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Policy Paper

Software Solutions for Environmental and Sustainability Management

Potentials, Challenges and Recommendations for Action

by:
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Abstract

Companies harbour a vast amount of potential for organising their processes, products and services in a more energy-efficient, environmentally friendly and sustainable way. The application of software solutions and new technologies may provide decisive advantages in this regard, for example by creating new bases for decision-making regarding more environmentally friendly process and product optimisations through the systematic collection, linking and analysis of a wide range of company data.

On behalf of the German Environment Agency, the research project "Digital management tools for environmental and sustainability management" (2021-2022, research code 3720 14 104 0) investigated the specific potentials inherent in the use of software and new digital technologies for environmental and sustainability management, which barriers are present and how they can be overcome. A particular focus of the study lay on the increased integration of dedicated environmental and sustainability software with Enterprise Resource Planning (ERP) systems and Business Intelligence (BI) tools.

This publication summarises key findings of the research project and formulates recommendations for action on how software providers and decision-makers in politics and companies can support the digital transformation in environmental and sustainability management.

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List of Abbreviations

API	Application Programming Interface
BAFA	Federal Office for Economic Affairs and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle)
BI	Business Intelligence
BMUV	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz)
BMWK	Federal Ministry for Economic Affairs and Climate Action (Bundesministerium für Wirtschaft und Klimaschutz)
CEAP	Circular Economy Action Plan
CSRD	Corporate Sustainability Reporting Directive
CO_2	Carbon Dioxide
DNK	The Sustainability Code (Deutscher Nachhaltigkeitskodex)
DPP	Digital Product Passport
EFRAG	European Financial Reporting Advisory Group
EM	Environmental Management
EMAS	Eco-Management and Audit Scheme
ERP	Enterprise Resource Planning
ESAP	European Single Access Point
EU	European Union
GHG	Greenhouse gas
GHG Protocol	Greenhouse Gas Protocol
GRI	Global Reporting Initiative
LkSG	Act on Corporate Due Diligence Obligations in Supply Chains (Lieferkettensorgfaltspflichtengesetz)
PCF	Product Carbon Footprint
PEF	Product Environmental Footprint
RENN	Regional Network Centres for Sustainability Strategies (Regionale Netzstellen Nachhaltigkeitsstrategien)

RoHs	Restriction of Hazardous Substances
SM	Sustainability Management
SME	Small and Medium Sized Enterprise
OEF	Organisational Environmental Footprint
SCM	Supply Chain Management
SPI	Sustainable Products Initiative
UBA	German Environment Agency (Umweltbundesamt)
UGA	The German EMAS Advisory Board (Umweltgutachterausschuss)
UN	United Nations
VR	Virtual Reality
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Glossary

Term	Description
Business Intelligence (BI-)Software	Software solution for collecting, analysing and processing raw data from different sources. For data analysis, different Big Data technologies are used in BI solutions, which can compare data in different ways and identify trends or patterns.
Enterprise Resource Planning (ERP-)Software	A software solution that maps a large part of a company's business processes in an interlinked system.
Sustainability Management	Encompasses the entirety of activities and processes of an organisation for the management of environmental and social impacts as well as sustainability-related risks and opportunities.
Environmental Management	Encompasses the entirety of activities and processes of an organisation for the management of environmental impacts, as well as environment-related risks and opportunities and the fulfilment of corresponding legal requirements.
Environment and Sustainability-Related Data	Data collected in the context of environmental and sustainability management and processed for decision-making (e.g. CO_2 emissions or proportion of female managers).
General Business Software	Software solutions whose area of application is not (yet) primarily assigned to environmental or sustainability management (e.g. ERP systems, BI software).
Special Software	Dedicated software for environmental and sustainability management, both for sub-areas (e.g. energy, waste or greenhouse gas management) as well as for elements of the management system (e.g. for process control or documentation).

Introduction

Digitalisation and sustainability - they are two megatrends of our time whose relationship to each other is characterised by both opportunities and risks. While the digital transformation in society and the economy is advancing rapidly, environmental and social requirements of sustainable corporate management are also increasingly being demanded. On the part of companies, both megatrends imply the need to continuously adapt their business processes to the corporate environment and to participate in shaping the transformation process towards a resilient, climate-neutral, and digital economy.

Environmental and sustainability-related data are becoming increasingly important for corporate success, particularly due to increasing regulatory requirements. Many companies and organisations already collect, analyse, and manage such data in environmental or sustainability management systems. The deployment of software solutions and digital technologies - ranging from automation and big data to artificial intelligence - offers numerous potentials for process optimisation, decision support and improvement of environmental performance. However, at the same time, it's known from corporate practice that there are obstacles and challenges in applying such software solutions. It is of crucial importance to process environmental and sustainability-related data and link them with other corporate data in order to be able to use them as a basis for corporate decisions.

In light of this background, the central questions of this publication are as follows:

How can the application of software solutions contribute to the environmental and social transformation of companies?

How can software solutions contribute to the digital transformation of environmental and sustainability management within companies?

An underlying premise of this publication is that environmental and sustainability-related information cannot be separated from a company's core processes, rather, they are embedded in them. Consequently, the digitalisation of corporate processes ought to follow an integrated approach. Therefore, the connection or integration of environmental and sustainability-related data into general business software, such as Enterprise Resource Planning (ERP) or Business Intelligence (BI) systems, is specifically highlighted at various points.

This publication is directed at software providers - both of dedicated software solutions for environmental and sustainability management and of general business software - as well as at decision-makers in politics and business. The findings are based on the results of the research project "Digital management tools for environmental and sustainability management" (2021-2022, research code 3720 14 104 0) commissioned by the German Environment Agency (Umweltbundesamt - UBA). Background information on the methodology and the empirical surveys can be found in the final report (Docke et al., forthcoming) on the research project.

First, the potentials of software solutions for environmental and sustainability management (EM and SM) are highlighted (Section 1.1) and future challenges for EM and SM are discussed (Section 1.2). Chapter 1 concludes with an overview of the current range of software solutions for EM and SM in Germany (section 1.3). In Chapter 2, the status quo of software use in EM and SM in Germany is examined (Section 2.1), whereby user-side obstacles and challenges are also discussed. Chapter 3 summarises the overarching findings of the project (section 3.1) along with recommendations for action for software providers (section 3.2) and policy makers (section 3.3).

1. Digitalisation in Environmental and Sustainability Management – Potentials for Software Application

1.1 Potentials of Software Solutions in Environmental and Sustainability Management

The importance of environmental and sustainability-related data for corporate management is currently increasing rapidly. In order to turn this data into decision-relevant information, strategies and processes for data collection, data quality assurance and data preparation are required. Software solutions play a decisive assisting role in this. The following section examines the potentials of software solutions for EM and SM in more detail.

At a glance | Software Solutions for Controlling Environmental and Sustainability-related Data

Environmental and sustainability-related data can be, for example, energy or water consumption data, company or product-related CO_2 emissions, data on workforce diversity, data on employee satisfaction (e.g. as an index), the staff turnover rate, or data on occupational accidents. Such data may also be collected along the supply chain, e.g. greenhouse gas emissions from transport and primary products, water consumption in regions with water stress or the existence of works councils at suppliers and sub-suppliers. Below, a distinction is made between two groups of software solutions for the control of corresponding data:

Dedicated special software for EM and SM | This includes software solutions for sub-areas (e.g. energy, waste or greenhouse gas management), or those that include elements of an environmental or sustainability management system (e.g. for process control, document guidance or environmental/sustainability reporting).

General Business Software | whose scope of application is not primarily assigned to EM or SM (e.g. ERP systems, BI software).

The following deliberations are based on a structured survey of software providers and users, which was conducted as part of the research project "Digital management tools for environmental and sustainability management" on behalf of the UBA. The methodology is outlined in the following info box.

At a glance | Methodology of the Empirical Surveys

Within the framework of the research project, the perspectives of software providers for the EM and SM and (potential) users were empirically investigated and evaluated. For this purpose, a total of 35 semi-structured interviews were conducted in autumn 2021, 20 of them on the user side and 13 on the provider side, as well as 2 interviews with experts[1].

Characteristics of the interview group "(Potential) users" | Company size from 160 to > 30,000 employees, with/without EM or SM system, with/without software solution for EM/SM already in use, interview partners were EM/SM officers.

Characteristics of the interview group "Software providers for EM and SM" | Company size from <10 to >300 employees, customer groups from SME to global corporations, interviewees were project staff, managers, or executive directors.

[1] Detailed information on the project procedure and methodology can be found in the final report on the research project (cf. Docke et al., forthcoming).

56 interview requests were sent to the target group **"software providers of general business software (ERP/BI software)"**, yielding no positive feedback. Instead, a short survey of 20 selected providers was used. In addition, it was possible to conduct dialogue with individual representatives of this target group within the framework of a digital **specialist workshop** in November 2021.

The interviews were accompanied by a comprehensive **online survey** of software providers for EM and SM, with a focus on the German market. For this purpose, an initial 356 software solutions related to EM and SM (including their sub-areas) were identified through research. The corresponding software providers were invited to participate in an online survey in spring 2021. In total, 136 software solutions and, in particular, their prioritised customer groups, areas of application covered, technical details and scope of functions were investigated by the survey (cf. section 1.3).

Software solutions as a management tool for efficiency and effectiveness

A significant opportunity for the use of software and new digital technologies in EM and SM is to harness collected data in such a way that it can be used for innovative strategic and operational decisions for sustainable economic activity. Possibilities for linking environment- and sustainability-related data with other company data enable the acquisition of new insights and, with the help of data analyses, for example, future scenarios can be simulated, or developments can be predicted. As a result, the decision-making process in the company can be supported.

In addition, the deployment of software solutions bears the potential to make processes more efficient. The possible increase in efficiency ranges from data collection to its analysis and utilisation and finally to reporting. Especially against the backdrop of increasing data volumes and ever more complex economic cycles, software providers and experts emphasise the potential of processing and visualising the collected data. On the user side, too, the potential to achieve progress in EM and SM through the use of software is rated as high. Of particular interest to these users is the handling of large amounts of data that arise in (different) management systems and whose (integrated) handling can be decisively supported by digital solutions. The larger a company and the more complex the value creation cycles, the more likely it is that manual data collection and evaluation - for instance by means of spreadsheets - will reach its limits. Software solutions can provide critical support here.

From the user's point of view, any form of automation[2] - whether it is automated data collection using smart metering[3] or automated analysis and visualisation of the collected data - is considered to be of great added value by making the work easier and able to be completed in less time. Accordingly, software as a digital platform on which the processed, linked and evaluated data can be clearly presented is of major interest. For example, dashboards, i.e. user interfaces with a visualised data overview, can facilitate the monitoring of the implementation status and the achievement of goals. High-quality analyses allow insights into which priority areas should be focused on at individual locations (e.g. with regard to energy consumption or occupational health and safety measures). At the same time, prepared and visualised information is available that provides a clear overview of a company and can be used for internal and external communication.

[2] Automation means the support of work steps by means of information and communication solutions (algorithms).
[3] Smart metering describes the computer-based recording and control of energy consumption and supply.

Good to know | Digitisation Trends in Environmental and Sustainability Management

Trends in digitalisation such as automation, artificial intelligence, blockchain, big data, the Internet of Things or augmented reality offer a multitude of opportunities for improved and more agile EM and SM.

Within the framework of the research project "Digital management tools for environmental and sustainability management" on behalf of the UBA, profiles on 10 digitisation trends were created. These include detailed descriptions of the trends, their areas of application in EM and SM as well as opportunities, challenges and the prerequisites for their use.

The fact sheets are published on the UBA website together with the brochure "Environmental Management and Digitalisation - Practical Approaches to Improving Environmental Performance" (Pagano and Krause, 2019). | Link

Apart from data collection, analysis and visualisation, software solutions can facilitate collaborative work between colleagues from different organisational areas or locations. Moreover, cooperation with auditors and experts can (partly) be moved into the digital space by means of suitable software solutions, which can lead to time and cost savings.

Furthermore, software solutions can create transparency in the supply chain. For example, digital collaborative (supply chain management) platforms can ensure that top-down company requirements at the end of the supply chain (e.g. on material quality, emissions during production, compliance with local environmental legislation) can be communicated throughout the supply chain. At the same time, suppliers can provide the required information "bottom-up" and thus contribute to supply chain transparency.

Nevertheless, in view of the potential of software solutions described above, it should be kept in mind that the use of digital technologies does not necessarily result in improved environmental or sustainability performance. This is because the improvement of a company's environmental or sustainability performance is determined first and foremost by the strategic objectives of management and the operational implementation of measures. Software solutions for EM and SM are to be viewed as comprehensive management tools that can contribute to improved decision-making.

In summary, on the basis of the conducted interviews, it can be stated that particularly the reduction of workload due to efficiency increases through process optimisation as well as automation are decisive motives why companies decide to use software solutions for EM and SM. In addition, increasing customer and market requirements as well as government regulations in the area of environment and sustainability influence the relevance of corresponding processes that need to be supported by software solutions against this background.

Software solutions as a better choice - for every company, in every case?

It is important to take a look at the preconditions and framework conditions under which the described potentials of the use of software in EM and SM can unfold their maximum effect for a company. The guiding principle should be the benefit that the digitalisation of processes and the introduction of software can offer to the company. The central question is therefore: Can the management of environmental and sustainability-related data be meaningfully optimised through the use of software?

The role of digitalisation to strengthen EM and SM is considered significant by experts as well as by providers and users. The experts described in their interviews that existing software

solutions are often tailored to the requirements and structures of large companies and are therefore less attractive for small and medium-sized enterprises (SME). In the interviews with SME representatives, it was observed that they currently rate the benefits of software use in their environmental and sustainability-related processes lower than large companies. From a different perspective, the use of software for EM and SM proves to be particularly attractive for those companies that, for example, benefit greatly from efficiency increases due to their size, the complexity of their business and value creation processes, regulatory requirements, or special customer requirements. For such companies, the benefits of introducing software usually outweigh the costs of acquiring and maintaining the software. Generally, it can be stated that the more complex the requirements and the topics or data to be controlled, the higher the benefit of using software. Particularly when data is included along the supply chain, the use of software can become unavoidable, depending on the complexity of the respective supplier relationships.

Relevance of general business software for environmental and sustainability management

Since environmental and sustainability information is of increasing importance for core business processes, the consideration and assessment of this data ought to be also integrated with other corporate data. In the discourse on digitalisation in EM and SM, the interaction with general business software, such as ERP and BI solutions, must also be examined.

At a glance | General Business Software: ERP and BI Software Solutions

The objective of an **Enterprise Resource Planning (ERP) system** is to map a large part of a company's business processes in an interlinked system. Accordingly, the modules of an ERP software solution ideally map all functional areas of the company, ranging from procurement, production and sales to human resources and finance or research and development. The key feature of the ERP system is that all data is linked across the modules through a shared database (implemented in a relational database). In this way, the ERP system enables a cross-functional, company-wide consolidation of data.

A **business intelligence (BI) software solution** is an application that collects, analyses and processes raw data from different sources. The aim is to prepare and visualise the results in a suitable format so that they can be used by decision-makers to support data-based decisions. A typical data source system is, for example, the company's own ERP system, the supply chain management (SCM) system or other dedicated software solutions, e.g. for the sustainability assessment of companies or products. To complement this, external data sources can be consulted, e.g. from statistical offices for energy prices, online databases with legal requirements on products (e.g. substances of very high concern, which are specified by the REACH regulation[4] and updated twice a year), with climate data or geo-information systems. For data analysis, different Big Data technologies are used in BI solutions, which makes it possible to relate data to other data in different ways or to identify trends and patterns. Finally, a BI solution enables different forms of data reporting. For instance, an ad-hoc report can be requested for a specific search query within the database. Additionally, the essential data (correlations) are visualised in a dashboard or report.

If special software is not integrated into the general company software, there is a risk of parallel systems and disconnected data pools. This is often not desired from a company perspective, which means that a connection via an application programming interface (API) or integration in the form of a module is usually preferred. The connection or integration at data level has the

[4] The REACH Regulation (EC) 1907/2006 is the European Chemicals Regulation on the registration, evaluation, authorisation and restriction of chemicals.

potential to improve integration at management level as well: An integrated view of different data areas makes it possible to recognise connections and dependencies, across business areas or departments. This potential needs to be supported at data and software level in order to connect EM and SM to the core processes of a company.

Connection and integration of environmental and sustainability information into the corporate software landscape

One important decision criterion for the users interviewed was the possibility of connecting special software for EM and SM to the existing IT infrastructure. This raises the question of whether and how such a connection can succeed. In principle, the following options are feasible:

- **Manually |** Data can be transferred manually from special software for EM and SM into general business software (e.g. export/import from spreadsheet programs).
- **API connection |** The special software can be connected to general company software (e.g. ERP system) by means of API programming. In this case, selected data exchange takes place automatically.
- **Integration as a software module |** Depending on the offer of the existing ERP system or the possibility of an individually developed software solution, the collection and control of environment and sustainability-related data can also be integrated directly into the general company software by means of a corresponding module.

At a glance | Application Programming Interfaces (API)

Programming software interfaces between two or more software solutions is often the means of choice to enable interactions between different software solutions. An application programming interface (API) is defined at the source code level of the software and enables the connection of one software system to another. Along with programming, the provision of an API also includes detailed documentation of the API's properties and functions.

If an API is publicly accessible and defined in publicly available documentation, it is referred to as an OpenAPI. This is manufacturer-neutral and described in a uniform manner (API standard). OpenAPIs offer numerous advantages, e.g. implementation, documentation and tests can be kept consistent during development and ongoing maintenance.

The connection via API is often preferred by the user if the EM and SM is, or is to be, controlled by special software. The strength of special software lies particularly in its specifications and the level of detail displayed. The corresponding software providers are specialised in the environment and sustainability context, have a high level of technical know-how and specific customer experience in this area. Due to this focus on a thematic area, the resulting relatively reduced scope of functions and requirements, and the (largely) independence from general business software, changes in the special software can be programmed more flexibly. Against this background, the application of digitalisation trends or the adaptation of the software to new corporate requirements (e.g. as a result of regulatory changes) is also theoretically easier to implement in special software.

Alternatively, it can be considered to integrate an additional software module for EM and SM into an existing ERP system. In that case, the costs for the complex interface programming are omitted. At the same time, the central strength of this option lies in the comprehensive integration of environmental and sustainability data with other company data. Thereby, it contributes to company-wide data transparency and can facilitate the identification of correlations if the diverse data available in the system is appropriately linked and analysed.

Particularly if the data from the ERP system flows automatically into the company's own BI tool, module integration means that the environmental and sustainability data is automatically included and mapped there too.

However, similar advantages, with greater flexibility and specialisation, are also offered by connecting the special software to the BI tool via API. This approach also creates the opportunity to connect the specialised software to different ERP systems and software of a company, e.g. at international locations.

Ultimately, the type of data connection or integration chosen must be weighed up on a company-specific basis. An interesting point here is that there can sometimes be different perspectives on this within a company: The demand for the integration of special software into the existing ERP system often comes from the IT department. From this perspective, a uniform system with a uniform IT structure and interface has many advantages, e.g. in system administration. In contrast, specialist departments use other decision criteria and often prefer special solutions that are tailored to their specific requirements, so in this case an API connection is often preferred. In addition to the technical options, the (human) competence to control the data is decisive in determining whether the available data is integrated, processed and made available to decision-makers in a meaningful way. It should also be taken into account that certain evaluation procedures or the derivation of certain trends and needs for action are only made possible via digitally captured data and the technical analysis possibilities of software solutions.

1.2 Requirements in Environmental and Sustainability Management

Sustainable development is a defined goal of the United Nations[5], Europe[6] and Germany[7]. The European Union is currently introducing new legal requirements that directly affect companies including their EM and SM. For instance, embedded in the European Green Deal[6], the European Taxonomy Regulation[8] came into force in January 2022. This set of rules defines which economic activities make a substantial contribution to European environmental goals. In addition, the Corporate Social Responsibility Directive[9] (CSRD) places extended requirements on sustainability reporting, which will affect a larger circle of companies than previously. The Supply Chain Due Diligence Act (Lieferkettensorgfaltspflichtengesetz - LkSG), which will come into force in 2023, will stipulate that large companies in Germany must ensure compliance with human rights and selected environmental agreements along their supply chains. At the European level, negotiations are underway for a Due Diligence Act (so-called Corporate Sustainability Due Diligence Directive). Overall, the development trend is moving away from a (production) site-based approach towards a consideration of the (upstream and downstream) value chains, be it in company-based or product-based analyses. Based on the European Green Deal and the European Commission's Circular Economy Action Plan (CEAP)[10] a wide range of product-related activities are also planned. These include, for example, the Sustainable Products Initiative[11] (SPI), which will extend the existing Ecodesign Directive that has so far focused on

[5] United Nations (UN, 2022)
[6] European Commission (n.d. a)
[7] Federal Government (2021)
[8] Regulation (EU) 2020/852
[9] European Commission (n.d. b)
[10] European Commission (2020)
[11] European Commission (2022)

energy-related products, to a wide range of products. The SPI aims, among other things, to reduce waste and move products produced or sold in Europe towards a resource-efficient, climate-neutral, and circular economy. In addition, a Digital Product Passport (DPP) is expected to become a new requirement in various industries (starting with batteries). The DPP should contain, among other things, information on the material composition, the product carbon footprint (PCF) and proof of origin of the product.

In addition to numerous legal changes aimed at accelerating the transformation towards a sustainable economy, market requirements are also increasingly exerting pressure on companies to act. More and more market actors - on the customer side, in business and supplier relationships or through investors - are demanding that sustainability aspects are taken into account in business activities and that the corresponding information is disclosed. Both investors and business partners are increasingly demanding compliance with minimum requirements in the areas of environment, human rights and occupational health and safety. Furthermore, social trends towards a sustainable and climate-friendly way of doing business and living (e.g. vegan diets, not using plastic, fair fashion) within (potential) customer groups are becoming relevant to companies' decisions.

The implications of changing framework conditions for the business model of companies are profound. It is becoming clear that especially those companies whose current business model cannot exist in an economy geared towards sustainability and climate neutrality or whose activities are vulnerable to the consequences of climate change and environmental degradation also face serious financial risks.

Implications for corresponding software solutions

The current and future requirements entail numerous uncertainties for companies. On the one hand, this results in the introduction of corresponding software solutions appearing to be increasingly useful in order to be able to control the growing number of requirements to be taken into account and data to be recorded. On the other hand, there is the challenge of setting the appropriate requirements for a software solution so that it can provide precise support now and in the future. The same degree to which the demands on EM and SM are increasing, the demands on corresponding software solutions are also increasing.

Software solutions must, for example, react to the large number of different standards and legal provisions in EM and SM in order to support users in the correct collection and preparation of the necessary data. These include, among others, standards and legal regulations with a corporate focus, such as the European Eco-Management and Audit Scheme (EMAS), sustainability reporting standards such as the Global Reporting Initiative (GRI) or the German Sustainability Code (Deutscher Nachhaltigkeitskodex - DNK), the CSRD or the EU taxonomy; with a product focus, such as product environmental footprints (PEF), product seals such as the EU Ecolabel or the Blue Angel, or ecodesign requirements; or with a facility focus, such as requirements from pollution control, water or waste legislation.

Example| The Act on Corporate Due Diligence in Supply Chains (Lieferkettensorgfaltspflichtengesetz - LkSG)

In the future, companies will be obliged by the Supply Chain Due Diligence Act (LkSG) to follow up on and report on their human rights and, in some cases, environmental due diligence obligations in the supply chain. The management of these due diligence obligations can take place within the framework of sustainability management and presents companies with new challenges. If a

company has so far worked with a primarily location-based EM and SM, there is often only insufficient environmental and sustainability-related information on the supply chains. Depending on the complexity of the supply chains, collecting this information can be very time-consuming. Moreover, in the context of the supply chain, the question of data quality and the auditability of collected data is particularly important. Various possible applications for software solutions are conceivable here, including:

- Recording and monitoring of suppliers and sub-suppliers, modelling and mapping of supply chains;
- Conducting risk analyses to identify human rights and environmental risks at suppliers
- Traceability of products and components along the supply chain
- Creation and follow-up of action plans
- Handling of complaints procedures
- Data preparation for reporting
- Transparency requirements and data quality

The increasing requirements for sustainability reporting and transparency raise the question about the necessary quality and auditability of environmental and sustainability-related data. In the current amendment process of the CSRD, it becomes apparent that the verification and reporting obligations of environmental and sustainability information will be subject to an external audit and thus must also be recorded and stored in an audit-proof, verifiable and auditable manner in the future. Thus, the requirements for data quality will be higher than currently often the case. In particular, data from the value chain (e.g. in climate management for Scope 3) often have a varying degree of detail or varying validity and reliability. The use of appropriate software can bring decisive advantages here compared to the comparatively error-prone manual data collection.

What is required to meet the challenges of the future?

In the context of current regulatory and market change processes, it is clear that the future need for expertise in the areas of environment and sustainability is constantly increasing on the part of companies and software users, but also on the part of software providers. Companies will be increasingly dependent on employing staff with sustainability competence. Along with relevant knowledge of applicable laws and relevant standards, communication skills and competence in the use of appropriate software solutions are also relevant. Considering the future increase in complexity, e.g. with regard to data along the supply chain, which can hardly be managed without appropriate software solutions, the digitalisation competence of employees and particularly the key personnel involved in EM and SM is also crucial. Overall, an increase in digitalisation readiness is required if the essential environmental and sustainability aspects (today and in the future) are dependent on digitalised control.

Being equipped for future challenges may also mean that companies have to comprehensively change their evolved structures. After all, the future challenges and requirements in EM and SM not only contain implications for individual areas of a company's business activities, but also influence all central business processes. For example, changes in production or procurement will be indispensable in order to achieve the necessary reduction of greenhouse gas (GHG) emissions and to avoid environmental destruction and human rights violations in supply chains. On a

strategic level, the transformation of the business model may accordingly become (economically) necessary, e.g. if a core business based on fossil fuels is no longer profitable due to resource scarcity, price increases and stricter regulation. This can be illustrated by the example of the necessary reduction of GHG emissions: A company's climate-relevant data includes direct and indirect emissions (Scope 1, 2 and 3) (cf. info box GHG accounting) and is distributed across all business areas. Hence, an ERP system that maps all business processes in a bundled way can also be a suitable starting point for calculating and controlling GHG emissions data.

Example | Greenhouse Gas Accounting

In a GHG balance, all GHG emissions that occur within a selected boundary (e.g. an organisation, an organisational location, a product) are mapped. The GHG emissions of an organisation and its upstream and downstream value chain are often divided into three categories (so-called scopes) according to the standards of the Greenhouse Gas (GHG) Protocol[12]: Scope 1 includes all direct emissions at the organisation site. Direct influence can be exerted on these emission sources, e.g. through the type and use of a production facility that uses fossil fuels or a vehicle fleet. Scope 2 covers indirect emissions from the generation of purchased energy, e.g. electricity, district heating/cooling or process steam. Scope 3 lists the remaining indirect GHG emissions from the upstream and downstream value chain. These include emissions from the production of primary products and components, upstream and downstream transport and the use and disposal of products. Emissions from business trips and employee commutes are also recorded here.

If Scope 3 emissions are of importance, the question of how these data can be collected reliably and recurrently with a reasonable amount of effort is particularly relevant. The larger the network of supplier relationships for example, the more complex and difficult the manual collection of relevant data can become. This applies equally to product related GHG balances or product life cycle assessments.

Software solutions can support this accounting process by facilitating collaboration during data collection, providing a structured framework for data collection and modelling of supply chains and processes, enabling automated calculation of GHG emissions from activity and consumption data, and allowing analysis and visualisation of the data.

A number of specialised software solutions already exist that cover different fields of application in GHG management, including.:

- Recording, calculating and presenting the Corporate Carbon Footprint (CCF) and reporting according to specific standards (e.g. GHG Protocol, ISO 14064-1 or the European Commission's Organisational Environmental Footprint (OEF) methodology)
- Quantification of Product Carbon Footprints (PCF) and identification of hotspots in the product life cycle (for hotspots e.g. identifying alternative materials with lower GHG emissions: Potential for energy-, resource- and climate-efficient product design)
- Quantification and presentation of economic savings potentials through environmental and climate protection measures

[12] WRI and WBCSD (2004)

1.3 Software Landscape for Environmental and Sustainability Management

After discussing the potentials of software use for EM and SM in the previous sections (section 1.1) and the future demands on organisations and software providers (section 1.2), we now take a look at the existing software offer for EM and SM in Germany (as of 2021).

For this purpose, the central results of the online survey of software providers for EM and SM conducted as part of the research project are presented below (on the methodology, cf. info box in section 1.1). These results do not represent a complete survey or a conclusive analysis of the software landscape and software use in Germany. Nevertheless, the results allow for a good overview of current software solutions for EM and SM and which use cases and trends are focused on.

The focus of the study lay on software solutions for the German market, which are used for EM and SM and their sub-areas. In the preliminary stages, 356 software solutions with this focus were identified through research and subsequently evaluated. These included 55 comprehensive management system solutions, 231 partial solutions, 6 calculators (e.g. CO_2 calculator) and 46 software solutions that were classified as ERP and/or BI solutions. No clear classification could be made for 18 identified software solutions.

The providers of the researched software solutions were invited to participate in an online survey, in which 103 software providers took part and submitted data for 136 software solutions. The software solutions recorded in this way are published (together with other software solutions) in an online database on the German EMAS website and are freely accessible (link to the online database; cf. info box in section 2.2).

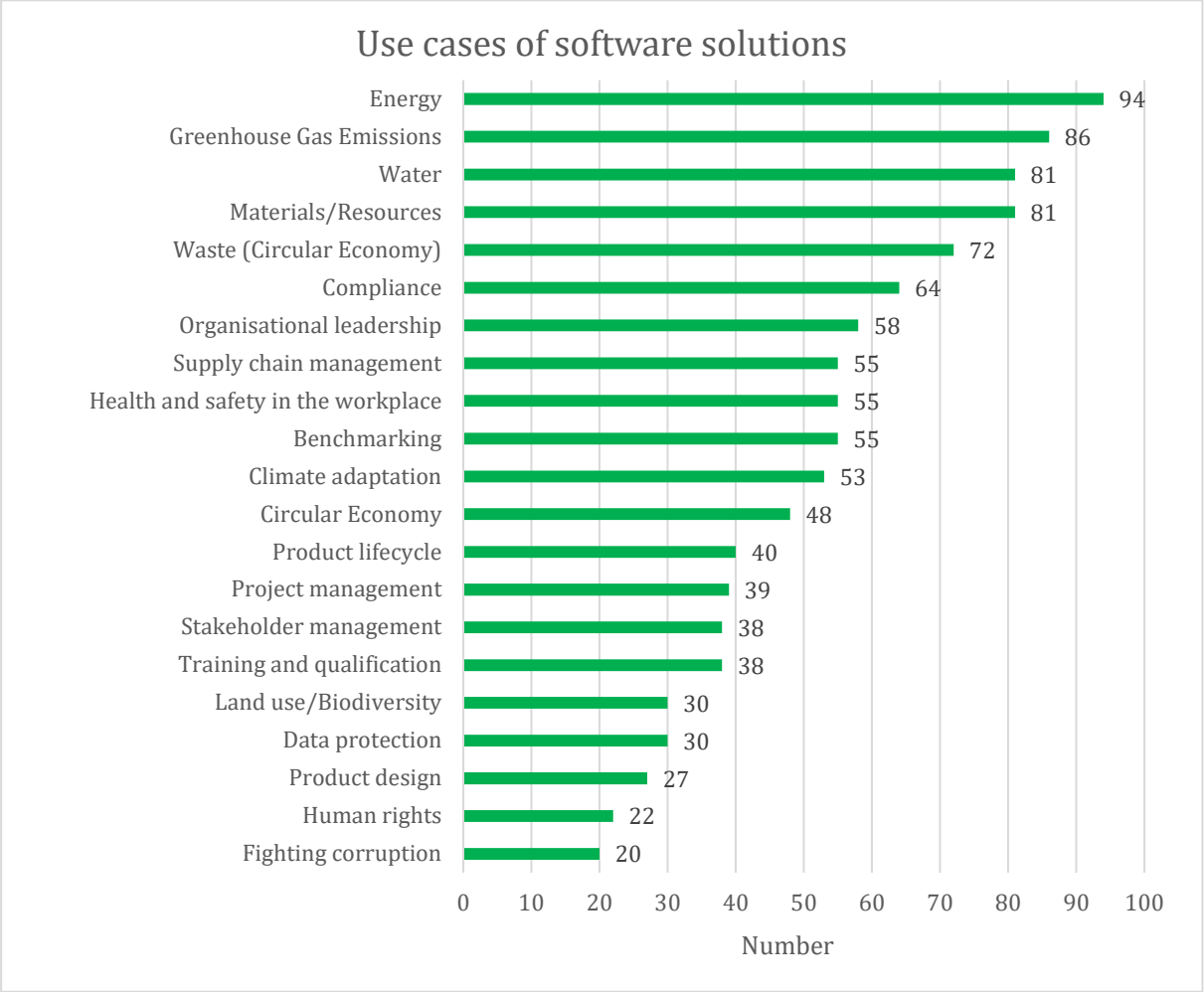
The results of the online survey were empirically evaluated and allow the following findings to be deduced:

Focused customer groups| 17% of the software solutions focus on SME and 12% on global companies. The vast majority, 71% of software solutions, do not explicitly focus on any customer group.

Focused Sectors | 83% of the software solutions do not have a sector focus. Only 4% state that they only focus on one sector.

Use cases | The majority of software solutions cover several use cases (see Figure 1). The overall analysis shows that software solutions prioritise the use cases of environmental, energy and climate management in particular. This is also reflected in the compatibility with standards at the company level.

Figure 1: Number of Software Solutions by Use Case



Source: own illustration, KATE.

Compatibility with Standards | Depending on their thematic orientation, these software solutions allow the requirements of various standards to be mapped at company or product level, as well as certain legal regulations.[13]:

- At the **company level**, particular compatibility is offered with the standards for an Environmental Management System according to ISO 14001 (64 in number), Energy Management System according to ISO 50001 (62), Environmental Management System according to EMAS (53), Corporate CO_2 Footprinting (CCF) according to Greenhouse Gas Protocol (GHG Protocol, 41) and the Energy Audit according to DIN EN 16247 (40) (see Figure 2).
- At the **product level**, it can be seen that standards for footprints or life cycle assessments in particular, such as Product Environmental Footprints (PEF) according to the PEF Guide of the European Commission (64 number), Life Cycle Assessment (LCA) according to ISO 14040/44 (62), Product Carbon Footprints (PCF) according to ISO 14067 (53) and Water Footprints according to ISO 14046 (40) are covered.

[13] Detailed information can be found in the final report on the research project (cf. Docke et al., forthcoming).

- Compatibility with **legislation** does not seem to have a particularly high relevance for the EM/SM softwares investigated due to their low coverage or seems to be relevant only for specialised software solutions.

Figure 2: Compatibility of Software Solutions with Standards at the Enterprise Level

Source: own illustration, KATE.

Availability | Some of the software solutions can be used in different ways. For example, 117 solutions are web-based, 66 solutions have to be installed locally. 33 solutions can be used via app. With regard to the licensing or usage models, it becomes apparent that different variants are possible for software solutions. The models range from annual licences (99 in number), to purchase (65), to subscription models with flexible terms (45).

Overall, the results show a broadly diversified market. It is apparent that the software landscape is characterised partly by specialised software solutions for sub-areas of EM and SM as well as partly by solutions with a broad spectrum of applications.

With regard to software providers of general business software, the results of this research project can be used to draw a picture of the market that essentially reflects the following tendencies:

Low response from software providers of general business software | At the time of the interview requests (autumn 2021), there was a very low level of willingness on the part of the contacted software providers for general business software to participate in interviews as part of this research project. In the previous online survey (spring 2021), the response from software providers of general software solutions was also very low. The methodological procedure of the research project was therefore adapted and an additional short survey on the relevance of EM

and SM offerings was conducted among 20 providers of general business software in order to obtain a picture of the overall sentiment.

EM and SM (currently) have a low presence in general business software | From the low response rate in the online survey and the feedback received in the course of the interview cancellations, it can be deduced that the inquired persons gave the topic of EM and SM a lower relevance at that time. As the project progressed, the impression emerged that the queried providers considered EM and SM to be less prominent topics and use cases of their general business software solutions up to that point. This impression was again confirmed during the short survey that was additionally conducted: No provider stated that their software solution could be used for EM and SM; six providers stated that this was not possible, and six others referred to individual configuration options. Overall, the combined project results suggest that software providers of general business software largely had no, or no standardised, functions in the area of EM and SM at the time of the empirical data collection in 2021.

Growing relevance of EM and SM for general business software | Similarly, it became apparent during the project that sustainability issues are becoming increasingly relevant for providers of general business software. In the context of a specialist workshop with various experts from the software sector in November 2021, it was emphasised, among other things, that the importance of climate management and company-related CO_2 accounting is growing as a potential area of application for ERP software solutions, as all company-relevant data is available transparently in ERP systems, making them a good starting point for calculating and controlling climate-relevant emissions. Against the background of the potentials discussed in previous chapters, which are offered by the linking and analysis of cross-departmental and cross-divisional company data, this development opens up numerous opportunities for the digitalisation of EM and SM.

2. Status Quo – Software Application and Challenges of Software Use in Environmental and Sustainability Management

In view of the described potential that digitisation holds for EM and SM (section 1.1) and against the background of the software landscape in Germany described in the previous chapter (section 1.3), this chapter presents how the use of corresponding software solutions is currently taking shape among the interviewed users as well as from the perspective of the providers and experts, and what challenges exist in this regard (section 2.1). In section 2.2, existing obstacles to the introduction and use of software are identified.

2.1 Software Use in Environmental and Sustainability Management

The results presented in section 1.3 demonstrate that software solutions exist particularly for the collection and analysis of environment- and sustainability-related data. However, the interview results highlight that software solutions for analysing environmental and sustainability-related data have not yet been widely applied in practice.

During the interviews, users indicated that software solutions are primarily used in the areas of reporting, life cycle analysis, document management and compliance, such as:

- Digital cadastre solutions, especially in areas for compliance and recording of legal regulations such as waste, hazardous materials, or general compliance management,
- Smart meter deployment for automated meter reading evaluation,
- Use of software solutions for process documentation, e.g. process landscapes/workflow management, or
- Calculation of company- or product-related greenhouse gas/environmental accounting.

In addition, software solutions are also used to support EM and SM across the company. For instance, web-based network and rating platforms are used to collaborate with business partners and suppliers or to provide transparency on their sustainability performance. Another frequently used tool is self-created spreadsheets (Excel, for example) in which data is collected and analysed, e.g. for recording commuting behaviour and calculating GHG emissions. In some cases, the companies surveyed also use self-programmed software that is tailored to their own requirements and use cases. In addition, the use of cloud solutions and applications for mobile working has become widespread in recent years - partly due to the Covid 19 pandemic.

Which software solutions are missing in the software landscape?

The users surveyed stated that they were particularly missing software solutions for visualising data and for monitoring the supply chain. In addition, users are looking for further software solutions in the area of data collection and evaluation, although according to the survey, the software offer and use in practice is best established in precisely this area. This suggests that the existing solutions as well as their functionalities are partly not known or that the solutions used do not (sufficiently) meet the expectations of the users.

The perspective of the providers of special software solutions for EM and SM focuses on further areas of application. They outline an increased user demand, especially for software solutions to monitor the supply chain or for data analysis providing output of forecast values. In the areas of risk management and internal auditing, anti-corruption with whistle-blower hotlines, for example, as well as knowledge and document management, the software landscape could be strengthened and expanded in the future from a provider perspective.

In the interviews, a number of key customer wishes were expressed as to which aspects are of importance for the further development of software solutions in EM and SM. These are outlined in the following info box.

At a glance | Expressed Customer Wishes for the Further Development of Software Solutions

On the user side, potential for optimisation is seen in a **reduction in the complexity** of software solutions. On the one hand, this can be achieved at the software level (e.g. through increased usability). On the other hand, it is also necessary to start with the users themselves and to strengthen their competence in handling (the necessary) complexity in software solutions. **Training courses** for employees can contribute to this (e.g. live training, demo versions). A lack of digital competence in general and a lack of training in software use and its potential applications in particular are seen as the main reasons why software functions are not used extensively. Enhanced **usability** is also relevant to ensure that people with little specialist knowledge are also able to use the software effectively. Besides optimising usability, increasing automation can also help to make the software easier to use for people with different levels of expertise.

Another customer concern is increased **flexibility** of the software in order to be adapted to **company-specific requirements**. This includes API integration with general business software, among other things. A fundamental challenge here is that users often want a perfectly refined solution that is tailored to their needs, but a software solution is generally subject to constant further development. Acceptance of this circumstance should be strengthened, for example by providing users with information about the process and the benefits of further software development.

2.2 Barriers to Software Use in Environmental and Sustainability Management

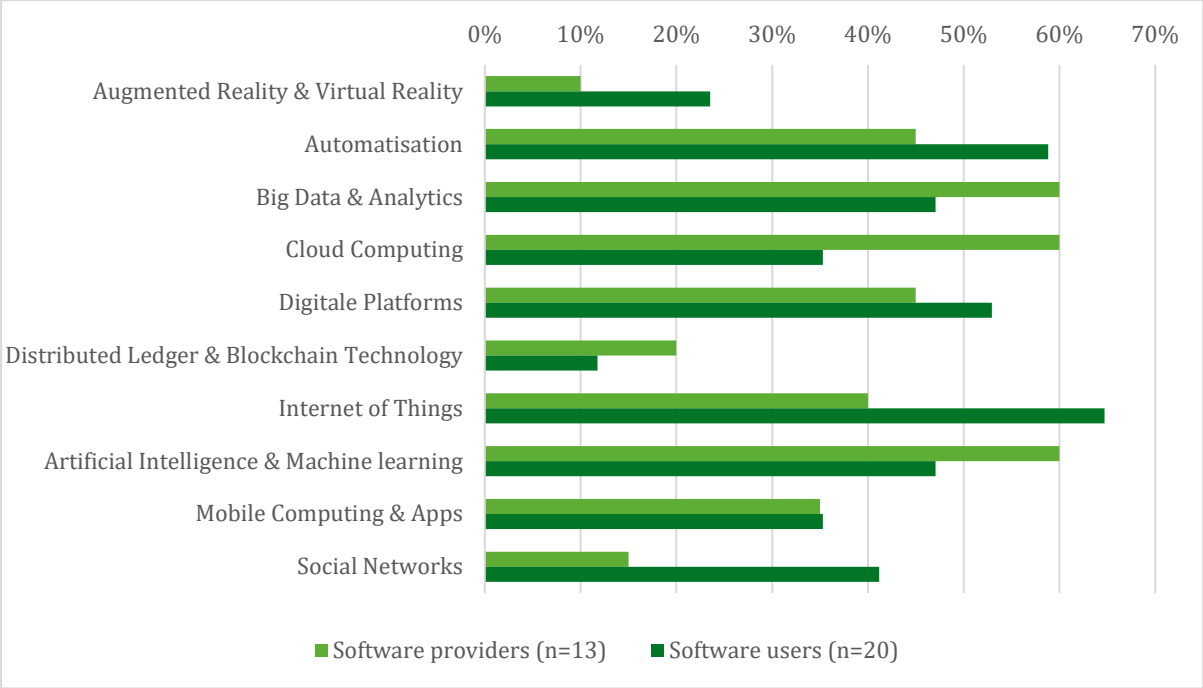
For companies, the selection and implementation process of a software is subject to various obstacles and hurdles. A selection of these is described below based on the results of the research project[14]. First, a general obstacle is identified, namely the different levels of knowledge about the potential of digitisation for EM and SM between providers and users. The following section describes obstacles in the (initial) selection and introduction process of a software solution for EM and SM on the one hand, and during existing software use and its connection or integration with general business software on the other.

Different levels of knowledge and assessments of potential determine the status quo

In general, it can be observed that software providers and users have different levels of knowledge and different perceptions of the potential of digitisation and digitisation trends in EM and SM. While providers, for example, already assess numerous digitisation trends and associated application possibilities as the usual state of the art, many users still see them as visions of the future. The frequent lack of knowledge on the part of users about the possible applications of certain technologies may result in an inaccurate assessment of the potential of software solutions in EM and SM. Figure 3 illustrates how differently the users and software providers surveyed assess the potential of certain digitisation trends for EM and SM in the interviews conducted.

[14] Detailed information on the methodology can be found in the final report on the research project (cf. Docke et al., forthcoming).

Figure 3: Evaluation of the Potential of Selected Digitisation trends for EM and SM from the Perspective of Software Providers and Users



Source: own graph, KATE.

It is striking that users focus on the potential of software use in the area of data acquisition, especially via automation and the Internet of Things. These potentials are seen, for example, in the use of smart metering (automated meter readings), which can replace time-consuming and error-prone manual data collection. In contrast, software providers emphasise in particular the potential in the area of data analysis, e.g. with regard to the recognition of correlations and patterns or the derivation of trends and forecasts, via Big Data & Analytics as well as Artificial Intelligence and Machine Learning.

It should be noted that the results of the survey of software providers and users are influenced by the research design and the interview partners (on the user side, primarily environmental/sustainability managers were interviewed, and on the provider side, partly also the management). With a different target group selection (e.g. on the user side: management), the assessments of potential may have turned out differently.

Different levels of knowledge as an obstacle to future-oriented further development of software solutions

For many software providers, in accordance with the principle “demand determines supply”, customer requirements are the decisive factor for the further development of their software solutions. In light of the different levels of knowledge and expectations between software providers and users, customer demand may lag behind the technical software potential. This may have the consequence that software providers rarely receive indications and incentives from their customers to include innovative technical use cases as new functions in the software or to promote their development. During the interviews conducted, it was expressed that, from the supplier's point of view, useful technical functions that were not used or hardly used by the customer were switched off again. Therefore, a strong focus on customer requirements may lead to a situation in which the further development of software solutions is geared primarily to current needs, future possibilities and requirements are not adequately anticipated, and

significant (technological and functional) topics are integrated into software solutions (too) late. As a result, the dynamics described can be an obstacle to exploiting the potential of new digital technologies and supporting users in implementing new legal or market requirements in EM and SM in a timely manner.

For a future-oriented further development of software solutions, it is therefore advisable that software providers also deal with trends and developments independently of current customer demands - in particular also with regard to future environmental or sustainability-related legal framework conditions. Accordingly, software providers face the challenge to anticipate future requirements at an early stage in order to find the right time for processing and integrating them into corresponding software solutions.

Obstacles in the selection and implementation process of a software solution in EM and SM

High requirements, the desire for interfaces as well as frequently low budgets - companies face a variety of obstacles the first time they introduce or switch to a software solution for their EM and SM.

In the decision-making process regarding the use of software in EM and SM, it must be thoroughly examined whether the digitisation of certain processes will bring a high (additional) benefit even if progress in EM and SM can basically be achieved without digital support. The benefits of digitisation and the use of software solutions often scale with the amount of data that needs to be processed. For example, if only a small amount of data is needed, it can often be collected manually and processed using spreadsheet tools, etc. In this context, however, it should likewise be questioned whether all the data that potentially needs to be collected and is relevant can already be collected. Digitisation processes allow for the collection of additional data or data collection in shorter cycles, which in turn can be used to make faster or different decisions and to make further progress. For example, digitised system control can enable real-time monitoring of energy consumption in order to align production in a more energy-efficient way.

In principle, before the introduction of a software solution, the user must weigh up the relationship between the additional benefits to be expected from the use of the software and the costs of introducing and configuring the software solution. The weighing up of benefits should include the expected savings in personnel efforts and financial expenses (efficiency potentials) on the one hand, and the expected additional benefits for the effectiveness of EM and SM (effectiveness potentials) through the use of the software on the other.

An example will illustrate this: In the practice of EM and SM, a significant amount of work often consists of compiling the environmental and sustainability-related data from different departments of the company. From the user's point of view, special software solutions without the possibility of automated data collection and maintenance offer in many cases only a small time saving (efficiency potential) compared to the widely used spreadsheets. Automated processes would bring high efficiency potentials, however, the automation of all processes would exceed the capacities and budgets of many companies, especially SME. Therefore, it should be weighed and prioritised in which use cases automation can provide the greatest possible benefit to EM and SM - both in terms of efficiency and effectiveness of EM and SM. Potential for effectiveness may lie, for instance, in the fact that the automation of processes enables certain forms of data collection and analysis that were not possible before. Insights and measures can be derived from corresponding analysis results that could not previously be made on the basis of data. Such potentials of software use typically lead to improved decision support in EM and SM.

Which software solution is the right one?

Once the decision to deploy the software has been made, the first difficulty for users is often to assess the added value and the accuracy of fit of a software solution for their own company in view of the large number of software providers and solutions on the market. In the EM and SM application area in particular, there are numerous standards, for example for certification processes or in reporting, for which the requirements should usually be taken into account by the software solution. In addition, there are other individual requirements and customer wishes, such as broad applicability of the software, ease of use, or requirements for data protection and security. The latter is becoming increasingly important, and companies are often uncertain whether a software solution meets security and data protection requirements. This is particularly true for web-based software solutions from providers based outside Germany or the EU. All in all, when selecting a suitable software solution, it is advisable to consult demo versions in order to gain an impression of the functionalities, usability and compatibility with the existing IT and software landscape at an early stage.

Good to Know | Database for Software Solutions in Environmental and Sustainability Management

In order to facilitate the search for suitable software solutions for corporate climate, energy, environmental or sustainability management, the office of the German EMAS Advisory Board (Umweltgutachterausschuss, UGA) has published a new online database with the support of the UBA. This also lists the software solutions for EM and SM covered by this research project.

The online database of the UGA is published on the EMAS website. | Link

Company-specific configuration of software solutions

The specific company requirements for a software solution can often not be met immediately by the purchased software solution. Rather, the introduction of a software solution often involves a significant amount of work to be done for the individual configuration. Regardless of the size of the company, the introduction of a software solution is in most cases associated with a high level of personnel effort and financial expense. The personnel workload is caused in particular by the transfer of data into the new system, the interfaces to already existing tools and the configuration of the software solutions as well as the training effort.

From the survey of software users, it became clear that there is often too little budget available for this generally comprehensive introduction process. On the supplier side, this impression was confirmed and it was noted, from the perspective of companies for example, that they are often unwilling to participate in or pay for software training. However, since digitisation competence is becoming increasingly relevant in EM and SM, a lack of know-how about the usability of the software solution or individual functions represents an obstacle to using the potential of an introduced software solution comprehensively for EM and SM.

The effort of the introduction process can be minimised by selecting software solutions with a high degree of coverage and modular structure compared to small-scale special solutions (e.g. usually less configuration effort, since, among other things, site structures only have to be set up once; less training, since the software modules follow a common logic; no costs for API connections to other software solutions, etc.).

Barriers to the integration of environmental and sustainability information into ERP systems

Interfaces for integrating environmental and sustainability information into general business software are feasible from the point of view of both providers and users, but they should not be

underestimated from a technical point of view and are mostly cost-intensive. The demand on the part of the users surveyed, however, is clear: the interface question is often a central decision criterion.

One reason for the high level of effort and cost of interface programming for ERP systems is their complex software structure. Due to high security requirements, ERP systems are often well protected, which may complicate API programming. In addition, ERP systems are usually already in use. For example, there is a risk that a technical incident during API programming could temporarily disable the entire system and thus affect business operations. Overall, companies face the question of the cost-benefit ratio of an API connection of the software solution in use. If it is merely a matter of exchanging a small amount of data and low exchange intervals, the need for an API must be questioned. In this case, the transfer of data from the special software to the ERP system by means of manual export/import or a one-way import interface can be an alternative with manageable effort (see also the connection or integration options in section 1.1).

In any case, the users interviewed consider it necessary to involve all relevant departments and persons in the introduction of an integrated software solution or the integration of environment and sustainability-related data in ERP systems. Together, it can be worked out whether, and if so, to what extent, such integration makes sense. It should be noted that technical data integration alone is only part of the benefit. In addition, competence is required to meaningfully process the data captured in the software solutions into usable information. After all, in order to exploit the potential of the database as a basis for business decision-making, data must be processed and, if necessary, linked. A BI solution, for example, can be used to support this process.

Different company-specific approaches can be found to meet the challenges of introducing and using software solutions. How political decision-makers and software providers can contribute to overcoming the described obstacles to the use of software in EM and SM is described in the recommendations for action in the following chapter 3.

3. Moving Towards Software-Supported Environmental and Sustainability Management – Recommendations for Action for Software Providers and Policy Makers

The potential for and obstacles to digitisation in EM and SM were presented in the previous chapters. It became clear that the use of software solutions offers numerous opportunities to make EM and SM more efficient and effective (Section 1.1). Digital technologies offer new possibilities for data collection, analysis, and control, which are becoming increasingly important, especially in light of future requirements in EM and SM (Section 1.2). Simultaneously, it became clear in Chapter B that in practice there are different impediments to the introduction and use of software solutions for the collection and control of environment- and sustainability-related data.

This chapter summarises the overarching findings (Section 3.1) and formulates recommendations for action that are aimed at providers of specialised as well as general business software (Section 3.2) on the one hand, and at political decision-makers (Section 3.3) on the other.

3.1 General Findings

1. **Regulatory framework conditions and market requirements are the main drivers for environmental and sustainability management.**

   Companies must meet various external sustainability requirements that have a direct impact on all corporate processes. At the top of this chain of effects are often government regulation and legislation, which increasingly set the framework conditions for EM and SM. Legislation on the one hand directly influences the requirements for companies, e.g. if they fall under the provisions of the CSRD, the LkSG or the DPP. On the other hand, it also indirectly influences market requirements, e.g. through increasing compliance requirements in customer/supplier relationships. Thus, new legal requirements for large companies can also become indirectly relevant for SME. In addition, there are also increasing sustainability requirements on the part of various market players, e.g. customers, investors or civil society, irrespective of legal regulations. In view of the expected increase in complexity in the handling of environmental and sustainability-related data due to regulatory and societal requirements, the need for appropriate software use to manage this data is increasing.

2. **There is considerable potential for targeted digitisation in environmental and sustainability management in the connection or integration of environmental and sustainability-related data in general business software.**

   EM and SM cannot be separated from the core processes of a company, instead it is an intrinsic part of corporate management. For the company's success, it is increasingly relevant to prepare environment and sustainability-related data and to link them with other company data in such a way that they can be used as a basis for decision-making. The linking of the various data can be done, for example, by means of API, in the form of an integrated module in the ERP system, or to a certain extent manually (e.g. via manual data export/import).

3.2 Recommendations for Action for Software Providers

1. **Environmental and sustainability data should be integrated more deeply into general business software.**
   For the upcoming transformation towards a climate-neutral, sustainable way of doing business, environmental and sustainability-related data must be put into context and linked with other company data. This starts with basic linkages such as the attribution of building energy demand to the number of annual hours of use or the relationship between CO_2 emissions and sales or production volume, and extends to more complex representations of risk analyses in the supply chain.
   To simplify the interaction between existing specialised software and general business software, programming of standardised APIs is recommended for both specialised software vendors and ERP/BI software vendors. Standardisation of APIs can greatly facilitate their programming and thus provide for improved feasibility of API connections. It is also conceivable that standardised interfaces will enable the automated transmission of information to external parties, e.g. authorities or certification bodies. In the case of BI software solutions, for example, API standards are well established already, which facilitates the automated transfer of data more easily.
   In this context, software providers may also consider the possibility of open source for their own solutions. This can simplify interface programming - even without API standards - to other software solutions and advance practical implementation.
   In addition to an API connection and thus integration of data from external software solutions, ERP software providers should also consider integrating their own modules for EM and SM.

2. **Software providers should (further) develop software solutions that address foreseeable requirements in EM and SM at an early stage.**
   The legal framework and market requirements are changing, so that environmental and sustainability-related information is increasingly influencing the various business areas of a company. In particular, greenhouse gas accounting and systematic climate management, environmental and sustainability aspects along the supply chain (e.g. due diligence obligations according to LkSG) as well as increasing reporting requirements (e.g. according to CSRD, EU taxonomy and/or DPP) will become relevant for users in the coming years. To implement these requirements, established processes in EM and SM are likely to be linked even more closely with central corporate processes and financial data.

   On the customer side, the complexity associated with future requirements (in terms of data volume as well as standards to be considered) will increase the need for software usage. Providers who anticipate this need and incorporate it into the further development of the software solution(s) they offer can position their products on the market at an early stage. It is therefore advisable to build up competencies and processes on the supplier side in order to be able to identify trends and future legislation with environmental and sustainability relevance and to make them usable for one's own business model or the software solution(s) offered. Furthermore, this recommendation is explicitly addressed to providers of general business software: Even if environmental and sustainability issues are not yet necessarily reflected in increased customer demands (e.g. for APIs or corresponding modules in ERP systems), the project results indicate that the relevance of EM and SM for companies and, accordingly, the demand for supporting software solutions is increasing and that the linking of EM and SM key figures with other company data within the framework of business

software holds great opportunities (cf. Section 1.3). In order to support software providers in this process, the government should also play a supporting role (cf. Section 3.3).

3. **Software providers should expand their range of support services for users as well as for consultants in order to facilitate the use of software solutions.**

   There is a reciprocal relationship between the usability of the software and the digital competence of the user. In order to simplify the use of the software solution and thereby also facilitate its use by non-savvy users, many software providers focus on improving the usability of their software solutions. In addition, it is recommended that software providers examine the extent to which they can also support the user's competence building, e.g. by expanding their own range of software training courses or introductory materials such as explanatory videos.

   Moreover, strengthening interdisciplinary exchange, e.g. increased cooperation of software providers with consulting forces in the field of EM and SM, could strengthen digitisation expertise in different target groups. Advisory staff have important multiplication potential to carry the possibilities of digitisation into practice. In this way, overall competence building can be promoted among various actors. The recommendation to strengthen competence building is equally directed at political decision-makers (cf. 3.3, Recommendation 4).

3.3 Recommended Actions for Political Decision-makers

1. **Requirements for the quality and availability of environment and sustainability-related data should be standardised.**

   a) It is becoming apparent that higher quality requirements will be set for environment and sustainability-related data in the future compared to what has often been the case in the past (cf. Section 1.2), for example with regard to the value chain. In order to increase the reliability, comparability and relevance for the users of the information, a standardisation of the quality requirements for the reporting of environment and sustainability related information is recommended (e.g. level of detail of the data, auditability). One example of how data quality standards can be demanded is seen in the current legal developments in the revision of the CSRD and the development of reporting standards by the European Financial Reporting Advisory Group (EFRAG). For example, EFRAG proposes that sustainability-related information must meet quality requirements such as relevance, truthful presentation, and increased comparability, verifiability, and understandability[15]. In addition, a "digital taxonomy" under the CSRD should also enable machine-readable reports. It is recommended that, in addition, general quality requirements for environmental and sustainability-related data should be defined that are also applicable to organisations that are not covered by the provisions of the CSRD.

      More stringent quality requirements for sustainability information (in line with the CSRD) can be a strong argument, or necessity, for software use on the user side. Software vendors can specify for their software solutions what data quality is required, so that the software can create a uniform framework for users to ensure that, for example, data collection and retention meet legal standards

[15] EFRAG (2022)

b) Given the increasing relevance of environmental and sustainability-related data - for both market and government actors - it should be easily accessible and openly available to all interested parties. It is recommended to increase the availability of data on the sustainability performance of organisations (e.g. in line with the CSRD or the LkSG). An exemplary development that has already been initiated in this regard is the European Single Access Point[16] (ESAP). With the ESAP, a central European platform is planned in which all public financial and sustainability information of European companies will be digitally accessible in the future. In this way, the ESAP is intended to contribute to a sustainable economy in the context of the EU Green Deal. The further development of the ESAP as well as the promotion of the highest possible participation of European organisations (also SME) is recommended.

c) The availability of basic environmental and sustainability-related data and factors that companies can use for their operational EM and SM should also be increased. Examples are emission and conversion factors for different energy sources and processes that companies can access in a central location for their GHG management. In the United Kingdom, the Department for Business, Energy & Industrial Strategy publishes updated emission and conversion factors annually to help companies report their GHG emissions[17]. It is also advantageous that the conversion factors there are structured according to the scopes of the GHG Protocol. In Germany, there is no such central and continuously updated source of information for companies. Conversion factors or emission factors are just one area where up-to-date and public data is lacking, so that companies that want to prepare their GHG statements have to access expensive private databases or publicly limited and often outdated data. Policymakers could support the Open Data approach here and provide standardised, high-quality data, for example via the German Environment Agency's existing ProBas (Process-oriented Basic Data for Environmental Management Instruments) platform.[18] In this context, the European GAIA-X project is also relevant, in which representatives from business, science and politics are promoting a secure and networked European data infrastructure. The basic values of this infrastructure are openness, transparency and trust, so that digital sovereignty, innovation promotion and open data exchange are made possible. Accordingly, the GAIA-X[19] project progress should also consider environment- and sustainability-related data and their availability.

d) In the context of system connection and integration of different software solutions, it is essential to facilitate automated data transfer. Standardised file formats in certain fields of application could strengthen automation. Product-based life cycle assessments, for example, could be automated more easily if the bills of materials required for this were available in a standard file format. Governmental actors could advocate for a corresponding standardisation or initiate corresponding standardisation projects or regulations.

2. Practical support offers should be provided both for users and especially for software providers for the implementation of (new) legal requirements.

Complex legal requirements and applicable standards in EM and SM can lead to uncertainties regarding their fulfilment. On the part of users and providers, this can mean a lack of clarity with regard to corresponding software requirements. To counteract this, more

[16] European Economic and Social Committee (2022)
[17] GOV.UK - Department for Business, Energy & Industrial Strategy (2021)
[18] UBA (n.d.)
[19] BMWK (n.d.)

practical support offers could be provided by policy-makers as to how the legal requirements can be translated to the operational level. Such support could be provided in the form of practical guidelines, for example.

Existing support offerings can also be directed at the target group of software providers, since they are faced with the challenge of operationalising new legal requirements at the software level. Corresponding specifications and operational recommendations for action from the government reduce the vagueness and the room for interpretation on the market in the definition of the legal requirements, allowing support for targeted, timely operational implementation - both in organisations and in the corresponding software offerings.

An existing example of this is the "Helpdesk on Business & Human Rights"[20] of the German Agency for Business & Economic Development. Companies that want to make their supply chains environmentally and socially responsible can find free advice, training and other support materials there. Analogously, a helpdesk, for example, could bundle free offers to support companies (as well as software providers) in implementing future requirements, e.g. on EU taxonomy or CSRD. This helpdesk could be implemented at European or national level, for example. Since the EU taxonomy and CSRD also impose requirements for data quality and availability, the helpdesk could also address issues relating to data processing and digitisation in EM and SM and bundle offers of support for the appropriate use of software in EM and SM.

3. **Financial support opportunities for the use of software in EM and SM should be expanded.**

   Financial support for the introduction of software solutions can promote digitisation in EM and SM. Particularly the introduction process of a software solution is often cost-intensive on the user side. In order to support the introduction of software solutions, initial consultations on digitisation in EM and SM could be offered free of charge, for example. Direct financial support for the introduction of a software solution (e.g. pro-rata support for the first annual license fee) can also provide an incentive to switch from manual to software-supported data processing. Funding for specific software solutions for EM and SM, according to a defined set of criteria or a list, could also be considered. In this regard, the criteria should consider not only specialised software, but also modules for the EM and SM of general business software (e.g. an ERP system). Furthermore, it is recommended to provide financial incentives for the API connection of special software for EM and SM to general business software.

   For instance, there is already a list of eligible software solutions for energy management published by the Federal Office for Economic Affairs and Export Control (BAFA). [21] Eligibility is based on the guideline of the Federal Ministry for Economic Affairs and Energy "Bundesförderung für Energieeffizienz in der Wirtschaft - Zuschuss" (Federal funding for energy efficiency in the economy – grant) of 15.02.2020. Building on this list, financial support for software solutions for the broader EM and SM could also be realised.

4. **Software providers and users should be supported in building up competences in EM and SM and its digitisation. To this end, the promotion of a corresponding further training offer is recommended.**

   For the successful management of EM and SM, a corresponding level of professional competence is relevant. The digitalisation of EM and SM creates further (new) relevant

[20] Agency for Business & Economic Development (n.d.)
[21] BAFA (n.d.)

competence requirements for employees and managers. Given the increasing relevance and interconnection of both topics, a general development of competences in companies is recommended. The creation or expansion of a corresponding further training offer could be supported by financial support programmes for training providers. The focus of subsidised further training offers could be, for example, the use of certain digital technologies and/or the requirements in the EM and SM.

The creation or expansion of a corresponding training offer benefits not only the users, but also the software providers, especially those of general business software such as ERP systems. These see themselves being confronted with the new requirements (e.g. EU taxonomy, CSRD or the LkSG). Through targeted further training of employees, know-how can be built up to master the challenges and to design the software solution also for EM and SM issues.

The acquisition of competences in the areas of sustainability and digitalisation should also be further strengthened in vocational training. This was anchored in the updated standard vocational training positions for apprenticeship occupations[22] in August 2021. It is recommended that the implementation of the updated standard occupational profile positions be vigorously pursued so that the areas of competence in sustainability and digitisation become an integral part of in-company training in all training occupations as soon as possible.

5. **The stakeholder dialogue should be strengthened in order to support relevant actors to leverage the potentials of digitisation in EM and SM.**

In view of the different levels of knowledge among software users and providers regarding the potentials of digitisation (cf. section 2.2), the strengthening of a cross-stakeholder dialogue is advisable in order to exchange perspectives, convey competences and explore interdisciplinary solutions for existing challenges. Therefore, it is recommended to examine existing networks of relevant stakeholder groups to see to what extent content regarding digitisation in EM and SM can be integrated there. The aim should be to discuss the potentials, obstacles, and approaches to solutions within the framework of a broad dialogue of the relevant groups of actors (e.g. providers and users; special software providers and business software providers; users with software and users with an interest in software introduction). Suitable discussion platforms would be, for example, EMAS clubs, Regional Hubs for Sustainability Strategies (RENN), the Initiative Energy Efficiency and Climate Protection Networks (BMWK, BMUV), and also industry associations such as BITKOM or networks such as Ökoprofit.

Furthermore, the promotion of research and development as well as pilot projects in companies is also advisable, in which the potential of new digital technologies for EM and SM are tested and the benefits of the resulting data for corporate decision-making support are explicitly investigated. The standardisation of APIs and the integration of environmental and sustainability-related data in ERP and BI software should also be addressed. Initiatives aimed at developing digital data infrastructures along the supply chain are also promising. One example is the Catena-X Automotive Network[23], in which the vision of a continuous data exchange for all actors in the automotive value chain (in alliance with GAIA-X) is to be realised. Planned use cases for Catena-X include the traceability of hardware and software components as well as others in the area of circular economy and for minimising CO_2 emissions[23]. Such initiatives would also likely have great potential in other sectors to

[22] Federal Institute for Vocational Education and Training (2021)
[23] Catena-X Automotive Network (n.d.)

strengthen the digitalisation of environmental and sustainability-related data along the supply chain.

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