Naturschutz BW (Hrsg.), Jan. 2013)
- EMAS & Biodiversity – How to address biodiversity protection through environmental management systems (Publisher: Lake Constance Foundation (LCF) and Global Nature Fund (GNF), Germany With contributions from European Commission, DG Environment, Dec. 2016) https://ec.europa.eu/environment/emas/pdf/other/EMAS_Biodiversity_Guidelines_2016.pdf

From Our Experience

Lawn and early bloomers at the HLRS

A lawn containing plants such as yarrow, daisies, dandelions, prunellas, various types of clover, and meadow sage, in addition to grasses, was planted around the HLRS / IHR. The lawn is not cut too often in order to ensure that the plants will blossom. This way, the flowering plants can serve as food for bees and other insects. A wildflower strip was also created to provide a source of food for insects.

Early bloomers were planted at the HLRS / IHR to increase species diversity. A large planting campaign took place to accomplish this. Employees contributed to the planting of thousands of crocuses and daffodils around the building over the course of a multi-day campaign.

Flowering lawn in front of the HLRS

Determining the environmental policy

EMAS requires the development of an environmental policy. This policy defines the company's primary environmental goals.

The environmental policy:

- Offers an action framework for the concrete environmental goals and environmental program
- Contains a commitment to comply with the legal requirements and
- A commitment to improve the environmental performance continuously
- It is shared with all employees and made available to the public.

This can be done in the form of environmental guidelines. According to EMAS requirements, the environmental policy is determined by management (computing center management).

From Our Experience

Development of sustainability and energy guidelines

The HLRS sustainability guidelines were adopted in August 2015. They contain environmental guidelines in accordance with EMAS requirements. Due to its close association with HLRS, the IHR was included in the sustainability guidelines in the EMAS process in June 2018. Because operating high-performance computers at HLRS is especially energy-intensive, additional energy guidelines were also determined for HLRS. The guidelines were adopted by HLRS's director and management. The sustainability and energy guidelines specify the primary goals on which HLRS and IHR want to base their actions.

Form our Experience:

Sustainability policy for HLRS and the IHR

(Management board resolution of August 5, 2015, extended to include the IHR on June 20, 2018, updated on June 16, 2020)

Corporate responsibility for sustainable action

We at the High-Performance Computing Center of the University of Stuttgart and the Institute for High Performance Computing (IHR) take responsibility for acting sustainably.

We are committed to continual improvement of environmental and climate protection. For this reason, we see applicable laws and regulations as minimum requirements and aspire to exceed them whenever possible. To achieve this, we have introduced a documented sustainability management system and have established sustainability goals and measures for achieving them that will develop further over time. We regularly record and evaluate our achievements in the area of sustainability as well as effects of our activities on the environment.

Responsible use of resources and avoidance of pollution

We place high value on the economical and efficient use of all resources and intend to improve energy efficiency. Whenever it is economically feasible, we deploy the best available technology for optimizing the cooling and energy consumption of our high-performance computing systems and for reusing the resulting waste heat.

We pay attention to the reusability and possibilities for the recycling of all technologies that we use and consider ecological perspectives during their procurement and disposal.

We are committed to avoiding negative impacts on the environment and health, or at least to reduce them to a minimum. To the extent that we have influence, we use environmentally friendly materials during construction and renovation and are dedicated to creating good living conditions for plants and animals on the property surrounding our buildings.

Research and teaching

High-performance computing offers many opportunities to conserve energy and resources. We want to intensify sustainability research and increase the number of projects focused on sustainability-related topics. We perform and support simulation research addressing the themes of energy, health, mobility, and environment and make our own contributions in these areas.

We include our knowledge and experience in the field of sustainability in our teaching activities, particularly in the area of energy efficient usage of high-performance computing systems.

Engagement with HLRS employees

We want to embed sustainability as a matter of course in the thoughts and actions of all of our employees, and place a high value on the dissemination of information related to sustainability in our internal and external training activities, as well as additional education measures. Our employees are included in discussions surrounding the establishment and implementation of our sustainability goals.

Work environment and employee health

Within the framework of the University of Stuttgart we promote the health of our employees. We want to create a family-friendly work atmosphere and strive to enable stable along-term employment.

HLRS as a role model

Through our engagement with sustainability we aim to become a role model for other high-performance computing centers.

IHR as a role model

We would like to act as a role model in teaching in the area of sustainability for the University of Stuttgart.

Providing information regularly

We maintain an open dialog with our stakeholders and publish a sustainability report regularly.

Early bloomers (daffodils) in front of the HLRS

From Our Experience

HLRS energy policy

(Resolved by the advisory board on June 14, 2016; updated June 16, 2020)

To ensure sustainable development of the HLRS, it is our responsibility to minimize energy consumption within the bounds of technical and economic constraints. Continuous improvement of energy efficiency is a precondition for achieving this goal. We have implemented an energy management system, including defining strategic and operational targets to optimize our energy balance as well as measures to achieve them. Our adherence to energy targets is checked regularly and documented based on energy performance indicators.

Achievement of energy management system targets is supported by transparent information sharing and the allocation of necessary resources (manpower, special skills, technical and financial support).

We consider economical energy consumption in the operation and purchase of devices, especially for high-performance computers, cooling facilities, and the provision of services. We actively involve our employees in our energy management system. They are informed regularly about energy targets, measures we are undertaking, and accomplishments of the energy management system. Employees have opportunities to suggest and support new ideas for saving energy.

We train our employees regularly in energy-conscious behavior and encourage them to incorporate these measures into their daily work.

Determining the environmental program

According to EMAS, an environmental program must be determined. This usually contains:

- Environmental goals
- Measures to achieve the goals
- Necessary resources such as financial and human resources
- Those responsible for and in charge of the implementation of the measures, and
- Deadlines for implementing the goals
- The priority of the goals

Achieving the goals

At least once a year, an internal environmental audit[11] is carried out to determine whether the goals have been achieved on time. A check is also made to compare actual conditions and targets to measure the degree to which each goal was achieved. Likewise, the successes of measures that are implemented on an "ongoing" basis should be recorded regularly. If applicable, the reasons that led to a failure to achieve goals should also be examined and documented. It might be possible that circumstances have changed and the goals and measures to achieve them must be reconsidered and restated.

Tip:

Give your employees the opportunity to contribute to the development of the environmental policy and goals from the beginning. For example, this can be done in workshops in which suggestions for the goals are collected and a first draft of the environmental policy can be discussed. This will allow you to achieve greater acceptance of EMAS in the company.

[11] Internal environmental audit: corresponds to the internal environmental audit according to EMAS.

From Our Experience: Excerpt from the 2018 to 2021 sustainability and environmental program for HLRS and IHR

Field of action	Sustainability goal	Measure	Resources / estimated costs	Responsible / in charge	Date	Priority
Waste	Better waste separation	Encourage employees to separate waste and integrate "new employees" in the process	Organizational	Administration	2019	**A**
	Waste prevention	Check whether 10- or 12-year batteries are being used in the uninterruptible power supplies instead of 5-year batteries and put into practice if necessary	Approximately 36% higher investment costs per battery	Infrastructure	2019	**B**
Procurement	Conversion to environmentally friendly printed products	Obtain appropriate offers from printers; Print the *Inside* magazine, sustainability report, annual report, flyers, and invitations on recycled paper, preferably with environmentally friendly inks	3 - 5 person-days	Administration / COIN + central administration	2019	**B**
	Utilization of servers and mainframes	1) Reuse old servers for less demanding tasks 2) Consider manufacturers' reuse and recycling of HPC hardware in purchasing decision-making	Low	Software & Systems/ HPCN Production	Ongoing	**B**
Energy	Reduce energy consumption	Encourage energy-efficient behavior of employees in the workplace: - Conduct regular training sessions / presentations - Offer power strips with switches	5 person-days	Administration, support by infrastructure & sustainability team	Ongoing	**A**
	Energy-efficient cooling	Chilled water buffer tank for more stable operation of equipment	New construction in budget for 2023	Infrastructure	2023	**A**
		Increase the proportion of free cooling by dividing the cooling circuit into two circuits and maintain a higher temperature in the computer circuit	Budget for reconstruction for new Hawk computer	Infrastructure	2020	**A**

Field of action	Sustainability goal	Measure	Resources / estimated costs	Responsible / in charge	Date	Priority
Research	Energy efficiency from high-performance computing Energy-efficient high-performance computing	- Increase in research activities that enable better energy efficiency in the area of production processes - Increase in research activities to improve the efficiency of high-performance computing	Organizational	Manager	Ongoing	**B**
Communication	Improve sustainability communication	Better information about sustainability: - Develop internal and external communications concept - Set up our own sustainability page on the HLRS homepage and keep it current	Organizational	Administration / Communications & Industrial Trainings (COIN) + sustainability team	Ongoing	**A**
Mobility	Promotion of sustainable mobility	Establishment of a carpool exchange	5 person-days	Administration / COIN + sustainability team	2019	**A**
Training	More efficient use of the high-performance computer	Expand customer training to include the subject of energy efficiency in programming	Duty	Software & Systems / Parallel Computing, Training & Application Services	Ongoing	**A**
	Employee involvement, employee motivation	Conduct sustainability competition for new ideas	Organizational	Infrastructure / sustainability team	2020	**A**
Water	Reduce water consumption	Water saving in evaporation cooling systems: - Regulation and coarse filter for cooling tower filter: - Switch from fixed intervals to needs-based intervals	Organizational	Infrastructure	2020	**A**

Abbreviations: COIN: Communication & Industrial Trainings department of the HLRS; NHK: Sustainability
ITW: Institute for Thermodynamics and Heat Technology at the University of Stuttgart

Structure of the environmental management system

After you have established an environmental program, you can begin to develop a formal structure of the environmental management system (EMS). To do this, you must define roles, responsibilities, and authorities in environmental protection. This can be done in the form of a responsibility matrix. A clear assignment of responsibilities and authorities will assure the functioning of the environmental management system and ensure that everyone knows his or her duties well. The management of the computing center is ultimately responsible for the environmental management system. The management of the computing center must *"ensure that the resources required for the EMS, such as the necessary human resources and special skills, infrastructure as well as technical and financial resources, are available. Tasks, responsibilities, and decision-making authority must be defined, documented, and communicated"* (Geschäftsstelle des Umweltgutachterausschusses, Okt. 2012). In order for a management system to work, it is important for the management of the computing center to act as a role model in environmental protection and support the environmental management representative in his or her work.

EMAS requires that an environmental management representative be appointed in writing. He or she coordinates the management system, is the contact person for environmental issues in the computing center, and reports to management concerning the environmental benefits produced and the performance of the EMS. Environmental management representatives are often referred to as "caretakers" for environmental protection. The duties of the environmental management representative must be made known to the employees.

Duties of the environmental management representative:

- Establish, maintain, and further develop the environmental management system
- Integrate the environmental management system into the overall concept of the company
- Monitor compliance with environmental policies and long-term environmental goals
- Review compliance with the relevant legal and administrative regulations together with the computing center attorney
- Conduct internal environmental audits

- Manage the environmental team
- Prepare the environmental statement
- Create and maintain an environmental management manual
- Represent the environmental management system publicly

The environmental management representative should take part in regular training to keep up to date with innovations in the areas of environmental protection, environmental law and EMAS.

Tip: Forming an environmental team

It is recommended that an environmental team be formed to support the environmental management representative. In order for the team to work well, it requires adequate motivation and expertise. It is also important for the team to receive the full support of the computing center management.

Internal environmental audits

Internal audits are an important part of the continual improvement process (CIP) of the management system. According to EMAS and ISO 14001, regular audits – at least once a year – are mandatory.

The EMAS regulation defines the internal environmental audit as follows: An *"environmental audit [is] the systematic, documented, regular, and objective evaluation of the environmental performance of an organization, the management system, and processes for the protection of the environment."*

The goals of the internal environmental audit include:

- To examine the effectiveness of the management system
- To improve the management system
- To determine whether the management system is consistent with the environmental guidelines and the environmental program
- To determine whether environmental regulations are being complied with

Environmental audits are carried out by inspecting the building(s) and, if necessary, interviewing employees and reviewing environmentally relevant documents (such as inspection documents for equipment).

The environmental management representative is responsible for carrying out internal environmental audits (at least once a year). He or she arranges the audit team in such a way that all the audited areas are covered.

The results of the audits are recorded in writing. An audit report must be produced at the end of the environmental audit. It has the following functions:

- Documentation of the recorded scope of the audit
- Information regarding compliance with environmental guidelines
- Information regarding the extent to which the environmental goals were implemented
- Information regarding the effectiveness of the regulations used to monitor the environmental effects
- Statement of weaknesses and potential for improvement
- Statement of the need for any corrective measures

The audit report is the basis for the environmental management review (see below) that is carried out regularly by the management.

The audit report contains suggestions for corrective measures. Corrective measures that have become necessary are prepared, adopted by the computing center management, implemented, and then reviewed for their effectiveness.

Corrective measures

Regular reviews and internal audits identify deviations from the stipulated regulations and necessary corrective measures. The respective manager is in charge of determining corrective measures. Together with the employee in charge, the manager – and if necessary, in cooperation with the environmental management representative – determines suitable corrective measures, documents, and monitors their implementation and effectiveness. The results are included in the environmental management review.

Environmental management review

The evaluation of the environmental management system (EMS) by the computing center management in an environmental management review shows the extent to which the environmental goals have been achieved. It makes it possible to ensure the effectiveness of the environmental management system and to improve the EMS continually.

The EMS is evaluated at least once a year after the internal audits. The environmental management representative provides the necessary information (audit report, current environmental data, etc.) for the review in a report of receipt.

The following is used for the evaluation:

- Environmental policy
- Environmental goals
- Environmental statement
- Legal provisions
- Audit reports
- Suggestions for improvement, inquiries, complaints
- Corrective measures
- Training certificates
- Report of receipt by the environmental management representative

A review is made to determine the extent to which the goals set have been achieved. If necessary, new goals are determined. The evaluation of the management is recorded in a written report.

Communication

Internal communication

In order to implement an environmental management system at all levels of a company, comprehensive information and good communication with all those involved are required. Employees should be informed regularly of the status of environmental activities via the intranet or a newsletter, for example. Employees should also receive information regarding the results of the annual collection of environmental data and internal / external audits.

Environmental suggestion system

The involvement of employees is important and contributes to good communication across the organization. In addition, considering the ideas and suggestions of employees is important to the continual improvement process. For this purpose, it is a good idea to establish an environmental suggestion system. This way, suggestions for improvement are recorded, processed, evaluated, and if possible, implemented. If possible, you should reward good suggestions appropriately. This will increase employee motivation to contribute ideas and suggestions regularly.

Tip: Ideas competition

A good way to motivate employees to contribute their ideas and suggestions and to establish an environmental suggestions system to your computing center is to hold an ideas competition.

Rewards for suggestions

Find out beforehand which regulations concerning the suggestion system have to be complied with. For example, publicly owned computing centers in Baden-Württemberg must comply with the joint administrative regulation of the ministries on the awarding of proposals for improving the state administration (VwV Vorschlagswesen) of January 15, 2018.

External communication

An open dialog should be maintained with external stakeholders (neighbors, authorities, suppliers, contract partners, the general public). EMAS makes provisions for the regular publication of an environmental statement for this purpose. You can also inform your external stakeholders of your environmental activities and successes by providing environmental information on your homepage, information leaflets, and special information events such as “environment days”, for example. How external communication occurs can be determined according to the needs and capabilities of the organization.

Inquiries, suggestions, and complaints from the public, residents, authorities, and other interested parties must be documented. Inquiries or complaints from stakeholders should always be answered. For example, this can be done by the environmental management representative after consultation with company management. The documented inquiries / complaints are included in the management review.

Tip: Sustainability action days

In addition to regular information for employees and the public via the environmental statement (see the section *The environmental statement*), you have many other options to disseminate information regarding the environmental and sustainability activities of your computing center. For example, "open house" days offer opportunities to inform the public. In Germany, you and your computing center can participate in the “German Sustainability Action Days” that are held every year in late May / early June.

If you would like to participate in the “German Sustainability Action Days” or the “N!-Tage Baden-Württemberg”, you can register your campaign at:
https://www.tatenfuermorgen.de/en/deutsche-aktionstage-nachhaltigkeit/
Here you will also find many examples and suggestions on how to organize your sustainability days. You can also visit sustainability days held by other companies with your environmental team. You can find information on campaigns of many companies or public institutions on the above-mentioned website. There is sure to be something of interest in your area.

From Our Experience

Information for employees and the public

HLRS employees can find out more regarding the subject of sustainability in the HLRS **internal information platform**, the "HLRS Wiki". The project team ensures that the information published there is always current.

Sustainability days were established at the HLRS in 2014. At first, these sustainability campaigns and information days were offered only internally. Since 2017 they have been held in cooperation with other participants from across the university, such as the energy manager of the University of Stuttgart and Greening Stuttgart, as part of the statewide sustainability days in Baden-Württemberg.

A **sustainability network** was established at the University of Stuttgart in order to organize events such as the sustainability says and also to share ideas about other sustainability activities.

Another important building block for the HLRS sustainability concept is public relations that go beyond the university. Since 2015, interested members of the public have been able to find out more about sustainability at HLRS as part of the University of Stuttgart's "Science Day" (**Open House Day**).

Environmental management manual

The environmental management system is documented in the environmental management manual and in the reference documents. The manual describes who is responsible for what and how environmental protection is organized at the computing center.

In the manual, the computing center commits to carry out its activities according to the environmental guidelines, and if any, the energy guidelines and the requirements specified in the environmental management system.

Among other things, the environmental management manual describes:

- How environmental goals are to be planned and achieved
- Which resources (organizational, technical, and financial) are available for environmental protection
- How energy management works
- How waste disposal is regulated
- How emergency preparedness is regulated

The environmental, and if applicable, the energy guidelines can also be found in the environmental management system. It should be accessible to all employees and should be presented to customers and other stakeholders on request. The manual is usually approved by the head of the computing center and adopted upon his/her signature.

The environmental management manual is based on the EU Environmental Audit Regulation (EC) No. 1221/2009 and Commission Regulation (EU) 2017/1505 of August 28, 2017. It is a good idea to structure the manual according to the standard ISO 14001:2015.

The manual should be kept as lean as possible. You can provide more detailed descriptions of environmental protection in the company in work and process instructions designated as reference documents accompanying the environmental management system, for example. In the manual, reference documents should be mentioned in their respective sections.

Additional examples of reference documents are:

- Waste concept
- Hazardous substances list
- Training certificates
- Communication matrix
- Hazard assessments

Tip: Combined manual for EMS and EnMS

If you also establish an energy management system according to ISO 50001, you do not need a second manual. You can integrate the description of the energy management system in the environmental management manual.

Control of the documents

Documents such as the management manual, procedural, and operating instructions, must be controlled. To control the documents, a system must be established to ensure that only valid versions of documents are in circulation. A version control process will ensure that the change status / revision status can be recognized in the documents.

To control the documents, you should clarify the following basic questions:

- In what form and via which channels are the documents distributed?
- Who is allowed access and in which form (read only or change authorization as well)?
- What standardized naming convention will be used to identify the documents?
- Where are the documents filed and saved?
- How is protection against loss of documents guaranteed?
- Who monitors the changes and replaces outdated documents according to the established rules?
- How is version control guaranteed with frequent changes?
- Which legal time limits apply to the storage and availability of documents?

The environmental statement

EMAS requires the publication of an environmental statement. The public is informed regarding the environmental activities and successes of the computing center based on the validated environmental statement. The environmental statement is updated annually and is also validated annually by an approved environmental verifier.

The environmental statement contains the following:

- A description of the organization (structure and activities)
- All important environmental data and key figures regarding emissions, energy and water consumption, waste generation, etc.
- Environmental policy and a description of the environmental management system
- Environmental aspects and impacts
- Environmental program, objectives, and targets

- Environmental performance and compliance with applicable legal obligations relating to the environment as set out in Annex IV of the EU Environmental Audit Regulation
- An environmental timeline, if applicable

Audit by an environmental verifier

If you have established your environmental management system, you can have it audited by a state-approved environmental verifier according to EMAS, and if desired, according to ISO 14001. When selecting the environmental verifier, you must take into account that *"EMAS organizations [...] are assigned to certain sectors according to the classification of economic sectors (NACE[12] codes). Only an environmental verifier that is approved for these NACE codes may audit the company "* (Umweltgutachterausschuss, 2020).

Tip: Selecting the environmental verifier

It is a good idea to obtain bids from environmental verifiers who are approved for the NACE codes that apply to you and to contact the environmental verifier selected as early as possible.

The German Accreditation and Approval Society for Environmental Verifiers (Die Deutsche Akkreditierungs- und Zulassungsgesellschaft für Umweltgutachter mbH – DAU) is responsible for the testing, approval, and supervision of environmental verifiers. If your organization is in Germany, you can find suitable environmental verifiers for your computing center in the DAU environmental verifier database: *http://www.dau-bonn-gmbh.de/dauAdrList.htm?cid=209*.

[12] French: Nomenclature statistique des activités économiques dans la Communauté européenne.

Tip: Finding the applicable NACE code

German organizations can find the NACE code that applies to you in the book *Klassifikation Wirtschaftszweige – Mit Erläuterungen* (Classification of economic sectors – with explanations), 2008 by the German Federal Statistical Office. You can find the book at the following Internet address:

https://www.destatis.de/DE/Methoden/Klassifikationen/Gueter-Wirtschaftsklassifikationen/klassifikation-wz-2008.html?nn=205976.

Here you can find an overview of the NACE code in German and English from the German Federal Statistical Office: https://www.euregiolocator.eu/downloads/NACE-Codes.pdf.

In section *J* of the book you will find the industries that are classified in the section "Information und Kommunikation" (Information and Communication). This section is assigned code 62 "Erbringung von Dienstleistungen der Informationstechnologie" (Computer programming, consultancy and related activities). Below that, even more refined breakdowns such as the code 62.03 "Betrieb von Datenverarbeitungseinrichtungen für Dritte" (Computer facilities management activities) or 62.09 "Erbringung von sonstigen Dienstleistungen der Informationstechnologie" (Other information technology and computer service activities) can be found.

If you have questions, you should be able to obtain information regarding the NACE code from your local Chamber of Commerce and Industry (Industrie- und Handelskammer).

How and what environmental verifiers audit

It is customary to send the environmental verifier the most important documents four to six weeks before the actual audit. As a rule, these are:

- The environmental statement
- The environmental policy
- The environmental program
- Environmental management manual with a description of the EMS
- Reports on the environmental audit and management review

The environmental verifier will prepare a verification program with your organization for the on-site audit. In addition to auditing documents, the verifier will also conduct conversations with management and employees from various functions and levels, and will perform a site inspection.

In addition to the documents mentioned above, you should definitely have the following ready for the audit by the verifier:

- Permits (e.g. building permits)
- Proof of disposal of hazardous waste
- Test reports (e.g. reports for cooling water monitoring)
- Letters of appointment (e.g. of the environmental management representative)
- Training certificates (e.g. training of the waste management representative and safety officer, environmental protection training, safety instructions)

You will receive an audit report from the environmental verifier regarding the results of the verification. If you pass the EMAS audit, the verifier will validate your environmental statement.

With the validated environmental statement, you can apply for registration in the EMAS register at your local registration body. In Baden-Württemberg, the Industrie und Handelskammer (IHK) Hochrhein-Bodensee (Chamber of Industry and Commerce) is responsible for this registration. Here you can also obtain the necessary application forms.

Tip:

Helpful websites for registration according to EMAS

(As of: January 14, 2020)

The EMAS register can be found at: https://www.emas-register.de/en and the relevant Chamber of Industry and Commerce responsible for registration in the EMAS register at: https://www.emas-register.de/en/registration-bodies.

Establishing an energy management system

If you want to establish an energy management system in addition to EMAS, it is advisable to set it up and have it certified according to the international standard DIN EN ISO 50001 for energy management systems. According to ISO 50001, you must demonstrate the improvement in energy performance. To do this, you yourself determine your energy performance, your energy goals, and your verification method. The energy performance is based on the energy efficiency, energy consumption, and energy use.

The involvement of employees is also important for the success of the energy management system (EnMS) (see also the section on *Employee involvement*).

Management must commit to the following steps when deciding to establish a energy management system:

- Determine an energy policy
- Provide the required resources
- Define responsibilities and decision-making authority
- Decide on strategic measures
- Review the results of the EnMS (management review)
- Communicate the significance of the EnMS within the organization

Energy management systems according to ISO 50001 also work according to the PDCA cycle system for the continual improvement of the energy performance and the energy management system itself (see the section *Plan-do-check-act* cycle).

Tip: Bibliography

nqa: ISO 50001:2018 ENERGY MANAGEMENT SYSTEM IMPLEMENTATION GUIDE (https://www.nqa.com/medialibraries/NQA/NQA-Media-Library/PDFs/NQA-ISO-50001-Implementation-Guide.pdf).

GUTcert: In 18 Schritten über drei Stufen zum effizienten Energiemanagement nach ISO 50001, Ein Leitfaden für Einsteiger 2018.

German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) (publisher): Energiemanagementsysteme in der Praxis — Vom Energieaudit zum Managementsystem nach ISO 50001: Leitfaden für Unternehmen und Organizsationen, 2. Dez. 2019[13].

Steps to an energy management system according to ISO 50001

Determining an energy policy

In structured energy management, all processes and measures are based on the long-term overall goals and the principles of action determined in the energy policy. This document presents energy-related guidelines for you as a computing center to express your energy-related goals and requirements for the organization. The energy policy is binding.

According to ISO 50001, the energy policy statement must contain the following points:

- Commitment to a continuous increase in energy performance
- Obligation on the part of management to provide information and all means necessary to implement the measures
- Obligation to meet all energy-related legal requirements
- Increased focus on energy efficiency in the procurement of products and services

[13] Successor of the guide for energy management systems in practice – ISO 50001: Guide for companies and organizations from 2012.

As part of the continual improvement process, you should review the energy policy regularly and adapt it to changing conditions.

The obligation to appoint an energy management team instead of an energy management representative is intended to further emphasize the joint responsibility of the management of the computing center, and at the same time, to improve the effectiveness of the EnMS through a broader distribution of responsibilities and authorities. However, the energy management team can also consist of one person if this is appropriate for the size of your computing center.

Within the context of employee involvement, you should announce the energy guidelines, the members of the energy management team, and their duties. Publication of the energy policy is not required by the EMAS standard, but can improve the public image of the organization.

Tip: Energy policy

You can find an example of energy guidelines in the section *Determining the environmental* policy.

If you are establishing an environmental management system in addition to the energy management system, we recommend that you publish the energy policy in the environmental statement and have it certified according to EMAS.

Determining the energy strategy

The systematic recording of all energy data within the computing center is the basis for an increase in the energy efficiency and can reveal potential for reducing financial expenditures. Therefore, the standard requires structured, documented planning for the collection of all energy data. “Energy data” refers to the types of energy used, the energy used, and the energy consumption.

The following generally applies:

- The greater the consumption, the more detailed the measurement (measurement intervals and measurement accuracy) should be.
- The more detailed the measurement, the greater the measurement costs.

For this reason, measuring intervals and measuring accuracies must be proportionate to the actual benefit.

From Our Experience

Measurement infrastructure

Often a measurement infrastructure installed purely for accounting purposes is not adequately detailed to identify potential savings in individual systems and processes. Therefore, especially in the case of large consumers, additional measuring instruments must be installed. Since most computing centers must always guarantee the availability of computing time and redundant cables are rarely available to install measuring instruments during operation, only a few days a year are typically available for installation of these instruments. Therefore, advance planning is necessary to complete the energy evaluation within a reasonable time frame.

To make the energy data more understandable, not only the entire computing center, but also the individual areas (computer operation, building technology, administration, etc.) should be considered. For a meaningful recording of energy, the scope and boundaries for the computing center must be defined and the individual areas or individual systems must be considered separately according to defined system boundaries. This can also include the definition of operating conditions in order to explain irregularities as the energy data is being recorded.

Tip: Measuring point concept

You can find an example of a measuring point concept that includes the special features of computing centers in the award criteria of the “Blue Angel for energy-efficient data center operation" (DE-UZ-161)[14].

To record the energy data, you can use energy bills and meter readings, or in rented buildings, energy reports from the building management or information from the administration. If any relevant energy data is still missing, you can also make assumptions temporarily, but not without a reasonable margin of error. Taking meter readings can tie up human resources and incorrect or missing measured values must be accepted. The automatic recording of energy data by software in a central database offers great added value for a one-time cost. In this case, it is worthwhile to call in outside specialists.

The plan for energy data collection must be reviewed regularly as part of the PDCA cycle and updated if necessary.

The **energy evaluation** of the computing center contains the following analyses and evaluations:

- Current types of energy
- Previous and current energy use and consumption
- Significant energy use (SEU)
- Current energy performance from each SEU
- People who have an influence on the SEU
- Opportunities to improve the energy performance
- Estimate of the future energy use and consumption

Using the information from the energy evaluation, define an **en**ergy **b**aseline (EnB). This represents a reference scenario for the comparison of all future energy performance.

The absolute measured energy data is not sufficient to be able to measure, monitor, and ultimately improve the energy performance of your computing center. To do this, key figures must be calculated from absolute measurement data, which can then be used to control the

[14] https://www.blauer-engel.de/en/products/electric-devices/data-centers

energy consumption and to plan for future strategic development of energy management and long-term cost reduction. In the EMAS standard, these indicators are referred to as energy performance indicators (EnPIs). Possible influencing factors on the energy performance indicators, such as weather conditions, must be discussed and taken into account in order to obtain comparable figures. Also for later analysis and interpretation, the context of the period under consideration must be known and taken into account in order to prevent misinterpretations, and accordingly, incorrect decisions. While the recording, calculation, and clean-up can and should be automated, in most cases the analysis and interpretation must be done by the technical staff involved in operations and system engineering, which will require additional working time. This is the only way to actually identify and use any optimization potential.

From Our Experience

Determining the energy performance indicators

You can find examples of energy performance indicators that include the properties of computing centers in the section *Significant environmental aspect in computing centers: Energy*

An energy strategy is not a document required by the standard, but is often used in practice to summarize the parts of an EnMS described above – mostly for internal communication:

- Energy evaluation
- Energy baseline
- Energy performance indicators
- Plan for energy data collection
- Energy efficiency projects

Determining the energy program

You determine concrete goals from the results of the energy evaluation, and then combine them to develop an energy program (with action plans for the measures).

Based on the first energy evaluation of your computing center, goals and energy targets should be determined that represent the overall framework for improving the energy performance compared to the first analysis or the defined energy baseline. In the next step, you must develop and implement action plans to achieve the goals you determined.

Action plans contain the following information:

- Action to be taken
- Necessary resources or estimated costs
- Responsibility
- Timeframe for implementation
- Evaluation of the results

You can find more information on the procedure used to evaluate the results for improving energy performance in the section *Assessment of environmental impacts*. You can apply this procedure directly to the evaluation of energy issues.

From Our Experience

Energy-related measures at HLRS

Energy-related measures can be found along with other environmentally relevant measures in the section of the "2018 to 2021 sustainability and environmental program for the HLRS and IHR" in the section *Determining the environmental* program.

Structure of the energy management system

The success of an energy management system essentially depends on the employees, meaning success can be achieved by involving and training the employees. You can find more information related to employee training and involvement in the practical tip on HLRS's sustainability concept in the section *Employee involvement*.

The computing center management should communicate the importance of energy management clearly. You can find detailed information on internal and external communication in the establishment of a management system in the section *Communication*. You can also apply this information in energy management systems.

An important goal when establishing an energy management system is compliance with energy-related legal regulations. To this end, you must first gather all the laws, ordinances, standards, and regulations relevant to your computing center in a structured manner and prepare them in a form that will allow you to easily verify compliance with the resulting obligations. The review must be done regularly in order both to respond to legislative changes in time and to be able to identify changing legal requirements due to changes in activities, energy consumption, or energy consumers within the organization. Those responsible must have the necessary technical, and in some cases, legal competencies or be trained in this respect. In the case of small computing centers, a summary in the form of a spreadsheet may be sufficient; for larger organizations, it is advisable to create a database for a better overview and faster availability. You can find further information on ensuing

legal compliance with the use of a legal register in the section *Additional significant environmental aspects*.

Tip: Relevant legal requirements

In Germany, the following legal requirements are particularly relevant to computing centers:

- Renewable Energy Sources Act (EEG)
- Energy Saving Ordinance (EnEV)
- Law on energy services and other energy efficiency measures (EDL-G)
- Energy Saving Act (EnEG)
- EU Energy Efficiency Directive (2012/27/EU)
- General administrative regulation on the procurement of energy-efficient products and services (AVV-EnEff)
- Peak Equalization Efficiency System Ordinance (SpaEfV)
- Electricity Tax Act (StromStG)
- Only for Baden-Württemberg: Baden-Württemberg Climate Protection Act (KSG BW)
- Only for state institutions in Baden-Württemberg: Administrative regulation of the Ministry of Finance and Economy for the operation of energy-consuming systems in buildings used by state authorities and state institutions (VwV operating instructions for energy)

From Our Experience: Legal check

In order to ensure long-term legal compliance, even after certification of the energy management system is complete, the process for determining and implementing legal regulations should be clearly defined and the responsibilities documented. In practice, a regular legal check in the form of questionnaires for different divisions, departments, activities, or responsibilities has proved to be very effective. A legal check allows efficient feedback from all those whose activities are affected by legal changes and reminds those involved in implementing legal obligations to review their area of responsibility regularly.

The scope of the documentation and the number of reference documents can vary considerably, depending on the size of your computing center and the type of your activities, as well as the complexity of your processes. You must ensure that all documents are available and designed to be easily usable at the locations and times they are needed. In addition, you must adequately protect confidential documents from improper use. The same principles apply for the control of the documents of the energy management system as for those related to the environmental management system (see the section *Control of the documents*).

Internal audits and energy management review

Internal audits are an important part of the continual improvement process (CIP). According to ISO 50001, audits are required at scheduled intervals.

The goals of internal audits include:

- To examine the improvement in energy performance
- To examine the effectiveness of the management system
- To improve the management system
- To determine whether the management system is consistent with the energy policy and the energy goals
- To determine whether energy regulations are being complied with

Internal audits can be carried out by the employees themselves or by outside individuals on behalf of the organization, provided that impartiality is guaranteed in the evaluation of the management system. You will have to proceed according to a pre-planned audit program that includes the following:

- Frequency of internal audits
- Methods
- Responsibilities
- Requirements of the plan
- Format of the report

The results of the audits are recorded in writing and must be reported to the computing center management. This is usually done as part of the management review.

From Our Experience

Internal audit

It may be worthwhile to hire a professional / accredited verifier for the first internal audit, in order to guarantee an unbiased, independent view of the organization and its management system “from outside” as well. This can also be used to prepare the responsible managers for the subsequent certification.

The evaluation of the energy management system by the computing center management (energy management review) shows the extent to which you have achieved energy-related goals. It allows you to ensure the effectiveness of the EnMS and to continue its development.

The evaluation of the EnMS is carried out after the internal audits. The energy management representative provides the necessary information (audit report, current energy data, etc.) for the review in an initial report.

The following is used for the evaluation:

- Energy policy
- Energy goals
- Legal provisions
- Audit reports
- Suggestions for improvement, inquiries, complaints
- Corrective measures
- Training certificates
- Report of receipt by the energy management representative

A review is made to determine the extent to which the previously determined goals have been achieved. If necessary, new goals are determined. The evaluation of the management is recorded in a written report.

Sustainability reporting

If you want to create a sustainability report in addition to the environmental statement, you have the option of expanding the statement to include sustainability aspects such as social and economic issues. Here, the German Sustainability Code (Deutsche Nachhaltigkeitskodex, DNK)[15], which provides a framework for reporting, can provide guidance. The study, "A Formula for Sustainable Success"[16] from 2019, commissioned by the German EMAS Advisory Board, examined how suitable EMAS and the "German Sustainability Code" (DNK) are for sustainable corporate governance and corporate reporting. The German EMAS Advisory Board concluded that *"with the reporting criteria of the DNK, […] EMAS organizations [can expand] their environmental management to include comprehensive sustainability management"* (Umweltgutachterausschuss, 2019).

There is a guide for universities: "Anwendung des hochschulspezifischen Nachhaltigkeitskodex – ein Weg zur Nachhaltigkeitsberichterstattung an Hochschulen" (Application of the university-specific sustainability code – a path for sustainability reporting at universities) (Universität Hamburg, Freie Universität Berlin und Universität Duisburg-Essen (Hrsg.), Oktober 2018).

In addition, there are also the standards and indicators of the Global Reporting Initiative (GRI) for sustainability reports. The so-called GRI guidelines have established themselves internationally as the standard of sustainable reporting (see also: https://www.globalreporting.org/standards/).

[15] Additional information on the German Sustainability Code: https://www.deutscher-nachhaltigkeitskodex.de/en-gb/ (March 21, 2019, 12:16 p.m.).

[16] **German EMAS Advisory Board at the Federal Environment Ministry (publisher). 2019.** Eine Formel für nachhaltigen Erfolg? (A formula for sustainable success?) Studie zur Schnittstelle zwischen EMAS und dem Deutschen Nachhaltigkeitskodex. (Study on the interface between EMAS and the German Sustainability Code.) 2019.

Keeping up with changes and managing them successfully

The establishment of management systems brings significant changes for employees as well as managers. Usually changes, even when they are well intended, are inconvenient or meet resistance: When workflows are revised and changed, those affected can suddenly be forced to adapt their routines. For some employees, new tasks are also added, such as those of a management representative. Other employees might be asked or appointed to collaborate actively in environmental and/or energy teams. Not all employees will do this without resistance. It is also often the case that employees do not communicate openly or managers do not acknowledge negative reactions to the changes.

Even small changes can produce great resistance. A simple example of this is the introduction of recycled paper to replace the customary bright white paper in the future. Even if everyone agrees that something should be done for environmental protection, opinions are often divided on such small changes.

Many projects intended to bring about major changes fail because the path leading to the changes was not properly prepared. You can prevent this, however, by monitoring the change processes from the beginning. All those affected should be adequately informed from the outset and kept up to date regarding the planned changes. You should always bear in mind that the focus of this process is on people. This will allow you to achieve goals more easily and better meet the requirements of the organization. See also: (Kotter, 2006).

Changes are carried out in eight steps (Kotter, 2006):

1. Raise awareness of the problem(s) to be addressed and a sense of urgency.
2. Appoint a carefully selected team to coordinate the change.
3. Develop a reasonable vision and strategy for the future.
4. Share this vision in such a way that it is understood and accepted by others.
5. Make sure that there is freedom to act: remove as many obstacles as possible.
6. Provide experiences that offer a sense of achievement in the short term.
7. Continue until the new (system) is established.

8. While a new culture is being created, adhere to new behavior patterns and ensure their success until they are solid enough to replace old traditions.

With change management, you can contribute to ensuring that changes are successfully managed and implemented in the long term. Even if this systematic monitoring of the change process costs you a bit more work in the beginning, the effort is worthwhile. Change management helps to secure the sustainable success of the newly introduced environmental and energy management system and ensures that the changes that are brought about can be anchored firmly in your corporate culture.

Tip: Preparing for and monitoring changes

Preparing all employees adequately for changes and involving them in planning the changes are crucial for success in the establishment of your environmental and energy management system.

Always bear in mind that emotions have a very great influence in a seemingly rational work routine and that changes always trigger strong emotions, even among management.

High-Performance Computing Center Stuttgart

The High-Performance Computing Center Stuttgart (HLRS) is a computing center that offers science and industry access to supercomputers. Founded in 1995 under the umbrella of the computing center of the University of Stuttgart and in 1996 became the first German national high-performance computing center. The HLRS has been an independent central institution of the University of Stuttgart since 2003.

From the beginning, HLRS has made its services available not only for science, but also for local industry. HLRS has been a member of the Gauss Centre for Supercomputing (GCS) since 2007 and works there with its partners to support scientists from Germany and Europe. . Since 2008, HLRS has also offered computing power and advice on the efficient use of mainframes in cooperation with the Automotive Simulation Center Stuttgart, the “asc(s”. HLRS not only provides computing time, but – as a center of excellence for scientific computing – supports its users in all questions related to simulation and high-performance computing.

Research at the HLRS

To maintain and expand its expertise, HLRS conducts research in the field of high-performance computing and participates in research projects funded by industry, state and federal governments, and the European Union.

HLRS and its users conduct research mainly in the field of engineering sciences, focusing on subjects related to energy, mobility, climate, and health. HLRS users come from a wide variety of areas, including automotive and aerospace engineering as well as chemical, pharmaceutical, and medical research. The center has a special focus on cooperation with small and medium-sized enterprises (SME's).

HLRS is involved in various centers of excellence. From a sustainability perspective, its involvement in activities in the field of “global systems science” is noteworthy. The intention is to use high-performance computing to help find solutions to complex social and scientific problems by working in this subject area.

To ensure that socially significant subjects are addressed in the simulation sciences, HLRS consults a sociopolitical advisory board for advice in its research and for support in identifying new subjects that are of sociopolitical relevance.

Energy

Simulation is a valuable tool on the path to a sustainable energy economy. Researchers use HLRS resources to model technologies to reduce emissions, such as the optimization of gas turbines. Simulation of technologies for renewable energy generation also plays an important role at HLRS, including the design and optimization of hydroelectric and tidal power plants as well as wind turbines.

Climate

Researchers also use HLRS resources to conduct climate impact research. High-performance computing makes it possible to make climate forecasts and estimate natural hazards better, because the realistic modelling of large natural systems such as the atmosphere and the oceans require very large computing power and data storage. High-performance computing also makes it possible to develop earth system models with coupled simulations of the atmosphere, oceans, land, and ice, as well as vegetation.

Mobility

The increasing volume of traffic worldwide requires sustainable mobility. Numerical simulations such as those conducted at the HLRS in cooperation with the Automotive Simulation Center Stuttgart can help develop energy- and resource-efficient mobility concepts. Examples include the design and layout of alternative propulsion concepts, such as e-mobility and new material combinations for lightweight hybrid construction.

Health

HLRS and its users are developing medical simulations in a variety of fields. For example, computational fluid dynamics are used to simulate the flow of air into the human respiratory tract to optimize the spread of inhaled medication. In addition, the blood flow in arteries is simulated to examine the basic mechanisms of the development of pathological

enlargements of the vein wall. Bone implant systems such as artificial hip joints and implants for fracture healing are also simulated numerically at HLRS.

Other research

In October 2014, a working group was established at HLRS to address issues of sociology, political science, and philosophy. The group "Philosophy of Science and Technology of Simulation" researches the relationship between simulation and society on three levels:

- Philosophical research on simulation (status of the knowledge: uncertainty, validation, and verification)
- Political decision making (results of computer simulations: evaluation and communication)
- Effects of simulation on the world of work (heuristic: change in ways of thinking in engineering)

This accompanying research includes a workshop series "Science and Art of Simulation", colloquia such as "Thoughts on Information" (see above), and university teaching in the fields of technology design and computer ethics.

Advanced training for high-performance computing

HLRS is Europe's largest advanced training facility for high-performance computing, with approximately 800 participants per year, and considers itself to be an institution that strives to continually share its knowledge with the outside world.

Rühle Lecture Hall at the HLRS

The Institute for High-Performance Computing

The Institute for High-Performance Computing (IHR) of the University of Stuttgart is located in the HLRS building. The director of HLRS is also the director of the IHR. The organization and work of the IHR are closely interlinked with HLRS.

For the students at the University of Stuttgart, the IHR offers lectures on the basics of computer science, computer-aided simulation methods in the modern development process, information technology in the work environment, and computer ethics. The IHR conducts research in the areas of nonlinear dynamics and wavelets.

Glossary

The most important terms according to EMAS

EU Environmental Audit Regulation: *Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organizations in a Community eco-management and audit scheme (EMAS), repealing Regulation (EC) No. 761/2001 and Commission Decisions 2001/681/EC and 2006/193/EC*

Environmental policy: *the binding intentions and directions of that organization's senior management means the overall intentions and direction of an organization relating to its environmental performance as formally expressed by top management including compliance with all applicable legal requirements relating to the environment and also a commitment to continuous improvement of environmental performance. It provides a framework for action and for the setting of environmental objectives and targets.*

Environmental performance: *means the measurable results of an organization's management of its environmental aspects.*

Environmental aspect: *means an element of an organization's activities, products or services that has or can have an impact on the environment.*

Environmental review: *an initial comprehensive analysis of environmental aspects, environmental impacts, and environmental performance related to an organization's activities, products, and services.*

Environmental impact: *means any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services.*

Environmental program: *means a description of the measures, responsibilities and means taken or envisaged to achieve environmental objectives and targets and the deadlines for achieving the environmental objectives and targets.*

Environmental objective: *means an overall environmental goal, arising from the environmental policy, that an organization sets itself to achieve, and which is quantified where practicable.*

Environmental target: *means a detailed performance requirement, arising from the environmental objectives, applicable to an organization or parts thereof, and that needs to be set and met in order to achieve those objectives.*

Environmental management system: *means the part of the overall management system that includes the organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy and managing the environmental aspects.*

Internal environmental audit: *means a systematic, documented, periodic and objective evaluation of the environmental performance of an organization, management system and processes designed to protect the environment*

Auditor: *means an individual or group of individuals, belonging to an organization itself or a natural or legal person external to that organization, acting on behalf of that organization, carrying out an assessment of, in particular, the environmental management system in place and determining conformity with the organization's environmental policy and program, including compliance with the applicable legal requirements relating to the environment;*

Environmental statement: *means the comprehensive information to the public and other interested parties regarding an organization's:*

a) *Structure and activities*
b) *Environmental policy and environmental management system*
c) *Environmental aspects and impacts*
d) *Environmental program, objectives, and targets*
e) *Environmental performance and compliance with applicable legal obligations relating to the environment as set out in Annex IV of the EU Environmental Audit Regulation*

Environmental verifier:

a) *A conformity assessment body as defined in Regulation (EC) No. 765/2008 or any association or group of such bodies, which has obtained accreditation in accordance with this Regulation.*

b) *Any natural or legal person, or any association or group of such persons, which has obtained a license to carryout verification and validation in accordance with this Regulation.*

Site: *means a distinct geographic location under the management control of an organization covering activities, products and services, including all infrastructure, equipment and materials; a site is the smallest entity to be considered for registration.*

Validation: *means the confirmation by the environmental verifier who carried out the verification, that the information and data in an organization's environmental statement and updated environmental statement are reliable, credible and correct and meet the requirements of this Regulation.*

Determining the context of the organization: *The organization must determine the external and internal issues that can have a positive or negative impact on its ability to achieve the intended results of its environmental management system. These issues must include relevant environmental conditions such as climate, air quality, water quality, availability of natural resources, and biodiversity. They can also include the following conditions: — external conditions (such as cultural, social, political, legal, regulatory, financial, technological, economic, natural, and competitive circumstances),— internal conditions related to the characteristics of the organization (such as activities, products and services, strategic orientation, culture, and capabilities).*

Registration of the interested parties and determination of their relevant requirements and expectations: *The organization must determine which of the interested parties are relevant to the environmental management system, which of their requirements and expectations are relevant, and which of these requirements and expectations it must or wants to satisfy. If the organization voluntarily decides to comply with or consent to relevant requirements or expectations of interested parties, to which no legal obligations apply, they will become part of their* compliance *obligations.*

The most important terms from DIN EN ISO 50001

Energy baseline (EnB): *quantitative reference(s) providing a basis for comparison of energy performance*

Energy evaluation: Analysis of the energy efficiency, energy use, and consumption, based on data and other information leading to the identification of SEUs (significant energy uses) and options to improve energy performance

Energy action plan: *Energy saving program in which energy goals are defined and energy saving measures are determined*

Energy performance: *Energy performance is a concept based on the energy efficiency, energy use, and energy consumption.*

Energy performance indicators (EnPI): *An EnPI is a "standard" for comparing energy performance before (reference EnPI value) and after (resulting or current EnPI value) the implementation of action plans and other measures.*

Energy policy: *Statement by the organization regarding the primary intention(s), direction(s), and obligation(s) with respect to their energy performance, as formally expressed by senior management.*

Energy goal: *quantifiable goal to improve the energy performance*

Significant energy use (SEU): *Energy use that has a significant share in energy consumption and/or offers considerable potential for improving energy performance.*

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http://www.nachhaltige-beschaffung.info/DE/Home/home_node.html (Homepage of the Competence Center for Sustainable Procurement of the Procurement Agency of the Federal Ministry of the Interior, the central portal for sustainable procurement by public clients - in German)

https://green-it.baden-wuerttemberg.de/ (Homepage of the Green IT Competence Center of the State of Baden-Württemberg - in German)

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https://www.borderstep.org/ (Homepage of the Borderstep Institute for Innovation and Sustainability)

https://www.emas.de/en (English website of the German EMAS Advisory Board with lots of information about EMAS)

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https://www.emas-register.de/en (EMAS Register)

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https://www.globalreporting.org/standards/ (Homepage for GRI Standards)

https://www.nachhaltigkeitsrat.de/en/ (Homepage of the German Council for Sustainable Development of the Federal Government)

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Appendix 1: Overview of steps to an environmental management system according to EMAS

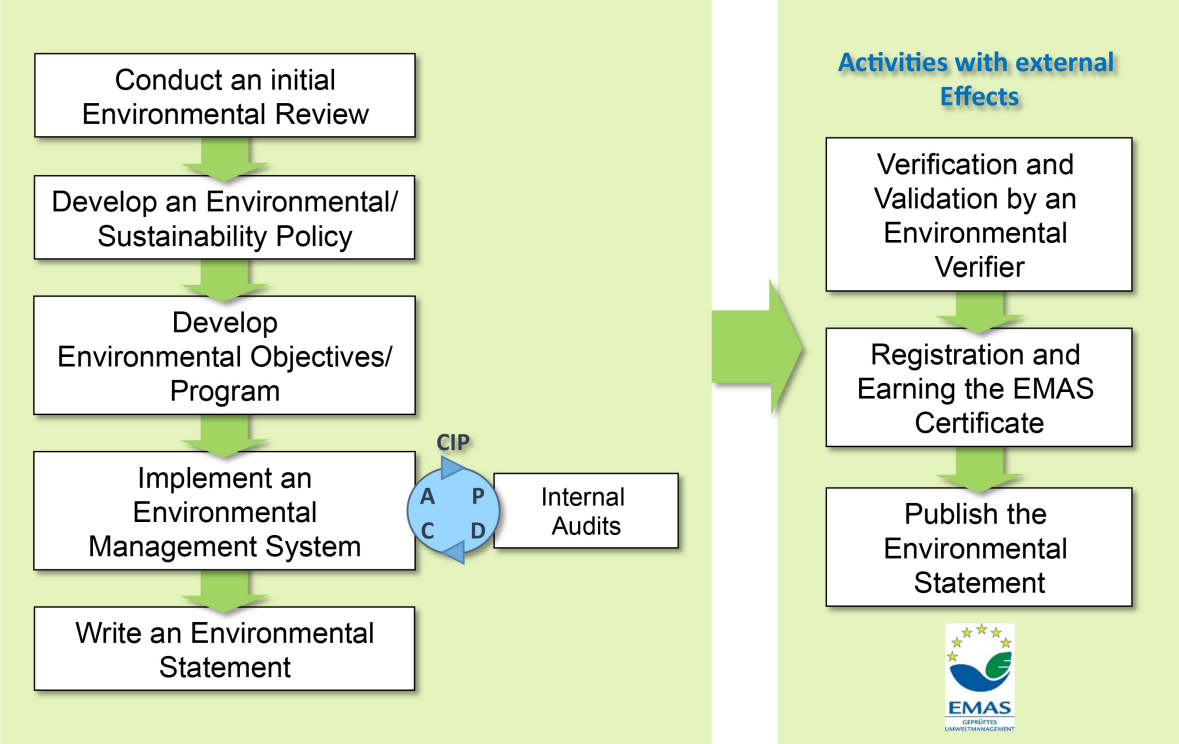

Figure 13: Steps to an environmental management system according to EMAS

Steps to an environmental management system (see Fig. 13):

Step (1): Carry out a comprehensive **environmental review**. The **environmental review forms the basis** for the establishment of an **environmental management system**. Current environmental data (energy and water consumption, waste generation, etc.) must be collected every year.

Step (2): An **Environmental policy is** developed, adopted, and announced to employees.

Step (3): Concrete goals are determined from the results of the environmental review. They are summarized in an **environmental program**. This program also determines the measures required to implement the goals, responsibilities, financial and organizational resources, as well as the dates by which the goals are to be implemented.

Step (4): An **Environmental management system (EMS)** is established. The establishment of a management system determines the necessary organizational structures and responsibilities and creates conditions for compliance with the environmental guidelines.

Note: An environmental management system can be expanded further to a sustainability management system.

Step (5): An **internal audit** must be carried out to examine the effectiveness and success of the management system. Internal audits must be carried out regularly (at least once a year). They are part of the **PDCA cycle** that is **used** to keep the **continual improvement process (CIP) going.**

Step (6): An **environmental statement** is prepared. It publishes key environmental figures as well as environmental guidelines, goals, and an environmental program, among other things.

Note: The environmental statement can be expanded to a sustainability report.

Step (7): The **environmental management system** is **audited** by an accredited **environmental verifier**.

Note: Because there is no officially recognized certification process for sustainability management systems, the environmental verifier can audit the environmental management system only as part of the certification, which nevertheless is a large part of the sustainability management system. The environmental verifier validates the environmental statement.

Step (8): Applying for registration at the Chamber of Industry and Commerce (IHK): If all EMAS conditions are met and there is an environmental statement that has been validated, an application for registration in the EMAS register can be made at the relevant registration body.

Step (10): Registration and receipt of the EMAS certificate. After entry in the EMAS register, the company is entitled to print the EMAS logo on its letterhead, reports, and information material.

Step (9): Publishing the environmental statement: The environmental statement is made available to the public, preferably in electronic format.

Appendix 2: Steps to an energy management system according to ISO 50001 at a glance

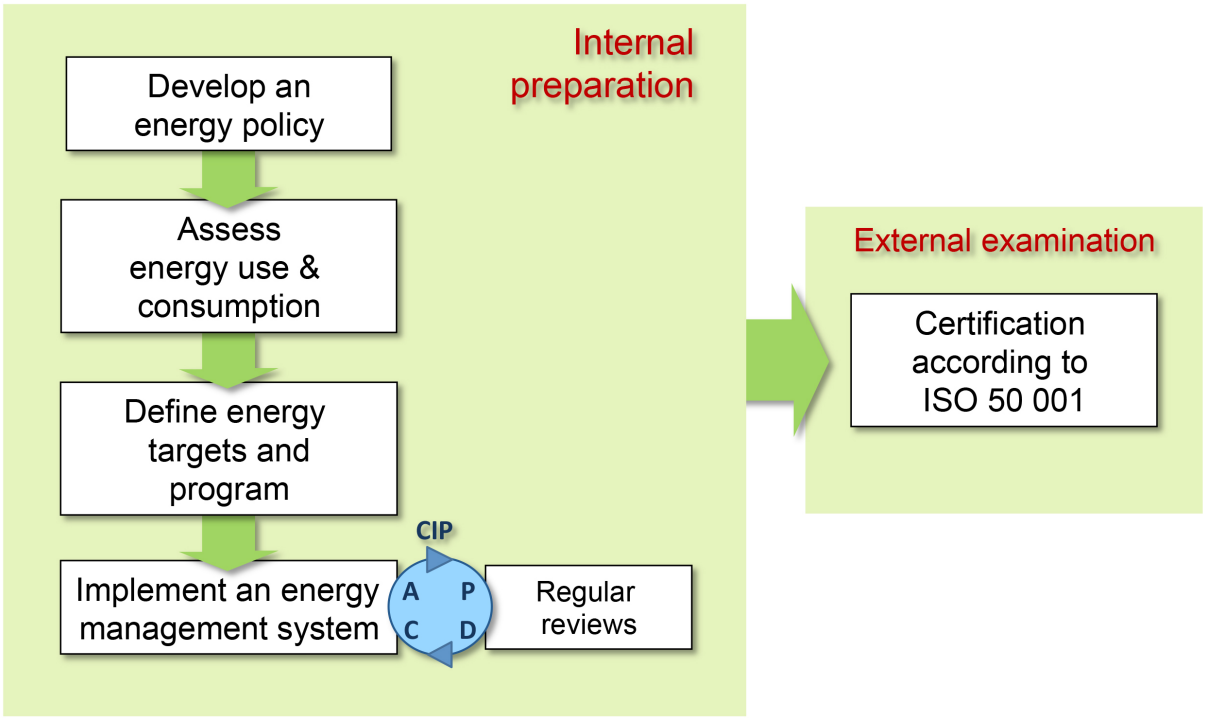

Figure 14: Steps to an energy management system

Steps to an energy management system (see Fig. 14):

Step (1): Energy guidelines are developed, adopted, and announced to the employees.

Step (2): A comprehensive audit of the energy use, the energy evaluation, is carried out. Here, the **types of energy, the energy used, and the energy consumption are analyzed** and **evaluated** using **suitable energy performance indicators**. To do this, the organization must explicitly determine the scope and boundaries of the management system.

Step (3): Concrete energy goals are determined from the results of the **energy evaluation**. They are summarized in an **energy program** (with action plans for the measures).

Step (4): An **energy management system is established.** Organizational measures such as determining the control of documents, training and involvement of employees, and establishing communication must be documented and implemented. All energy-related legal regulations must be determined and reviewed for compliance.

Step (5): At this stage the energy management system is established. In the first round (later, at least once a year), an **internal audit must be carried out** to examine the effectiveness of the management system and to keep the **continual improvement process (CIP) going, using the PDCA cycle.**

Step (6): The **energy management system** is **audited by a certifier according to ISO 50001.**

Appendix 3:

List of figures

Legal statement

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Photos on pages 25, 26, and 55: Sabine Molter
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Date: June 2020

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