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CHALLENGES AND OPPORTUNITIES OF ERP AND SCADA SYSTEMS IN ESG REPORTING

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Purpose: The purpose of this paper is to analyse the challenges and opportunities associated with the application and integration of IT systems, particularly Enterprise Resource Planning (ERP) and Supervisory Control and Data Acquisition (SCADA), in the collection, processing and reporting of ESG data.
Design/methodology/approach: The study is based on a mixed method approach that combines a review of the literature with quantitative and qualitative analyses, based on pilot data collected among small and medium-sized enterprises (SMEs) in Poland.
Findings: The research showed that the integration of ERP and SCADA software can significantly increase the efficiency of monitoring and reporting ESG indicators by automating processes and improving data quality and consistency. The main challenges include high implementation costs, data fragmentation, compatibility limitations, and lack of uniform standards.
Research limitations/implications: The data from the pilot study are focused on SMEs in Poland, which limits the generalisability of the results.
Practical implications: Integration of ERP and SCADA systems improves data management processes, including data for ESG reporting, reducing reporting costs, and ensuring compliance with the CSRD and ESRS standards. Research indicates that key actions for small and medium enterprises (SMEs) and software vendors include the development of competencies for the automation of ESG reporting and the more efficient implementation of sustainable business practices.
Social implications: Improving ESG reporting promotes greater transparency and accountability, which can influence public trust and support for sustainable practices. The study highlights the potential social benefits of implementing robust ESG systems, such as reduced environmental impact and improved corporate responsibility.
Originality/value: The article fills a research gap by analysing the applicability of ERP and SCADA systems in ESG reporting in the context of CSRD requirements in SMEs in Poland. It provides relevant lessons for policy makers, business leaders, and technology providers, highlighting the potential of IT systems integration in automating processes, improving data quality, and supporting sustainability in line with ESG regulations.
Keywords: ERP, SCADA, ESG Reporting, CSRD, Sustainability.
Category of the paper: Research paper.

1. Introduction

In the face of increasing sustainability and social responsibility requirements, small and medium enterprises (SMEs) face the need to adapt their management processes to new regulations. The Corporate Sustainability Reporting Directive (CSRD) (Directive (EU) 2022/2464), introduced by the European Union, is a key element of these changes. Although its requirements are not mandatory for SMEs, social and economic pressures increasingly require companies to disclose detailed environmental, social, and corporate governance (ESG) information (Ozkan et al., 2023; Kuzior et al., 2024). The main objective of the CSRD is to increase the transparency and quality of reporting of sustainability-related activities, which necessitates the use of advanced systems to collect, process, and report data. Adapting to these requirements is particularly challenging for SMEs, which often face technological, financial, and organisational constraints. Traditional data collection methods, such as manually collecting and entering data and information into spreadsheets, are characterised by poor quality of the resulting outputs, frequent errors, and delays, making it significantly more difficult to meet regulatory requirements (KPMG, 2024). In this context, integrated IT systems (Dudek and Kulej-Dudek, 2024) supporting management, e.g., ERP (Enterprise Resource Planning) (Ruivo et al., 2012) and SCADA (Supervisory Control and Data Acquisition) systems, which enable automation of processes, improvement of data quality (Borda et al., 2024), and monitoring of ESG indicators, can play an important role. The integration of these systems with modern technologies, such as artificial intelligence (AI) and the Internet of Things (IoT) (Huang et al., 2024; Boye et al., 2023), creates new opportunities for ESG data acquisition and management, allowing for efficient data acquisition, analysis, and reporting. The implementation of modern solutions for ESG data acquisition and reporting in an enterprise is associated with a number of challenges, such as high implementation costs, lack of appropriate technological competence, and compatibility issues with existing systems (Tutak, Brodny, 2024). Therefore, it is worth considering integrating already functioning solutions and extending them with new, dedicated functionalities. The use of integrated IT technologies has significant potential to meet the requirements of the CSRD, improve the quality of ESG data, and support the implementation of sustainability strategies (Székely et al., 2017).

In this context, advanced technological systems such as enterprise resource planning (ERP) and supervisory control and data acquisition (SCADA) are becoming crucial (Martins, Belfo, 2023). These systems offer the ability to automate and streamline the processes of collecting and reporting data that can be used directly or indirectly for ESG reporting. This approach increases the accuracy and quality of the reporting, making it more compliant with the European Sustainability Reporting Standards (ESRS). Despite their potential, the implementation and integration of these technologies, especially in small and medium enterprises (SMEs), presents numerous challenges, such as high implementation costs, limited technical resources,

and organisational barriers. In Poland, the verification of ESG reports will be carried out by auditors (Act of 6 December 2024), making this process an important element in the professionalisation of sustainability reporting. At the same time, it forces companies to raise their reporting standards. To meet increasing regulatory requirements, organisations should invest in improving the quality of ESG data (Biju et al., 2023). One solution is the use and integration of management support systems (e.g., ERP, SCADA) and training of teams responsible for reporting (Hossain, 2023).

CSRD requires that ESG reports be independently verified by auditors or other accredited bodies. Their main tasks are to assess the compliance of the report with the ESRS, to ensure the consistency and completeness of the data in the context of the sustainability objectives, and to identify and report noncompliance and ESG risks. The audit verification of ESG reports plays a key role in ensuring their credibility and compliance with regulations, including the European Sustainability Reporting Standards (ESRS) and the requirements of the CSRD. The purpose of the audit is to confirm the reliability, completeness, and accuracy of ESG disclosures, which promotes transparency and builds stakeholder confidence. The scope of the audit covers three key areas: environmental indicators (e.g., CO2 emissions, waste management) (Afshan et al., 2024; Lin et al., 2025), social aspects (e.g., diversity policy, employee rights) and corporate governance (e.g., internal control systems, anticorruption). Verification is based on international standards, such as, e.g. GRI, SASB and ESRS, and auditors apply procedures analogous to those used in the audit of financial reports, including, inter alia, compliance testing and risk analyses. Auditing for ESGESG by auditors is not only a regulatory requirement but also a tool to support responsible management and sustainability of organisations.

Individual ERP software modules (https://www.comarch.pl/erp/esg/), once indicators have been standardised and appropriate reporting algorithms have been created based on the right selection of attributes and entities, can play a key role in the ESG reporting process and in meeting the requirements of the CSRD. Dedicated software / modules can provide tools to manage data and processes in different areas of the organisation. The financial module in conjunction with the production module will enable the consolidation of ESG data, such as CO_2 emissions or RES production (Dao, 2022; Gu et al., 2023), with financial performance, supporting the production of reports compliant with ESRS. The HR module (Martins, Belfo, 2023) will monitor diversity policies and respect employee rights, providing social data. The production module will track energy and resource consumption, waste management, and optimise processes for sustainability. The supply chain management module (SCM) will support the monitoring of sustainable supplier practices and the management of the carbon footprint of logistics (Lin, Li, 2024). The sales and marketing and CRM modules will allow reporting of corporate social responsibility (CSR) activities and analysis of the environmental impact of products. The Analysis and Reporting (BI) module will provide advanced analytical tools such as forecasting and analysis of key ESG indicators. In addition, the compliance and

document management modules will support the control of compliance with ESRS regulations and the automation of ESG reporting workflows. The integration of a project management module will allow the monitoring of ESG initiatives such as emission reductions or infrastructure upgrades (Osnes et al., 2018). SCADA system modules (Sbjörnsson et al., 2024; Molinari et al., 2023) would play a key role in the ESG reporting process and in meeting the requirements of the CSRD. The monitoring and visualisation module would enable visualisation of environmental data, such as CO_2 emissions, and real-time monitoring of ESG indicators. The control module would support remote management of processes and automation of operations to minimise environmental impact. A data archiving module would store historical data that could be used for ESG analyses and ESRS-compliant audits (Ab Aziz et al., 2023). An alerts and notifications module would generate alerts when emission or resource consumption standards are exceeded, allowing rapid intervention. The reporting module would automate the creation of ESG reports, visualise the results, and support their compliance with the ESRS. The integration module with external systems would allow data exchange with ERP and IoT, enabling the consolidation of ESG information. The analytics and optimisation module would identify trends in resource consumption and support process optimisation to achieve sustainability goals. The user management module would provide access control to ESG data and its security. The communication and protocols module would enable the transfer of ESG data between devices and the central database, ensuring transmission reliability. The maintenance management module would support the planning of technical activities and equipment upgrades, which would contribute to reducing resource consumption. A cyber security module would protect ESG data from unauthorised access, ensuring its integrity and confidentiality. A mobile access module would allow operators to remotely monitor and manage ESG reporting. The integration of ERP and SCADA systems will enable companies to meet CSRD requirements and improve the quality of ESG reporting. ERP modules support the management of data and processes in different areas of the organisation, while SCADA modules provide data monitoring and analysis for ESG reporting in real time (Szmechta et al., 2013). The collaboration of these systems allows for operational optimisation, reduced reporting costs, and effective implementation of sustainability goals. The integration of ERP and SCADA systems enables comprehensive business management, combining operational and business data to optimise processes and meet requirements, e.g., in ESG reporting (Barakat et al., 2024; Dao, 2022). ERP systems play a key role in consolidating operational and financial data, enabling their effective management and analysis. SCADA systems, on the other hand, support real-time data monitoring, which is particularly important in the context of dynamic indicators such as CO_2 emissions or natural resource consumption. The integration of these systems allows the automation of ESG reporting processes and the improvement of data quality, which is essential to meet the stringent requirements of the European Sustainability Reporting Standards (ESRS).

One of the main challenges for small and medium companies (SMEs) is the quality of ESG data (Kotsantonis et al., 2019), its often poor quality resulting from the use of manual methods to collect information, such as spreadsheets. This results in errors, delays, and inconsistencies, making it difficult to comply with CSRD requirements. ERP and SCADA systems offer the potential to address these issues through automation and data standardisation. Nevertheless, their implementation in the SME sector faces technological and organisational barriers such as high implementation costs, lack of technical competence, and system compatibility issues.

The literature (Dudek, Kulej-Dudek, 2024) also highlights the importance of modern technologies such as AI (Artificial Intelligence) and IoT (Internet of Things), Big Data, Blockchain (Baker, 2023; Kuzior et al., 2023), which, when combined with ERP and SCADA systems, enable advanced ESG data analysis and trend forecasting. These technologies support real-time monitoring of ESG indicators and integration of data from different sources, which is key to creating comprehensive and reliable reports.

Another aspect discussed in the literature (Huang et al., 2024) is the role of ESG auditing, which is an important element in the professionalisation of sustainability reporting. The verification of ESG reports by auditors requires high data quality and compliance with international standards. Such an audit covers key areas, including environmental, social, and corporate governance indicators, which increases transparency and stakeholder confidence. The low level of implementation of ERP and SCADA systems in SMEs in Poland indicates an urgent need for investment in technology and the development of competencies related to their implementation. It is particularly important to provide financial support, such as grants or investment allowances, which can help overcome cost barriers. Furthermore, the development of technology awareness and training for management and staff is key to maximising the full potential of these solutions. ERP and SCADA systems, supported by modern technology, are an essential tool to improve ESG reporting (Martins, Belfo, 2023). Their integration enables the automation of processes, improvement of data quality, and compliance with the requirements of the CSRD, while contributing to the achievement of sustainability goals. However, the introduction of these systems in SMEs requires overcoming numerous technological and organisational barriers, which represents a challenge but also an opportunity to develop innovative business practices.

2. Materials and Methods

The research carried out to assess perceptions of the role of data acquisition and to identify challenges and opportunities associated with the implementation of ERP and SCADA systems in the reporting of ESGs was based on a mixed methods approach, combining qualitative and quantitative research techniques. The main objective of the study was to analyse the potential

for the use of management support systems in small and medium enterprises (SMEs) in Poland in the context of ESG reporting. The potential of these technologies to ensure compliance with the requirements of the CSRD and the possibility of using existing data sources to improve the quality and consistency of the data necessary for reliable reporting was also considered.

The utilitarian objective of the study was to fill the research gap by analysing employee and management attitudes towards the use of ERP and SCADA systems in ESG reporting processes and to develop recommendations for companies and software developers. Specifically, the study focused on assessing how these technologies can support the overcoming of current challenges such as low data quality for ESG reporting, high implementation costs of ESG specialist software, lack of technological competence or system integration issues. Furthermore, the potential of using existing technology solutions to automate and standardise ESG reporting processes and their role in promoting sustainable business practices in the SME sector was analysed. The results of the study provide valuable insights into the practical applications of ERP and SCADA systems and their potential integration with modern technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), to effectively manage ESG data and adapt to increasing regulatory requirements.

The qualitative research included a review of the academic literature related to ESG reporting and the use of ERP and SCADA systems to identify key challenges and opportunities that arise from the implementation of these technologies. It analysed how the use of these systems can support data integration, data quality improvement, and compliance with ESG regulations such as the CSRD and ESRS standards. This approach provided a deeper understanding of the role of these technologies in sustainability reporting processes.

The quantitative part of the study consisted of a survey aimed at small and medium enterprises (SMEs). A structured questionnaire was used to collect demographic data and analyse the opinions of the respondents. The survey covered key issues such as the level of technology adoption, barriers to implementation, and the perceived benefits of using existing IT solutions for ESG reporting.

The pilot research sample comprised 41 SMEs from various sectors of the economy, focussing mainly on the southern Poland region, where manufacturing and trading companies stood out in particular. The survey was primarily aimed at those responsible for sustainability issues in the companies surveyed. The analysis shows that these were mainly managers and executives, providing insight into organisational perspectives on ESG compliance and readiness for the integration of technologies to support sustainability reporting. The results allowed for an assessment of the extent to which ERP and SCADA systems can be used in data capture and reporting and the identification of barriers.

Demographic analyses took into account variables such as gender, age, education, and professional roles of participants to understand their impact on readiness to implement ESG and perceptions of the role of modern technologies or readiness to adopt them. The level of integration of ERP and SCADA systems and their functionalities to support ESG reporting were

assessed. Barriers such as high costs and competence gaps were also identified. The scope of the study was geographically limited to Poland and the analyses were mainly based on pilot data. However, it provided valuable information on the adoption of ERP and SCADA systems in ESG reporting. Future studies can cover a wider sample and allow cross-country comparisons to generalise the results. The methodological approach adopted provided a holistic view of how advanced technology systems can support ESG data management, regulatory compliance, and sustainable business practices.

For most of the closed questions, the responses were rated on a scale of 1-5, where 1 meant total disagreement and 5 meant full agreement with the statement. A Likert scale was used to score the survey to assess perceptions and the impact and potential role of ERP and SCADA technology on the effectiveness of ESG processes.

This study provides an opportunity to analyse the challenges and opportunities for the use of ERP and SCADA systems in ESG reporting in small and medium enterprises (SMEs), the issues are divided into four key areas: assessment of data quality and efficiency of data acquisition processes, use of tools and implementation of ESG support systems, technologies and their integration in ESG reporting, and barriers and challenges. This division allows for a comprehensive discussion of the topic, starting with an analysis of the current situation in terms of data quality and tools used, through the identification of the most promising ESG support technologies and opportunities for their integration, to a discussion of the barriers and challenges faced by companies. Research was carried out to better understand perceptions of the role of data acquisition in ESG reporting and to assess the potential of ERP and SCADA systems to overcome the difficulties of acquiring reliable and high-quality data. They also allowed an analysis of the potential for effective use of these data in reporting. Challenges associated with the implementation of ERP and SCADA systems in SMEs to increase compliance with ESG regulations were also identified. The purpose of the survey was to identify which data acquisition and management support systems, according to the respondents, hold the most promise for ESG reporting processes. It also explored whether these technologies have the potential to improve ESG reporting and increase compliance with regulations such as the CSRD. A key element was to assess the quality of the data and the efficiency of the data capture processes in the context of the challenges and opportunities associated with the use of ERP and SCADA systems. The analysis considered both the difficulties and opportunities for the development of IT systems in data acquisition processes and their application in reporting. The study identified the extent to which and how these systems can support the acquisition of data necessary for reliable reporting in line with the requirements of the CSRD and address technical and organisational barriers. On this basis, a detailed assessment of the quality of the data and the efficiency of the data capture processes was carried out.

3. Results and Discussion

Analysis of the demographics of survey respondents on the challenges and opportunities of using ERP and SCADA systems for ESG reporting provides important information on their diversity in terms of gender, age, education, type of business, and location of company headquarters. The results make it possible to identify the professional groups and industries most involved in the implementation of IT systems to support ESG reporting.

In terms of gender, the proportion of men (51.22%) and women (48.78%) is almost equal, indicating widespread interest in implementing ERP and SCADA systems among both men and women. This suggests that ESG reporting using advanced technology tools is considered an important topic regardless of the gender of users.

The largest group of respondents were those 45 to 54 years of age (51.22%), followed by those 35 to 44 years of age (29.27%), indicating the dominance of experienced professionals and managers playing a key role in the ERP and SCADA implementation processes. Younger individuals, under the age of 25, accounted for only 2.44% of respondents, which may reflect fewer years of experience in this area. In addition, as many as 90.24% of respondents had a university degree (Master's, Bachelor's or Engineering) and only 9.76% had a high school education, suggesting that the implementation and use of ERP and SCADA systems in ESG reporting requires advanced knowledge and skills, more often found among those with higher education.

The largest number of respondents came from manufacturing (31.71%) and trading companies (29.27%), while service companies accounted for 21.95%. Other categories, such as educational, scientific, or trade/service companies, accounted for 4.88%. The dominance of manufacturing and trading companies may be due to their greater need to collect and analyse process and logistics data, making SCADA and ERP systems crucial for ESG reporting.

A significant proportion of the respondents were decision makers, including senior management (22.00%) and middle management (19.51%). The business owners accounted for 12.20% and the administrative staff 17.07%. This structure indicates the proportion of people who influence the implementation of technology and ESG strategies in organisations. In terms of location, companies from southern Poland dominated, with the majority coming from the Silesian Voivodeship, reflecting the concentration of industry in this region. Demographic analysis indicates that the implementation of ERP and SCADA systems in ESG reporting is most advanced in manufacturing and trading companies.

ERP and SCADA technologies show significant potential in improving the efficiency of reporting processes through automation, error reduction, and increased data quality. A key aspect of the research was to assess the feasibility of using them to meet the requirements of the CSRD and to analyse the challenges and opportunities associated with implementing these systems in ESG reporting. The results indicate the significant benefits that can be derived from

the use of these technologies, both in terms of improving data quality and operational efficiency. The research carried out has provided a better understanding of the role of data acquisition in ESG reporting and the potential of ERP and SCADA systems to overcome the difficulties associated with acquiring reliable and high-quality data, as well as its effective use in reporting. The quality of the data and the efficiency of the data capture processes were evaluated, identifying the support opportunities that these systems offer in the context of CSRD-compliant reporting. The perceptions of companies of the data used in ESG reporting indicate serious problems in this area. As many as 43.90% of companies rate their existing data as low or very low quality, which is a significant barrier to meeting regulatory requirements such as the CSRD. The largest number of companies (26.83%) indicated difficulties in using the data they already have, and 17.07% of respondents believe they do not have reliable data for ESG purposes. Only 2.44% of the respondents believe they have very high-quality data. In this context, ERP and SCADA systems, through their ability to automate processes and better structure data, can significantly improve data quality. In addition, by cross-correlating existing data, these systems can generate new information and, with a slight extension of the databases with additional attributes, enable synergies to be achieved when analysing and inferring based on new entities. This approach can significantly increase the accuracy and efficiency of ESG reporting. The implementation of these technologies helps overcome the difficulties of obtaining high-quality data, eliminating qualitative and quantitative errors resulting from manual input of information, while ensuring greater consistency and reliability.

An evaluation of the effectiveness of ESG data collection tools shows that 53.66% of companies rate their tools as neutral, suggesting that there are no clear benefits or problems associated with their use. On the contrary, 26.83% of respondents from the companies surveyed rate these tools as ineffective or very ineffective, indicating an urgent need to upgrade them. Only 12.20% of companies rate their tools as effective or very effective, suggesting that the companies surveyed lack integrated and automated solutions to support ESG reporting. ERP and SCADA systems can be key tools in this area, as they enable the automation of data collection processes and the integration of data from different sources using relational databases, providing the opportunity for effective data collection and reporting including ESG data.

Aligning companies' data capture processes with ESRS requirements remains a significant challenge. Only 2.44% of companies rate their processes as fully compliant with ESRS requirements, while 39.02% indicate a low degree of alignment and 14.64% consider their processes noncompliant with the regulations. ERP and SCADA systems can significantly support companies in complying with regulatory requirements by enabling the integration of the data they have from different sources, automating the analysis and acquisition of data, and transforming it into information useful for reporting on specific indicators. The proper integration of these systems allows companies to comply with ESG standards faster, cheaper and with less effort, consequently increasing compliance with the requirements of the CSRD.

With the ability to automate processes and make efficient use of data, ERP and SCADA contribute to eliminating technical barriers and streamlined reporting processes.

The analysis of the responses regarding the potential of already existing and applied tools used or possible to be used in the ESG reporting process showed that the respondents assessed the ERP and SCADA systems as tools with significant potential in the effective collection and processing of data, as well as being important to ensure regulatory compliance.

The study also identified opportunities for further expansion and integration of these systems, which could improve the consistency and accuracy of the information captured. An important element of the analyses was an assessment of the ability to use and implement IT systems already present in companies or easily implemented to support ESG reporting. Respondents highlighted the key role of ERP and SCADA systems as tools to increase data collection efficiency, including sustainability. An important aspect of the survey was an analysis of the tools currently used in SMEs to collect and analyse data that can be used for reporting on ESG. It was shown that in many cases traditional approaches such as manual data entry in spreadsheets and reports dominate (58.54%). These approaches are associated with risks of errors, delays, higher costs, and more work.

An important element of the research conducted was to analyse the potential of different types of software for information processing, indicator analysis, and the preparation of ESG reports. The aim was to identify the potentially most effective tools to support these processes, taking into account their ability to integrate data and comply with regulations such as the CSRD. The study identified opportunities for the use of advanced technologies to improve the quality and effectiveness of ESG reporting. Analysis of the survey results shows that ERP systems were considered by 39.02% of respondents the most promising tool to support the ESG reporting process. Their popularity is due to their ability to integrate operational and financial data, making them an important element in the effective management and analysis of ESG information. SCADA systems, identified by 17.07% of respondents, stand out for their ability to monitor data in real time, which is particularly important for dynamic indicators such as energy consumption, raw materials, or emissions.

Artificial intelligence (AI) technologies alone were rated useful by 12.20% of the respondents, highlighting their role in advanced analysis and forecasting of complex ESG data. The Internet of Things (IoT), although identified by only 4.88% of respondents, offers potential for real-time data collection, but its importance in ESG reporting appears to be less recognised among SMEs. The survey also identified perceptions of the applicability of integrated technology solutions. The results show that 9.76% of the respondents see the potential of integrating ERP systems with SCADA or ERP with AI, indicating a growing awareness of the benefits of technology synergies. On the contrary, 4.88% of the respondents indicated the combination of IoT and AI, suggesting that the full integration of modern technologies is not yet widely prioritised among SMEs. At the same time, 2.44% of the respondents were unable

to identify the appropriate tools, which may indicate a low level of awareness of available IT solutions to support ESG reporting.

The findings indicate that, in the minds of decision makers, ERP systems will play a key role in ESG reporting, particularly in terms of data integration and analysis, making them an essential tool for companies seeking regulatory compliance. The low awareness of the ability to fully integrate technologies such as ERP, SCADA, AI and IoT highlights the need for education and awareness among businesses. Although SCADA and AI technologies are less popular, their potential in optimising ESG processes, especially in monitoring indicators in real time, is significant. The results of the survey also highlight the need for training and awareness of modern technologies. A gradual and functionality-aware implementation of integrated IT systems, starting with ERP, can help companies minimise costs and risks, while increasing efficiency and compliance of ESG reporting with regulations such as the CSRD. The survey results indicate that ERP systems are seen as the most promising tool to support ESG reporting, due to their ability to integrate operational and financial data. At the same time, SCADA and AI technologies have gained recognition as key elements supporting real-time monitoring of ESG indicators and data analysis. However, the integration of modern technologies such as IoT and AI remains a challenge due to limited awareness of their capabilities among SMEs.

A significant problem identified in the research is the failure to fully exploit the potential for synergies between different IT systems. Only 9.76% of the respondents indicated that they combined ERP with SCADA or AI and 4.88% incorporated IoT and AI. This demonstrates the need to educate businesses on the benefits of advanced integration of ESG-supporting technologies.

In summary, the results of the study highlight the importance of automation, integration, and the development of analytical tools in the ESG reporting process. The implementation of advanced IT systems, such as ERP and SCADA, can significantly improve data collection and analysis processes, improving consistency and regulatory compliance. However, fully exploiting the potential of technology requires both investment in IT infrastructure and competence development among staff, which is a significant challenge for the SME sector.

An analysis of the responses on the potential of current tools and technologies in the ESG reporting process (Table 1) indicates that the ERP and SCADA systems are rated by the respondents as tools with significant potential in the effective collection and processing of data and key to ensuring regulatory compliance. The survey also revealed opportunities for further expansion and integration of these systems, which can improve the consistency and precision of the information captured. An important element of the analyses was an assessment of the ability to use and implement IT systems that are already present in companies or can be easily implemented to support ESG reporting. The respondents highlighted the key role of ERP and SCADA systems as tools to increase the efficiency of data collection, including sustainability data.

Table 1.
Results of responses to the question: Which software / IT tools should potentially be used in the ESG reporting process in your company?

Software/IT tools	
ERP (Enterprise Resource Planning)	39.02%
SCADA (Supervisory Control and Data Acquisition)	17.07%
AI (Artificial Intelligence)	12.20%
IoT (Internet of Things)	4.88%
ERP and SCADA	9.76%
ERP and AI	9.76%
IoT and AI	4.88%
None of the above/I don't know	2.44%

The survey analysed the tools currently used by SMEs to collect and analyse ESG-related data. It showed that in many cases traditional approaches, such as manual data entry in spreadsheets and reports, are dominant (58.54%). However, these approaches are fraught with the risk of errors, delays, higher costs, and more work. Therefore, the implementation of advanced technologies, such as ERP and SCADA systems, can significantly improve the quality and efficiency of ESG reporting.

Analysis of the survey results shows that 39.02% of the respondents considered ERP systems to be the most promising tool to support the ESG reporting process. Their popularity is due to their ability to integrate operational and financial data, making them an important element in the management and analysis of ESG information. In contrast, SCADA systems, identified by 17.07% of respondents, stand out for their ability to monitor data in real time, which is particularly relevant for dynamic indicators such as energy consumption or emissions. Artificial intelligence (AI) technologies were rated as useful by 12.20% of the respondents, highlighting their role in advanced analysis and forecasting of complex ESG data. The Internet of Things (IoT), identified by 4.88% of the respondents, offers potential in real-time data collection, but its importance in reporting on ESG appears to be less recognised among SMEs.

The survey also identified perceptions of the potential for integrated technology solutions. The results show that 9.76% of the respondents see the potential to integrate ERP with SCADA or ERP with AI, indicating a growing awareness of the benefits of technology synergies. In contrast, 4.88% of the respondents indicated the combination of IoT and AI, suggesting that the full integration of modern technologies is still not widely perceived as a priority among SMEs. At the same time, 2.44% of the respondents were unable to identify relevant tools, which may indicate a low level of awareness of available IT solutions to support ESG. ERP systems are seen to play a key role in ESG reporting, especially in terms of data integration and analysis. The low awareness of the potential for full integration of technologies such as ERP, SCADA, AI, and IoT highlights the need for education and increased awareness among businesses. Although SCADA and AI technologies are less popular than ERP, their potential in optimising ESG processes, especially monitoring indicators in real time, is significant.

The survey results also highlight the need for training and technological competence to support the implementation of integrated IT systems.

The surveys identified technologies that can support ESG reporting and identified key areas for optimisation in data acquisition and processing. The results of the survey indicate that the greatest potential in ESG reporting is attributed to ERP and SCADA systems, which are rated as key tools for automation, data integration, and improving data quality and regulatory compliance.

In order to identify the key technical areas that require optimisation in ESG reporting, an analysis was carried out that included data processing automation, integration of different systems, analytical and visualisation tools, real-time data collection and data structuring and standardisation. The most important area for optimisation, identified by 26.83% of the respondents, is data processing automation. Traditional data entry methods, such as manually filling in spreadsheets, have a high risk of errors and delays, which significantly reduces the quality of the report data. Automation not only enables the elimination of errors but also speeds up the analysis process, which is crucial in a dynamically changing environment. Integration of data from different systems, indicated by 19.51% of the respondents, is another technological challenge that needs to be addressed. Many SMEs use dispersed data sources, making it difficult to collate data consistently. ERP and SCADA systems, with their ability to consolidate data, can significantly improve the quality of ESG reports by integrating operational and financial information.

The development of analytical and visualisation tools, also indicated by 19.51% of the respondents, plays an important role in improving the quality of ESG reporting. Advanced analytical tools support the identification of trends and enable a clearer presentation of the data, which increases its usability for both internal and external stakeholders.

Real-time data collection, highlighted by 17.07% of respondents, is particularly important in sectors where key ESG indicators, such as emissions or energy consumption, change rapidly. In these applications, SCADA systems, supported by IoT technologies, enable real-time monitoring of indicators, which is essential to make fast and accurate operational decisions. The final area for improvement is the structuring and standardisation of the data for the ESG indicators, also identified by 17.07% of the respondents. The introduction of uniform data standards, in line with ESG regulations such as the CSRD, would facilitate their analysis and the automation of reporting processes (Table 2).

Table 2.
Survey results for the question: Which technical areas require the most optimisation to improve ESG reporting?

Which technical areas require the most optimisation to improve ESG reporting?	
Data Processing Automation	26.83%
Integration of data from various systems	19.51%
Analytical and Visualisation Tools	19.51%
Real-time data collection	17,07%
Data Structure and Standardisation	17.07%

The survey identified key barriers and challenges to the integration of ERP and SCADA systems in ESG reporting processes. Analysis of the survey results indicates significant technological and organisational difficulties. Among the technological barriers, the high costs of implementing new IT systems and solutions, problems with compatibility of systems from different manufacturers or generations, and the lack of qualified human resources were singled out. At the same time, organisational challenges, such as lack of knowledge and competence of staff and resistance to change, significantly hinder the effective implementation of technologies to support ESG reporting.

The research identified key barriers to the implementation and integration of ERP and SCADA systems in ESG reporting, considering both technological and organisational challenges. The main technological constraints include high implementation costs (17.07%), lack of staff competence (14.64%), and system compatibility issues (12.20%), which hinder the effective collection, processing, and analysis of ESG data. These limitations significantly reduce the ability of companies to meet regulatory requirements.

In the organisational area, lack of knowledge and competence (43.90%) and unclear regulatory requirements (34.15%) were found to be the biggest obstacles. Reluctance to change, indicated by 34.15% of the respondents, and insufficient management support (14.64%) further complicate the implementation of new technologies. Deficiencies in training and experience, highlighted by 26.83% of respondents, highlight the urgent need to develop ESG competencies and technologies to support the process. Despite these challenges, ERP and SCADA systems were evaluated as tools with great potential in ESG reporting, especially in terms of automation, data integration, and data quality improvement. The survey also highlighted the potential for further integration of these systems, which could significantly improve the consistency and accuracy of information. The use of existing IT systems that can be adapted to meet ESG requirements was identified as a key element in minimising costs and increasing reporting efficiency.

Research points to the need for investment in IT infrastructure, development of technological competence, and ESG education. Removal of organisational and technological barriers, as well as increasing awareness of the benefits of integrating ERP and SCADA systems, can significantly improve reporting processes. Despite the initial costs, implementing these technologies is a necessary step towards sustainable and effective ESG reporting that complies with current regulations.

4. Conclusions and Recommendations

The research and analysis carried out indicated the significant potential of ERP and SCADA systems in ESG reporting, especially in terms of improving data quality, process automation, and compliance with regulatory requirements. The main technological barriers are high implementation costs, lack of staff competence, and system compatibility issues, which limit the ability of companies to effectively collect, process, and analyse ESG data. Organisational difficulties, such as lack of knowledge and competence and reluctance to change, further hinder technology implementation, pointing to the need for management education and support.

However, respondents recognise the potential of integrating ERP and SCADA with AI and IoT technologies to enable end-to-end ESG data management, real-time monitoring of indicators, and automation of reporting processes. ERP systems integrate operational and financial data throughout the supply chain, while SCADA provides real-time monitoring of manufacturing processes to support environmental management and CSRD compliance. The integration of these systems improves data consistency, quality, and efficiency, while reducing the risk of errors.

The results of the research indicate an urgent need to modernise ESG reporting tools, especially in the SME sector, where manual data collection methods dominate, generating errors and delays. Improving reporting quality requires the implementation of integrated IT systems that allow data structuring and analysis in accordance with ESRS standards. The gradual implementation of ERP and SCADA technologies, supported by financial support and the development of technological competencies, can help companies overcome implementation barriers and raise awareness of their benefits.

Integrated ERP and SCADA solutions, when expanded with new functionalities, have the potential to become key tools in ESG reporting, supporting the optimisation of operational processes, reduction of reporting costs, and implementation of sustainability strategies. Their integration with AI and IoT technologies will allow for a more complete use of data, resulting in better environmental management and regulatory compliance. The implementation of these systems, although it requires investment, is a key step toward effective and efficient ESG reporting.

Based on the research and analysis carried out, key recommendations were made on the use of ERP and SCADA systems in reporting for sustainability and sustainability purposes.

Automating data collection and processing processes using ERP and SCADA systems reduces errors resulting from manual data entry and improves analysis. Integration of SCADA systems with ERP enables real-time monitoring of indicators, which significantly improves the efficiency of reporting processes.

The development of technologies integrating ERP, SCADA, AI, and IoT supports the comprehensive management of ESG data, improving its quality, consistency, and compliance with the requirements of the CSRD and ESRS standards. The implementation of dedicated modules for structuring and standardising ESG data and reporting tools that enable the automatic generation of reports and streamline audit processes is crucial.

Companies must develop advanced analytical and visualisation tools to monitor key ESG indicators and respond to environmental exceedances in real time. Optimising processes for monitoring resource consumption and emissions through SCADA integration with ERP can contribute to reducing the carbon footprint and increasing operational efficiency.

It is important to implement ESRS-compliant IT systems and to provide training to employees in the use of ERP, SCADA systems and knowledge of ESG-related regulations. Raising organisational competence and awareness is key to the successful implementation of ESG-supportive technologies.

The SME sector should gradually introduce ERP and SCADA systems, focussing on key business areas, but should integrate solutions to support ESG reporting from the outset.

Financial support in the form of grants or concessions can help overcome economic barriers to the implementation of IT solutions also for ESG reporting. Problems with system compatibility and resistance to change can be mitigated by promoting innovative solutions and highlighting the benefits of implementing new technologies.

Digitisation of supply chain processes, including automation of data collection and integration of IT systems, allows effective monitoring and reporting of ESG data.

Summary

ERP and SCADA systems, supported by modern technologies such as AI and IoT, offer significant potential in automating ESG reporting processes, improving data quality, and ensuring compliance with CSRD requirements. The implementation of these systems eliminates manual data entry errors, integrates information from different sources, and monitors ESG indicators in real time. Such solutions contribute to the optimisation of operational processes and the implementation of sustainability strategies.

Despite the numerous benefits, the implementation of ERP and SCADA systems, especially in small and medium enterprises (SMEs), faces significant challenges, such as high implementation costs, problems of compatibility of systems with current software, and lack of technological competence. At the organisational level, key barriers include resistance to change and low awareness of the synergies of technology integration for ESG reporting.

However, these difficulties also represent an opportunity for development. The gradual deployment of integrated systems, financial support for SMEs, and the development of technological competencies among employees and managers are key to realising the full potential of these technologies. The integration of ERP and SCADA with AI and IoT is not only an opportunity to help meet ESG regulatory requirements, but also increases the operational efficiency and competitiveness of companies in the market.

To overcome technological and organisational barriers, actions such as collaboration with technology providers, ESG education, and management commitment to integrate technology with sustainability goals are required. The identified lessons point to the need for increased investment in advanced systems and alignment of business processes with new requirements, allowing companies to effectively manage ESG reporting and meet long-term sustainability goals.

The research conducted highlights the need for further analysis of the feasibility of implementing modern systems to support ESG management and reporting. Particular attention should be paid to identifying implementation barriers, assessing the effectiveness of existing solutions, and developing recommendations for integrating ERP, SCADA systems in terms of new functionalities related to data analysis for ESG needs. Such an approach supported by modern technologies such as AI and IoT will allow to streamlining reporting processes in line with the requirements of the CSRD Directive and the ESRS standards.

This paper discusses the challenges and opportunities associated with the implementation and development of ERP (Enterprise Resource Planning) and SCADA (Supervisory Control and Data Acquisition) IT systems in the collection and processing of ESG data. The study indicates how these systems can support the acquisition of reliable data necessary for reliable reporting and eliminate technological and organisational barriers. The integration of ERP and SCADA systems improves data quality by automating processes, enables real-time management of dynamic ESG indicators (e.g., emissions, resource consumption) and ensures compliance with regulations such as the CSRD and ESRS standards.

Through better data and process management, strategic sustainability goals can be achieved and reporting costs reduced. Investment in ERP and SCADA systems, the development of analytical tools, and the employment of ESG experts are key to increasing competitiveness and regulatory compliance. Integrating these technologies supports companies in effectively managing ESG reporting, meeting regulatory requirements, and long-term sustainability goals.

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