From Compliance to Control: A Roadmap for ERP-Based Emission Reporting

Investigating how ERP systems, like SAP, can enable automated sustainability reporting and strategic decision-making under CSRD and ESRS E1

MSc Complex Systems Engineering and Management - TU Delft

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TU Delft

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Investigating how ERP systems, like SAP, can enable automated sustainability reporting and strategic decision-making under CSRD and ESRS E1

by

T.A.J.C. (Teun) van Pelt

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TU Delft

Preface

Dear reader,

With a sense of pride and fulfillment, I present to you my thesis: *From Compliance to Control: A Roadmap for ERP-Based Emission Reporting.* This research focuses on the use of SAP as an ERP system to comply with emission reporting regulations. An increasingly relevant topic that has surprisingly received little academic attention. This thesis marks the conclusion of my studies in Complex Systems Engineering & Management at TU Delft and represents the final step toward obtaining my MSc degree and the title Ir.

Back in 2013, when I was in my first year of high school, I had to decide whether to stay at the HAVO level or move up to VWO. I never imagined myself attending university. *"I'm not going to university anyway, so why should I do VWO?"* I thought. Looking back, however, this turned out to be one of the first steps on a path full of exciting challenges.

Another major decision came when choosing my studies. For a long time, it seemed likely that I would study in Tilburg or Eindhoven. I had even visited Delft once for my 'profielwerkstuk', meeting with a professor from the EWI faculty. I was not used to a campus like this and found it overwhelming. I even said: *"I don't know what I want to study, but I definitely don't want to study here."* And yet, suddenly, the bachelor 'Technische Bestuurskunde' caught my attention. The combination of mathematics, economics, and law was exactly what I was looking for. After a last-minute open day visit, I was immediately convinced, and the decision was made quickly. Looking back, it was perhaps one of the best choices I have made in my life so far.

With this thesis, my time as a student in Delft also comes to an end. A period of 6.5 years that I look back on with great joy. I am incredibly grateful to all my friends who have made my time in Delft unforgettable. A special mention goes to my housemates at HvGL, with whom I shared a unique experience during the pandemic and where I always felt at home.

Beyond my friends, I would also like to express my gratitude to my thesis committee: Dr. J.A. Annema, Dr. J.H.R. van Duin, and J. Ubacht, who guided me as experts in academic research and provided me with invaluable feedback. Over time, I have come to appreciate the role of a researcher more and more, realizing that research is truly an iterative process. I also want to extend my gratitude to my colleagues at PwC, with special thanks to my supervisors Amy Zhou and Martijn Meester. We had almost weekly meetings, and at the office, I could always turn to you for guidance. From the very beginning, I felt at home at PwC, and I look back on the past six months with warm memories.

Finally, I want to express my heartfelt thanks to my loved ones. To my girlfriend, who supported me at every moment, even when my motivation was lacking. To my family, who helped me through the final stretch. With the highlight being the 'schrijverskamp' at my mother's place. For a little while, it felt like I was back in high school, with a fruit snack and a cup of tea waiting for me every afternoon.

Now that I have expressed my gratitude, my work is done. It is now up to you, the reader, to dive into this research. I hope you enjoy reading it!

T.A.J.C. (Teun) van Pelt
Delft, March 2025

Summary

Today, sustainability is a hot topic for companies within their business operations. This is partly due to the introduction of the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS). These are legislations which have been drawn up that require companies to report on their business processes on the basis of Environment, Social and Governance. Within these guidelines, ESRS E1 focuses specifically on climate change and requires companies to disclose their emissions. These emissions include direct emissions (Scope 1), purchased emissions (Scope 2) and further emissions from the value chain (Scope 3). The implementation of this legislation brings new challenges for companies in terms of data collection, standardization and integration within business processes.

A potential solution to these challenges is the use of Enterprise Resource Planning (ERP) systems. ERP systems are widely implemented across industries to streamline business processes and centralize data, positioning them as a viable solution for sustainability reporting. Within this context, SAP is a leading ERP system that offers specific functionalities for sustainability reporting, including tools designed to facilitate emissions tracking and compliance with regulatory standards.

Despite the widespread adoption of SAP and other ERP systems, structured research on their effective implementation for emissions reporting in compliance with ESRS E1 and CSRD remains limited. To bridge this knowledge and implementation gap, this thesis focuses on the following central question:

> *"What structured approach can companies follow to implement ERP systems, with a focus on SAP, for emissions reporting in compliance with ESRS E1 and CSRD?"*

An exploratory research was conducted using a qualitative approach to answer this main question. In this study, an analysis of regulatory reporting requirements under the CSRD and ESRS E1 was first conducted through desk research. This showed that ESRS E1-5, E1-6 and E1-7 in particular are the most critical reporting requirements, as they form the quantitative basis on which the remaining ESRS E1 disclosure requirements are built.

A case analysis on a specific ERP system was then conducted to assess the suitability of this ERP system for emissions reporting according to ESRS standards. In this study, SAP was chosen as the ERP system. It was found that SAP currently provides the capability to populate 19 quantitative metric points within the SAP Sustainability Control Tower (SCT). This is essential because SAP SCT only functions optimally and enables full reporting to ESRS E1 when these 19 data points are correctly populated and integrated within the broader business operations. Finally, eight experts from consultancy and software development (PwC and SAP) were interviewed to understand implementation challenges and best practices for using ERP systems in emissions reporting.

Based on these insights, a structured roadmap was developed to guide companies in the effective integration of ERP systems for emissions reporting. This roadmap consists of 12 key steps that help organizations address technical, organizational, and strategic challenges, ensuring compliance with ESRS E1 and CSRD.

The research highlights technical, organizational as well as strategic challenges in implementing ERP systems, such as SAP, for emissions reporting. Technically, the study found that the reporting system within SAP is well-designed and contains the necessary functionalities to support ESRS E1 reporting. However, the biggest challenge lies with data collection. When emissions data is not collected correctly or is incomplete, it has a

direct impact on the reliability of the entire reporting in the ERP system. This is particularly evident with Scope 3 emissions, which experts say are considered the most complex to collect. Incorrect or inconsistent data results in even a well-functioning ERP system generating unreliable reports.

Besides these technical challenges, organizationally there is often a lack of clear responsibilities, limited internal expertise, and insufficient cooperation between departments. Strategically, emissions reporting is still often approached as a compliance obligation rather than an opportunity to optimize business processes and gain competitive advantage.

To address these challenges, best practices have been identified that support companies in integrating emissions reporting into their ERP systems. At the technical level, it appears that centralizing emissions data within an integrated data management system, combined with automation, API links, and AI-driven validations, could help reduce data fragmentation and increase the reliability of reports. At an organizational level, it is important to assign clear responsibilities within existing departments and invest in knowledge development. This contributes to better data quality and reduces dependence on external consultants. In addition, cooperation with external parties, such as suppliers, can be organized more effectively through standardized reporting requirements and technological support.

At the strategic level, companies achieve better results when they consider emissions reporting not as a mandatory burden but as a strategic opportunity. Continuous monitoring of emission data within the ERP system allows companies to make real-time adjustments and optimize operational processes. Finally, it appears that a step-by-step implementation helps companies respond flexibly to changing laws and regulations. By taking into account the data requirements of the ERP system from the start, inefficient solutions can be avoided.

The 12-step roadmap developed in this study provides a structured, actionable approach for companies to integrate emissions reporting into their ERP systems effectively. By following this roadmap, companies can enhance reporting accuracy, ensure compliance with ESRS E1 and CSRD, and optimize business processes.

Since this study is exploratory in nature, it is important to emphasize that further validation of the roadmap is needed. This can be done, for example, by testing the plan in practice with companies using SAP or other ERP systems for emissions reporting. This can evaluate the extent to which the proposed steps actually contribute to better reporting processes. Uncertainties also play a role, such as changing legislation and new sustainability standards. Because the ESRS reporting requirements are currently under development, future changes may start to impose different requirements. Therefore, the roadmap must remain flexible to keep up with changes and remain compliant with new guidelines and technological innovations.

This study provides an initial contribution to scientific knowledge on the use of ERP systems, like SAP, for emissions reporting. In addition, it provides practical insights for companies seeking to improve their reporting processes. The results show that a combination of technology, process optimization, and organizational change is essential to meet the EU's increasingly stringent sustainability guidelines. Moreover, this study confirms that ERP systems, when properly designed and integrated, can be a powerful tool for accurate and efficient emissions reporting.

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Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
API	Application Programming Interface
CO_2	Carbon Dioxide
CH_4	Methane
CSRD	Corporate Sustainability Reporting Directive
DaaS	Data-as-a-service
DPI	Data Point Indicator
EFRAG	European Financial Reporting Advisory Group
EH&S	Environment, Health, and Safety (SAP)
ERP	Enterprise Resource Planning
ESG	Environmental, Social, and Governance
ESRS	European Sustainability Reporting Standards
EU ETS	European Union Emissions Trading System
GHG	Greenhouse Gas
HFCs	Hydrofluorocarbons
HR	Human Resources
IoT	Internet of Things
KPI	Key Performance Indicator
MWh	Megawatt-hour
N_2O	Nitrous Oxide
NF_3	Nitrogen Trifluoride
NFRD	Non-Financial Reporting Directive
NGO	Non-Governmental Organization
PFCs	Perfluorocarbons
PwC	PricewaterhouseCoopers
SAP	System Analyse Programmentwicklung (ERP-software)
SCT	Sustainability Control Tower (SAP)
SF_6	Sulfur Hexafluoride
SME	Small and Medium-sized Enterprises
TCFD	Task Force on Climate-related Financial Disclosures
tCO_2eq	Tons of CO_2 Equivalent

1 Introduction

Global climate change is one of the most pressing challenges of our time, driven by human activities that result in the emission of greenhouse gases (GHG). These emissions, particularly carbon dioxide (CO_2), significantly contribute to global warming. According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2023), human activities such as the burning of fossil fuels, deforestation, and agriculture have led to an increase in global temperatures of approximately 1.1°C since the early 20th century. In the European Union, the energy sector accounted for 27.4% of total greenhouse gas emissions in 2022, followed by domestic transport with 23.8% and industry accounted for 20.3% (European Parlement, 2024).

To reduce these emissions and achieve climate targets, the European Union (EU) is taking a leading role by implementing stricter regulations. A key initiative is the Corporate Sustainability Reporting Directive (CSRD), which requires companies to transparently report on their environmental impact, including their CO_2 emissions (SER, 2023). The European Sustainability Reporting Standards (ESRS) have been developed within this regulation, with ESRS E1 specifically focusing on climate change. Companies are not only required to report their direct emissions (Scope 1) but also their indirect emissions from purchased energy (Scope 2) and the broader value chain (Scope 3) (National Grid Group, 2023). This presents significant challenges, particularly because many companies still lack robust systems to collect these data consistently and accurately.

This is where Enterprise Resource Planning (ERP) systems, such as those developed by SAP, come into play. ERP systems are designed to streamline business processes by integrating data across various departments, such as finance, logistics, and production (SAP, 2024g). SAP, as a market leader in ERP software, offers dedicated solutions for sustainability reporting, such as SAP Sustainability Control Tower. These tools enable companies to systematically collect, analyze, and report emissions data, helping them comply with CSRD and ESRS reporting requirements (Yuzgenc & Aydemir, 2023). This is especially relevant as companies worldwide struggle to integrate new sustainability standards into their existing operational systems (Cleveland et al., 2023).

However, despite the potential of ERP systems and SAP-specific solutions, research shows that many companies are still not effectively utilizing the available functionalities to meet the requirements of the CSRD and ESRS (including ESRS E1). A study by PwC (2024) revealed that currently, 74% of large companies worldwide still rely on various spreadsheets for sustainability reporting, collecting and implementing the data (semi-) manually.

This study focuses on how companies can report their CO_2 emissions in compliance with the CSRD and, more specifically, the climate-related requirements of ESRS E1, using SAP as an ERP system. The goal is to identify the necessary data points, analyze

the challenges in collecting this data, and formulate best practices for the effective implementation of sustainability reporting within ERP systems, following a structured approach specifically tailored to SAP solutions.

Since large enterprises predominantly use ERP systems like SAP, this study primarily examines organizations that have the technical and financial capacity to integrate such systems into their sustainability reporting frameworks. While the insights from this research may be relevant to a broader range of companies, the roadmap developed in this study is specifically designed for corporations with sufficient digital maturity and resources to support ERP-based sustainability reporting. Small and medium-sized enterprises (SMEs), which often lack the infrastructure to implement full-scale ERP solutions, may require alternative approaches to ESG reporting.

1.1. Societal and Scientific Relevance

The societal relevance of this research can hardly be overstated. In a world where climate change increasingly affects daily life and economic stability, companies are facing growing expectations from both consumers and regulators to reduce their environmental impact (Davis, 2012). Failure to adequately report emissions can lead to reputational damage, fines, and loss of market share (Minimum, 2024). For this reason, 82% of companies in the Netherlands took measures in 2023 to make their business operations more sustainable (CBS, 2023). In this context, the development of effective and reliable reporting systems is also crucial for the long-term viability of businesses, as regulatory compliance is becoming a prerequisite for maintaining access to capital, securing investor confidence, and sustaining competitive advantage in increasingly sustainability-driven markets. Companies that fail to integrate robust reporting mechanisms risk falling behind as stricter policies and stakeholder expectations continue to evolve.

From a scientific perspective, this research aligns with the literature on ERP systems and sustainability. There is growing academic interest in the role of technology in facilitating sustainable business practices, especially in light of the increasing emphasis on Environmental, Social, and Governance (ESG) objectives (Betlem, 2024; EcoActive, 2024). While research has been conducted on the potential of ERP systems to integrate financial and operational data, relatively little is known about how these systems can be used for the specific task of sustainability reporting, particularly in the context of complex regulations such as the CSRD and ESRS E1 (Pizzi et al., 2024).

This research contributes to the scientific literature by exploring the link between ERP systems and sustainability reporting, with a specific focus on SAP solutions that address the climate-disclosure requirements of ESRS E1. Despite the growing academic interest in the role of technology in sustainable business practices, little specific research has been conducted on the use of ERP systems, such as SAP, for reporting under complex regulations like the CSRD and ESRS (Lin et al., 2022). This exploratory study maps these possibilities through literature research, an initial case study with SAP, and semi-structured expert interviews. The key outcome is a roadmap that supports companies in implementing ERP-based sustainability reporting, enabling them to comply more effectively with CSRD and ESRS E1 requirements. Although this roadmap is based on collected research data, practical validation is still required. Due to the increasing societal pressure on companies to enhance transparency in reporting their environmental performance, further research remains essential to refine and validate the applicability and effectiveness of this approach.

1.2. CoSEM Suitability

This study aligns well with the objectives of the Complex Systems Engineering & Management (CoSEM) program at TU Delft. The CoSEM program is designed to address complex societal challenges by integrating technical systems with management strategies (TU Delft, 2024). Sustainability reporting, particularly in the context of emissions

(ESRS E1), is a multifaceted issue that spans various technical and organizational domains, making it an ideal subject for CoSEM research.

ERP systems are central to managing large-scale corporate processes, and their application in sustainability reporting involves navigating complex data flows, regulatory frameworks, and organizational behavior. This research combines elements of systems engineering (understanding how SAP integrates with business operations) with management strategies (how organizations can meet external sustainability requirements efficiently). The study also ties into key CoSEM themes such as sustainability, digital transformation, and regulatory compliance, offering practical solutions that can be directly applied in the corporate world.

Moreover, the interdisciplinary nature of CoSEM is reflected in the study's approach, as it incorporates knowledge from supply chain management, environmental regulation, and information systems. By focusing on how technical systems (ERP) can address societal goals (sustainability), this research contributes to the broader goals of the CoSEM program in fostering responsible and innovative solutions to global challenges.

1.3. Research Context PwC

This research was conducted in the role of a master's thesis intern within the SAP Consulting team at PwC. PwC is a globally operating consulting firm specializing in consultancy, accountancy, and tax advisory services. The company supports organizations in navigating complex regulatory frameworks and optimizing business processes (PwC, 2025). As sustainability reporting becomes an increasingly important aspect of corporate governance, PwC provides expertise in the implementation of ERP solutions, such as SAP, to help companies comply with the ever-tightening requirements of regulations from CSRD and the ESRS E1.

Conducting this research within PwC provided access to valuable practical insights and expertise from consultants. This enabled the study to develop a comprehensive understanding of the challenges and opportunities surrounding sustainability reporting. The primary outcome of this study, a roadmap for ERP-based sustainability reporting, is based on semi-structured interviews with experts from PwC Netherlands, PwC Germany, PwC Luxembourg, and contacts at SAP.

2

Research Question

This chapter describes the structured literature review that forms the foundation of this research. The focus is on the role of ERP systems, specifically SAP, in supporting emissions reporting in line with ESRS E1 under the CSRD. The research explores how companies can utilize these systems to meet the increasingly stringent reporting obligations regarding sustainability and emissions. For a more detailed explanation of how this scope was established, please refer to Appendix A, which provides a comprehensive description of the scope.

In this chapter, starting from this scope, the search strategy, the selection criteria for the literature, and an overview of the selected academic sources will be presented. The structured literature review focuses on the existing scientific knowledge regarding the use of ERP systems for sustainability reporting. This analysis serves as the basis for formulating the research question, and uncovering the current knowledge and implementation gap in the literature.

2.1. Structured Literature Review

A structured literature review is conducted to gather comprehensive information on ERP systems and their role in emissions reporting and CSRD compliance. This review provided a structured approach to collecting and analyzing the most relevant academic studies, industry reports, and policy papers. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology is applied to ensure transparency and rigor in the research process, following the guidelines outlined by (Liberati et al. (2009). PRISMA's 27-item checklist and four-phase flow were utilized to structurally review, screen, and select the most relevant literature (Liberati et al., 2009). In Figure 2.1 the combination of synonyms and aspects are presented that are used to develop the appropriate search string.

Combine the synonyms with ←OR→	Combine the aspects with ←AND→		
	ERP System	**Sustainability**	**Reporting**
	• "ERP System*" • ERP-System*	• Sustainab* • Emission* • ESG	• Report* • CSRD • "Corporate Sustainability Reporting Directive" • ESRS • "Environmental Standards Reporting Framework"

Figure 2.1: Synonyms and Aspects for Search String

In Table 2.1, you can see the search strings used to find the papers based on the correct terms and the number of results they generated in Scopus and Web of Science.

Table 2.1: Search String and Results

Search Strings	Results(N =)
(TITLE-ABS-KEY(”ERP systems”) OR TITLE-ABS-KEY(ERP-system*) AND TITLE-ABS-KEY(emission*) OR TITLE-ABS-KEY(esg) OR TITLE-ABS-KEY(sustainab*) AND TITLE-ABS-KEY(report*) OR TITLE-ABS-KEY(csrd) OR TITLE-ABS-KEY(”corporate sustainability reporting directive”) OR TITLE-ABS-KEY(”environmental standards reporting framework”)) Via **Scopus - 01/10/2024**	43
(TITLE-ABS-KEY(”ERP systems”) OR TITLE-ABS-KEY(ERP-system*) AND TITLE-ABS-KEY(emission*) OR TITLE-ABS-KEY(esg) OR TITLE-ABS-KEY(sustainab*) AND TITLE-ABS-KEY(report*) OR TITLE-ABS-KEY(csrd) OR TITLE-ABS-KEY(”corporate sustainability reporting directive”) OR TITLE-ABS-KEY(”environmental standards reporting framework”)) Via **Web of Science - 01/10/2024**	15

2.2. Paper selection

The next step in the PRISMA method involves the structured selection of papers, which is divided into four phases: identification, screening, eligibility, and inclusion (see Figure 2.2).

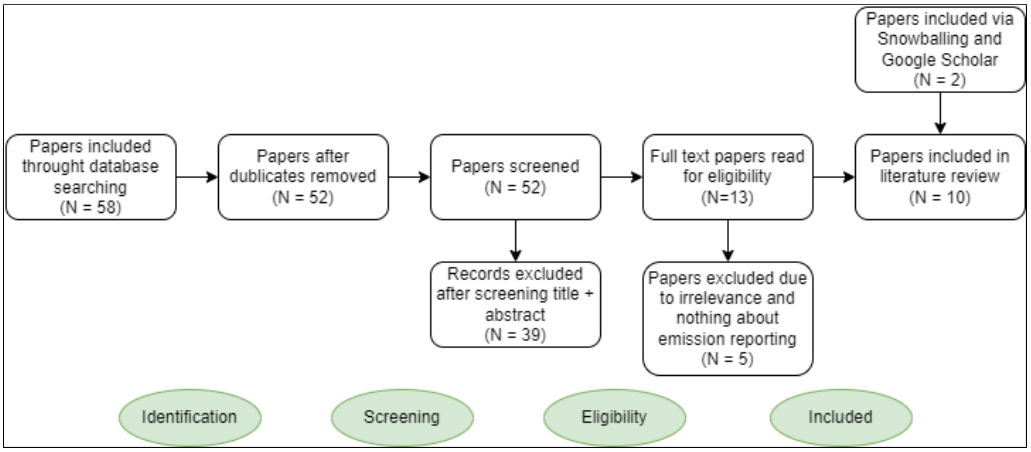

Figure 2.2: structured Selection of Papers

In the identification phase, 58 papers were initially collected from databases such as Scopus and Web of Science. After removing duplicates, 52 papers were retained for further analysis. This step was necessary to focus only on unique contributions to the research area and avoid redundant sources.

During the screening phase, the titles and abstracts of the remaining 52 papers were evaluated based on their relevance to the research topic, which focuses on the role of ERP systems in emissions reporting and CSRD compliance. As a result of this phase, 39 papers were excluded, primarily because they either focused on ERP systems without addressing emissions reporting or discussed emissions reporting without mentioning ERP systems.

In the eligibility phase, the full text of the 13 remaining articles was reviewed to ensure their relevance. Five papers were excluded due to insufficient discussion on the integration of ERP systems and emissions reporting. To supplement the pool of papers, the snowballing method was employed. As outlined by Wohlin et al. (2022), this method involves identifying additional relevant studies by reviewing references cited in the selected papers. Using this approach, and further searches on Google Scholar, two additional papers were included in the final review.

In the inclusion phase, a total of 10 papers were ultimately selected as the most relevant to the research topic. These papers provide essential insights into how ERP systems can be leveraged for emissions reporting and some support compliance with regulations. However, it is important to note that, while these 10 papers represent the best available literature, there is still a significant lack of studies specifically focusing on integrating ERP systems with CSRD and ESRS regulations.

Although there is a wealth of literature on ERP systems and separately on emissions reporting, the combination of these two fields—where ERP systems are used as tools for emissions data management and reporting—remains relatively under-explored. This gap underscores the need for further research into how ERP systems can effectively support emissions tracking and reporting, particularly in light of the growing importance of regulatory frameworks CSRD and ESRS.

2.3. Overview of the selected literature

In this section, a summary of the ten papers selected after the final review process is provided. These papers were chosen based on their direct relevance to the research topic, which explores how ERP systems are used for emissions reporting. Table 2.2 lists the ten papers included in the structured literature review, which will form the foundation for the subsequent analysis.

Table 2.2: Selected Literature

Title	Authors	Year	DOI
ERP System Implementation and Sustainability Practices in Developing Countries	Simmonds D.; Tadesse A.F.; Murthy U.	**2018**	N/A
The digitalization of sustainability reporting as a tool for integrated reporting: A global perspective	Pizzi S.; Mastroleo G.; Venturelli A.; Caputo F.	**2024**	10.1002/bse.3544
Role of ERP Systems in Carbon Data Management	Agharkar A.; Hall J.	**2023**	N/A
Toward a Digital Sustainability Reporting Framework: Enhancing transparency and decision-making	Olsen C.	**2023**	10.1007/978-3-031-17746-0_37
Towards a multidisciplinary approach on creating a responsible and inclusive innovation ecosystem	De Soete W.	**2016**	10.3390/systems4010016
Designing and ERP System: A Sustainability Approach	Adriansyah A.K.;Ridwan A.Y.;Hediyanto U.Y.K.S.	**2022**	10.30630/joiv.6.2-2.1117
Calculating Carbon Footprints—Made Easy	Bieszczat S.	**2023**	N/A
Implications for Sustainability Accounting and ERP Systems	Dumitru V.F.; Ionescu B.-Ú.; Rîndasu S.-M.; Barbu M.C.	**2023**	10.3390/electronics12081819
Integration of the Resource of Electric Energy into Enterprise-Resource-Planning for the Compliance of EU Policies	Rodlauer J.; Junghans S.; Trommer M.; Leonhardt S.	**2022**	10.1007/978-3-031-21333-5_67
An Overview of Key Sustainability Theories, Regulations and S ERP for Business Education, Business Research and Digital Business Practitioners	Olsen C.	**2022**	10.1007/978-3-030-93464-4_57

2.4. Literature Review

As described in previous sections, the increasing pressure from climate change and the associated need for emissions reduction have led to various policy measures and guidelines, such as the CSRD and, subsequently, the ESRS. These measures require companies to provide accurate and transparent reporting on their environmental impact, with a specific focus on emissions, including CO_2. Although there is a wide range of literature on both ERP systems and emissions reporting, this literature review reveals that there has been little academic research into how companies can use ERP systems to comply precisely with the new ESRS and CSRD regulations.

The Role of ERP Systems in Business Processes

ERP systems are designed to streamline business processes by integrating data from various departments, such as finance, logistics, production, and human resource management. Historically, these systems were developed to improve operational efficiency, as demonstrated by numerous studies examining ERP systems in broader business contexts. Simmonds et al. (2018) argue that ERP systems play a key role in centralizing business data and promoting process optimization through automation and real-time data access. While these advantages are clear, studies such as that of Simmonds et al. (2018) often focus more on business optimization and remain superficial when it comes to sustainability reporting. In addition, besides mentioning the central functioning of ERP systems, distributed systems such as data spaces and blockchain solutions are discussed to a lesser extent

Although ERP systems have evolved significantly in recent years, with various modules developed for sustainability management, the question of how these systems can specifically contribute to meeting the CSRD and ESRS guidelines remains a key and underresearched topic. Many companies struggle to effectively utilize these systems to generate detailed and accurate reports (Agharkar & Hall, 2023), particularly concerning indirect emissions (Scope 3), which often come from suppliers and customers. This brings us to the core challenge of applying ERP systems for sustainability: the knowledge and implementation gap.

Challenges in Using ERP Systems for Emissions Reporting

Despite the clear potential of ERP systems, research shows that companies struggle to use these technologies effectively for sustainability reporting. According to PwC (2024), only 32% of large companies worldwide are currently able to collect and report emissions data through their ERP systems. This gap between technology and implementation is often exacerbated by the lack of seamless integration between various data streams within a company, such as production data, logistics processes, and energy consumption. Additionally, companies often fail to fully utilize the capabilities of available tools, for instance, by insufficiently configuring ERP modules tailored to sustainability or by not providing adequate training to employees on using these systems for emissions reporting.

Rodlauer et al. (2023) offer insights into how ERP systems can be further integrated to manage not only data on financial and operational processes but also to improve sustainability performance. In their study, they emphasize the role of ERP systems in complying with EU policy rules, including integrating energy management into ERP systems to meet increasingly stringent sustainability requirements. This aligns with the ESRS requirements, as companies must monitor and report their energy use and related emissions. The paper suggests that companies can further adapt their ERP systems by fully integrating energy management processes, which is a crucial part of both sustainability reporting and emissions reduction.

The study by Adriansyah et al. (2022) provides insights into how ERP systems can be designed to support sustainability, but this study focuses primarily on technical aspects of ERP functionalities without delving deeply into the specific CSRD or ESRS requirements. Many companies continue to struggle with monitoring their CO_2 emissions, particularly with reporting Scope 3 emissions, which are difficult to measure because they rely on

data from complex supply chains. This challenge is also acknowledged by Olsen (2023), who argues that while ERP systems offer powerful tools for digitization, many companies are not yet fully equipped to implement these systems into their sustainability strategies.

The Digitization of Sustainability Reporting

Pizzi et al. (2024) provide an in-depth analysis of the digitization of sustainability reporting processes. Their research focuses on the use of Sustainable Enterprise Resource Planning (S-ERP) systems, which enable companies to integrate sustainability requirements into their business processes. They emphasize the importance of a standardized approach, such as the integration of XBRL-based taxonomies, which are supported by both ESRS and international reporting standards. This allows companies to accurately collect and report emissions data, which is a critical aspect of the CSRD and ESRS regulations.

Similarly, the article The Digitalization of Sustainability Reporting Processes: A Conceptual Framework highlights the importance of digital tools in improving the quality of sustainability reporting. While this article does not explicitly talk about a lack of information infrastructure or standardization, it does imply that the implementation of digital solutions, such as S-ERP systems, can contribute to more standardized and efficient reporting processes (Pizzi et al., 2024). The implementation of such systems ensures more consistency in data collection and facilitates sustainability compliance.

Despite these positive developments, the study by Pizzi et al. (2024) emphasizes that many companies still struggle to implement these systems due to technical and organizational barriers. While various ERP software has developed specific modules for sustainability management, such as the SAP Sustainability Control Tower, companies must first ensure they have an adequate infrastructure and sufficient knowledge to use these systems effectively. This aligns with earlier findings by Dumitru et al. (2023), who highlight the benefits of automation for collecting and reporting emissions data, but also the challenges companies face in integrating these technologies.

Automation and Integration of ESG Data in ERP Systems

An important aspect often emphasized in the literature is the increasing role of automation in improving companies' sustainability performance. Dumitru et al. (2023) show how Robotic Process Automation (RPA) and Intelligent Process Automation (IPA) can be integrated into ERP systems to streamline processes and automate data collection. This is particularly relevant for companies that struggle to monitor and report Scope 3 emissions, as RPA systems can manage the complexity of supply chains by collecting data from various sources.

However, the authors caution that automation does not come without challenges. Implementing RPA and IPA in ERP systems requires significant investments in both technology and specialized knowledge. Companies must invest in training and infrastructure to fully utilize these advanced technologies. This poses a major barrier for companies that aim to meet ESRS requirements but lack the resources to fully leverage these technologies.

The Knowledge and Implementation Gap: The Need for Multidisciplinary Solutions

De Soete (2016) offers valuable insights into how a multidisciplinary approach can contribute to integrating sustainability into business processes. He points to the complexity of supply chains and the importance of data integration to accurately measure and report sustainability performance. This aligns with the challenges companies face when reporting Scope 3 emissions, which require data from multiple parties within the value chain.

De Soete (2016) suggests that companies need to work on better collaboration between various departments, such as finance, production, and logistics, to successfully integrate sustainability into their business processes. This interdisciplinary approach is essential for companies looking to use their ERP systems for sustainability reporting in line with the ESRS, as it involves not only technology but also organizational adjustments and collaboration throughout the entire value chain.

2.5. Synthesis of the Literature and Research Question

Based on the discussed literature, it is clear that ERP systems offer significant potential for reporting emissions in line with CSRD guidelines and ESRS standards. These systems can help companies centralize their data and automate reporting processes. At the same time, there are considerable challenges, particularly in the areas of implementation and data integration, that companies must overcome to meet the increasingly stringent sustainability standards.

The literature suggests that although many companies are starting to implement ERP systems for sustainability, significant challenges remain. Besides technological obstacles, such as the integration of emissions data within ERP modules, several studies show that many companies also face fundamental problems with their information infrastructure and data standardization. Without a robust digital architecture and uniform reporting standards, the effective implementation of ERP systems for emissions reporting remains a challenge. This is especially true for Scope 3 emissions, where data come from complex and often fragmented supply chains.

The current literature on ERP systems for emission reporting mainly discusses general ERP functionalities and challenges, without clearly distinguishing between systems from different vendors. Specific attention to SAP is almost completely absent. While, as mentioned earlier, SAP can be seen as the global market leader in ERP software. Since many organizations already use ERP systems as a central system for processing operational and financial data, SAP is one of the possible ERP systems to integrate sustainability data, such as emissions, into existing business reporting processes. In order to close this identified knowledge gap, this research therefore focuses specifically on the implementation of SAP as an ERP system for emission reporting in accordance with the requirements of ESRS and CSRD.

Additionally, since this research specifically targets emissions reporting, only the climate-related standard ESRS E1 is relevant within the broader set of CSRD requirements. Although the ESRS cover various sustainability topics, ESRS E1 specifically addresses detailed disclosure of greenhouse gas emissions (Scope 1, 2, and 3). Due to this explicit focus on emissions, the decision was made to concentrate exclusively on ESRS E1 within this study.

This research therefore specifically aims to bridge the identified knowledge and implementation gap by explicitly linking SAP solutions to the concrete emissions reporting requirements outlined in ESRS E1. By adopting this targeted approach, the research enables an in-depth analysis of how companies can systematically implement ERP systems, with a focus on SAP, to meet regulatory obligations, thereby connecting the general capabilities of ERP systems to the specific disclosure obligations under ESRS E1 and the CSRD.

Based on these findings, we can formulate the central research question:

”What structured approach can companies follow to implement ERP systems, with a focus on SAP, for emissions reporting in compliance with ESRS E1 and CSRD?”

This research question forms the basis for further investigation into how companies can effectively optimize their technological and organizational processes to accurately measure and report emissions using SAP ERP systems. Specifically, this exploratory study examines the structured approach that organizations can adopt to successfully implement SAP solutions for emissions reporting, aligning with the requirements of ESRS E1 and the CSRD.

To systematically address this research question, the study is structured around four subquestions:

1. *What specific reporting requirements for emissions are outlined in the CSRD and ESRS E1?*

2. *What specific emissions data is required from ERP systems, such as SAP, to meet the reporting requirements of the CSRD and ESRS E1?*
3. *What are the biggest challenges companies face when collecting and reporting emissions-related data through ERP systems, particularly in SAP?*
4. *What are the best practices for companies to overcome challenges in collecting and reporting emissions-related data through ERP systems with a focus on SAP for ESRS E1 compliance?*

By answering these sub-questions, this research contributes to the literature by providing a structured understanding of digital sustainability reporting and practical guidance for companies seeking to enhance their emissions reporting capabilities. The next chapter outlines the research approach and methodology used to answer these questions.

3

Research Approach

The previous chapters identified the knowledge and implementation gap regarding the use of ERP systems for emissions reporting in line with European sustainability legislation. This chapter describes the research approach and methodology that were applied to answer the sub-questions and ultimately the main research question. The research focused on how companies could use ERP systems, such as SAP, to report their emissions in line with the CSRD and ESRS. In doing so, the research provided companies with concrete insights and guidelines for the effective and compliant application of SAP ERP systems within the emissions reporting process.

To answer the research question, three research methods were applied, each linked to a sub-question:

- Sub-question 1: Desk research to identify the reporting requirements.
- Sub-question 2: A case on SAP as an ERP system for emissions reporting.
- Sub-questions 3 & 4: Interviews with experts from various specializations within PwC and SAP.

By combining these methods, insights were gathered from both theoretical frameworks and practical applications, leading to a holistic view of the challenges and opportunities of SAP ERP-based emissions reporting.

3.1. Methodology

This research follows a qualitative, exploratory approach to gain insights into the implementation of ERP systems, such as SAP, for emissions reporting in line with the CSRD and ESRS E1. Given the limited academic literature on the application of ERP systems within this specific regulatory framework, an exploratory approach allows for the generation of both theoretical and practice-oriented insights (Kalu & Bwalya, 2017).

Through a combination of literature review, case analysis, and expert interviews, this study examines how SAP, as an ERP system, can support companies in emissions reporting. The literature review maps out the legal reporting requirements and existing knowledge on ERP-based emissions reporting. The case analysis focuses on the extent to which existing ERP systems, with particular attention to SAP ERP, are capable of collecting and processing the required emissions data. The insights from expert interviews provide additional perspectives on implementation challenges and best practices in practice. This combined approach forms a comprehensive and structured understanding of the role ERP systems, like SAP, play in compliance with emissions reporting obligations and the factors that influence successful implementation.

This qualitative approach was chosen because the focus is on understanding underlying

mechanisms and implementation issues, rather than quantifying effects or conducting statistical analyses. The insights from this research serve as a foundation for further scientific exploration and practical applications within organizations that aim to use ERP systems, such as SAP, for emissions reporting.

3.1.1. Desk Research

The first phase of the research involved a structured desk study, analyzing relevant regulatory documents and supplementary sources, including grey literature. This research examined laws and regulations, particularly the CSRD guidelines and the ESRS standards, with a specific focus on ESRS E1 due to its relevance to climate change. The goal was to identify the specific reporting requirements regarding emissions, including distinctions between emission scopes (Scope 1, 2, and 3).

The desk research included the following sources:

- The European CSRD guidelines.
- ESRS E1 standards and additional relevant ESRS guidelines.
- Articles and reports on laws and regulations, including grey literature.

The findings from this analysis specified the requirements that companies must adhere to when reporting their emissions. These insights formed the foundation for answering the first sub-question:

"What specific reporting requirements for emissions are outlined in the CSRD and ESRS E1?"

3.1.2. Case Analysis

An important part of this research involves an exploratory qualitative analysis of the application of ERP systems for emissions reporting. Within this broader analysis, a case analysis of SAP, one of the most widely used ERP systems, is included to gain insights into the extent to which ERP systems can meet the requirements of the CSRD and ESRS E1. The choice of SAP as an example case within this exploratory research is based on the following considerations:

- *Market Leadership:* SAP is the most widely used ERP system worldwide and is extensively applied for sustainability reporting (Gilg, 2024).
- *Consultancy Context:* This research was conducted within a professional consultancy environment where SAP plays a central role, ensuring the direct applicability and practice-oriented nature of the findings.
- *Access to Practical Information:* Within the research context, access was available to practical information and expertise specifically related to SAP, enabling an in-depth analysis.

The exploratory study focuses on analyzing SAP as an ERP system and how it can be used to collect, process, and report the required emissions data to comply with the reporting obligations of the CSRD and ESRS E1. This analysis not only examines SAP's technical capabilities but also broader implementation challenges and necessary adjustments.

Applied Analytical Techniques

A qualitative approach was adopted in this exploratory research, combining different methods to obtain in-depth insights:

- SAP is used as an example to gain insights into the current capabilities and limitations of ERP systems for emissions reporting.
- The functionalities and available data points within SAP are compared to the established requirements identified through desk research.

This approach develops a comprehensive understanding of the extent to which SAP and similar ERP systems can effectively contribute to emissions reporting and the obstacles companies face in this process. This leads to answering the second sub-question:

"What specific emissions data is required from ERP systems, such as SAP, to meet the reporting requirements of the CSRD and ESRS E1?"

3.1.3. Interviews with Experts

To obtain in-depth and practice-oriented insights into the implementation of SAP as an ERP system for emissions reporting, the third part of the research utilized expert interviews. The focus was on implementation challenges, practical experiences, and best practices within organizations that use SAP for emissions reporting.

Semi-structured interviews

Semi-structured interviews were chosen as the research method due to the exploratory nature of the study and the varying expertise of the interviewees. As noted by Brinkmann (2020), semi-structured interviews promote knowledge production through dialogue, allowing interviewees more freedom to explore topics they find important. Compared to structured interviews, semi-structured interviews provide more flexibility and enable more meaningful conversations on topics relevant to the study.

In this study, the interviews focused on the practical implementation of ERP systems for emissions reporting. The discussions helped to understand not only technical but also organizational and strategic aspects. By using an open conversation structure, interviewees could freely reflect on the challenges and opportunities of integrating emissions reporting into ERP systems. SAP was used as a case, with specific questions about its functionalities as an example of an ERP system.

Additionally, this approach enabled an in-depth exploration of complex and multidisciplinary topics, such as the integration of emissions reporting in ERP systems. A fixed questionnaire would not have captured all nuances and practical experiences. By employing an open conversation structure, interviewees could freely reflect on the technical, organizational, and strategic aspects of emissions reporting within ERP systems.

Finally, this method provided the qualitative depth necessary not only to identify available solutions but also to understand how companies implement them and the challenges they face in doing so. SAP was used as a case study, with specific questions about its functionalities as an example of an ERP system within the broader context of emissions reporting.

Selection and Composition of the Expert Group

For this study, eight experts were interviewed, seven of whom work at PwC and one at SAP. The selection of experts aimed to obtain a broad perspective on the implementation of ERP systems for emission reporting, particularly in the context of CSRD and ESRS compliance.

The experts are categorized into three main groups based on their expertise:

- *ERP- & Sustainability Reporting Experts:* These experts have extensive knowledge of SAP ERP systems and their application in emission reporting. They work as consultants or technical specialists, advising companies on how to integrate sustainability reporting within ERP platforms.
- *Sustainability Reporting Specialists:* These professionals focus on sustainability regulations, including CSRD and ESRS, and advise organizations on how to structure their reporting processes. Some also have knowledge of ERP systems but primarily approach the topic from a regulatory and compliance perspective.
- *ERP Technology Specialist:* This expert specializes in the technical aspects of ERP systems in a broader sense, such as system integration, implementation, and data management, but has a less specific focus on SAP for emission reporting.

To ensure consistency and data quality, all interviews followed a structured format with predefined questions, while also allowing room for open-ended answers and in-depth discussions. All interviews were conducted via Microsoft Teams and recorded for transcription and analysis.

Depending on the expertise category of the interviewees, follow-up questions were asked to obtain complete and in-depth answers. In some cases, the focus was specifically on SAP ERP systems and their role in emission reporting, while in other cases, a broader approach was taken, referencing ERP systems in general for collecting and reporting emission data.

Interview #	**Expertise Category**	**Specific Focus**	**Years of Experience**	**Interview Date**
1	ERP- & Sustainability Reporting Expert	SAP ERP specialist for emission reporting and sustainability consulting at PwC	3.5 years	16-01-2025
2	ERP Technology Specialist	ERP system integration at PwC	10+ years	22-01-2025 **(1)**
3	Sustainability Reporting Specialist	ESG reporting strategy and CSRD compliance expert at PwC	10 years	22-01-2025 **(2)**
3	Sustainability Reporting Specialist	ESG reporting strategy and CSRD compliance expert at PwC	15+ years	22-01-2025 **(2)**
4	ERP- & Sustainability Reporting Expert	SAP ERP specialist for emission reporting and sustainability consulting at PwC Luxembourg	10+ years	24-01-2025
5	Sustainability Reporting Specialist	ESG reporting strategy expert with ERP knowledge at PwC	15+ years	31-01-2025
6	ERP- & Sustainability Reporting Expert	Implementation specialist for SAP ERP in ESG reporting at PwC Germany	15 years	03-02-2025
7	ERP- & Sustainability Reporting Expert	SAP technical functionalities for ESG reporting at SAP	3.5 years	10-02-2025

Table 3.1: Overview of the interviewed experts and their areas of expertise

By categorizing the experts into these three main groups, insights were gathered from different perspectives—ranging from regulation and compliance to the implementation of SAP ERP systems and the technical development of ERP solutions.

Interview Setup and Questionnaire

The interviews consisted of four main sections, each addressing different aspects of emissions reporting in ERP systems. The complete interview setup is included in Appendix D. Below is a summary of the main interview components:

1. *General Insights*
   The interview began with a brief introduction to the study and the objectives of the conversation. Interviewees then shared their background and experience with ERP systems and sustainability reporting. They described their specific role within the organization and their involvement in the implementation or advisory aspects of emissions reporting. This provided valuable context for understanding the perspective from which they shared their insights.

Depending on their expertise, discussions included their familiarity with CSRD and ESRS requirements and how they were involved in the technical or strategic implementation of emissions reporting within ERP systems like SAP. This section served as both an introduction and a means to better understand the interviewees' context and viewpoints.

2. *Specific Challenges*
   This section focused on the main challenges companies face when collecting, processing, and reporting emissions data through ERP systems. Interviewees shared their experiences with data collection and provided insights into how companies currently manage emissions reporting. Specific attention was given to the types of emissions data that are most challenging to collect and the underlying reasons for these challenges. These questions were informed by the findings from the desk research and the case.

   The reliability and consistency of data within ERP systems were also discussed. Interviewees shared their experiences with the quality of available data and discussed the challenges companies face when integrating emissions data into existing systems. This section provided valuable insights into the technical, organizational, and strategic obstacles that can hinder the implementation of emissions reporting.

3. *Improvements*
   This section focused on potential improvements in emissions reporting through ERP systems. Interviewees reflected on ways organizations could optimize their data collection and processing, with specific attention to automation, integration of data flows, and the use of additional software modules within SAP. Additionally, they discussed technological and organizational changes that companies are implementing to enhance the accuracy and efficiency of their emissions reporting.

   In addition to technological improvements, internal collaboration was also discussed. Interviewees explained how companies are adjusting their internal processes to better comply with CSRD and ESRS reporting requirements.

4. *Recommendations*
   The final section of the interview focused on best practices and strategies that companies have successfully applied to implement emissions reporting within ERP systems. Interviewees shared real-world examples of companies that successfully integrated emissions reporting and explained the key success factors. They also discussed the measures organizations have taken to make their reporting processes more efficient and better aligned with CSRD and ESRS requirements.

   Finally, the first steps companies can take when implementing emissions reporting in ERP systems were discussed, along with potential pitfalls to avoid. These insights ultimately contributed to the development of the 12-step roadmap in Chapter 8.

The interview structure combined open and structured questions, allowing experts to share their experiences while also addressing specific research themes.

Interview Analysis

As discussed in the previous section, the interviews were structured into four main sections. The analysis of these interviews consisted of a combination of qualitative thematic coding and structured ranking. This process involved multiple methodological steps, which are outlined below.

1. *Transcription and Thematic Coding*
   All interviews were recorded, transcribed, and systematically analyzed. The analysis was conducted using open thematic coding, identifying recurring concepts and bottlenecks in the collection and reporting of emission data. Within the section on specific challenges (part 2), these challenges were structured into three main categories:

- Technical challenges
- Organizational challenges
- Strategic challenges

These categories were partially derived from existing literature, but the theme of strategic challenges was specifically added based on interview findings, as multiple respondents indicated that emission reporting is not always perceived as a strategic process within companies. By systematically organizing and grouping the collected insights, a structured framework was developed to analyze the challenges in emission reporting in a coherent manner and compare them with the existing knowledge base.

2. *Quantitative Analysis of the Most Difficult Metrics*
   In addition to qualitative coding, a structured ranking analysis was applied to identify the most complex emission metrics. The interviews included a specific question asking respondents to name their top three most difficult-to-collect metrics from the 19 quantitative metrics essential for CSRD and ESRS E1 reporting (see Table 5.4 in Chapter 5).

   To systematically analyze this data, a Ranked Difficulty Matrix was constructed. Points were assigned as follows: the most difficult metric received 3 points, the second most difficult received 2 points, and the third received 1 point. This approach enabled the identification of patterns and structural bottlenecks in emission reporting. It provided an objective way to determine which metrics were perceived as the most problematic and confirmed insights derived from thematic coding.
3. *Synthesis of Solutions and Best Practices*
   After identifying challenges, the third section of the interviews focused on best practices and technological or organizational improvements. Solutions were systematically linked to the previously identified challenges and analyzed based on repetition and applicability. This resulted in a categorized overview of best practices that companies can use to collect and report emission data more efficiently via ERP systems such as SAP.
4. *Formulating the Roadmap*
   In the final part of the interviews, respondents were specifically asked about concrete steps companies can take to effectively use SAP for emission reporting. The responses were clustered and compared to develop a coherent and practical step-by-step plan. This process resulted in the roadmap presented in Chapter 8, outlining a systematic approach for companies to gradually comply with CSRD and ESRS E1 requirements.

This approach enabled experts from diverse backgrounds to share their insights in a way that respected their expertise while contributing to a coherent and comparable analysis. As a result, the interviews provided valuable insights that not only highlighted the technical, organizational, and strategic challenges of ERP-based emission reporting but also identified concrete best practices that companies can implement. Based on this, the following sub-questions have been answered:

"What are the biggest challenges companies face when collecting and reporting emissions-related data through ERP systems, particularly in SAP?"

and

"What are the best practices for companies to overcome challenges in collecting and reporting emissions-related data through ERP systems with a focus on SAP for ESRS E1 compliance?"

All interviews were conducted in accordance with the Human Research Ethics Committee (HREC) guidelines of TU Delft, application number: 4893. With the consent of the interviewees, the conversations were recorded and transcribed for further analysis. The data collected from these interviews includes both the transcriptions and any supplementary notes or documents provided by the interviewees. Due to the extensive length of the interview transcripts, exceeding 40 pages, they have not been included as an appendix to this report. However, researchers interested in the interview data may contact T. van Pelt or the chair of the committee, J. A. Annema, who holds the research data and can provide access upon request. The interview data has been securely stored on the TU Delft computer and the researcher's computer throughout the study, ensuring compliance with data protection and ethical guidelines.

3.2. Validity and Reliability

Various measures were taken to ensure the reliability and validity of this research. The findings from the desk research and case analysis were compared with the requirements outlined in the literature and relevant regulations. Additionally, these findings were presented to experts during interviews, where their practical applicability was assessed, and best practices were identified. Through this triangulation of methods, a robust foundation for the results was established.

During the writing of this thesis, AI tools were used to support language related aspects. ChatGPT and DeepL were employed for translations, rewording, and grammar checks, while Mendeley was used for managing references and citations. AI was solely applied as a tool for textual refinement and had no influence on the substantive analysis, interpretation, or conclusions of this study. The responsibility for the accuracy, justification, and scientific integrity of this thesis lies entirely with the author.

3.3. Syntheses and Report Structure

The qualitative, exploratory research methods in this study—desk research, a case analysis of SAP, and expert interviews—build upon each other to provide a comprehensive perspective on the application of ERP systems for emissions reporting in accordance with the CSRD and ESRS guidelines. The desk research, discussed in Chapter 4, identifies the legal reporting requirements and forms the foundation for further analysis. In Chapter 5, the case analysis of SAP is used to examine the extent to which ERP systems, such as SAP, are technically and functionally capable of supporting emissions reporting. The expert interviews, analyzed in Chapters 6 and 7, identify the key challenges and best practices that organizations encounter when implementing SAP ERP-based emissions reporting.

To translate these findings into a concrete and applicable approach, a roadmap is presented in Chapter 8. This roadmap is the final product of the study and provides companies with a structured roadmap for implementing emissions reporting within SAP ERP systems. The roadmap consists of 12 practical steps derived from the results of the exploratory research. Its purpose is to support organizations in an efficient and compliant implementation of emissions reporting and to avoid pitfalls identified in the research.

In doing so, Chapter 8 acts as the synthesis of the key insights and provides a concrete framework that companies can use to effectively implement emissions reporting within ERP systems, like SAP.

4

Reporting requirements CSRD and ESRS E1

This chapter addresses the first sub-question: ”What specific reporting requirements for emissions are outlined in the CSRD and ESRS E1?” In previous chapters, the importance of sustainability reporting was established, along with the role ERP systems, like SAP, can play in helping companies comply with regulations such as the CSRD and ESRS. Additionally, the research methodology was outlined, emphasizing a structured approach to bridging the knowledge and implementation gap.

To develop a structured framework for analyzing sustainability reporting legislation, this study conducts an extensive review of policy documents, grey literature, and relevant legislation. Following the framework of Florian (Florian, 2023), the scope progresses from a broad overview of ESG criteria to the European Green Deal, then narrows down to the CSRD, and ultimately focuses on the specific provisions of ESRS E1, as illustrated in Figure 4.1.

Figure 4.1: Scope of Sustainable Reporting (Florian, 2023)

Building upon the information on ESG and the Green Deal, described in Appendix A, this chapter provides a detailed analysis of the reporting requirements under the CSRD and ESRS E1.

Although the ESRS framework consists of twelve separate standards covering a broad range of sustainability topics, this study focuses exclusively on ESRS E1 due to its direct relevance to emissions reporting. Given the primary research objective of analyzing how companies report their emissions in compliance with European regulations, ESRS E1 is the most applicable standard. A full examination of all ESRS standards is beyond the scope of this study; therefore, this chapter specifically delves into the legislative requirements and disclosure obligations prescribed under ESRS E1, ensuring a focused and relevant approach that aligns with the research objectives.

First, Section 4.1 provides a comprehensive explanation of the CSRD and its role within sustainability reporting. Next, the link between the CSRD and the twelve ESRS standards is examined to contextualize ESRS E1 within the broader regulatory framework. Section 4.3 then explores ESRS E1 in detail, focusing on its specific relevance to emissions reporting. Finally, Section 4.4 explains the three most important Disclosure Requirements (DRs) of ESRS E1 and how they shape corporate emission reporting.

4.1. Corporate Sustainability Reporting Directive (CSRD)

The CSRD is a new legislative measure from the European Union that requires companies to be more transparent about their environmental, social, and governance (ESG) performance (NBA, 2024). It plays a crucial role in promoting sustainability and responsible business practices across Europe. The goal of the CSRD is to ensure harmonized, detailed, and transparent sustainability reporting, which will help companies better meet the increasing demands of investors, customers, and governments (MVO Nederland, 2024). This chapter discusses the background, objectives, and challenges of the CSRD, as well as the practical difficulties companies face when implementing these reporting requirements.

4.1.1. Origins of the CSRD

The CSRD was proposed by the European Commission in April 2021 as part of the broader efforts of the European Union to promote sustainable economic growth, as outlined in the European Green Deal (European Commission, 2019). The new directive was developed to address the shortcomings of the Non-Financial Reporting Directive (NFRD), which had been in effect since 2014. Under the NFRD, companies were required to provide information on how they addressed social and environmental issues, human rights, anti-corruption, and diversity on the board of directors (European Parlement, 2022). However, many companies only met the minimum requirements, and the information provided was often inadequate and difficult to compare (PwC, 2024c).

The NFRD was therefore considered insufficient to effectively compel companies to adequately report their ESG performance. This led to the development of the CSRD, which requires companies to provide more detailed, reliable, and verified information about their sustainability performance. This new directive significantly expands the scope of the NFRD and aims to ensure standardized and transparent ESG reporting, helping both companies and investors make responsible decisions.

4.1.2. Objectives of the CSRD

The main objectives of the CSRD are as follows:

- *Improving the quality of ESG reporting:* The CSRD imposes stricter requirements on companies to provide more detailed and reliable information about their ESG performance. This is intended to harmonize the information companies provide, making it more comparable across different sectors and countries (European Parlement, 2020). The reports must comply with European sustainability reporting standards,

currently being developed by the European Financial Reporting Advisory Group (EFRAG).

- *Expanding the scope:* The CSRD expands the reporting requirement to include more companies. While the NFRD only applied to the largest companies with more than 500 employees, the CSRD will also apply to medium-sized and large privately held companies, significantly increasing the number of companies subject to the directive (EFRAG, 2024a).
- *Mandatory audit and verification:* An important feature of the CSRD is that companies must have their sustainability reports audited by external auditors. This ensures that the information is reliable and of high quality, which is essential for investors who incorporate ESG performance into their decision-making processes (PwC, 2024c).
- *Digitization of reporting:* The CSRD requires companies to make their sustainability data available digitally, facilitating access to and analysis of the information. The data must be reported in a common European digital accessibility standard, further increasing transparency (European Parlement, 2022).

4.1.3. Comply with the CSRD

The CSRD requires companies to report on their ESG performance, but not all companies are currently subject to this directive. Below is a description of the companies currently required to comply and those that will be required in the near future. For completeness, this is also illustrated in Figure 4.2.

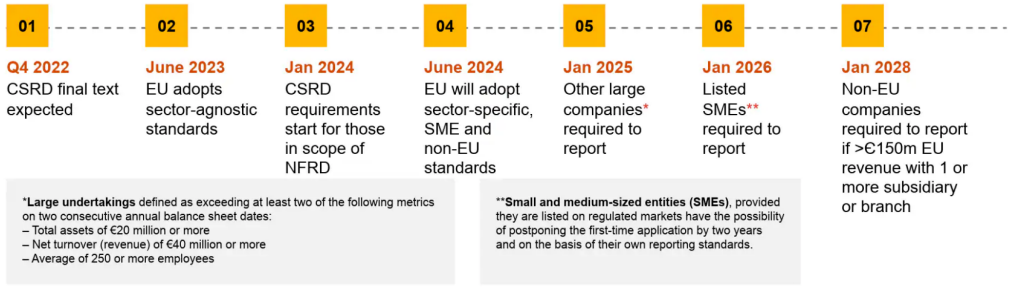

Figure 4.2: CSRD Timeline (PwC, 2022, p. 1)

Current Obligations Under the CSRD (Starting in 2024)

As of January 1, 2024, companies that were already subject to the NFRD must comply with the new CSRD reporting requirements. These companies include:

- *Large publicly traded companies:* Companies listed on regulated markets with more than 500 employees were already covered by the NFRD and are now expected to improve and adapt their ESG reporting to the CSRD requirements (European Parlement, 2022).
- *Financial institutions:* Banks, insurers, and other large financial institutions that have a significant impact on the environment and society must comply with the reporting requirements.

Expansion of Obligations in the Coming Years (Starting in 2025 and Beyond)

Starting on January 1, 2025, the scope of the CSRD will be significantly expanded, and more companies will fall under the reporting obligation. This includes:

- *Medium and large privately held companies:* Companies that meet two of the following three criteria: a net turnover of more than €40 million, a balance sheet total of more than €20 million, and/or more than 250 employees. This means that privately

held companies will also be required to disclose their sustainability information (European Parlement, 2022).

- *Small and medium publicly traded companies:* These companies have been granted a delay until 2026, after which they must also comply with the CSRD. Simplified reporting standards will be applied to help ease the implementation for these companies.

4.1.4. Challenges and Complexity of CSRD Reporting

Although the CSRD offers clear goals and benefits, its implementation still faces significant challenges. Many companies, especially those not previously subject to the NFRD, are struggling to meet the reporting obligations. The complexity of the directive, combined with detailed data collection requirements, raises concerns about feasibility and costs.

1. *Lack of experience and internal expertise* Many companies lack the internal expertise to meet the extensive ESG reporting requirements imposed by the CSRD (PwC, 2024a). Medium-sized companies, in particular, which were not previously required to report ESG information, face difficulties in setting up the necessary systems and processes to collect reliable data. This results in significant costs for hiring external consultants and auditors to ensure compliance (PwC, 2024c).
2. *Data standardization* Although the CSRD introduces standardized ESG reporting guidelines, many companies are still in the process of implementing appropriate systems (EFRAG, 2024a). Sectoral differences make it difficult to apply uniform reporting criteria, leading to inconsistencies in data (S&P Global, 2024). This poses challenges, as investors rely on consistent, comparable information for decision-making.
3. *Mandatory audit and costs* The requirement for external audits of ESG reports imposes significant costs, particularly for companies not previously subject to such regulations (PwC, 2024c). While audits improve report reliability, mid-market companies struggle with the financial and operational burden. Additionally, auditors still have limited experience in ESG assessments, adding to the challenge (PwC, 2024c).
4. *Data collection and Scope 3 emissions* Scope 3 emissions—those from a company's supply chain—pose a particularly complex challenge (PwC, 2023b). Many companies lack insight into supplier and customer emissions, making accurate reporting difficult. Since Scope 3 often represents the largest share of emissions but is the least directly controllable, compliance remains a major hurdle.

4.1.5. Implications for Companies and Investors

The CSRD requires companies to be more transparent about their sustainability strategy and performance, enhancing reputation and access to capital markets. However, poor ESG performance can erode competitiveness as investors increasingly integrate ESG factors into decision-making (PwC, 2024b).

For investors, the directive ensures better and more reliable ESG data, allowing for informed investment decisions and risk assessments (S&P Global, 2023). Higher data quality will further embed ESG considerations into portfolio strategies.

In summary, the CSRD marks a significant step forward in regulating ESG reporting across Europe. It compels companies to enhance transparency in sustainability efforts, creating a robust framework for measuring and improving ESG performance. While the benefits are clear, companies face substantial implementation challenges, particularly in data collection, standardization, and auditing. As the directive evolves, it is essential for companies to develop structured systems and processes to ensure accurate and reliable sustainability reporting.

4.2. European Sustainability Reporting Standards (ESRS)

Building on the CSRD, the ESRS standards were developed to guide sustainability reporting. These standards are designed to help companies disclose their performance in the areas of ESG. The ESRS provide detailed guidelines on what information companies need to disclose, how to measure it, and how to report on it (PwC, 2023a). This chapter provides an in-depth overview of the 12 standards, setting the stage for the next section, which focuses specifically on ESRS E1.

4.2.1. What are the ESRS?

The ESRS were developed by EFRAG in collaboration with the European Commission and other stakeholders. The ESRS are the specific reporting standards that help companies comply with the CSRD requirements. They are the detailed rules and guidelines that companies must follow when reporting on sustainability (EFRAG, 2024b). The ESRS outline what sustainability information companies must report, how these data should be presented, and what measurement methods should be used. This includes reporting on topics such as climate change, biodiversity, social factors, human rights, and governance (European Parlement, 2023). The ESRS are the technical elaboration of the obligations set out in the CSRD. While the CSRD provides the framework and obligations, the ESRS specify how these obligations should be fulfilled (PwC, 2023a).

As shown in Figure 4.3, the ESRS are divided into multiple categories and guidelines specifically designed to help companies report their performance on various ESG areas, including environmental, social responsibility, and governance. The standards are designed to increase the transparency of companies and to provide investors, policymakers, and other stakeholders with reliable information to make informed decisions.

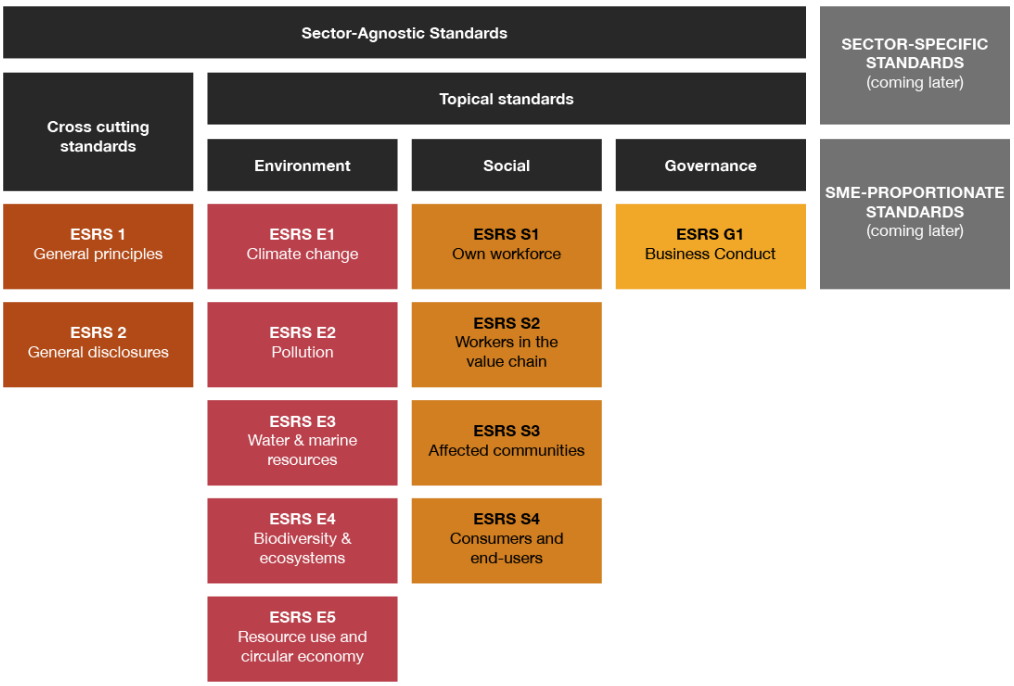

Figure 4.3: ESRS Standards (PwC, 2024b, p. 1)

4.2.2. The 12 ESRS Standards

The ESRS are divided into 12 different standards, each focused on a specific aspect of sustainability. These standards are divided into four main themes: general, environmental, social, and governance (European Parlement, 2023).

1. General Standards

   ESRS 1: General Requirements for Sustainability Reporting
   ESRS 1 defines the general requirements for preparing sustainability reports. It includes principles such as materiality, comparability, and reliability. Companies must base their reporting on the principle of materiality, meaning they must report on issues that are significant for their business and stakeholders. This standard helps companies determine which sustainability information is relevant to report (European Parlement, 2023).

   ESRS 2: General Disclosure Policy
   This standard specifies the requirements for how companies must disclose sustainability information. This includes how companies disclose their business model, strategy, governance, and policies related to ESG issues. ESRS 2 also emphasizes the obligation to report risks and opportunities related to sustainability issues, as well as companies' long-term strategies for sustainability (European Parlement, 2023).

2. Environmental Standards

   ESRS E1: Climate Change (CO_2 Emissions)
   ESRS E1 is one of the most important standards within the ESRS, focusing specifically on the reporting of CO_2 emissions and other climate-related information (PwC, 2023b). Companies must disclose their emissions in three categories: Scope 1 (direct emissions), Scope 2 (indirect emissions from energy consumption), and Scope 3 (other indirect emissions within the value chain). The objective of this standard is to help companies measure, manage, and reduce their impact on climate change (PwC, 2023b).

   The standard requires companies to report on emission reduction targets, transition plans, and implemented measures to achieve these goals. Additionally, it provides detailed guidelines for the calculation and reporting of CO_2 emissions, ensuring consistency and comparability across companies. ESRS E1 aligns with existing European climate policies and sustainability directives, reinforcing the need for transparent and standardized climate disclosures (European Parlement, 2023).

   ESRS E2: Pollution
   This standard focuses on how companies manage the emissions of pollutants, such as air and water pollution. Companies must report their impact on the local and global environment and the measures they are taking to reduce pollution (European Parlement, 2023).

   ESRS E3: Water and Marine Resources
   ESRS E3 requires companies to provide information about their water consumption and the impact of their activities on water resources. Companies must report on water use, water conservation, and pollution of water sources, as well as measures taken to limit the impact on marine ecosystems (European Parlement, 2023).

   ESRS E4: Biodiversity and Ecosystems
   This standard focuses on the impact of business activities on biodiversity and ecosystems. Companies must disclose their contributions to habitat loss, deforestation, and other negative impacts on nature. They must also report on the strategies and measures they are taking to protect and restore biodiversity (European Parlement, 2023).

   ESRS E5: Resource Use and Circular Economy
   The focus of ESRS E5 is on the efficient use of resources and the transition to

a circular economy. Companies must disclose their resource consumption, waste management, and recycling practices, as well as their plans to promote circular business practices (European Parlement, 2023).

3. Social Standards
   ESRS S1: Own Workforce
   This standard focuses on how companies treat their employees, including working conditions, wages, health and safety, and promoting diversity and inclusion. Companies must provide information about their personnel policies and their social outcomes (European Parlement, 2023).

   ESRS S2: Workers in the Value Chain
   This standard goes beyond a company's own employees and focuses on how companies deal with workers in their supply chain. This includes working conditions, fair wages, and the prevention of child labor and forced labor among suppliers (European Parlement, 2023).

   ESRS S3: Affected Communities
   ESRS S3 requires companies to provide information about their impact on local communities. This includes how companies address issues such as human rights, land rights, and the social impact of their activities on vulnerable communities (European Parlement, 2023).

   ESRS S4: Consumers and End-Users
   This standard focuses on companies' relationships with their customers and end-users. Companies must report on product safety, consumer protection, and the ethical marketing of their products and services (European Parlement, 2023).

4. Governance Standards
   ESRS G1: Governance, Risk Management, and Internal Control
   This standard focuses on companies' governance structures, including their board models, risk management processes, and internal control systems. Companies must be transparent about how they manage ESG risks and integrate them into their broader business strategy (European Parlement, 2023).

4.3. European Sustainability Reporting Standard E1 - Climate Change

The ESRS E1 standard is specifically developed to support companies in complying with the CSRD's emissions reporting requirements (European Parlement, 2023). While the ESRS framework includes twelve reporting standards, this study focuses exclusively on ESRS E1 due to its direct relevance to emissions disclosure and climate impact assessment. Since emissions reporting plays a central role in sustainability compliance, this section provides a detailed analysis of ESRS E1 and its mandatory reporting requirements.

ESRS E1 focuses on two core areas:

- *Climate Change Mitigation:* Reducing emissions and contributing to limiting global warming to 1.5°C above pre-industrial levels.
- *Climate Change Adaptation:* Adapting business models and strategies to manage the impacts of climate change and leverage new opportunities.

Additionally, ESRS E1 addresses energy-related topics, such as energy consumption and the mix of energy sources, which are closely linked to climate change.

4.3.1. Development and Standardization of ESRS E1

The development of ESRS E1 has been coordinated by EFRAG (European Financial Reporting Advisory Group) in close collaboration with the European Commission. EFRAG (2024b) designed the standard as a technical elaboration of the obligations arising from the CSRD.

The standards aim to promote consistency and comparability in corporate sustainability reporting (European Parlement, 2023). By integrating international and European policy frameworks, such as the EU Green Deal and the EU Taxonomy[1], ESRS E1 aligns with existing regulations and guidelines. This ensures that the standard is not only applicable within the EU but also compatible with global sustainability frameworks like the Paris Agreement.

With these standards, EFRAG (2024b) establishes a harmonized reporting framework that mandates and supports companies in delivering high-quality sustainability information. It provides investors, policymakers, and other stakeholders with reliable and standardized data to inform decision-making processes.

4.3.2. Objectives of ESRS E1

The primary objective of ESRS E1 is to guide companies in reporting climate-related information that enhances transparency, consistency, and actionability. The standard defines specific Disclosure Requirements that enable companies to provide insights into the following aspects, as outlined by Baker-Friesen (2024):

- *Impact of the company on climate change:* Reporting on the positive and negative, actual and potential impacts of corporate activities on climate change.
- *Mitigation efforts:* Explanation of historical, current, and planned actions by the company to reduce emissions in alignment with limiting global warming to 1.5°C.
- *Adaptation strategies and capabilities:* Information on how the company adjusts its strategies and business models to support the transition to a sustainable economy and manage physical climate risks.
- *Actions and outcomes:* Description of actions undertaken, their outcomes, and the extent to which they mitigate negative impacts and leverage opportunities.

[1] The EU Taxonomy is a classification system developed by the European Union to define which economic activities are environmentally sustainable. It provides clear criteria for companies and investors to assess the environmental impact of investments and ensure alignment with the EU's climate and sustainability objectives.(European Parlement, 2020)

- *Material risks and opportunities:* Identification and description of the nature, scale, and effects of risks and opportunities arising from the company's impact on and dependency on climate change.
- *Financial impacts:* Analysis of the short-, medium-, and long-term impacts of climate-related risks and opportunities on the company's financial performance.

These objectives are explicitly aligned with existing EU legislation and regulations to help companies meet their legal obligations while contributing to broader climate goals.

4.3.3. The 9 Disclosure Requirements of ESRS E1

The core of reporting for ESRS E1 is formed by the 9 Disclosure Requirements (DRs) outlined in the European Sustainability Reporting Standards (2024b). These requirements provide a framework for companies to transparently and uniformly report their climate performance, risks, and opportunities. These 9 DRs can be divided into 3 categories, as shown in Figure 4.4, namely *"Strategy"*, *"Impact, Risk and Opportunity Management"*, and *"Metrics and Targets"* (Shukri & Steingrímsdóttir, 2024).

Figure 4.4: 9 Disclosure Requirements ESRS E1 (Shukri & Steingrímsdóttir, 2024)

Below, the 9 DRs are briefly explained. In the following paragraphs and in Appendix B, each DR will be elaborated upon, detailing what companies are required to report for each.

- Strategy
  E1-1: Transition Plan for Climate Change Mitigation
  Companies must develop a transition plan aligned with the Paris Agreement to limit global warming to 1.5°C. This includes reduction targets and implementation strategies.

- Impact, Risk & Opportunity Management
  E1-2: Policies Related to Climate Change Mitigation and Adaptation
  Description of policies aimed at emission reduction and climate adaptation.

  E1-3: Actions and Resources in Relation to Climate Change Policies
  Requires an overview of actions, resources, and resource allocation used by companies to achieve their climate goals.

- Metrics & Targets
  E1-4: Targets Related to Climate Change Mitigation and Adaptation
  This includes detailed climate targets, time horizons, baselines, and how progress is measured using relevant KPIs.

E1-5: Energy Consumption and Mix
Companies are required to report their energy consumption and energy source mix (renewable vs. non-renewable), including their transition to renewable energy.

E1-6: Gross Scopes 1, 2, 3 and Total GHG Emissions
Companies must report their emissions according to Scopes 1, 2, and 3, as well as their total greenhouse gas emissions.

E1-7: GHG Removals and GHG Mitigation Projects Financed Through Carbon Credits
Requires reporting on projects focused on greenhouse gas removal and the use of carbon credits to offset emissions.

E1-8: Internal Carbon Pricing
Companies must report internal carbon prices and explain how these are used to guide strategic and operational decisions.

E1-9: Anticipated Financial Effects from Material Physical and Transition Risks and Potential Climate-Related Opportunities
This includes quantifying the financial implications of physical and transition risks, as well as opportunities related to climate change.

4.3.4. ESRS E1 implementation

Meeting the reporting requirements of the CSRD and specifically ESRS E1 is proving to be an extensive and detailed task for companies. To fully comply with these standards, a considerable amount of data is required, which needs to provide both qualitative and quantitative insights. The large amount of data requires not only careful collection but also a well-structured approach to integrate it effectively into the reporting process.

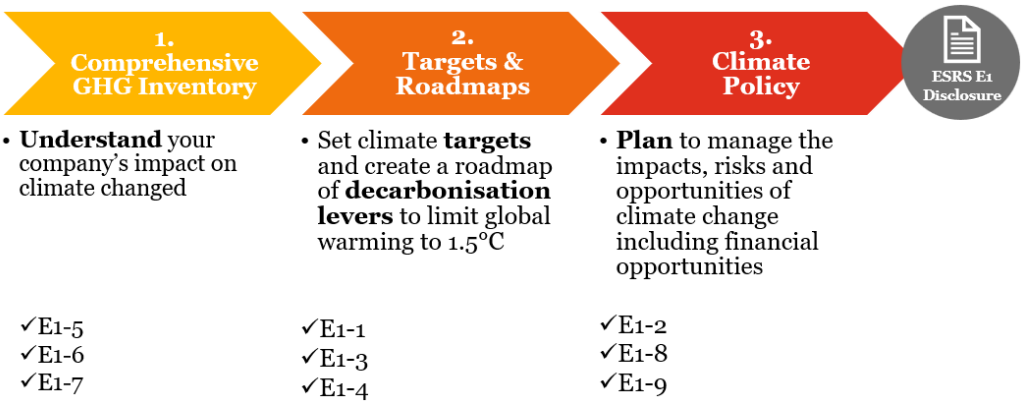

Figure 4.5: ESRS E1 implementation, copied from Luttin (2024)

A practical approach has therefore been proposed, based on the framework of Luttin (2024). This framework consists of three steps, as illustrated in Figure 4.5. The first step focuses on the disclosure requirements E1-5, E1-6, and E1-7, forming the foundation of the entire process. In this step, quantitative data is collected and reported, such as greenhouse gas emissions. This data is crucial as it serves as the basis for subsequent steps, where the data is used to establish climate goals and manage risks and opportunities (E1-1 through E1-9). This first step highlights the importance of thoroughly understanding the organization's impact on climate change before effective actions can be undertaken in the following phases. Given their central role in emissions reporting, E1-5, E1-6, and E1-7 will be explored in greater detail in the next Section 4.4.

4.4. Disclosure Requirements ESRS E1

The previous sections of this chapter provided an introduction to the CSRD and outlined the underlying objectives, content, and scope of this new European directive. After this, the focus shifted to the ESRS, specifically on ESRS E1. The objectives of ESRS E1 were discussed, as well as the nine disclosure requirements that support companies in reporting emissions data and climate-related measures.

While ESRS E1 consists of nine disclosure requirements, this section focuses exclusively on the three most critical ones for emissions reporting:

- E1-5: Energy Consumption and Mix
- E1-6: Gross Scopes 1, 2, 3 and Total GHG Emissions
- E1-7: GHG Removals and GHG Mitigation Projects

These disclosure requirements form the foundation of emissions reporting, as they provide the essential quantitative data needed for compliance with sustainability regulations. A more detailed explanation of the remaining six disclosure requirements can be found in Appendix B.

For each of the three key disclosure requirements, this section discusses the specific reporting requirements, relevant data needs, and underlying principles that enable companies to report fully and accurately. This structured approach provides a clear overview of what is expected of companies and how they can integrate these reporting obligations effectively.

By analyzing these disclosure requirements, this section contributes to answering the first sub-question of this study, as it clarifies which specific emissions-related data companies are required to collect and report under ESRS E1. Understanding these requirements is crucial for evaluating how ERP systems, like SAP, can support accurate and compliant emissions reporting.

4.4.1. E1-5: Energy Consumption and Mix

Disclosure Requirement E1-5, part of the *"Metrics and Targets"* category, is highly significant within ESRS E1 as it represents the first obligation requiring detailed quantitative data to be collected and reported. This requirement focuses on providing insights into a company's total energy consumption and its distribution across different energy sources, such as fossil fuels, nuclear energy, and renewable energy. Additionally, it specifically addresses energy efficiency, dependence on fossil fuels, and steps taken to reduce this dependency by increasing the use of renewable energy sources.

Reporting this data forms an important foundation for meeting the broader ESRS E1 requirements. These quantitative data points are essential for providing stakeholders with clarity about the organization's impact and serve as the basis for strategic decision-making in later phases of reporting, such as setting climate goals and managing climate risks.

Reporting Requirements for E1-5

ESRS E1-5 focuses on providing transparency regarding energy-related data and specifies requirements for reporting on energy consumption, efficiency, and the composition of the energy mix. Below, the requirements outlined by EFRAG (2024b) in the report are described in detail:

- *Total Energy Consumption and Breakdown*
  Companies must report their total energy consumption in megawatt-hours (MWh). This must include the amount of energy derived from fossil fuels, nuclear sources, and renewable energy. For renewable energy, further specifications are required:
  - Fuel consumption from renewable sources (such as biomass, biogas, hydrogen from renewable sources).

  - Consumption of purchased or self-generated renewable electricity, heat, steam, or cooling.

- *Energy Savings and Fossil Fuels*
  Companies must report energy efficiency improvements realized during the reporting period, including quantifications where possible. Additionally, exposure to fossil fuels must be described, with further breakdowns into specific fossil fuels such as coal, oil, and natural gas.
- *Energy Balance and Intensity*
  The energy mix must be presented as a percentage of total energy consumption per source (fossil, nuclear, renewable). For companies in high climate impact sectors, the energy balance must be further detailed. These are companies that significantly contribute to greenhouse gas emissions and are part of sectors such as Energy, Mining, Manufacturing, Transport, Heavy Industry, Agriculture, Water Supply, Construction, Real Estate, or Food and Beverage. These companies must also report on the share of coal, oil, natural gas, and other fossil fuels.

  In addition to reporting the energy balance of these fossil fuels, companies in these sectors must calculate their energy intensity. Energy intensity reflects the relationship between total energy consumption and net revenue, providing a valuable measure of energy efficiency (EFRAG, 2024b, p. 36):

$$\text{Energy Intensity} = \frac{\text{Total energy consumption from activities in high climate impact sectors (MWh)}}{\text{Net revenue from activities in high climate impact sectors (Monetary unit)}}$$

  This calculation helps map current performance and provides insights into how efficiently energy is converted into economic output. By specifically linking these data to activities in high climate impact sectors, a clearer picture emerges of where the greatest improvements in energy management and efficiency are possible.

  Furthermore, energy intensity figures must be consistent with financial reporting. This means that companies must link the net revenue data used in the calculation of energy intensity to the relevant items or notes in their financial statements. This linkage not only enhances the reliability of the reporting but also demonstrates how energy management and economic performance are interconnected. This enables effective analysis of how companies in these sectors contribute to both economic value and sustainability.
- *Future Energy Plans*
  Companies must describe initiatives and objectives aimed at increasing the share of renewable energy in the energy mix and improving energy efficiency in line with climate-related objectives.

Data Requirements for E1-5

Following the reporting requirements discussed earlier, this section focuses on the specific data points needed for full and consistent compliance with ESRS E1-5. These data points form the basis for accurate reporting on energy use and related sustainability aspects. The emphasis is on measurable and standardized data, such as total energy consumption, energy intensity, and the share of renewable energy in the energy mix.

The importance of these specific data points is twofold: on the one hand, they enable companies to monitor internal progress, and on the other, they provide stakeholders with transparency and comparability across organizations. Table 4.1 presents an overview of the required data points, broken down into the core components of ESRS E1-5 from the EFRAG report (2024b). Each data point is linked to measurement units to clarify what information must be collected and reported.

Table 4.1: Data Requirements for ESRS E1-5, based on (EFRAG, 2024b).

Requirements	Required Data
Total Energy Consumption	• Total energy consumption in MWh. • Energy consumption broken down by fossil fuels: – Coal (MWh). – Oil (MWh). – Natural gas (MWh). – Other fossil sources (MWh). • Energy consumption from nuclear sources (MWh). • Energy consumption from renewable energy sources (MWh).
Energy Efficiency	• Data on realized energy efficiency improvements (MWh saved per year).
Renewable Energy	• Share of renewable energy in the energy mix (%). • Energy consumption from specific renewable sources: – Biomass (MWh). – Biogas (MWh). – Hydrogen (MWh). • Investments in renewable energy capacity (EUR).
Energy Intensity	• Energy consumption per net revenue (MWh per EUR net revenue). • Net revenue data (EUR).

To ensure consistency across companies, the ESRS report (2024b) provides a tabular format for E1-5. In Table 4.2, energy consumption is categorized into fossil, nuclear, and renewable energy sources. For fossil fuels, five specific categories are detailed for *high climate impact sectors*. Table 4.3 illustrates how companies must report their energy intensity per net revenue, specifically for high climate impact sectors. The data in the table provides an overview of current values, comparisons with previous years, and percentage changes. The goal is to offer insights into energy efficiency and identify areas for improvement or inefficiency. This structured approach forms the basis for monitoring energy performance in line with sustainability objectives.

Table 4.2: Energy consumption and mix disclosure requirements ESRS E1-5 (EFRAG, 2024b, p. 34)

Energy consumption and mix	**Comparative**	**Year N**
(1) Fuel consumption from coal and coal products (MWh)		
(2) Fuel consumption from crude oil and petroleum products (MWh)		
(3) Fuel consumption from natural gas (MWh)		
(4) Fuel consumption from other fossil sources (MWh)		
(5) Consumption of purchased or acquired electricity, heat, steam, and cooling from fossil sources (MWh)		
(6) Total fossil energy consumption (MWh) (calculated as the sum of lines 1 to 5)		
Share of fossil sources in total energy consumption (%)		
(7) Consumption from nuclear sources (MWh)		
Share of consumption from nuclear sources in total energy consumption (%)		
(8) Fuel consumption for renewable sources, including biomass (also comprising industrial and municipal waste of biologic origin, biogas, renewable hydrogen, etc.) (MWh)		
(9) Consumption of purchased or acquired electricity, heat, steam, and cooling from renewable sources (MWh)		
(10) The consumption of self-generated non-fuel renewable energy (MWh)		
(11) Total renewable energy consumption (MWh) (calculated as the sum of lines 8 to 10)		
Share of renewable sources in total energy consumption (%)		
Total energy consumption (MWh) (calculated as the sum of lines 6, 7 and 11)		

Table 4.3: Energy Intensity Per Net Revenue Table ESRS E1-5 (EFRAG, 2024b, p. 37)

Energy intensity per net revenue	**Comparative**	**N**	**% N / N-1**
Total energy consumption from activities in high climate impact sectors per net revenue from activities in high climate impact sectors (MWh/Monetary unit)			

4.4.2. E1-6: Gross Scopes 1, 2, 3 and Total GHG emissions

Disclosure Requirement ESRS E1-6 belongs to the *"Metrics and Targets"* category and is considered one of the most important and complex requirements within the ESRS framework. Among the total of 84 requirements within the ESRS framework, E1-6 stands out due to the scope and depth of its reporting requirements. The complex nature of E1-6 arises from the necessity to collect, analyze, and report detailed data on greenhouse gas emissions, including direct emissions, energy consumption-related emissions, and emissions from the entire value chain (Van Geel, 2024).

The complexity of E1-6 is further amplified by the fact that the required data is not only essential for emission reporting but also for setting emission reduction targets, measuring progress against climate-related policies, and understanding climate risks and opportunities (Lüttin, 2024). The data must be processed consistently and accurately, as it directly influences other components of the ESRS requirements, such as E1-1 (Transition Plan) and E1-4 (Objectives). Among all emission-related reporting requirements, E1-6 is the most critical, as it provides a comprehensive view of a company's total emissions, including all direct and indirect emissions, which is significant for this research.

Requirements for Reporting E1-6

The requirements for ESRS E1-6, as outlined in the ESRS report prepared by EFRAG (EFRAG, 2024b), focus on detailed reporting of emissions resulting from a company's energy consumption. This reporting helps to provide a clear understanding of the climate impact of their activities. Below, the specific requirements are outlined, starting with Scope 1:

- *Scope 1 Emissions*
  Scope 1 emissions include all direct greenhouse gas emissions resulting from an organization's activities. This includes, for example, emissions from the combustion of fossil fuels in company-owned vehicles or installations and fugitive emissions, such as refrigerant leaks. The company must report data on fuel consumption (e.g., natural gas, diesel) and the emission factors used to calculate emissions. These factors must be based on reliable sources, such as the IPCC. To limit the volume and complexity of all greenhouse gas emissions, it is expected that the following six types of emissions will be included: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3.
- *Scope 2 Emissions*
  Scope 2 emissions are indirect emissions arising from an organization's energy use, such as purchased electricity, heat, or steam. Reporting requires differentiation between emissions calculated based on:
  - *Location-based method*: This method uses average emission factors based on the electricity grid in the organization's geographic region.
  - *Market-based method*: This method considers specific emission factors linked to contracts for green energy or other specific energy sources.

  Reporting both methods enables a comprehensive understanding of the company's energy choices and impacts.
- *Scope 3 Emissions*
  Scope 3 emissions encompass the entire value chain of an organization, both upstream (e.g., transportation and procurement of goods) and downstream (e.g., the use of sold products). Key requirements include:
  - *Breakdown of Scope 3 categories*: Companies must report significant categories separately, such as transportation, production, waste management, and product use.
  - *Percentage of emissions based on primary data from suppliers*: This refers to the share of Scope 3 emissions calculated using direct data from suppliers or partners. Primary data is considered more reliable than estimates based on

secondary sources. A higher percentage of primary data demonstrates that the company uses accurate and specific data.

- *Justification for exclusions*: If certain categories are not included in the calculations, clear reasons must be provided, such as negligible emissions or data unavailability.

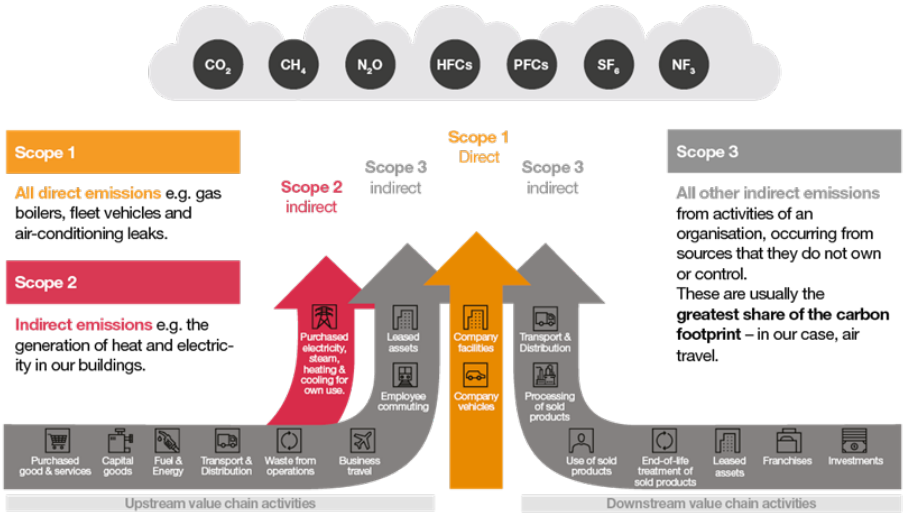

Figure 4.6: Scope 1, 2 & 3 (PwC Luxembourg, 2023, p. 1)

- *Total GHG emissions*
  Once the emissions from each scope have been mapped, the total GHG emissions must be reported. This includes a complete overview of emissions arising from the organisation's own activities, as well as from upstream and downstream value chains. Reporting this data is essential to measure progress in reducing GHG emissions in line with the organisation's climate objectives and EU policy. In this, it is necessary to distinguish between the location-based method and the market-based method in scope 2 emissions. This is done with the following two formulas (EFRAG, 2024b, p. 47):

$$\begin{aligned}\text{TotaleGHG} - \text{emissies}_{\text{location-based}}(\text{t CO}_2\text{eq}) &= \text{Gross Scope 1} + \text{Gross Scope 2}_{\text{location-based}} \\ &\quad + \text{Gross Scope 3 Total} \\ \text{TotaleGHG} - \text{emissies}_{\text{market-based}}(\text{t CO}_2\text{eq}) &= \text{Gross Scope 1} + \text{Gross Scope 2}_{\text{market-based}} \\ &\quad + \text{Gross Scope 3 Total}\end{aligned}$$

- *GHG-intensity*
  Last but not least, GHG intensity is calculated by dividing total GHG emissions (Scope 1, 2 and 3) by an organisation's net sales. This involves the following formula (EFRAG, 2024b, p. 53):

$$\text{GHG Intensity Ratio} = \frac{\text{Total GHG emissions (t CO}_2\text{eq)}}{\text{Net revenue (Monetary unit)}}$$

  This provides a measure of the organisation's emission efficiency. Examples could include tonnes of CO_2-equivalent per million euros of turnover. This enables comparisons between companies within a sector.

- *Methodological Details*
  In their reporting, companies must clarify the methodologies and emission factors they have used, such as the GHG Protocol or IPCC guidelines. In doing so, they must (Charluet, 2024):

  - Specify which tools or software were used for the calculations.
  - Explain why certain emission factors were chosen.
  - Indicate whether and how they considered the latest Global Warming Potential (GWP) values, which are an important factor in calculating the CO_2-equivalent of other gases such as methane and nitrous oxide.

- *Disaggregation*
  Total emissions must be broken down according to relevant criteria, such as geographic regions, operational segments, or specific activities. This disaggregation helps identify emission hotspots within the organization and makes the reporting more transparent.

Data Requirements E1-6

Table 4.4 summarizes the specific data requirements for each emission category. These requirements cover a wide range of data, including greenhouse gas emissions (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3), and provide a clear overview of what is needed for compliant and complete reporting under ESRS E1-6. This table serves as a practical guide for organizations to understand the required data and how it contributes to their climate reporting.

Table 4.4: Data Requirements for ESRS E1-6, based on (EFRAG, 2024b)

Requirement	Required Data
Scope 1 Emissions	• Fuel consumption (liters, m³, kg) per fuel type. • Emissions from industrial processes and fugitive emissions. • Emission factors per fuel and process. • Breakdown of emissions per greenhouse gas (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3).
Scope 2 Emissions	• Purchased electricity, heat, and steam (kWh or MWh), broken down by source (fossil, renewable, nuclear). • Location-specific and market-based emission factors.
Scope 3 Emissions	• Data on transportation (distance, fuel consumption). • Procurement of goods and services (production emissions). • Waste management (emissions from processing and recycling). • Use of sold products (e.g., fuel consumption by customers). • Percentage of emissions based on primary data from suppliers.
GHG Intensity	• Total emissions (Scopes 1, 2, and 3) in metric tons of CO_2-equivalent. • Net revenue in monetary units (e.g., euros). • Emission factors and calculation methods used.

For completeness and consistency in greenhouse gas emissions reporting, EFRAG (2024b) has developed a table format within the ESRS report that companies can use as a template. This is Table 4.5, designed specifically for ESRS E1-6, providing a standardized structure for companies to report their Scope 1, Scope 2, and Scope 3 emissions. The format aims to improve comparability and transparency between organizations while helping companies organize their reporting obligations effectively.

Table 4.5 differentiates between various emission sources and presents data in a clear and structured way. It includes both retrospective data and targets for future reporting years, with specific attention to milestones such as 2025, 2030, and 2050, the legally mandated target year for climate neutrality. Additionally, the table allows for the reporting of annual progress relative to baseline years, including the percentage of targets achieved per baseline year, enabling companies to monitor trends and improvements in emission reductions accurately.

By breaking down emissions into Scope 1, Scope 2 (location-based and market-based), and the 15 categories of Scope 3 emissions, as shown in Figure 4.6, companies can report their emission sources in detail. This format not only provides an overview of current emission levels but also highlights correlations between activities in the value chain and their environmental impact. The template further supports companies in identifying emission-intensive processes, enabling targeted reduction actions aligned with regulations and policies.

With this setup, EFRAG has established a critical foundation for consistent and efficient reporting practices, allowing companies not only to meet reporting requirements but also to contribute to broader sustainability goals.

Table 4.5: GHG Emissions Reporting Table for E1-6 (EFRAG, 2024b, p. 48)

	Retrospective				**Milestones and target years**			
	Base year	**Comparative**	**N**	**% N / N-1**	**2025**	**2030**	**(2050)**	**Annual % target / Base year**
Scope 1 GHG emissions								
Gross Scope 1 GHG emissions (tCO_2eq)								
Percentage of Scope 1 GHG emissions from regulated emission trading schemes (%)								
Scope 2 GHG emissions								
Gross location-based Scope 2 GHG emissions (tCO_2eq)								
Gross market-based Scope 2 GHG emissions (tCO_2eq)								
Significant Scope 3 GHG emissions								
Total Gross indirect (Scope 3) GHG emissions (tCO_2eq)								
1 Purchased goods and services								

Continued on next page

Continuation of Table 4.5

	Retrospective				Milestones and target years			
	Base year	**Compa-rative**	**N**	**% N / N-1**	**2025**	**2030**	**(2050)**	**Annual % target / Base year**
Optional sub-category: Cloud computing and data centre services								
2 Capital goods								
3 Fuel and energy-related activities (not included in Scope 1 or Scope 2)								
4 Upstream transportation and distribution								
5 Waste generated in operations								
6 Business traveling								
7 Employee commuting								
8 Upstream leased assets								
9 Downstream transportation								
10 Processing of sold products								
11 Use of sold products								
12 End-of-life treatment of sold products								
13 Downstream leased assets								
14 Franchises								
15 Investments								
Total GHG emissions								
Total GHG emissions (location-based) (tCO_2eq)								
Total GHG emissions (market-based) (tCO_2eq)								

4.4.3. E1-7: GHG removals and GHG mitigation projects financed through carbon credits

Disclosure Requirement E1-7 builds on E1-6 by not only identifying GHG emissions but also focusing on the ways in which companies reduce or neutralize these emissions. Whereas E1-6 mainly looks at Scope 1, 2 and 3 emissions, E1-7 focuses on the measures taken to remove GHG from the atmosphere and the use of carbon credits to offset emissions outside the value chain (Charluet, 2024). This makes E1-7 special because it goes beyond simply reporting emissions and requires an understanding of how companies contribute to net emissions reductions.

E1-7 requires companies to make transparent both direct removal activities within their value chain and external projects through carbon credits. Reporting this data is important to assess the reliability of climate claims such as net-zero or climate neutrality. In addition, E1-7 avoids double accounting, for example by not double reporting carbon credits and Scope 3 emissions.

Reporting Requirements for E1-7

The requirements for ESRS E1-7 have been developed by EFRAG (2024b) and focus on the reporting of greenhouse gas (GHG) emissions. Companies are required to provide detailed and specific emission data. These requirements are described in detail below.

- *GHG Removals and Storage*
  Companies must report the total amount of removed and stored greenhouse gases in metric tons of CO_2-equivalent. This must be broken down into removals within their own operations as well as those in the upstream and downstream value chain. Furthermore, it is important to distinguish between different types of removal activities, such as:
  - *Biogenic activities:* Such as reforestation and carbon sequestration in agricultural soils.
  - *Technological activities:* Such as direct air capture and carbon storage.
  - *Hybrid activities:* A combination of biogenic and technological removals, such as bioenergy with carbon capture and storage (BECCS).
- *GHG Mitigation via Carbon Credits*
  E1-7 requires companies to report on the use of carbon credits to finance emission reductions. They must provide insights into:
  - The amount of purchased carbon credits in CO_2eq, both qualified as reductions within the reporting period.
  - Credits planned for future reductions.
  - A breakdown by project type (reduction or removal), the nature of the removal (biogenic or technological), and geographical origin (e.g., within the EU).

  It is essential that carbon credits remain outside the company's value chain. This prevents the same emissions from being reported both as reductions under E1-7 and as Scope 3 emissions under E1-6.
- *Transparency and Risks*
  Another key aspect of E1-7 is addressing risks, such as the risk of reversals. Companies must explain how they minimize this risk, for example, in forest management projects where stored carbon could be lost due to deforestation.

Data Requirements for E1-7

The data requirements for ESRS E1-7 focus on measuring and reporting GHG removals and the use of carbon credits within and outside companies' value chains (Charluet, 2024). These requirements provide a structured overview of measurable data that are essential to ensure transparency regarding companies' actions on GHG removals, storage, and financial contributions to climate mitigation through carbon credits.

Table 4.6 provides an overview of the specific data points that companies must collect and report in metric tons of CO_2-equivalent (tCO_2eq). The goal is to promote consistency and comparability among companies and to provide stakeholders with insights into the impact of GHG removal projects and the use of carbon credits. Additionally, explicit attention is given to reversals and their impact on prior reports.

Table 4.6: Data Requirements for ESRS E1-7, based on (EFRAG, 2024b).

Requirement	Required Data
GHG Removals and Storage	• Total amount of GHG removals (tCO_2eq). • Total amount of GHG storage (tCO_2eq). • GHG emissions related to storage or transportation (tCO_2eq).
Carbon Credits	• Amount of canceled carbon credits (tCO_2eq). • Amount of planned cancellations (tCO_2eq). • Amount of carbon credits from reduction projects (tCO_2eq). • Amount of carbon credits from removal projects (tCO_2eq).
Reversals	• Amount of reversed removals (tCO_2eq).

Tables 4.7 and 4.8, both developed by EFRAG (2024b), serve as standardized templates to provide companies with a consistent framework for reporting their activities and performance in climate change mitigation as required under ESRS E1-7. These tables are designed to ensure uniformity and comparability in reporting, which is essential for providing insights to policymakers, investors, and other stakeholders.

Table 4.7 focuses on GHG removals and related activities, including any reversals, expressed in metric tons of CO_2-equivalent (tCO_2eq). This table provides a structured overview of removal activities within a company's own operations and across the upstream and downstream value chain. The distinction between own operations and value chains contributes to a clear understanding of the scope and effectiveness of GHG removal efforts. Documenting reversals further enhances transparency regarding the lasting impact of reported removals on climate goals.

Table 4.7: GHG Removals and Reversals Table for E1-7 (EFRAG, 2024b, p. 60)

Removals	**Comparative**	**N**	**% N / N-1**
GHG removal activity 1 (e.g., forest restoration)	-	-	-
GHG removal activity 2 (e.g., direct air capture)	-	-	-
...	-	-	-
Total GHG removals from own operations (tCO_2eq)			
GHG removal activity 1 (e.g., forest restoration)	-	-	-
GHG removal activity 2 (e.g., direct air capture)	-	-	-
...	-	-	-
Total GHG removals in the upstream and downstream value chain (tCO_2eq)			
Reversals (tCO_2eq)			

Table 4.8 provides a standardized format for reporting carbon credits purchased, canceled, or scheduled for cancellation outside the value chain. This table distinguishes itself by supporting companies in specifying canceled carbon credits based on project type (reduction or removal), quality standards applied, and geographical origin (e.g. within the EU). In addition, the table provides space to report future commitments related to carbon credits, which is crucial to underpin long-term strategy and commitment to climate goals.

Together, these templates not only provide companies with a tool to ensure transparency and accuracy in their reporting, but also to avoid double counting and ensure a clear separation between internal emissions and external offsetting mechanisms.

Table 4.8: Carbon credits cancelling (EFRAG, 2024b, p.64)

Carbon credits cancelled in the reporting year	**Comparative**	**N**
Total (tCO_2eq)		
Share from removal projects (%)		
Share from reduction projects (%)		
recognized quality standard 1 (%)		
recognized quality standard 2 (%)		
recognized quality standard 3 (%)		
…		
Share from projects within the EU (%)		
Share of carbon credits that qualify as corresponding adjustments (%)		
Carbon credits planned to be cancelled in the future	**Amount until [period]**	
Total (tCO_2eq)		

4.5. Conclusion

Chapter 4 has offered a thorough analysis of the reporting requirements under the CSRD and ESRS, with particular emphasis on ESRS E1, which focuses on climate change and emission reduction. It is clear that the CSRD and ESRS have extensive and complex requirements for companies to report emissions and other sustainability data transparently and in detail. At the core of the specific reporting requirements for ESRS E1 are nine different disclosure requirements. Together, these requirements form a detailed framework that requires companies to report their climate performance, emission reductions and related risks and opportunities in a transparent and consistent manner. While each of these DRs is important, the greatest challenges and complexity lie with disclosure requirements E1-5, E1-6 and E1-7.

These three DRs mainly require quantitative data, such as absolute and relative emission rates, energy consumption in specific categories and deployment of carbon offset projects. These data are not only essential for direct reporting under these DRs, but also form the basis for other disclosures, such as transition plans and policies (e.g. E1-1 and E1-2). This highlights the importance of a streamlined and integrated approach in data collection and processing. To promote uniformity and consistency in reporting, EFRAG has developed standardized templates that support companies in meeting these requirements.

In particular, DR E1-6, which requires companies to provide complete and accurate reporting on all emissions within Scope 1, 2 and 3, is considered the most complex. Scope 3, which covers indirect emissions throughout the value chain, includes as many as 15 specific reporting requirements. These requirements present significant challenges, as the data depend on external parties within complex and often international supply chains. The diversity and volume of information required make this process time-consuming and require close cooperation with suppliers, customers and other stakeholders.

In summary, Chapter 4 provides a clear answer to the sub-question, ‘What specific reporting requirements for emissions are included in the CSRD and ESRS E1?’ It shows that companies face 9 extensive requirements of disclosure requirements, with the focus in the case of quantitative data being on DR E1-5, E1-6 and E1-7. From policy, data reporting requirements are now clearly defined for emissions (ESRS E1). While EFRAG’s templates and guidance support companies in the reporting process and promote uniformity, the question remains how companies can effectively collect and integrate this data to meet the requirements. This represents the next challenge in the implementation of the ESRS E1 standards. This will be looked at in the following chapters.

5

Case Analysis: SAP as ERP system for emission reporting

The previous chapter outlined the sustainability reporting requirements as established in the CSRD and ESRS, with particular emphasis on ESRS E1, which focuses on emissions reporting. This analysis provided a clear overview of the (data) requirements companies need to meet to document their emissions in line with European sustainability standards.

Existing literature highlights that ERP systems offer a valuable solution for the integrated and efficient utilization of data for sustainability reporting. By consolidating data from various business processes, these systems can support companies in meeting complex reporting requirements. However, the question remains to what extent ERP systems are already being used to comply with these reporting obligations and which critical data points are essential yet challenging to integrate for this purpose. As discussed in Section 3.1.2, SAP was selected as a case due to its dominant position as the world's leading ERP system, the relevant consultancy context of this research, and the availability of practice-oriented information. Building on this foundation, this chapter examines the role of SAP in emissions reporting under the CSRD and ESRS, with a specific focus on the emission data required to comply with the regulatory framework.

The chapter begins with an introduction to ERP systems, their general benefits, challenges and applications. Next, section 5.2 zooms in on SAP with case analysis, highlighting its functionalities and relevance within the context of sustainability and emissions reporting. Section 5.3 discusses the ESG Reporting Manager - CSRD framework, an innovative solution that helps companies meet the complex reporting requirements of the CSRD and ESRS using SAP. Section 5.4 presents the findings related to the data requirements within SAP, analyzing both available data and missing components.

The objective of this chapter is to clarify which specific emission data is essential within SAP systems and to what extent these systems can support companies in CSRD-compliant reporting. This is summarized in the following research question: 'What specific emission data is needed from ERP systems, such as SAP, to meet the reporting requirements of the CSRD and ESRS E1?'.

5.1. Enterprise Resource Planning (ERP)

This section discusses the role of ERP systems within organizations. ERP systems are integrated software platforms designed to streamline and automate various business processes, such as finance, logistics, and human resources. Implementing ERP systems offers organizations significant advantages in terms of efficiency, cost savings, and regulatory compliance (Monk & Wagner, 2013).

To determine which emissions data should be captured within ERP systems to comply with reporting requirements, it is first necessary to understand what ERP systems are, their core functionalities, and their relevance to sustainability reporting. This section explores the basic principles of ERP systems, the benefits they offer, and the challenges associated with their implementation. By first outlining these general principles, the analysis of SAP as a specific ERP system in Section 5.2 is placed in the correct context.

5.1.1. What are ERP Systems?

ERP systems are integrated software platforms designed to manage and automate the core processes of an organization. They serve as a central database where data from different departments, such as finance, production, supply chain management, human resources, and customer management, are consolidated (SAP, 2024f). These systems emerged from companies' need to increase operational efficiency by standardizing and integrating processes. In the 1990s, ERP gained popularity due to its ability to bring different business units into one system, providing a much clearer overview of operations (Jacobs & Weston, 2007).

ERP systems allow companies to monitor and analyze data in real-time, leading to better-informed decision-making (PwC, 2024d). An ERP system often replaces separate, decentralized software systems, consolidating previously fragmented data into a single platform (SAP, 2024f). The scalability of ERP systems makes them suitable for both small businesses and large multinationals.

ERP systems not only serve as tools for data management but also streamline processes through automation. This automation minimizes errors, speeds up manual processes, and ensures that all departments within a company work with the same accurate data. This leads to improved collaboration between departments and increased operational efficiency (Fui-Hoon Nah et al., 2001).

5.1.2. The Benefits and Implementation Goals of ERP Systems

Companies implement ERP systems for various reasons, often related to the need to optimize their operations. Below are some of the main benefits and reasons why organizations implement ERP systems (de Bruin, 2024; Monk & Wagner, 2013; Nwankpa, 2015):

1. *Integration of Business Processes*
   ERP systems integrate all business processes, from finance to logistics and human resources. This ensures that the flow of information between different departments is streamlined and consistent. Companies that previously used separate systems for different business processes, such as accounting and procurement, can now manage everything centrally with ERP. This leads to faster and more accurate information exchange between departments.
2. *Real-Time Data Analysis*
   A key feature of ERP systems is the ability to analyze data in real-time. Companies can gain immediate insights into key performance indicators (KPIs) such as revenue, costs, production efficiency, and inventory levels. This real-time data analysis enables faster and better-informed decision-making, which is essential for companies that want to compete in a rapidly changing market.
3. *Cost Reduction and Efficiency Improvement*
   ERP systems help companies reduce costs by automating processes and mini-

mizing human errors. By replacing manual processes with automated workflows, companies can work faster while increasing accuracy. This reduces the need for corrections and duplicate work. Additionally, the improved visibility of data within ERP systems contributes to more efficient procurement and production processes, leading to cost savings.

4. *Improved Customer Service*
   An ERP system provides companies with a complete view of their customers, including previous purchases, interactions, and preferences. This helps companies deliver personalized customer service and respond quickly to customer requests. The inventory management function of ERP systems also allows companies to better anticipate customer demand and deliver on time.
5. *Compliance with Laws and Regulations*
   Many companies implement ERP systems to better comply with laws and regulations. ERP systems offer advanced compliance management features, such as tracking financial data and reporting according to international standards. This is particularly relevant for companies operating in regulated sectors such as the pharmaceutical or food industries.

All these points directly illustrate why ERP systems offer a strong solution for emissions reporting. Emissions reporting requires the integration of entire business processes and real-time data analysis to ensure reliable and accurate information. With trustworthy data, companies can make more informed decisions and improve the services they provide to their customers. Additionally, since emissions reporting is a legal requirement that must be conducted annually, automation enhances efficiency and ensures compliance. In the long run, this automation leads to cost savings by reducing manual effort and minimizing errors.

5.1.3. Challenges in Implementing ERP Systems

Although ERP systems offer significant benefits, their implementation is often a complex and challenging task. Many companies face obstacles when successfully implementing an ERP system, including (de Bruin, 2024; Monk & Wagner, 2013; Nwankpa, 2015):

1. *High Implementation Costs*
   The costs of purchasing and implementing an ERP system are often high. This includes not only the software itself but also costs for hardware, consultancy, training, and maintenance. For many companies, these costs can be a barrier, especially for small and medium-sized enterprises.
2. *Changing Business Processes*
   Implementing an ERP system often requires existing business processes to be adjusted to align with the structure of the ERP system. This can lead to resistance within the organization, as employees need to adapt to new ways of working and procedures. Without proper change management, this resistance can jeopardize the success of the implementation.
3. *Complexity of Data Integration*
   Migrating existing data to a new ERP system is a time-consuming process. Data integration can be particularly challenging when data comes from different, isolated systems that are not compatible with the new ERP platform. Errors in data migration can lead to delays and system disruptions.
4. *Time-Intensive Implementation Process*
   Implementing an ERP system can take months to years, depending on the complexity of the organization and the scope of the system. During this period, companies may experience disruptions to their business processes, which can hinder day-to-day operations.

So, in addition to these general challenges, using ERP systems for emissions reporting brings some additional complexities. For emissions data has to be collected from vari-

ous business processes, which often requires integration efforts. Although real-time data analysis offers advantages, it places high demands on system architecture and data accuracy. Without careful implementation and sound data management, companies risk incomplete or inaccurate reporting, with potential legal and financial consequences. Finally, although automation can improve efficiency, the high implementation costs and specialist knowledge required to set up ERP systems for emissions reporting remain a significant barrier, especially for smaller organisations.

5.2. Introduction to SAP

SAP is one of the most widely used and advanced ERP software platforms in the world. Its purpose is to provide companies with an integrated software solution that automates various business processes within a single platform. SAP has evolved into a global leader in ERP software and business solutions (Gilg, 2024).

5.2.1. Usage of SAP

SAP supports organizations in managing and automating core processes such as financial administration, supply chain management, production, and human resource management (SAP, 2024g). The software operates through a modular system, allowing companies to choose and configure modules to meet their specific needs. It offers a central database that integrates data from various departments, eliminating silos and fostering collaboration.

The strength of SAP lies in its ability to standardize and automate processes while providing real-time insights into business data (SAP, 2024g). This makes it an essential tool for strategic decision-making, improving efficiency, and ensuring regulatory compliance. Today, SAP serves over 450,000 customers worldwide, ranging from small businesses to multinationals.

5.2.2. Core Processes Supported by SAP

SAP plays a vital role in facilitating key business processes across organizations. As an integrated ERP system, it streamlines and connects various functions, ensuring efficiency and consistency in operations (SAP, 2024f):

- *Supply Chain Management*
  By integrating inventory management, procurement, and logistics, SAP helps businesses optimize their supply chains. This leads to cost reductions, improved delivery timelines, and enhanced customer satisfaction.
- *Production Management*
  SAP supports businesses in planning, tracking, and optimizing production processes. It enhances operational efficiency by ensuring effective resource allocation and maintaining product quality standards.
- *Financial Management*
  SAP provides tools for financial administration, accounting, and reporting. It enables companies to manage their finances accurately, minimize risks, and comply with legal requirements. Key functionalities include general ledger accounting, accounts payable and receivable, asset management, and profitability analysis.
- *Human Capital Management*
  SAP streamlines HR processes, including recruitment, performance evaluation, and payroll management. It provides valuable insights into workforce data, enabling organizations to make informed decisions and align human resources with strategic goals.

5.2.3. Role of SAP in Sustainability Reporting

The recent introduction of regulations from the CSRD and ESRS compels companies worldwide to make their sustainability practices transparent. This reporting process re-

quires detailed and accurate data on emissions, energy consumption, and other environmental factors. Since much of this data already exists within organizations or can be captured, an ERP system like SAP offers a logical solution for collecting, managing, and reporting this data.

SAP addresses these developments by advancing its ERP platform, specifically to support sustainability reporting (SAP, 2024c). The company collaborates with partners such as PwC to develop systems that enable businesses to measure, analyze, and report their emissions and other sustainability indicators in accordance with the new standards (Lösken & Liebich, 2024).

This process, however, is highly complex. Gathering data from various business processes, integrating external data sources (such as emission factors), and meeting the specific requirements of ESRS E1, among others, demand advanced technology and extensive collaboration across departments. Moreover, the adoption of these solutions is currently limited. Only a few organizations have fully integrated processes that utilize SAP's capabilities to their full potential, primarily due to the complexity of the required data and its integration into SAP systems (Lösken & Liebich, 2024).

The following section of this chapter explores the essential data required within SAP to use the ERP system for emission reporting.

5.3. SAP System: ESG Reporting Manager - CSRD

To understand the data required to meet the complex sustainability reporting demands of the CSRD and ESRS, it is essential to comprehend the various SAP systems and their interconnections. SAP offers a wide range of systems, each tailored to specific business processes and data needs (SAP, 2024a). However, no single system is currently sufficient to cover the entire reporting requirements of the CSRD. This has led to innovations that combine multiple SAP solutions.

SAP Sustainability Control Tower is one of the most suitable platforms for this purpose. It acts as a centralized dashboard for managing and visualizing ESG goals (SAP, 2024e). This platform enables organizations to measure, monitor, and optimize their sustainability performance. However, in practice, the SAP SCT cannot independently support all the reporting requirements of the CSRD (PwC Germany, 2024). The complexity of the requirements and the detailed calculation logic for specific ESRS key performance indicators exceed the current capabilities of the platform. For instance, it lacks flexibility in data modeling and the integration of calculations necessary for ESRS compliance.

PwC has recognized this challenge and is currently developing a supplementary solution: the ESG Reporting Manager - CSRD (PwC Germany, 2024). One of these solutions is that it builds on the existing functionalities of the SAP SCT and provides companies with an advanced, compliant reporting system. By combining the ESG Reporting Manager with the SAP SCT, a process environment is created where all ESG data can be consolidated into a single central source, see Figure 5.1. This system streamlines reporting processes, automates calculations, and clearly defines responsibilities. Additionally, it provides real-time insights into the required data and ensures consistent workflows, improving the reliability and timeliness of reports.

A significant contribution of the ESG Reporting Manager - CSRD is the integration of detailed calculation logic and workflows that meet the stringent CSRD requirements (PwC Germany, 2024). Unlike traditional methods, often manual and fragmented, this combination creates an efficient and automated process environment. This allows organizations to save time, minimize errors, and respond more quickly to new regulations.

To better understand the complexity of this system, it is important to examine the broader architecture, where various SAP solutions work together to meet reporting requirements. In addition to the SAP Sustainability Control Tower, systems such as SAP Datasphere, SAP Build Apps, SAP Analytics Cloud, and SAP Fiori are also part of this architecture

(Lösken et al., 2024). This combination enables organizations to collect, harmonize, and present data from diverse sources within an intuitive and user-friendly interface.

5.3.1. ESG Reporting Manager - CSRD Framework

The architecture of the ESG Reporting Manager - CSRD is divided into three main components: the Reporting Layer, the Data Management Layer, and the Data Source Layer (Lösken et al., 2024). This structure ensures that companies can collect, process, and report both quantitative and qualitative data in an integrated and standardized manner. As Lösken and Liebich (2024) note, over 1,000 quantitative and qualitative data points must be interpreted and calculated under these requirements.

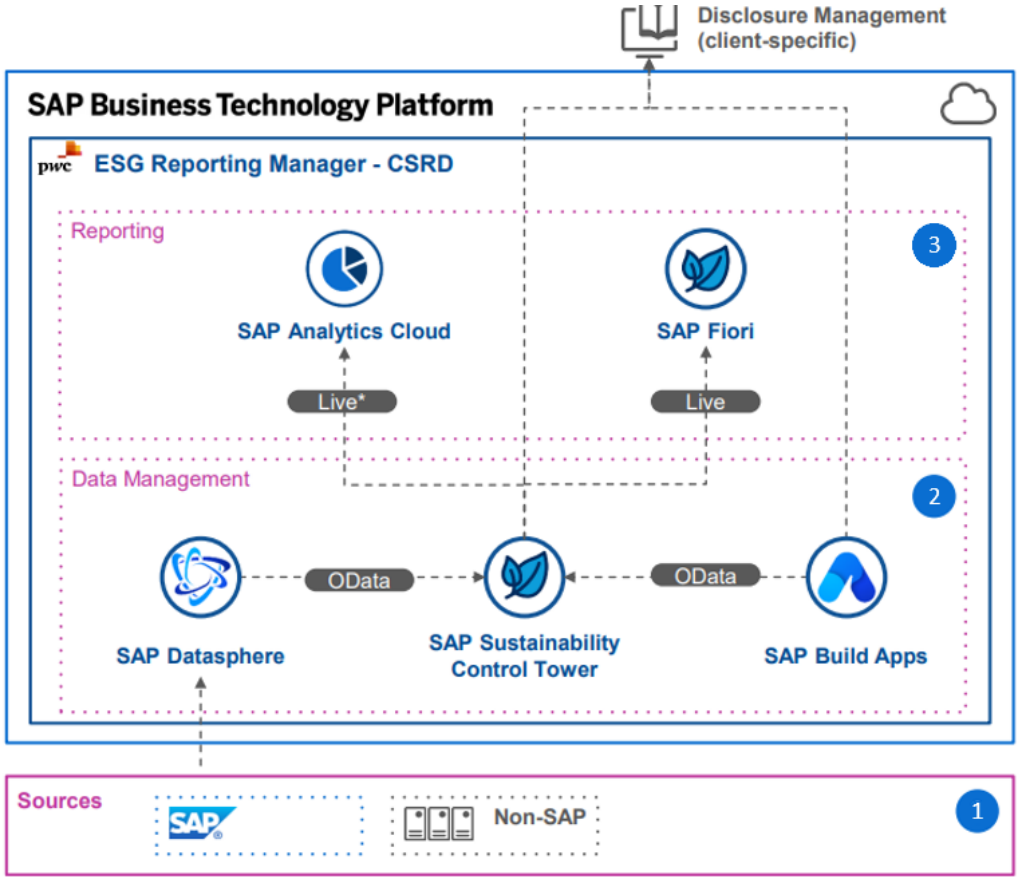

Figure 5.1: SAP Business Technology Platform with ESG Reporting Manager - CSRD (SAP, 2024a, p. 9)

1. **Data Source Layer**
   The Data Source Layer forms the foundation of the architecture, containing the various data sources required to populate the system. These sources may include both SAP and non-SAP systems (Lösken et al., 2024).

   - *SAP Data:* Within SAP, this could include financial data from SAP S/4HANA, HR data from SAP SuccessFactors, procurement data from SAP Ariba, and environmental information from SAP EH&S. These data points form the basis for ESG metric calculations and are integrated into the Data Management Layer for further processing.
   - *Non-SAP Data:* External data sources, such as Internet of Things (IoT) sensors, third-party data, and manual inputs like Excel files.

   Integrating these sources is crucial to creating a complete and consistent data model, preventing companies from missing key ESG data or encountering inconsistencies in their reporting.

2. **Data Management Layer**
   The Data Management Layer is the core of the system, aimed at integrating, modeling, and preparing data for analysis. This layer leverages three key SAP components (Lösken et al., 2024):

   - *SAP Sustainability Control Tower:* SCT acts as a central hub for all ESG data. It provides an integrated data model that consolidates both quantitative and qualitative ESG data, reducing silos within organizations and offering a solid foundation for consistent reporting.
   - *SAP Datasphere:* This solution adds flexibility by harmonizing data from various internal and external sources. This allows companies to integrate not only SAP data but also data from non-SAP systems, enhancing data richness and completeness.
   - *SAP Build Apps:* PwC has utilized SAP Build to develop standardized workflows and forms for collecting qualitative data. This facilitates the input of non-numerical data and ensures more comprehensive reporting.

   This layer is essential for automating complex calculations, integrating diverse data streams, and creating a robust foundation for further analysis.

3. **Reporting Layer**
   The Reporting Layer is designed to make data accessible and understandable for decision-makers. It utilizes two powerful SAP tools (Lösken et al., 2024):

   - *SAP Analytics Cloud:* This tool provides extensive dashboards and analytical capabilities to visualize ESG data. PwC offers predefined reporting templates that companies can use to analyze complex ESG indicators.
   - *SAP Fiori:* As the interface of the SCT, Fiori allows users to perform in-depth analyses at various levels, such as by legal entity or production site.

   This layer enables companies not only to meet CSRD requirements but also to gain strategic insights to improve sustainability performance.

This architecture provides a future-proof solution for stricter sustainability standards and can meet the ESRS requirements set by the CSRD.

5.4. Data in SAP

As mentioned in the previous section, using the SAP system to fully meet ESRS requirements involves filling in over 1,000 data points in SAP (Lösken & Liebich, 2024). These data points cover all 12 ESRS requirements. In this research, the focus is on ESRS E1. This section applies several filtering steps in SAP to identify the most relevant data points for ESRS E1 reporting.

Additionally, a distinction is made between quantitative and qualitative data. A secondary table will outline the main data points linked to ESRS requirements.

5.4.1. Filter to Datapoints

To determine the required data points for ESRS E1, an iterative filtering process was applied, carefully selecting the most relevant data step by step for emission reporting. This process identified 132 essential data points, including both qualitative and quantitative data. Below is a step-by-step description of the filtering process:

1. *Initial Filter: Reporting Standard*
   From the complete data structure provided by SAP, the first step was to select data points that comply with the *European Sustainability Reporting Standards*. Other standards, such as the *EU Taxonomy* and *Other Voluntary Reporting Standards*, were excluded to sharpen the focus (SAP, 2024d).

Table 5.1: Reporting Standards filters, based on (SAP, 2024d)

Reporting Standards		
European Sustainability Reporting Standards	EU Taxonomy	Other Voluntary Reporting Standards

2. *Second Filter: ESG Area*
   Subsequently, within the selected ESRS data points in SAP (2024d), a further filter was applied based on the category *Environmental*. The other ESG areas, such as *Economic*, *Governance*, and *Social*, were excluded as they do not directly contribute to emission reporting.

Table 5.2: ESG Area filters, based on (SAP, 2024d)

ESG Areas			
Economic	**Environmental**	Governance	Social

3. *Third Filter: Measures*
   From the remaining data, a selection was made of six specific measures that form the core of emission- and energy-related reporting: *Amount*, *Carbon Credits*, *CO_2 Emissions*, *CO_2 Emissions from Regulated ETS*, *Energy Consumption*, and *Energy Production*. This selection was carefully determined by applying an iterative filtering process to the complete list of 46 available measures, such as *Absence*, *Age*, *Base Salary*, *Capital Expenditure*, and many others, as shown in Table 5.3 (SAP, 2024d). The process systematically focused on the most relevant and direct metrics contributing to the reporting requirements of ESRS E1, as outlined in Chapter 4. The other measures primarily pertain to requirements outside of ESRS E1. This process ensured that only the most accurate and usable data points were retained for this study.

Table 5.3: Measures Filters, based on (SAP, 2024d)

Measures				
Absence	Age	**Amount**	Base Salary	Capital Expenditure
Carbon Credits	**CO_2 Emissions**	**CO_2 Emissions from Regulated ETS**	Complaints	Contracts Terminated
Corruption Incidents	Days Lost by Injury	Emissions to Air	Emissions to Soil	Emissions to Water
Energy Consumption	**Energy Production**	Governance Body Count	Headcount Covered by Collective Bargaining Agreements	Headcount Covered by Worker Representatives
Headcount Earning Below the Applicable Adequate Wage	Health and Safety Coverage	Hours Worked	Injured	Land Use - Area
Land Use - Sites	Land Use Change	Local Minimum Wage	Median Workforce Remuneration	Operational Expenditure
Payments	Performance Reviews	Persons With Disability	Remuneration	Restriction
Substances of Concern Inflows	Substances of Concern Outflows	Total CEO Compensation	Training Costs	Training Duration
Training on Anti-Corruption Policies Headcount	Turnover	Waste	Water - Quantity	Weight of Inflows
Weight of Materials Used	Weight of Outflows			

Through these three consecutive filters – first based on Reporting Standards, then on ESG Area, and finally on Measures – the original set of over 1,000 data points has been reduced to 132 data points. This carefully selected set forms the core of emission reporting under ESRS E1.

The filtered data points consist of a combination of both qualitative and quantitative information, with a focus on direct emission measurements and energy consumption. This selective approach ensures that only the most relevant and accurate data points are included in the further reporting process.

5.4.2. Data Overview

After applying the three filtering steps described earlier – based on *Reporting Standards*, *ESG Area*, and *Measures* – a list of 132 relevant data points has been established. These data points include essential metrics for emission and energy-related reporting under ESRS E1. While many metrics, such as CO_2 Emissions or Energy Consumption, may appear similar at first glance, they differ based on their specific dimension.

The dimension determines the context in which a metric is applied and thereby differentiates between similar data points. For instance, a metric can take on different meanings depending on variations such as emission scope, value chain stage, or energy source. As a result, some metrics appear multiple times but represent different values and applications within the reporting process.

This distinction ensures an accurate and structured approach to emission reporting. By combining metrics with their dimensions, a detailed overview is created, enabling organizations to analyze emissions and energy consumption from multiple perspectives. The table of all 132 data points and their specific dimensions is included in Appendix C.

Quantitative Data

In addition to the table of 132 data points, which includes both qualitative and quantitative information, a second list has been compiled. This list focuses exclusively on quantitative data points that are directly measurable and required for reporting within the SAP system (SAP, 2024b). This selection specifically supports emission reporting under the requirements of ESRS E1-5 through ESRS E1-7, as identified in Chapter 4.3.4 in Figure 4.5 as being necessary to collect for full compliance with the requirements of ESRS and CSRD.

From the original dataset of 97 quantitative metrics, 19 essential quantitative metrics have been identified in SAP (SAP, 2024b). Due to their direct contribution to emission and energy-related reporting (ESRS E1) and their measurability in consistent units, they form the foundation for generating accurate reporting structures within SAP systems for emission reporting.

Table 5.4 presents an overview of these 19 quantitative metrics:

Table 5.4: Quantative Metrics voor ESRS E1-5 t/m E1-7, based on (SAP, 2024b)

#	Metric	Unit of Measure	Reference
1	Energy Intensity Based on Net Revenue	MWh/Mil €	ESRS E1-5
2	Percentage of Fossil Sources in Total Energy Consumption	%	ESRS E1-5
3	Percentage of Nuclear Sources in Total Energy Consumption	%	ESRS E1-5
4	Percentage of Renewable Sources in Total Energy Consumption	%	ESRS E1-5
5	Renewable Energy Production	MWh	ESRS E1-5
6	Total Energy Consumption	MWh	ESRS E1-5
7	Total Energy Consumption from Renewable Sources	MWh	ESRS E1-5
8	Total Energy Production	MWh	ESRS E1-5
9	GHG Emission Intensity, Location-Based per Net Revenue	t/Mil €	ESRS E1-6
10	GHG Emission Intensity, Market-Based per Net Revenue	t/Mil €	ESRS E1-6
11	Gross GHG Emissions - Scope 1	Tonne (t)	ESRS E1-6
12	Gross GHG Emissions - Scope 2, Location-Based	Tonne (t)	ESRS E1-6
13	Gross GHG Emissions - Scope 2, Market-Based	Tonne (t)	ESRS E1-6
14	Gross GHG Emissions - Scope 3	Tonne (t)	ESRS E1-6
15	Percentage of Scope 1 Emissions under Regulated ETS	%	ESRS E1-6
16	Total Gross GHG Emissions - Location-Based	Tonne (t)	ESRS E1-6
17	Total Gross GHG Emissions - Market-Based	Tonne (t)	ESRS E1-6
18	Carbon Credits	Tonne (t)	ESRS E1-7
19	GHG Removals and Storage	Tonne (t)	ESRS E1-7

These data points are the building blocks for accurate, integrated and audit-proof emissions reporting. When the systems described in the ESG Reporting Manager will be used, the data points of Table 5.4 will need to be completed in SAP. If complied with, this will enable organizations to comply with CSRD requirements and provide a solid basis for reliable, transparent and sustainable emissions reporting.

5.5. Conclusion

This chapter has examined how SAP as an ERP system supports companies in emissions reporting in line with the requirements of the CSRD and ESRS, with a specific focus on ESRS E1. The analysis shows that SAP has the technical capabilities to integrate and automate complex reporting requirements. However, due to the complexity of SAP and the detailed reporting requirements of the CSRD, additional functionality is needed to effectively operationalize emissions reporting. For this reason, the ESG Reporting Manager was developed in collaboration with PwC. This system, with the use of SAP Sustainability Control Tower, among others, can provide a solution that helps companies collect, harmonise and report emissions data in line with CSRD standards.

Within this architecture, it is SAP Sustainability Control Tower acts as a central hub for data consolidation and visualization of emissions data. The ESG Reporting Manager adds structured reporting functionalities, while additional tools such as SAP Datasphere, SAP Analytics Cloud, and SAP Fiori ensure integration, flexibility and user-friendliness. This combination enables effective management of both quantitative and qualitative data and provides the basis for a CSRD-compliant reporting structure.

The research question of this chapter is: *'What specific emission data is needed from ERP systems, such as SAP, to meet the reporting requirements of the CSRD and ESRS E1?'*. To answer this question, an analysis was performed on the more than 1,000 data points needed for full compliance with all ESRS requirements. The filtering process focused on ESRS E1 and resulted in a selection of 132 essential data points. Further filtering was then applied to quantitative emission indicators within ESRS E1-5, E1-6 and E1-7, leading to the identification of 19 critical quantitative data points. These indicators represent the beginning of the emissions reporting process and are essential for the effective collection and implementation of emissions data within SAP.

In the following chapters, the findings from this analysis are tested against practice through expert interviews. These explore the biggest challenges in collecting and implementing emissions data within SAP, as well as best practices for successful implementation. These insights form the basis for the development of a 12-step roadmap, which supports companies in setting up a fully integrated and compliant (SAP) ERP system for emissions reporting.

6

Collecting and Reporting Emission Data

The previous chapter examined the role of SAP as an ERP system for emissions reporting, with a specific focus on compliance with CSRD and ESRS E1. The analysis revealed that SAP, through tools such as the ESG Reporting Manager and the Sustainability Control Tower, provides a structured framework for collecting, integrating, and reporting emissions data. Within this ecosystem, 19 key quantitative metrics have been identified as crucial for emissions reporting according to ESRS E1-5, E1-6, and E1-7.

Although these systems provide a solid technical foundation, their implementation in practice proves to be significantly complex. Many companies are in a transition phase where existing processes and systems need to be adapted to the new reporting requirements. The insights presented in this chapter are based on expert interviews with professionals from PwC and SAP, whose expertise spans ESG reporting, CSRD compliance, and SAP configuration. The composition and selection criteria of this expert group are discussed in detail in Section 3.1.3.

Discussions with these experts indicate that the biggest challenges can be categorized into three main areas: technical, organizational, and strategic barriers. This chapter analyzes these challenges and answers the research question:

"What are the biggest challenges companies face when collecting and reporting emissions-related data through ERP systems, particularly in SAP?"

This chapter is designed as an exploratory study that combines qualitative insights from expert interviews with an in-depth analysis of implementation challenges. The results of this study form the basis for the next chapter, which discusses potential solutions and best practices to support companies in achieving more efficient and reliable implementation of ERP-based emissions reporting systems.

6.1. Technical Challenges in Emissions Reporting through ERP Systems

Although companies are increasingly using ERP systems such as SAP to report emissions in line with ESRS E1 and the CSRD, the biggest technical challenge is not in the reporting itself but in the collection and integration of the required data. According to experts, the technological infrastructure for reporting is already well established, but these systems are only as effective as the data they receive. Without complete and accurate emissions data, reporting systems remain limited in their functionality and reliability.

The challenges in data collection are caused by fragmented data sources, inconsistencies

in data quality, the complexity of Scope 3 emissions, and limitations within SAP and other ERP systems. This section analyzes these technical obstacles and explains why a solid data collection strategy is essential for reliable emissions reporting.

6.1.1. Fragmented and Inconsistent Data Sources

One of the biggest technological challenges in emissions reporting is the fragmentation of data sources. Emissions data is collected from a wide variety of systems, such as ERP modules, energy management systems, sensor networks, and external databases. These systems often operate independently, making it difficult for companies to obtain a complete and accurate overview of their emissions. As one expert stated:

> *"Companies have data everywhere, and they don't even know where all the data is." (Interview 4)*

This illustrates how companies often lack a comprehensive view of where their emissions data is located, complicating the integration and analysis of this data.

In addition, emissions data is distributed across multiple IT platforms that are not always compatible. This forces companies to manually extract and convert data, which is error-prone and time-consuming.

> *"The technology is available for companies to report their emissions data, but the biggest technical challenge is that data is spread across multiple systems. This makes collecting and integrating emissions data particularly complex." (Interview 1)*

While the technology to record and report emissions data already exists, the fragmentation of this data across different systems poses a significant obstacle. This fragmentation makes it difficult to efficiently consolidate emissions data and generate automated reports.

6.1.2. Quality and Completeness of Emissions Data

Aside from the issue of fragmented data sources, the quality and completeness of emissions data present another significant challenge. Although ERP systems like SAP provide a centralized structure for emissions reporting, they depend on the accuracy and consistency of the data provided. Incomplete, incorrect, or inaccurate measurements can lead to discrepancies in reports and complicate regulatory compliance.

> *"A lot of emissions data is incomplete and therefore not accurate. It doesn't all come from the same source, which makes it like comparing apples and oranges." (Interview 2)*

This highlights how inconsistencies in data collection result in emissions data that are difficult to compare, undermining the reliability of reports.

A major cause of these data quality issues is the lack of standardized measurement methods within and between organizations. Some companies use advanced measurement equipment and IoT solutions for real-time emissions registration, while others still rely on manual calculations or estimates.

> *"When you are a multinational with 300 factories worldwide, it is not easy to collect emissions data. Some locations have smart meters, while others are still fully manual. This leads to huge differences in data quality." (Interview 6)*

This illustrates how, even within the same organization, the availability of measurement tools can vary widely, resulting in differences in the precision and completeness of emissions data. Additionally, standardized procedures for filling in data gaps are often lacking, leading to gaps in emissions reports and requiring extra correction work.

6.2. Organizational Challenges in Emissions Reporting through ERP Systems

In addition to the technical challenges of emissions reporting through ERP systems, significant organizational obstacles also exist. Companies struggle with a lack of ownership over emissions data, insufficient internal expertise and collaboration between departments, and the complexity of standardizing internal and external emissions reporting structures. This chapter analyzes these challenges and how they hinder the implementation of efficient and reliable emissions reporting.

6.2.1. Lack of Ownership and Responsibility

One of the most fundamental issues in emissions reporting is the lack of clear responsibilities within companies. Unlike financial or HR data, which are typically assigned to specific departments, emissions data is dispersed across various business units, such as operations, supply chain, and finance. This leads to fragmentation and a lack of ownership, negatively affecting the accuracy and consistency of reports.

> *"Data is fragmented across departments - Finance, HR, Supply Chain - and no one feels truly responsible." (Interview 3)*

Many companies do not have designated data owners, leading to a lack of centralized control and responsibility over the collection and processing of emissions data. As a result, employees often forward emissions data without further validation, merely to complete a task. The absence of accountability results in emissions data that is often incomplete or of low quality, significantly hindering the reporting process.

As one expert noted:

> *"When employees start feeling responsible for the process and standardize it, the quality of data will improve and the process will be more streamlined." (Interview 1)*

6.2.2. Insufficient Internal Expertise and Training

The lack of specialized knowledge within companies is another significant barrier to effective emissions reporting. Many organizations are relatively new to ESG reporting, and the required skills are not widely distributed among organizations.

Many employees lack a clear understanding of what is required for emissions reporting. This leads to confusion about which data should be collected, how it should be interpreted, and which standards should be applied. In some cases, this leads to companies using suboptimal methods, such as continuing to rely on Excel and manual processes instead of investing in specialized tools like SAP ERP systems for automation.

Moreover, many companies approach ESG reporting merely as a compliance requirement rather than a strategic opportunity. This mindset leads to limited investment in employee training and capacity-building initiatives, resulting in inconsistent and error-prone reports.

An expert described this situation as follows:

> *"Regarding emissions data collection, they don't know how to do it, they don't want to do it, and they can't do it. So the organization needs to be trained." (Interview 5)*

Companies that invest in expertise and training will in all likelihood be better able to structure their emissions data effectively and produce more reliable reports. However, without this investment, ESG reporting remains a time-consuming and error-prone process.

6.2.3. Limited Collaboration Within and Outside the Organization

Another significant challenge is the limited collaboration between internal departments and external stakeholders. Collecting emissions data requires input from multiple de-

partments, such as supply chain, finance, and operations, but in practice, a coordinated approach is often lacking, and it is treated as an isolated project.

The lack of responsibility for data quality within different departments contributes to suboptimal internal collaboration. Companies frequently opt to organize sustainability reporting as isolated projects. However, this approach overlooks the sustainability reporting department's dependence on data from other departments. Isolated processes lead to fragmented collaboration and limited accountability. Without effective collaboration and clear accountability, organizations struggle to obtain a comprehensive and accurate view of their total emissions footprint, hindering accurate reporting.

> *"If sustainability reporting is kept separate from core business processes, it will never be fully integrated." (Interview 5)*

This collaboration also needs to be improved with external parties. Effective collaboration with external stakeholders, especially in collecting Scope 3 data, is crucial. Suppliers are not always willing or able to share their emissions data, and even when they do, the quality of this data is often insufficient, as noted in section 6.1.2. Consequently, companies must rely on rough estimates, undermining the reliability of their reports.

Overall, a lack of collaboration, both internally and externally, not only complicates reporting but also causes companies to waste considerable time and resources on correcting and restructuring data.

6.2.4. Lack of Standardization and Process Optimization

Finally, there is an organizational lack of standardization and process optimization around emissions reporting.

> *"Organizationally, companies often do not have a standardized process. They often do it in different ways." (Interview 1)*

Since ESG reporting is relatively new, many companies have not yet developed uniform methodologies for measuring and reporting emissions. This leads to inconsistencies and inefficiencies within and between companies.

Many organizations use different methods and tools to collect emissions data, making it difficult to process data in a standardized way. Moreover, regulations and reporting standards are constantly changing, requiring companies to regularly adjust their methodologies.

The lack of uniform processes means that companies face the same issues year after year, lack accountability, and experience poor internal and external collaboration.

6.3. Strategic Challenges in Emissions Reporting through ERP Systems

In addition to technical and organizational challenges, companies face strategic obstacles when implementing emissions reporting systems. Many organizations treat emissions reporting primarily as a compliance obligation and fail to leverage its potential strategic benefits. Meanwhile, legislation is constantly evolving, leading to uncertainty and hesitation to invest in comprehensive reporting systems. This section analyzes these strategic challenges and their impact on companies.

6.3.1. Emissions Reporting as Compliance Rather Than Strategic Advantage

For many companies, emissions reporting is merely an obligation stemming from CSRD and ESRS E1 regulations. This results in minimal effort to meet legal requirements, without considering how emissions data could contribute to broader business strategies such as cost savings, process optimization, and sustainability innovation.

> *"At this moment, companies' top priority is disclosing their emissions and not monitoring or steering. They just want to finish their reporting and get out of it." (Interview 4)*

Companies often focus on completing their reports within deadlines rather than implementing structural improvements in data collection and management. As a result, input processes remain inefficient and error-prone, despite opportunities to automate emissions reporting and link it to broader ESG strategies. Many organizations continue to use manual and ad-hoc approaches, relying on Excel and manual data entry. This undermines the consistency and reliability needed to use emissions reporting as a valuable strategic tool.

Another problem is that emissions reporting is often assigned to a specific department, such as finance or compliance, rather than being seen as an integral part of business operations. This means companies miss out on the synergy between emissions reporting and other strategic objectives, such as energy efficiency, cost savings, and sustainable procurement strategies. When emissions data is integrated into broader operational processes, companies can not only comply with regulations but also gain insights that lead to better decision-making and competitive advantage.

6.3.2. Constantly Changing Regulations and Market Development

A second strategic challenge is the speed at which regulations and market expectations are evolving. The introduction of the CSRD and ESRS E1 has compelled companies to take emissions reporting seriously, but the details and implementation guidelines are still evolving. For instance, in November 2024, a new legislative proposal called Omnibus [1] was submitted to the EU, indicating potential regulatory changes (Twillert, 2025). This creates challenges for companies trying to make long-term investment decisions related to emissions reporting.

An expert compared the situation to a constantly changing game:

> *"It's like playing a sport where the goals keep moving on both sides all the time. This makes it incredibly complex for people in companies who have to make these kinds of decisions." (Interview 2)*

Additionally, requirements vary by sector and country, posing complex compliance challenges for companies. Multinational corporations need to collect and report emissions data across multiple jurisdictions, each with its own standards and regulations. This leads to added complexity and the need to remain flexible in the choice of reporting tools and methods.

Not only regulations but also the expectations of investors, customers, and other stakeholders are constantly changing. Sustainability criteria are becoming increasingly important in financial decision-making, and companies that fail to be transparent about their emissions may face reputational damage, reduced access to capital, or even legal action. A current example is Shell, which is currently involved in ongoing litigation (Koster, 2025).

At the same time, the market for ESG data providers and specialized reporting tools is growing, leading companies to question whether their current investments in ERP systems like SAP are the best long-term choice.

> *"ERP systems must be cautious about being overtaken by various smaller companies that focus exclusively on emissions reporting. They are developing user-friendly front-end portals that enable companies to quickly generate CSRD-compliant reports." (Interview 3)*

[1] The Omnibus legislation aims to simplify and potentially reduce existing sustainability reporting obligations under the CSRD, CS3D, and the EU Taxonomy. While the exact impact remains uncertain, draft proposals have already been published end of February 2025, indicating significant changes to reporting requirements. See: https://klimaatweb.nl/nieuws/omnibus-het-voorstel-van-de-europese-commissie-op-hoofdlijnen/

The combination of rapidly changing regulations and market developments makes companies hesitant to invest in ERP-based reporting solutions. As a result, some companies continue to rely on temporary or manual solutions instead of investing structurally in an integrated reporting approach.

6.4. Challenges of Scope 3 in SAP ESG Reporting Manager

In Chapter 5, SAP was used as a case analysis to examine how components such as the ESG Reporting Manager and the Sustainability Control Tower can provide an integrated and standardized reporting environment. During this analysis, 19 quantitative metrics were identified as crucial for emissions reporting in compliance with ESRS E1-5, E1-6, and E1-7.

To gain insights into the practical challenges associated with these metrics, these findings were incorporated into the expert interviews. This research focused on the complexity companies experience when collecting specific metrics, including energy consumption, energy production, and emissions within Scope 1, 2, and 3. Although SAP theoretically offers a powerful platform with the capability to implement these 19 metrics, companies in practice struggle to collect this data consistently, completely, and reliably. This presents one of the biggest obstacles to effectively implementing emissions reporting within ERP systems such as SAP.

6.4.1. Analysis of the 19 SAP Metrics

The study specifically focused on the 19 quantitative metrics from Chapter 5 in Table 5.4 that are essential for CSRD and ESRS E1-compliant reporting. During the interviews, it was explored which of these metrics companies find most challenging to collect and why.

Respondents were asked to name their top three most complex metrics and explain why these are problematic to collect. This helped identify shared challenges and reveal structural bottlenecks of emissions data in the reporting process.

The results were analyzed using a Ranked Difficulty Matrix. A rank-based method was applied, where respondents gave the most difficult metric 3 points, the second most difficult 2 points, and the third most difficult 1 point. This approach enabled the identification of patterns and critical bottlenecks within the emissions reporting process (Makosiewicz, 2024).

The Heatmap in Figure 6.1 visualizes how these difficulty scores were distributed across interviews, with darker shades representing higher difficulty rankings. This provides insight into which metrics (see Table 5.4 for all 19 metrics) were consistently perceived as challenging and where expert opinions diverged. The bar chart in Figure 6.2 further illustrates the average difficulty score per metric, with error bars representing the standard deviation. The standard deviation (SD) indicates how much the scores varied across interviews. A high SD means that experts had differing opinions on the difficulty of a metric, while a low SD suggests strong agreement.

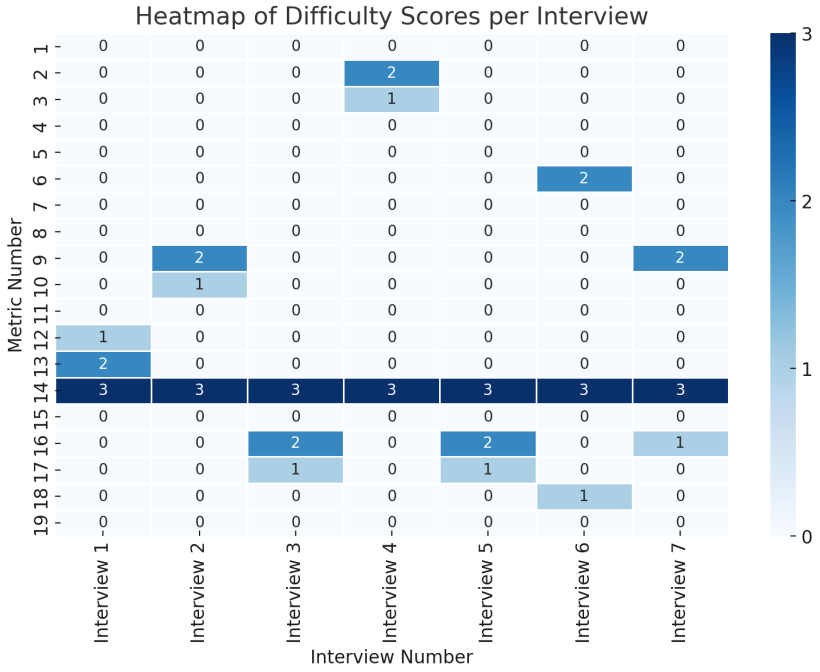

Figure 6.1: Ranked Difficulty Matrix per Metric

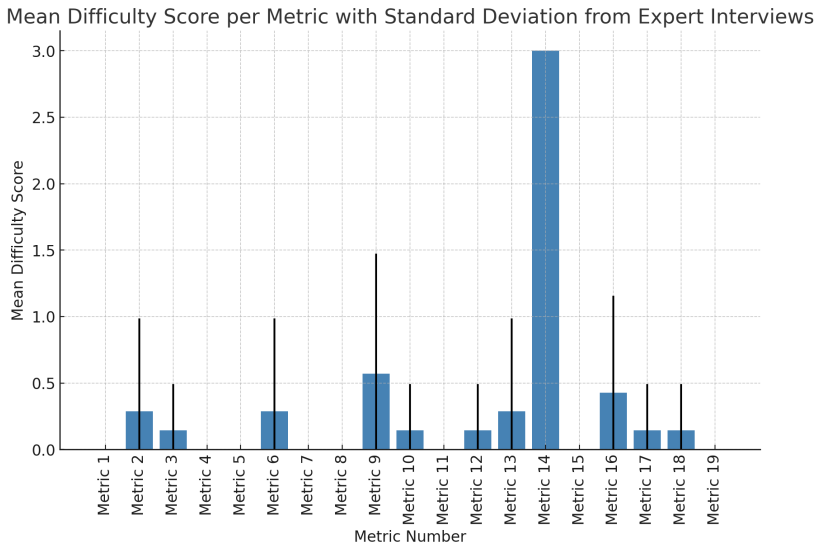

Figure 6.2: Mean and Standard Deviation per Metric

From the analysis, it appears that Metric 14 *(Gross GHG Emissions - Scope 3)* is by far the most complex metric within SAP's Sustainability Control Tower. All respondents agreed on this and ranked this metric as the most challenging, resulting in an average difficulty score of 3.0 with no standard deviation. This finding aligns with existing literature, as Scope 3 emissions require data from external suppliers and partners, making them significantly more difficult to quantify and verify compared to Scope 1 and 2 emissions. One respondent emphasized this by stating:

> *"By far Scope 3: here lies the biggest challenge. Since Scope 3 is so difficult, total emissions calculations are also challenging." (Interview 5)*

Beyond Scope 3, Metric 9 *(GHG Emission Intensity, Location-Based per Net Revenue)* and Metric 16 *(Total Gross GHG Emissions - Location-Based)* were also identified as problematic.

GHG Emission Intensity (Metric 9) received varying scores from experts, resulting in a high standard deviation. This suggests that the complexity of this metric depends on how companies calculate their emissions. Respondents indicated that different methodologies exist within companies for determining emission intensity, leading to inconsistencies and ambiguity in reporting.

Total Gross GHG Emissions (Metric 16) was perceived as problematic due to its dependency on Scope 3 emissions. Companies that struggle with Scope 3 reporting also face difficulties in determining their total emissions.

Furthermore, it is important to note that no strict distinction was made between location-based and market-based calculations. Both methods were frequently mentioned by experts, but the location-based approach was generally prioritized, which explains why Metric 9 ranked higher than Metric 10 and Metric 16 ranked higher than Metric 17.

Beyond these three frequently mentioned metrics, *Other Scopes*, *Energy Consumption*, and the Registration of *Carbon Credits* were also occasionally identified as complex. However, it became clear that the greatest complexity lies in Scope 3. This outcome aligns with the literature from Chapter 2, where Scope 3 was also consistently indicated as the biggest challenge in emissions reporting.

6.4.2. Limitations of SAP and ESG Reporting Manager

Although SAP's Sustainability Control Tower and ESG Reporting Manager provide a powerful framework for emissions reporting, they remain highly dependent on the quality and availability of input data. Incomplete or inconsistent Scope 3 data undermines the reliability of reports and limits SAP's effectiveness in providing audit-proof reporting.

SAP offers extensive tools for processing and standardizing emissions data, but it does not solve the fundamental problem of missing or incorrect data. Companies that fail to collect complete and reliable Scope 3 data will continue to face reporting issues.

> *"The ESG Reporting Manager will not solve anything if the data is missing or incorrect. If one part in the circle is missing, the entire reporting structure does not work." (Interview 6)*

While Scope 1 and 2 emissions are relatively easy to process within SAP due to internal data collection and standardization, Scope 3 remains a challenge. This is because companies receive data from various sources, in different formats, and with differing emission factors, making it difficult for SAP to create a consistent, standardized overview.

6.5. Conclusion

The implementation of ERP systems, like SAP, for emissions reporting presents significant challenges. This chapter analyzed the main obstacles companies face when collecting and reporting emissions data through ERP systems, thereby answering the research question:

"What are the biggest challenges companies face when collecting and reporting emissions-related data through ERP systems, particularly in SAP?"

The findings from this exploratory study reveal that the challenges primarily manifest at three levels: technical, organizational, and strategic. The results were validated and reinforced through expert interviews, providing insights into the practical bottlenecks companies encounter.

Technical Challenges

- Companies struggle with fragmented and inconsistent data sources, complicating the integration of emissions data within ERP systems.
- The quality and completeness of emissions data are major issues, as different measurement methods and non-standardized processes lead to varying and sometimes unreliable data.
- Scope 3 emissions reporting is particularly complex due to dependency on external suppliers and the lack of uniform calculation methods.

Organizational Challenges

- The lack of data ownership and clear responsibilities leads to fragmentation and inconsistency in emissions reporting within companies.
- Insufficient internal expertise and training result in inefficient and error-prone reporting processes.
- Limited collaboration between departments and external parties hinders streamlined and reliable reporting, especially for Scope 3 emissions.

Strategic Challenges

- Many companies view emissions reporting as a mandatory compliance exercise rather than a strategic opportunity to enhance sustainability and operational efficiency.
- Constantly changing regulations and market developments create uncertainty, leading to hesitancy in investing in robust ERP-based reporting solutions.

This analysis highlights that although ERP systems such as SAP offer extensive tools for emissions reporting, their effectiveness is highly dependent on the availability and quality of input data. The next chapter discusses potential solutions and best practices to overcome these challenges and optimize the implementation of ERP-based emissions reporting systems.

7

Best practices

The previous chapter demonstrated that companies face various challenges when collecting and reporting emissions data through ERP systems, like SAP. These challenges range from fragmented data and limited data quality to organizational bottlenecks and regulatory uncertainty. This chapter focuses on identifying best practices that can help companies overcome these obstacles and optimize their emissions reporting.

Based on insights from expert interviews and exploratory research, this chapter explores which technical, organizational, and strategic approaches are most effective. First, the technical aspects of emissions reporting are discussed, focusing on ways to improve data integration, enhance quality controls, and maximize the use of automation. Next, the organizational side is addressed, emphasizing the importance of ownership, internal knowledge development, and collaboration with external parties. Finally, the strategic implications are explored, viewing emissions reporting not only as a compliance obligation but also as an opportunity to improve business processes and support future-proof decision-making.

Through this integrated approach, this chapter provides an answer to the central research question:

"What are the best practices for companies to overcome challenges in collecting and reporting emissions-related data through ERP systems with a focus on SAP for ESRS E1 compliance?"

The chapter concludes with a summary of the key findings, which serve as the foundation for the next and final chapter. In that chapter, a concrete roadmap is presented for implementing a robust and efficient emissions reporting system.

7.1. Best Technical Approaches

Technical bottlenecks are one of the biggest challenges in emissions reporting through ERP systems. Data is often scattered across multiple systems, leading to inconsistencies and errors. Additionally, the quality of emissions data is not always reliable, especially for Scope 3 emissions, where companies rely on external parties.

This section discusses the key technical best practices to overcome these challenges. By implementing these technical improvements, companies can not only comply with regulations such as CSRD and ESRS but also optimize their operational processes and strategically leverage emissions data.

7.1.1. From Fragmented Emissions Data to an Integrated System

As described in Chapter 6.1, many companies that report their emissions struggle with data scattered across multiple systems, such as various SAP modules, Excel files, and

even manual inputs. This leads to inconsistencies and errors, making it difficult to obtain an accurate view of the total emissions.

A key example of this challenge is Metric 14 *(Gross GHG Emissions - Scope 3)*, where emissions data from external suppliers are often fragmented and inconsistent, making it one of the most difficult metrics to report reliably.

To overcome this challenge, experts suggest that companies should centralize their emissions reporting within an integrated data management system. This means bringing together all relevant emissions data from various sources into one central environment, where it can be standardized and verified. Such a system ensures a single source of truth, enabling companies to report more quickly and accurately while enhancing the traceability and reliability of the data.

The first step in this process is setting up a central data hub.

> *"Companies need to start using a large data hub that everyone can access, both internally and externally." (Interview 3)*

This data hub serves as a collection point where data from different departments and external sources are integrated and harmonized. Centralizing emissions data in one place allows companies to manage, validate, and analyze emissions data more efficiently.

7.1.2. Improving Data Quality and Completeness

Even when companies succeed in centralizing their data, a fundamental problem remains: the quality and completeness of emissions data. This is particularly challenging for Scope 3 emissions, as highlighted in Chapter 7.1, because companies rely on suppliers who are not always transparent or accurate in their reporting. Additionally, emissions data is often dispersed across various IT systems, resulting in inconsistencies and making validation difficult.

Real-time data collection is essential to ensure accurate reporting. By using IoT sensors, API integrations, and real-time data streams within SAP, companies can collect and process emissions data more efficiently. APIs enable companies to exchange emissions data directly with their suppliers, rather than relying on error-prone manual processes such as spreadsheets and periodic reports. This reduces the risk of errors, prevents delays, and ensures that ERP systems, like SAP, always work with the most up-to-date emissions data. This is particularly relevant for Metric 9 *(GHG Emission Intensity, Location-Based per Net Revenue)*, as inconsistencies in data sources can lead to inaccurate intensity calculations, affecting overall emissions reporting.

Additionally, automated validations within SAP can immediately detect anomalies and, if necessary, suggest corrections, further improving the accuracy of reports. As one of the interviewees explicitly stated:

> *"Automate as much as possible, minimize human intervention. Human handling causes data errors." (Interview 1)*

According to the experts, the role of AI-driven data processing is also expected to grow. Machine learning algorithms can detect missing or inconsistent data and, where necessary, make predictions based on historical datasets.

> *"With AI, you can structure unstructured data." (Interview 3)*

By leveraging these technological innovations, companies can not only report more quickly and accurately but also gain real-time insights into their emissions data. This contributes to a more robust reporting system and supports companies in complying with ESRS E1 and CSRD.

7.2. Best Organisational Approaches

The implementation of ERP systems, like SAP, for emissions reporting, requires not only technological improvements but also a strong organizational structure. As identified in Chapter 6.2, a lack of ownership, insufficient expertise, and limited collaboration lead to fragmented and inefficient reporting processes. This section outlines best practices and strategies to overcome these challenges, based on insights from expert interviews and successful case analysis.

7.2.1. Assigning Ownership

As mentioned in the previous chapter, one of the biggest organizational obstacles is the lack of clear ownership. This lack of responsibility results in inconsistent and incomplete data, delayed reporting processes, and increased risks of errors and non-compliance.

When implementing emissions reporting, companies generally have two organizational choices:

1. Establishing a separate reporting unit.
2. Integrating reporting within existing departments.

Experts acknowledge that both strategies have their value but emphasize that the second option is the most effective in the long term.

> *"In the long run, integrating it into the existing organization as quickly as possible seems to be the best approach." (Interview 3)*

Separate Reporting Unit

A separate reporting unit can be useful in the initial phase to quickly gain insights into emissions data and meet the first reporting requirements. This team's primary task is to collect, structure, and report emissions data without directly burdening other departments with additional responsibilities.

However, this approach comes with significant challenges. A separate reporting team depends on the departments generating the emissions data, such as finance, supply chain, and IT. Since these departments often see emissions reporting as a secondary priority, this leads to delays and inefficiencies. The reporting team constantly has to chase the required data, which not only slows down the process but also increases the likelihood of inconsistent and incomplete reports. Additionally, it can reduce the involvement of the core organization in emissions reporting, as responsibility is shifted to an external unit rather than being embedded within operational structures. This is particularly problematic for Metric 14 *(Gross GHG Emissions - Scope 3)* and Metric 16 *(Total Gross GHG Emissions - Location-Based)*, where Scope 3 data collection is already complex due to external dependencies.

Integrated Reporting Within Departments

Therefore, experts advise companies to integrate emissions reporting into existing departments as soon as possible. When reporting becomes part of the daily operations of finance, supply chain, and IT, emissions data is managed by the departments that generate it. This creates a natural and efficient data flow where emissions reporting is no longer seen as an external obligation but as an essential part of business operations. For example, finance can be responsible for emissions-related financial data, supply chain manages supplier emissions, and IT ensures the integration of emissions data within the ERP system.

This approach ensures that responsibilities are embedded within the departments themselves, as experts noted:

> *"Companies are increasingly entering new phases where sustainability teams are integrated with people responsible for the data in the business. This places the responsibility directly in the right place." (Interview 5)*

For this integration to succeed, it is crucial for companies to clearly define roles and responsibilities and to establish strong internal control mechanisms. As one expert pointed out:

> *"When people feel responsible for the process and it is standardized, the quality of data will improve, and the process will become more streamlined." (Interview 1)*

7.2.2. Best Approach for Training and Knowledge Development

In addition to clear ownership and well-structured reporting processes, internal expertise is a critical factor for effective emissions reporting. Many employees lack the knowledge needed to collect, interpret, and report emissions data within an ERP system, leading to inefficiencies, errors, and dependency on external consultants.

To ensure effective emissions reporting, companies must invest in continuous knowledge development. This starts with targeted training on emissions reporting and related regulations, such as the ESRS E1 guidelines and CSRD requirements. Employees must understand what data is needed, where it is located, and how to report it correctly. According to experts, this also contributes to improved data quality:

> *"You first need to understand it yourself, and then it becomes easier to retrieve the information and the data quality is more accurate." (Interview 3)*

Additionally, it is necessary for departments to become familiar with the technical software capabilities for emissions reporting, such as specialized modules within SAP ERP systems.

By fostering continuous knowledge development and improvement, companies can enhance the reliability of their emissions reporting and reduce dependency on external support. This not only contributes to a more efficient reporting process but also strengthens internal capacity to achieve sustainability objectives and strategically utilize emissions data.

7.2.3. Best Approaches with External Parties

Chapter 7.1 already highlighted the need for improved internal accountability. However, challenges also frequently arise with external parties, particularly in the area of Scope 3 emissions. Many companies encounter issues such as inconsistent reporting methods, poor data quality, and limited transparency within the supply chain.

This study shows that to overcome these challenges, companies must adopt a structured approach and collaborate with suppliers:

> *"Look at it not only from your own perspective but also with other companies in your value chain. So, with your suppliers and customers. Coordinate with them on measuring, using, and sharing data." (Interview 3)*

This requires a combination of mandatory and facilitative measures that together ensure improved data quality, uniformity, and efficiency in the reporting process.

Mandatory Measures

An effective way to ensure the quality of Scope 3 data *(Metric 14)* could be to contractually require suppliers to report emissions according to standardized methodologies, such as the ESRS E1 guidelines. By explicitly including emissions data as a requirement in purchasing contracts and delivery terms, collecting reliable data becomes a formal part of the collaboration.

Although obligations and penalties can be effective, an overly rigid approach can create resistance among suppliers, especially when they lack the necessary resources or expertise. This highlights the importance of facilitative measures.

Facilitative Measures

Many suppliers, especially smaller companies, lack advanced measurement methods or the capacity to produce detailed emissions reports. This often leads to the use of generic emission factors rather than primary data, reducing the accuracy and usability of the information. Companies can improve this by actively supporting suppliers in the reporting process.

By establishing clear agreements and utilizing technological measurement tools at the supplier level, as mentioned in Chapter 7.1, the completeness of emissions data is ensured. This not only enables faster and more accurate reporting but also allows companies to strategically use their emissions data for sustainability improvements.

7.3. Best Strategical Approaches

From the interviews, it became evident that emissions reporting is often viewed as a compliance obligation rather than an opportunity to improve operational processes and enhance strategic decision-making. Additionally, companies are often hesitant to invest due to uncertainty about changing regulations and the technical complexity of the implementation process.

This section discusses how companies can transform emissions reporting from an administrative burden into a strategic tool. By better utilizing emissions data and adopting a flexible approach to changing regulations, companies can not only comply with CSRD and ESRS requirements but also enhance their operational efficiency and competitive advantage.

7.3.1. From Obligation to Added Value

Companies need to realize that emissions reporting can be much more than just an obligation. When strategically utilized, emissions data can contribute to operational efficiency, cost savings, and risk management. As an expert pointed out:

> *"On the long term companies will not only use the data for yearly reporting. They can use it for steering to be more efficient and more cost effective." (Interview 6)*

This requires a fundamental shift in how companies structure their reporting processes and integrate them within the organization. Instead of collecting emissions data solely for external reporting, companies should actively use this data for internal policy and decision-making. This can be achieved by applying the following approaches:

- Continuous Monitoring
  Transforming emissions reporting into a continuous monitoring system allows companies to gain real-time insights into their emissions performance. As previously mentioned, many companies still follow an annual reporting cycle, where emissions data is collected and analyzed only once a year. This static process makes it challenging to adjust emissions reduction targets in a timely manner and to identify trends and areas for improvement.

  According to experts, modern SAP ERP solutions provide a future-proof solution for this challenge.

  > *"To avoid emissions reporting being an annual exercise with a lot of work, an ERP system is a logical solution." (Interview 7)*

  They enable companies to collect and analyze emissions data on a frequent basis. This allows companies to detect emissions trends early and take immediate action when deviations occur. A continuous monitoring strategy not only ensures better compliance with regulations but also allows emissions reduction measures to be implemented more efficiently and effectively. Additionally, it enables companies to link emissions data to other performance indicators, such as energy consumption

(Metric 6), production costs, and supply chain efficiency.

- Sustainability KPIs
  A best practice is for companies to link emissions data to broader business KPIs. Just as financial performance is continuously evaluated, emissions should become an integral part of management reports. This means that sustainability goals are not separate from operational processes but are directly integrated into purchasing decisions, supply chain management, and energy consumption, as described in Chapter 6.2.1. By linking emissions to performance indicators, such as carbon credit management *(Metric 18)*, companies can make informed decisions that enhance both sustainability and efficiency.

By viewing emissions reporting as a management tool rather than an obligation, companies can not only comply with regulations but also gain strategic advantages. This requires structural integration of emissions data into decision-making and operational processes, making sustainability a core part of the business strategy rather than a separate topic.

7.3.2. Regulatory Uncertainty

Another finding within the strategic approach was that companies are often hesitant to invest in ERP-based emissions reporting because large-scale implementations can be expensive, time-consuming, and complex. Moreover, regulations surrounding CSRD and ESRS are still evolving. As a result, organizations that do not yet use an ERP system often opt for temporary solutions, such as Excel reports or third-party software, to meet reporting requirements without immediately implementing a fully integrated ERP system.

A pragmatic approach to managing this uncertainty is to implement a phased strategy, where companies gradually work towards a fully integrated ERP system for emissions reporting. Instead of implementing a complete system all at once, organizations can start with a core implementation that lays the foundation for further expansion. This can begin, for example, with standardizing emissions data and centralizing data sources within a manageable ERP module, while additional functionalities and automation are integrated in later phases.

It is crucial to consider the possibilities of an ERP system from the very first steps. This approach allows companies to gradually familiarize themselves with the tool, understanding both the data requirements of the tool and where to find the necessary data. As one SAP expert explained:

> *"The information within the tool and testing and understanding it can really help in gathering the data." (Interview 7)*

This approach not only provides companies with the flexibility to adapt to changing regulations but also prevents them from relying on temporary solutions that are inefficient and time-consuming in the long run. As one expert noted:

> *"If you choose a temporary solution for the next 10 years, you standardize nothing, automate nothing, and ultimately it will cost you more time." (Interview 1)*

By establishing a solid foundation early on, companies can future-proof their emissions reporting process while keeping the transition to an integrated ERP system manageable and cost-effective.

7.4. Conclusion

The implementation of ERP systems, like SAP, for emissions reporting, requires not only technological solutions but also organizational and strategic adjustments. This chapter formulated best practices to overcome the challenges identified in Chapter 6, thereby answering the research question:

"What are the best practices for companies to overcome challenges in collecting and reporting emissions-related data through ERP systems with a focus on SAP for ESRS E1 compliance?"

The findings of this study indicate that companies can optimize emissions reporting through an integrated approach at three levels:

Technical Best Practices

- Centralizing emissions data within an integrated data management system reduces data fragmentation and increases the reliability of reports.
- The quality and completeness of emissions data can be improved through automation, API integrations, and AI-driven validations, minimizing human errors and inconsistencies.
- The use of real-time data collection and advanced ERP functionalities enables companies to process emissions data more accurately and efficiently.

Organizational Best Practices

- Assigning clear responsibilities and integrating emissions reporting within existing departments ensures a more efficient and consistent data flow.
- Structural knowledge development and employee training contribute to improved data quality and reduce dependency on external consultants.
- Collaboration with external parties, such as suppliers, can be enhanced through standardized reporting requirements and technological support.

Strategic Best Practices

- Companies that view emissions reporting not as an obligation but as a strategic tool can leverage this data for operational optimization and cost savings.
- Continuous monitoring of emissions data within ERP systems, like SAP, provides real-time insights and enables more effective emissions management.
- A phased implementation of ERP-based emissions reporting helps companies adapt flexibly to changing regulations without getting stuck in temporary, inefficient solutions, while also considering the requirements of the tool early on.

These findings highlight that an effective implementation of ERP systems, such as SAP, for emissions reporting goes beyond technology alone. It also requires structural and strategic changes. In the next and final chapter, based on the findings of this research, a concrete roadmap is presented to help companies implement a robust and efficient emissions reporting system.

8

Roadmap for Emissions Reporting with ERP Systems

This exploratory study shows that companies seeking to report emissions through ERP systems, such as SAP, mainly face challenges in collecting and obtaining reliable emissions data. This constitutes the biggest obstacle to complying with CSRD requirements and ESRS E1 guidelines. The complexity of emissions reporting lies not so much in the technical capabilities of the ERP system, but rather in structuring and obtaining the right data, particularly for Scope 3 emissions.

Based on the research findings, a roadmap has been developed to support companies in establishing a structured process for emissions reporting within a SAP ERP environment. This roadmap first focuses on obtaining, structuring, and managing emissions data, followed by further processing leading to final reporting. It addresses both internal data collection and responsibility allocation, as well as collaboration with external parties such as suppliers.

As this study conducted a case analysis of SAP as an ERP system, the roadmap specifically uses examples of the functionalities of SAP ESG Reporting Manager and SAP Sustainability Control Tower. These systems provide comprehensive capabilities to collect, process, and report emissions data within a structured framework. Although SAP is used as an example, this roadmap can largely be applied to other ERP systems that offer similar functionalities for sustainability reporting.

The roadmap is not only intended to help companies comply with the legal requirements of CSRD and ESRS E1, but also to enable them to use emissions data strategically. Through a well-structured approach, companies can not only report emissions data correctly but also leverage it to achieve sustainability goals and improve operational efficiency. To develop an effective roadmap, insights were gathered from expert interviews with sustainability and ERP specialists from PwC and SAP (see Section 3.1.3). During these interviews, discussions focused not only on the key challenges and best practices for implementing emissions reporting within ERP systems but also explicitly on how an effective step-by-step plan should be structured according to experts.

The roadmap was then compiled by structuring and integrating expert input into a cohesive framework, combined with an analysis of the findings from Chapters 6 and 7. Although this design was iteratively refined based on the discussed insights, no formal validation has taken place. Further testing in practice is therefore recommended to confirm the roadmap's applicability and effectiveness and refine it where necessary.

8.1. The Roadmap

Figure 8.1 presents the roadmap, developed based on the research findings. The roadmap consists of twelve steps, each of which is explained individually below the figure. An important aspect of this roadmap is its iterative approach. This means that at each step, the company must assess whether it is ready to proceed to the next phase or whether a previous step needs to be repeated or further refined. Approaching the process in this way ensures that each step is carefully implemented and tailored to the specific situation of the company. This prevents later stages from being based on incomplete or inconsistent data, organizational ambiguities, or insufficient technical integration (Interview 7).

The roadmap provides companies with not only a structured path to a robust emissions reporting system but also the flexibility to adapt to changing circumstances, such as new legislation or internal company-specific challenges. By critically evaluating each step before moving on to the next phase, the likelihood of successful implementation and sustainable effectiveness is increased.

In the following sections, the twelve steps of the roadmap are discussed individually, detailing the key considerations, required actions, and underlying best practices for each step.

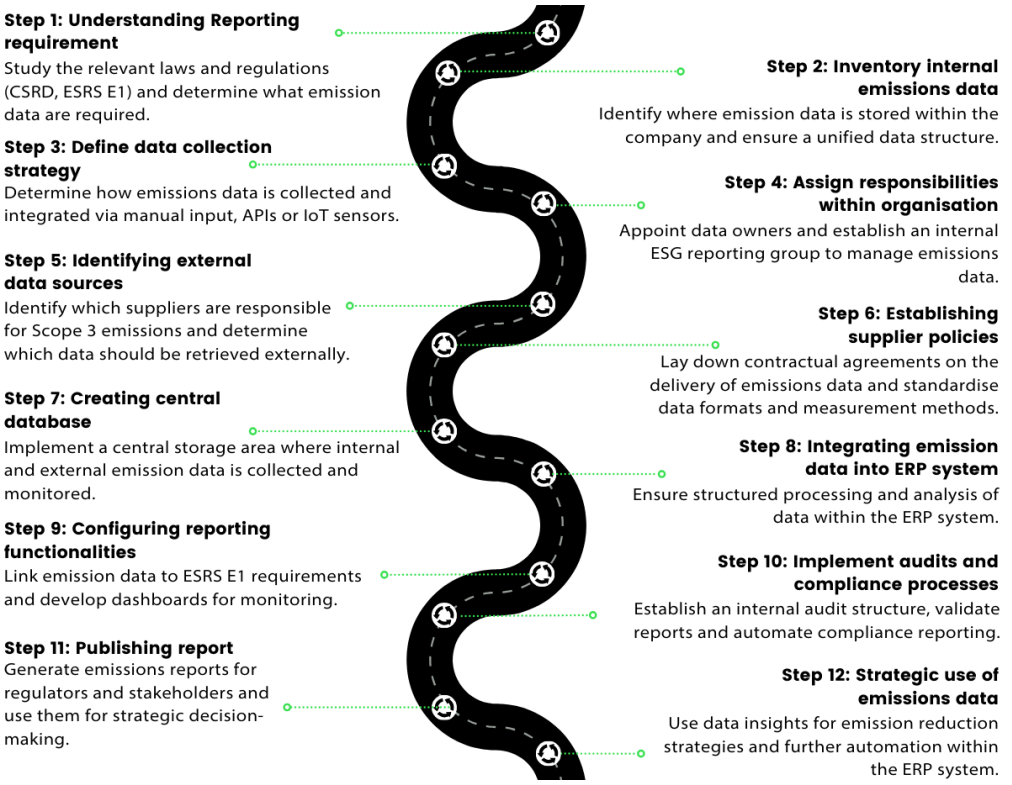

Figure 8.1: Roadmap for ERP using by emission reporting (Own work, 2025)

Step 1: Understand Reporting Requirements and Data Needs

Many companies are aware of the need to comply with sustainability reporting, but they often lack a clear understanding of what this entails. To gain clarity, companies must analyze the requirements of the CSRD and specifically the ESRS E1. Under ESRS E1, companies must meet 9 disclosure requirements, with emissions data being most relevant within ESRS E1-5 to ESRS E1-7. This forms the basis for accurate and compliant emissions reporting.

Step 2: Inventory and Structure Internal Emissions Data
To report emissions data accurately, companies must first determine where this data resides within the organization. Emissions data may be scattered across different systems, such as ERP software, spreadsheets, and standalone databases. A thorough inventory helps identify existing data sources and detect any data gaps. It is then essential to create a uniform data structure to ensure that data is stored and processed consistently and standardized across the organization.

Step 3: Define a Data Collection Strategy
Once it is clear what emissions data is needed and where it is located, a strategy must be developed to collect the data. Various methods can be used:

- Manual input via spreadsheets or entry into a centralized system.
- Automated data collection via APIs, IoT sensors, and external databases.
- Collecting external supplier data through reports and contractual obligations.

To ensure data quality, validation rules must be set to detect inconsistencies and errors. Companies should also determine how often emissions data is collected (e.g., monthly or annually) and how this data is verified before being used in a report.

Step 4: Assign Responsibilities Within the Organization
To effectively organize emissions reporting, it is recommended to integrate it into the existing corporate structure rather than setting up a separate sustainability team. This ensures that the responsibility for emissions data lies directly with the appropriate people and prevents sustainability from being isolated from core business activities.

Key aspects include:

- Integration within existing teams – Responsibility for emissions reporting lies with the departments already working with this data, such as Finance, Supply Chain, and Operations.
- Phasing out separate sustainability teams – Sustainability responsibilities are incorporated into regular business processes, reducing the need for additional sustainability departments.
- Capacity building and training – Employees within relevant departments must develop the necessary knowledge and skills to accurately collect, interpret, and report emissions data. This requires time and support.

This approach integrates emissions reporting into the business operations, leading to better data quality and more efficiency in the reporting process.

Step 5: Identifying External Data Sources
One of the biggest challenges in emissions reporting is obtaining reliable and consistent emissions data from suppliers and other external parties, particularly for Scope 3 emissions. Since companies rely on data outside their direct control, it is essential to first clearly map where the required data is located, who owns it, and how it can be collected.

In this step, a company should:

- Identify which suppliers and external parties possess relevant emissions data. This could include direct suppliers, logistics partners, or other links in the supply chain.
- Determine what data is needed from each supplier or external party and assess the extent to which this data is already available or still missing.
- Engage in early discussions with suppliers to understand the technical and practical obstacles in providing emissions data and how to resolve them.

This step focuses on understanding the external data chain and preparing for collaboration with suppliers, enabling companies to develop a clear strategy for efficiently and reliably collecting emissions data.

Step 6: Establish Supplier Policy and Data Obligations
After identifying which external parties can provide emissions data and how the collaboration can be structured, this must be formally documented in a supplier policy with clear data obligations. This ensures that suppliers provide emissions data consistently and compliantly.

In this step, a company should:

- Draft contractual agreements specifying what emissions data a supplier must provide, how often, and according to which methodology.
- Develop a standard format and data structure requiring suppliers to deliver data in a uniform manner, simplifying processing and analysis.
- Standardize measurement methods and emission factors so that submitted data is consistent and comparable with internal data.
- Implement a control and validation process to ensure the reliability and completeness of the data provided by the internal data owner.
- Establish a process for ongoing collaboration with suppliers, providing support in collecting and correctly supplying emissions data. This could be through regular meetings, joint training sessions, or creating a supplier portal for centralized data exchange.

This step emphasizes formalizing supplier collaboration and ensuring a structured and reliable process for external data collection. This helps companies receive emissions data on time and correctly, ensuring compliance with CSRD and ESRS E1 requirements.

Step 7: Create a Central Database for Integrated Emissions Data
To efficiently manage emissions data, a company should establish a central repository where internal and external emissions data converge. This could be a Data Lake, a centralized database, or a specialized ERP system. The database should:

- Integrate and standardize data from various sources.
- Support real-time validation and verification of data.
- Be accessible to all relevant stakeholders within the company.

A well-organized central database allows data to be managed more efficiently, analyses to be performed faster, and reports to be more reliable.

Step 8: Integrate Emissions Data into the ERP System
Once internal and external emissions data are collected and structured, the data must be integrated into the ERP system. This enables companies to efficiently process, analyze, and report emissions data within one streamlined system.

An ERP system should:

- Support automated data import from internal and external sources.
- Perform data validation and verification to minimize errors and inconsistencies.
- Establish standardized workflows and reporting structures to make emissions data accessible and usable.

SAP Datasphere can be used to consolidate and structure emissions data from various sources within the ERP ecosystem. By effectively integrating emissions data into the ERP system, manual entry is minimized, enabling companies to report more quickly and accurately. This ensures that emissions data is used not only for regulatory compliance but also for strategic decision-making and sustainability goals.

However, as indicated in Chapter 7.3, companies are advised to start exploring the functionalities of the ERP system in earlier stages. Utilize and explore the tool's capabilities. The information within the tool and testing and understanding its features can help in identifying and gathering the necessary data.

Step 9: Configure Reporting Functionalities
To comply with CSRD and ESRS E1 requirements, the ERP system must be correctly configured to process emissions data in a structured and auditable manner. This enables companies to effectively analyze emissions data and prepare it for reporting.

This process includes:

- Linking emissions data to the requirements of CSRD and ESRS E1 to ensure that reports comply with legal standards.
- Developing standardized reporting formats to structure emissions data uniformly.
- Automatic calculations and aggregation of emissions data by entity, region, or production line to provide a comprehensive emissions overview.
- Real-time monitoring of emissions data to detect anomalies promptly.

Within SAP, companies can use SAP ESG Reporting Manager for processing ESG data, with SAP Sustainability Control Tower serving as the central hub consolidating all ESG data. Additionally, SAP Analytics Cloud is utilized to provide analytical insights through dashboards for in-depth evaluations. Properly configuring these reporting functionalities ensures that emissions data is ready for validation and reporting.

Step 10: Implement Audits and Compliance Processes
To ensure the accuracy and reliability of emissions reports, companies must implement internal validation and audit mechanisms. This includes automated checks for data consistency, audit trails for transparency, and external verification by auditors to ensure compliance with CSRD requirements. Within SAP Sustainability Control Tower, companies can monitor and validate emissions data, maintaining consistent datasets with reporting requirements and easily adapting to changing regulations.

Step 11: Publish Reports
After validation and compliance checks, emissions reports must be compiled and made available to internal and external stakeholders. This requires a structured approach where emissions data is generated in the appropriate formats, fully compliant with CSRD and ESRS E1 requirements.

The final tool available within ESG Reporting Manager for this purpose is SAP Fiori, which provides the final report structure and publication of emissions data using SAP SCT.

Step 12: Continuous Optimization and Strategic Use of Emissions Data
After the first reporting cycle, companies must continue to analyze and optimize emissions data to improve sustainability performance and operational efficiency. By conducting trend analyses and benchmarking, bottlenecks can be identified and emissions reduction strategies can be refined. Additionally, KPIs can be adjusted based on the analyzed data, ensuring that companies continuously align their sustainability goals with current performance and regulations.

Further automation and integration with broader business processes ensure that emissions data not only remains a compliance tool but also plays a strategic role in decision-making and business development.

9 Discussion

Every study involves considerations, assumptions, and challenges. This chapter, the final one before the conclusion, reflects on the key findings and places them in the context of existing literature and practical insights. Before presenting the conclusion, the validity and reliability of the research are discussed, as well as methodological limitations and the generalizability of the results. Finally, the results are interpreted, and recommendations are made for future research on the implementation of SAP ERP-based emissions reporting.

9.1. Validation with Literature

This study shows that the findings are closely aligned with the existing literature on the role of ERP systems in emissions reporting. Various studies highlight both the possibilities and challenges of ERP systems, particularly in standardization, automation, and integration within business processes. The literature corresponds with the results of this thesis, identifying technical, organizational, and strategic barriers as key obstacles to effective implementation of ERP-based emissions reporting.

Pizzi et al. (2024) emphasize that standardized processes are essential for effective ESG reporting within ERP systems, yet many companies still struggle with implementation due to technical and organizational barriers. This directly aligns with the findings of this thesis, which revealed through expert interviews that companies face challenges integrating emissions reporting within their ERP systems, with missing expertise and fragmented data limiting effectiveness. Additionally, this study found that strategic challenges, such as a lack of long-term vision and insufficient investment in digitalization, also play a significant role.

Another important theme found in both the literature and this study is the complexity of Scope 3 emissions. Adriansyah et al. (2022) and Olsen (2022) note that Scope 3 data is challenging to collect due to the reliance on external suppliers and the lack of standardized methodologies. This aligns with the findings from Chapter 6, which revealed that companies mainly struggle to obtain consistent and reliable Scope 3 emissions data. Expert interviews confirmed this challenge, highlighting the need for better automation and agreements within the supply chain to make this data more accessible and accurate.

Moreover, Rodlauer (2023) argues that companies should not view their ERP systems as standalone tools for ESG reporting, but that emissions reporting should be fully integrated within broader energy management processes. This corresponds with the findings of this thesis, which established that companies that see emissions reporting as an integral part of their operations report more efficiently and accurately than those collecting and processing emissions data separately.

Dumitru et al. (2023) highlight the importance of automation, particularly for Scope 3 emissions reporting. This aligns with the findings from Chapter 7, which showed that companies investing in automated data collection within ERP systems are less reliant on error-prone manual entry. Both the literature and expert interviews confirm that further automation is necessary to make emissions reporting more efficient and reliable.

While the literature mainly focuses on standardization and automation, this study reveals that data quality, internal knowledge of reporting requirements, and a long-term vision are also crucial for successful implementation. Unlike technical and organizational obstacles, these factors are less explicitly emphasized in the literature. The results of this thesis demonstrate that companies not only struggle with the technical configuration of their ERP systems but also with correctly measuring and fully obtaining emissions data, which directly impacts the reliability of their reports.

De Soete (2016) emphasizes that interdisciplinary collaboration within companies is essential for successful ESG reporting implementation. However, his focus is mainly on the need for data integration between different systems and less on the role of human factors. This study, however, shows that human factors play a crucial role in the early stages of reporting. Since many companies are required to collect emissions data for the first time, they often lack the expertise and experience to perform this process adequately. This leads to inconsistent and incomplete reports, highlighting the need for internal knowledge development and training to structurally improve reporting processes.

Finally, this thesis shows that a lack of long-term vision is a significant barrier. Companies that approach emissions reporting solely as a compliance obligation rather than a strategic investment encounter more difficulties in implementation and standardization over time. While the literature notes that proactive companies report more efficiently, the influence of a sustainable, long-term strategy on the implementation of ERP-based emissions reporting is less explicitly addressed. The findings of this study show that companies that strategically approach emissions reporting from the outset and embed it within broader sustainability goals are better able to build an efficient and standardized reporting structure.

In summary, the findings of this thesis strongly correspond with the literature, particularly regarding standardization, automation, and integration of emissions reporting within ERP systems. However, unlike most existing studies, this thesis also emphasizes that data quality, internal knowledge, and a long-term vision are essential but underexposed factors. This underscores that companies must not only invest in technology but also in internal expertise and strategic planning to make emissions reporting future-proof.

9.2. Validation and Reliability of the Research

This study can be characterized as exploratory research, as it focuses on exploring the implementation of ERP systems, like SAP, for emissions reporting within the context of the CSRD and ESRS. Given the limited amount of empirical research available on this specific topic, a qualitative approach was chosen, based on expert interviews and supported by a case analysis of SAP as an ERP system. Exploratory research does not aim to test specific hypotheses but rather to identify patterns, challenges, and potential solutions (Merkus, 2023). This means that the findings provide valuable insights for further research and practical implementation but cannot be directly generalized to all companies and sectors.

Theoretical Saturation and Sample Limitations

The exploratory nature of this study influences the way theoretical saturation is achieved. Theoretical saturation is reached when additional data points no longer contribute new insights. In this research, eight experts were interviewed, seven of whom work at PwC and one from SAP.

The diversity of specializations within the expert group provides a broad perspective on the implementation of SAP as an ERP system for emissions reporting. The experts represent different fields, contributing to a holistic view of the interplay between regulation, technology, and business processes (see Section 3.1.3).

Despite this broad perspective, the sample is limited to a specific consultancy and technology context, mainly within PwC and SAP. This means that the results are highly applicable to large companies using SAP as an ERP system but may be less representative for organizations with other ERP systems or reporting strategies. Future research could address this limitation by adopting a broader sample, including companies from different sectors and with diverse ERP solutions, to increase the generalizability of the findings.

Limitations of the Case Analysis on SAP

A second key limitation lies in the choice of a case analysis approach. Case analysis allows for in-depth research of a subject but by definition focuses on one specific situation or technology, limiting generalizability. In this study, SAP was chosen as the ERP system because:

- SAP is the leading ERP system worldwide.
- The thesis was written in a professional consultancy environment where SAP plays a central role.
- Most of the available practical information within this context pertained to SAP.

Due to this scope, the research findings are particularly relevant for companies using or considering SAP for ESG reporting. However, other ERP systems such as Oracle and Microsoft Dynamics were excluded. As a result, the findings are less generalizable to companies using a different ERP platform for emissions reporting.

To address this limitation, future research could conduct a comparative analysis of different ERP systems to better map the differences and similarities in ESG reporting functionalities.

Applicability to Different Types of Companies

Another limitation concerns the assumption that companies are (or will be) using ERP systems for ESG reporting. The research generally refers to “companies,” but the reality is that mainly large enterprises use ERP systems, while many small and medium-sized enterprises lack the resources or capacity for this.

The roadmap outlined in this study assumes that companies will implement ERP systems, such as SAP, or are already partially using them. For large companies, this is a realistic expectation, as they are compelled to professionalize their ESG reporting due to CSRD

obligations. For SMEs, however, this is more complex. They often lack the financial or technical resources to set up a fully ERP-based ESG reporting system.

Nevertheless, it is just as important for these smaller companies to gain insights into their emissions data and responsibilities. The roadmap in this study remains relevant for them up to Step 7, as these steps relate to the collection, verification, and allocation of responsibilities concerning emissions data. However, the later phases of the roadmap, where data is integrated into an ERP system and automatically processed, will be less directly applicable to smaller companies. They are more likely to continue reporting their emissions data via Excel, standalone software tools, or other manual methods.

This means that the research mainly targets companies that are already digitized or in a digital transformation phase, while companies without ERP solutions or limited resources may not be able to directly apply all findings.

Challenges in Data Standardization

Even for large companies using ERP systems, a critical challenge remains: the lack of standardized data formats for emissions reporting. Many organizations rely on external suppliers and value chain partners for their Scope 3 emissions, assuming that ERP integration through platforms such as SAP facilitates seamless collaboration. However, in practice, suppliers interact with multiple organizations, each imposing different requirements on how emissions data should be provided. This results in inconsistencies, inefficiencies, and increased compliance costs.

Without harmonized, industry-wide standards, emissions reporting can become fragmented, forcing suppliers to adapt to multiple reporting formats. This not only increases administrative burdens but also undermines the accuracy and comparability of emissions data across value chains. While ERP systems such as SAP offer functionalities to integrate emissions data, their effectiveness remains limited as long as input from external parties is unstructured or inconsistent.

Future research should focus on how universal data exchange protocols, standardized ESG reporting formats, and Data-as-a-Service (DaaS) solutions can help mitigate these interoperability challenges. Establishing a uniform reporting standard for suppliers could significantly enhance the scalability, efficiency, and reliability of ERP-based emissions reporting. Without further progress in standardization, even the most advanced ERP solutions for sustainability reporting risk becoming fragmented and inefficient.

Focus on ESRS E1 and Its Implications

An important methodological limitation of this research is that the analysis focuses exclusively on ESRS E1, the standard for emissions reporting within the broader ESRS. ESRS E1 is just one of the twelve ESRS components required for full compliance with the CSRD.

The choice to specifically investigate ESRS E1 is based on the fact that emissions reporting is the most complex and challenging component for many companies and therefore has the highest priority within their ESG strategy. However, because the roadmap developed in this study is based on ESRS E1, it cannot be directly applied to other ESRS components, such as social or governance-related reporting requirements.

Although the methodological approach and best practices in this study can provide guidance for broader ESRS compliance, the roadmap cannot be considered a generic model for all sustainability aspects. Future research should explore to what extent the roadmap can be adapted or expanded to other ESRS standards so that companies can develop an integrated reporting strategy that meets the full CSRD obligations.

Impact of Changing Legislation on Validity

A final important limitation is the ongoing evolution of legislation and regulations on ESG reporting. The desk research, which forms the basis for Chapter 4, is largely based on the current CSRD and ESRS guidelines. Since these regulations are relatively new and are

expected to be further refined in the coming months or years, there is a risk that certain insights may become less accurate or relevant in the future.

The dynamic nature of ESG legislation means that companies must continuously anticipate new obligations and reporting structures. This has two significant implications for the validity of this research:

1. *Interpretation of ESG guidelines may change:*
   This means that some recommendations in the thesis may need to be adjusted over time.
2. *ERP systems' functionalities will adapt:*
   SAP and other ERP vendors are continuously developing new modules to respond to changing regulations. This means that some of the challenges identified in this study may be partially resolved in the coming years.

Due to this factor, it remains essential to view ESG reporting not only as a technical issue but also as a constantly changing policy domain in which companies must remain flexible.

9.3. Reflection on Research Methods

This section reflects on the research methods used throughout this study in the following three subsections.

Desk Research

The first sub-question was answered through desk research, primarily consisting of an analysis of legislation and regulations. The core of this analysis was the CSRD and ESRS guidelines, which currently form the basis for emissions reporting within Europe.

However, an important limitation is that these regulations are still subject to change. Since November 2024, there have been indications that the European Commission intends to amend sustainability reporting requirements under the CSRD, EU Taxonomy, and the Corporate Sustainability Due Diligence Directive (CSDDD). The EU is currently working on this Omnibus legislation (Foy, 2024). This means that some requirements may be adjusted, which could affect how SAP and other ERP systems will need to be configured for ESG reporting in the future. As a result, some insights from the desk research may become less relevant over time.

Case Analysis

The case analysis on SAP was conducted by exploring the system firsthand, rather than investigating how companies currently use SAP for emissions reporting. Although this was the original plan, it was not feasible to find a company willing or able to share its SAP data on this topic. This is partly because few companies have currently configured SAP to actually generate ESG reports.

Due to this limitation, the case analysis mainly focuses on what SAP theoretically makes possible, rather than how companies are currently using it. This led to useful insights but made the study less practice-oriented than initially intended.

Another key aspect of the case analysis was the role of the ESG Reporting Manager within SAP. The analysis revealed that ESG reporting in SAP is not limited to a single module but relies on multiple components within the system. The ESG Reporting Manager integrates these components and plays a crucial role in consolidating emissions data from various SAP modules. This insight is essential for companies considering SAP for their ESG reporting.

While the case analysis provided valuable insights into SAP's functionalities, the depth of the analysis could have been further enhanced by examining real-world cases from companies. Future research could build on this by studying companies that are already using advanced ESG reporting in SAP in greater detail.

Expert Interviews

The expert interviews were a valuable method for gaining practical insights into the implementation of SAP for ESG reporting. One point of attention is that only eight experts were interviewed, which could lead to differences in interpretation depending on their background and specialization.

Although the interviews revealed significant challenges, such as data quality issues and the complexity of ERP integration, a broader range of respondents might have yielded more sector-specific insights. Future research could complement this by conducting a quantitative survey among companies actively working on ESG reporting within SAP.

9.4. Interpretation of Results and Recommendations for Future Research

This exploratory study developed a roadmap for implementing SAP ERP-based emissions reporting within the context of ESRS E1, based on semi-structured interviews. This roadmap provides companies with a structured approach to overcoming technical, organizational, and strategic barriers. However, an important caveat is that the roadmap has not yet been empirically validated in practice.

Although the roadmap is based on insights from experts and theoretical foundations from the literature, a crucial next step is to systematically test it within organizations implementing ERP systems for emissions reporting. Future research should focus on practical validation, for example, through:

- *Case studies* at companies implementing the roadmap to evaluate which steps are most effective.
- *Action research* where companies are actively guided through the implementation process, and challenges are addressed in real time.
- *Comparative studies* between companies that follow the roadmap and those that do not, to measure effectiveness and feasibility.

This could contribute to further refinement of the roadmap and provide a better understanding of the preconditions required for successful implementation in different sectors.

Another insight is that the roadmap is exclusively developed for ESRS E1, while CSRD compliance requires reporting on twelve ESRS components. ESRS E1 is one of the most complex standards and is a priority for many companies, but the roadmap cannot be directly applied to other ESRS guidelines, such as social or governance-related reporting. Future research should explore the extent to which the roadmap can be adapted or expanded to other ESRS standards, enabling companies to develop an integrated ESG reporting strategy that complies with CSRD.

By empirically validating the roadmap and further investigating the organizational and strategic aspects of emissions reporting, companies can be better supported in establishing a robust, future-proof, and integrated reporting system that not only meets regulatory requirements but also contributes to sustainable business operations.

10

Conclusion

The increasing obligations for companies to accurately and comprehensively document their emissions are further reinforced by the introduction of the CSRD and the accompanying ESRS E1. This regulation imposes strict requirements on how organizations record and report their greenhouse gas emissions. In particular, tracking Scope 3 emissions, which pertain to indirect emissions within the value chain, presents a significant challenge. Scientific studies suggest that ERP systems can play a crucial role in streamlining and automating these processes, yet their successful implementation requires a structured approach. This research explores how companies can leverage ERP systems, like SAP, to ensure compliance with ESRS E1 and CSRD, identifying the necessary steps for effective integration. Therefore, this study focuses on the following main research question:

"What structured approach can companies follow to implement ERP systems, with a focus on SAP, for emissions reporting in compliance with ESRS E1 and CSRD?"

To answer this question, this study proposes a structured framework, informed by expert interviews and best practices, that can support companies in the effective implementation of ERP systems, such as SAP, for emissions reporting. The analysis identifies three critical pillars for a successful implementation: *technological*, *organizational*, and *strategic* integration. Technologically, companies face fragmented and inconsistent data sources, particularly regarding Scope 3 emissions, which rely on external supplier data. Organizationally, a lack of ownership and internal expertise often hinders progress, requiring clear responsibilities, training, and stronger stakeholder collaboration. Strategically, many companies still perceive emissions reporting primarily as a compliance obligation rather than an opportunity to optimize sustainability efforts and operational efficiency. A broader vision is needed in which ERP systems serve as strategic tools that support long-term value creation.

Building on these findings, the roadmap translates these three pillars into actionable steps, providing companies with a structured, step-by-step approach to integrating ERP-based emissions reporting more effectively. It offers guidance on overcoming key challenges, including fragmented data management, governance structures, and the strategic alignment of emissions reporting with broader sustainability objectives. To facilitate this transition, companies can follow a series of steps that address technological, organizational, and strategic barriers. This includes:

- *Data integration and governance:* Ensuring accurate and consistent emissions reporting.
- *Process optimization:* Streamlining internal workflows to improve reporting efficiency.

- *Supplier collaboration:* Enhancing data exchange to improve Scope 3 emissions tracking.
- *ESG expertise development:* Providing training to strengthen internal knowledge and compliance capabilities.

By following these steps, companies can move from a fragmented, compliance-driven approach to a more automated and strategic emissions reporting framework.

This framework helps companies align emissions reporting with current CSRD and ESRS E1 requirements while preparing for future regulatory and technological developments. While this approach serves as a valuable guideline, it must be emphasized that its effectiveness has not yet been empirically validated. This study represents a first step in developing a structured approach, but further practical implementation and evaluation are needed to assess its applicability and effectiveness.

Additionally, sustainability reporting regulations continue to evolve. The exact requirements for CSRD and ESRS E1 compliance may change in the coming years, requiring companies to maintain flexibility in their reporting processes and ERP systems. This highlights the need for an adaptive implementation strategy, ensuring that companies not only meet current obligations but are also prepared for future regulatory changes and technological innovations.

This study highlights the potential of ERP systems. like SAP, for structured emissions reporting. While further validation is needed, this framework lays the foundation for a more integrated and future-proof approach to corporate sustainability compliance.

10.1. Recommendation for PwC

PwC can play a pivotal role in supporting companies with the implementation of emissions reporting within ERP systems. The interviews reveal that companies primarily struggle with understanding and applying the CSRD and ESRS guidelines, structuring their data collection, and optimizing their internal processes. PwC can address these challenges by placing a stronger emphasis on advising on data integration within ERP systems and guiding companies through the transition to automated reporting. This includes not only technical support in configuring SAP modules such as the ESG Reporting Manager but also organizational guidance, such as helping to establish internal governance structures and standardizing reporting processes.

Additionally, the interviews indicate that companies often lack a clear strategy for obtaining Scope 3 data from suppliers. PwC can assist companies in developing collaboration models and contractual agreements with suppliers, ensuring that emissions data is delivered and processed in a standardized manner. PwC could also play a more significant role in translating the continuously evolving legislation into concrete guidelines for companies, enabling them to be prepared for future changes in CSRD requirements.

Although ERP systems such as SAP can provide a robust solution for integrated emissions reporting, it is important to recognize that not all companies can use these systems. For organizations that do not yet have an extensive ERP infrastructure, alternative solutions, such as specialized emissions tracking software, can also play a role. PwC can assist companies in making a strategic choice between these solutions, depending on their existing IT landscape, data volumes, and reporting requirements.

Finally, the research shows that many companies still lack sufficient insight into how to strategically leverage their ERP systems not only to comply with regulations but also to achieve sustainability objectives. PwC can expand its advisory services beyond compliance to include value-driven sustainability strategies. By guiding companies in proactively monitoring and reducing emissions, PwC can contribute to a broader transition towards more sustainable business practices.

10.2. Recommendation for Science

This study has taken the first step in developing a structured framework for implementing ERP systems, such as SAP, for emissions reporting, with a focus on CSRD and ESRS E1 requirements. The findings indicate that technology, organizational adjustments, and strategic decision-making play a crucial role in successful implementation. Based on these insights, several avenues for further scientific research can be identified.

Empirical validation of the roadmap through case studies will refine its applicability and effectiveness across different business contexts. Future research could focus on case studies of companies implementing ERP systems for ESG reporting to refine the roadmap and adapt it to different business contexts. Additionally, it would be valuable to investigate the factors contributing to a successful implementation and the barriers companies face when adopting an ERP-based ESG reporting system.

Furthermore, research is needed on the standardization of emissions reporting, particularly for smaller companies. This study primarily focused on large enterprises already using or considering SAP. However, small and medium-sized enterprises often lack the resources or expertise to implement a fully integrated ERP-based emissions reporting system. A key research question is how SMEs can still comply with CSRD and ESRS reporting requirements without a fully developed ERP infrastructure. Future studies could explore the potential of standardized, user-friendly reporting methods, such as cloud-based ESG tools or simplified reporting templates that align with the needs of SMEs.

Finally, the development of ESG technologies within ERP systems remains a relevant research field. The integration of AI, blockchain, and IoT into ESG reporting could enhance the reliability, transparency, and efficiency of emissions reporting. Additionally, Data-as-a-Service (DaaS) could play a crucial role in standardizing and improving access to emissions data, particularly for Scope 3 emissions, where companies heavily rely on external suppliers and partners. Future research could investigate how DaaS solutions contribute to a more uniform and automated exchange of emissions data within ERP systems and how they align with existing and emerging ESG regulations.

Continued research and collaboration are essential in developing accessible, future-proof solutions for emissions reporting. By bridging the gap between technology, regulation, and business practices, both large corporations and SMEs can accelerate their sustainability efforts. Ultimately, this collective effort will drive the global reduction of emissions, bringing us closer to a more transparent and sustainable future.

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A

Scope

An initial scope is developed based on an extensive review of the available literature to construct a comprehensive framework for analyzing which legislation exists regarding sustainable reporting. This included both scientific and grey literature, policy documents, and relevant legislation. The scope is based on the framework of Florian (2023) in Figure 4.1 and begins with an overview of ESG criteria, progressing through the European Green Deal, followed by the CSRD, and culminating in the specific provisions of ESRS E1.
In this appendix, the initial steps of the scope will be outlined, and the terms ESG and Green Deal will be explained. Based on this, Chapter 4 can directly continue with CSRD and ESRS E1. After all the legislation on sustainable reporting has been discussed, section 5.1 will describe what ERP systems are.

A.1. Environmental, Social, and Governance (ESG)

ESG criteria form an important framework that companies and investors use to evaluate non-financial performance, with a focus on both ethical and risk management aspects. Over the past few decades, ESG has evolved into an essential component of business and investment strategies (Plan A, 2024). This chapter explores the origins of ESG, the key reasons for its importance, and the impact of ESG on business operations and investment strategies. It also examines four key sources from the academic literature that help in understanding the influence of ESG.

History of ESG

The roots of ESG lie in the social movements of the 1960s and 1970s, which advocated for responsible business practices and ethical investing. Companies and investors increasingly recognized the need to consider their environmental and social impact (Carroll, 1999). By the 1980s, socially responsible investing gained traction, particularly in the US and Europe, leading to the rise of Socially Responsible Investing (SRI), where investors not only focused on profit but also on the ethical aspects of business activities (Sparkes & Cowton, 2004).

The term ESG was formally introduced in 2004 in the UN report Who Cares Wins, which called for the integration of ESG factors into investment decisions (UN Global Compact, 2004). This report emphasized that companies improving their ESG performance are better positioned to manage financial risks.

A.1.1. Why ESG is Important

ESG has developed into a crucial tool for companies and investors to manage long-term risks and meet societal expectations. The main reasons why ESG is important can be divided into four categories:

Risk Management: ESG criteria help companies identify and manage risks related to the environment, labor conditions, and governance (Eccles & Serafeim, 2013). Companies with strong ESG profiles tend to be more resilient to legal and reputational risks, as demonstrated by research on the role of ESG in legal proceedings in the Netherlands (van der Velden, 2023). Here, legal procedures are often used to enforce compliance with ESG criteria, especially for companies that neglect their obligations.

Investor Perspective: Numerous studies show a positive correlation between ESG performance and financial results. A meta-analysis of over 2,000 studies indicates that companies that take ESG seriously often outperform in the long term (Friede et al., 2015). Investors increasingly view ESG criteria as an important indicator of financial stability and long-term profitability (Giese et al., 2019).

Transparency and Compliance: Increasingly, governments, such as the European Union, are introducing regulations that require companies to transparently report on their ESG performance. The CSRD is a key example of how ESG obligations are being legally enforced (SER, 2023).

Societal Expectations: Consumers and employees are placing higher demands on companies to take responsibility for their impact on the environment and society. Companies that fail in their ESG responsibilities risk losing market share and may find it harder to attract talent (Elkington, 1998).

A.1.2. The Components of ESG

Environmental, Social, and Governance form the three pillars of sustainability criteria that evaluate companies on their performance in non-financial domains. Each of these components encompasses various aspects that together provide an integrated view of how companies manage their impact on the world. These criteria not only help companies manage risks but also promote transparency and stakeholder trust. In table A.1 the ESG framework described by Li et al. (2021) is outlined. This framework emphasizes the integration of the three ESG pillars into the core activities of companies. According to the framework, ESG criteria should not be seen as separate initiatives but as interconnected elements that help companies create long-term value. Companies that perform well in all three pillars, environmental, social, and governance, build resilience against external risks and are better positioned to meet the expectations of both investors and regulators.

Table A.1: ESG Framework (Li et al., 2021)

Dimension	Factors
Environmental (E)	- Climate Change and Carbon Management - Water Management - Biodiversity and Land Use - Waste Management and Circular Economy
Social (S)	- Labor Conditions and Human Rights - Diversity and Inclusion - Community Engagement and Social Impact - Product Safety and Customer Protection
Governance (G)	- Ethical Governance and Transparency - Board Composition: - Anti-Corruption and Regulatory Compliance - Executive Compensation

Environmental

The environmental pillar of ESG focuses on how companies manage their impact on the natural environment. This includes matters such as energy use, carbon emissions, waste management, biodiversity, and the use of natural resources. With increasing pressure to comply with climate agreements such as the Paris Agreement, companies are encouraged to actively develop policies that reduce their ecological footprint.

Key sub-themes within the environmental pillar:

- *Climate Change and Carbon Management:* This involves measuring and reporting a company's carbon emissions, with an emphasis on Scope 1 (direct emissions), Scope 2 (indirect emissions from energy use), and Scope 3 (emissions in the value chain). Companies must develop strategies to reduce their emissions, for example, by switching to renewable energy sources or through energy efficiency programs (Bebbington & Larrinaga, 2014).
- *Water Management:* Companies are increasingly urged to manage water consumption and pollution, especially in industries that are water-intensive, such as agriculture, mining, and manufacturing. This also includes water conservation and preventing contamination of water sources.
- *Biodiversity and Land Use:* Organizations that source raw materials from agriculture or natural ecosystems must ensure sustainable practices that protect biodiversity. This is especially important for companies in agriculture, mining, and forestry.
- *Waste Management and Circular Economy:* Companies are encouraged to optimize their waste management through recycling and transitioning to a circular economy, where waste is reused as raw material.

According to Li et al. (2021), technology and innovation play a crucial role in improving companies' environmental performance. The ESG framework emphasizes that companies should use advanced technologies to minimize their ecological impact and operate in an environmentally responsible manner. Companies that successfully innovate in this area can reduce costs and improve their competitive position.

Social

The social pillar of ESG focuses on a company's relationships with its employees, customers, suppliers, and the broader community. It addresses how a company impacts its internal and external stakeholders, with particular attention to ethical issues such as human rights, labor conditions, diversity, and inclusion. Social responsibility means that companies treat their employees fairly, contribute to the development of local communities, and provide safe and ethical products and services.

Key sub-themes within the social pillar:

- *Labor Conditions and Human Rights:* Companies are increasingly held accountable for ensuring fair labor practices, both within their own organization and in their supply chains. This includes issues such as decent working conditions, fair wages, workplace health and safety, and preventing forced labor and child labor.
- *Diversity and Inclusion:* Companies that promote inclusive workplaces where diversity is valued often achieve better organizational outcomes. This is due to the innovative ideas that arise from diverse perspectives. Organizations that support diversity also enjoy a better reputation with customers and employees, which can help attract talent and foster customer loyalty (Hunt et al., 2015).
- *Community Engagement and Social Impact:* Companies are encouraged to give back to the communities in which they operate. This can be through charitable programs, volunteer work, and investments in local infrastructure and social programs. Companies that take their social responsibility seriously can enhance their reputation and contribute to long-term value creation.

- *Product Safety and Customer Protection:* Ensuring product safety and protecting customers from harmful products or misleading information is vital. Companies that fail in this area may face legal issues and reputational damage.

Li et al. (2021) ESG framework highlights that the social pillar of ESG is increasingly in the spotlight, as companies that pay attention to the well-being of employees, customers, and communities perform better in terms of long-term value creation. The paper emphasizes that companies must proactively identify and address social risks, such as human rights violations or poor labor conditions. However, according to Halbritter and Dorfleitner (2015), the relationship between social responsibility and financial performance remains complex. They suggest that while companies invest in socially responsible policies, the financial rewards are not always immediately apparent.

Governance

The governance pillar of ESG focuses on how companies are governed. This includes transparency, ethical leadership, board composition and compensation structures, and how companies handle shareholder interests. Good corporate governance is essential for building trust with investors and stakeholders, and for minimizing risks such as fraud, corruption, and mismanagement.

Key sub-themes within the governance pillar:

- *Ethical Governance and Transparency:* Companies must act ethically and promote transparency in their decision-making processes. This means that organizations must have clear ethical guidelines and provide accurate and timely information to their stakeholders, including shareholders, about significant business developments.
- *Board Composition:* The diversity, independence, and competence of board members are crucial for making informed and responsible decisions. Companies are increasingly encouraged to ensure that their boards of directors have a wide range of experiences and perspectives and that members are independent from day-to-day operations.
- *Anti-Corruption and Regulatory Compliance:* Companies are being evaluated more and more on their ability to prevent fraud and corruption and to comply with national and international regulations. Companies that fail in this regard can face significant legal and financial consequences.
- *Executive Compensation:* The compensation structures of board members are under increasing scrutiny, especially when rewards are not aligned with company performance. Transparency around compensation structures and ensuring that they are fair contribute to building trust and avoiding conflicts of interest.

According to the ESG framework of Li et al. (2021), governance is often the most direct and measurable pillar of ESG, as it helps companies implement systems that ensure compliance with laws and ethical standards. Companies with strong governance structures tend to experience fewer legal problems, scandals, and financial misconduct, which provides them with stability in the long term. Halbritter and Dorfleitner (2015) suggest that governance is the most directly measurable and actionable factor of ESG, as there are clear links between good governance and company performance.

A.1.3. Impact of ESG on Business Practices and Investment Strategies

ESG has a significant impact on both business operations and investment strategies. Companies implement ESG strategies to meet regulatory requirements and societal expectations. According to Giese et al. (2019), companies with strong ESG profiles improve their stock valuations and lower their capital costs. This is because ESG criteria help reduce risks and enhance reputation.

Additionally, investors increasingly see ESG as a key factor in determining long-term returns. However, the findings of The Wages of Social Responsibility (Halbritter & Dorfleitner, 2015) show that the correlation between ESG performance and financial rewards is not always immediately apparent, especially in terms of social responsibility. It is important to evaluate ESG criteria in the long term, rather than focusing on short-term gains.

A.1.4. Future of ESG and Regulation

With growing concerns over climate change and social inequality, the influence of ESG is likely to continue increasing. In the Netherlands, the interaction between the government and the judiciary is crucial for the implementation of ESG policies (van der Velden, 2023). The judiciary plays an important role in forcing both companies and governments to meet their climate commitments, particularly through private legislation and contractual obligations.

Researchers also point out that ESG criteria need to be further standardized to ensure more effective regulation and improve the transparency of corporate reporting (Li et al., 2021). This process will be accelerated by international initiatives such as the European Green Deal and the CSRD, which require companies to be more accountable for their ESG performance.

A.2. Green Deal

The European Green Deal is an ambitious policy agenda aimed at transforming the economy of the European Union into a sustainable, climate-neutral economy by 2050 (Rijksoverheid, 2024). The initiative was launched in December 2019 by the European Commission in response to the growing ecological and economic challenges posed by climate change. This transition is closely linked to the Environmental (E) pillar of ESG, which encourages companies and governments to reduce their environmental impact and contribute to a more sustainable future.

A.2.1. What is the Green Deal?

The European Green Deal is a policy framework aimed at thoroughly reforming the European economy to create a sustainable and climate-neutral society. The core of the Green Deal is the goal of achieving net-zero greenhouse gas emissions by 2050, meaning that the EU will not emit more CO2 and other greenhouse gases than it can absorb (Rijksoverheid, 2024). To achieve this ambitious goal, the Green Deal focuses on several key areas, including:

- *Sustainable energy:* The transition from fossil fuels to renewable energy sources such as wind and solar energy.
- *Circular economy:* Promoting reuse, recycling, and reducing waste production to ensure more sustainable use of resources.
- *Clean mobility:* Encouraging clean transportation solutions such as electric vehicles and improving public transportation.
- *Biodiversity and agriculture:* Protecting ecosystems and promoting sustainable agricultural practices.
- *Construction and renovation:* Promoting energy efficiency in buildings to reduce energy consumption.

The Green Deal encompasses a wide range of policies, funding programs, and legislative initiatives that all EU member states must support in their transition to a more sustainable economy.

A.2.2. The Origin of the Green Deal from the E-Pillar of ESG

The Green Deal directly stems from growing global concerns about the effects of climate change, a core aspect of the Environmental (E) pillar of ESG. The E pillar emphasizes reducing the negative impact that companies, governments, and economic activities have on the environment. Over the past decades, this pillar has gained increasing importance due to the growing scientific consensus on the need for urgent climate action.

In 2015, the Paris Climate Agreement became a key milestone in global climate policy, committing to limiting global warming to well below 2°C, with an aspirational goal of 1.5°C (UNFCCC, 2015). The European Union, as a leader in global sustainability initiatives, recognized the need to take more extensive measures. The Green Deal was born from the EU's ambition to meet its climate goals and take responsibility within the framework of international agreements like the Paris Agreement.

The connection between the Green Deal and the E-pillar of ESG is clear: both emphasize reducing CO2 emissions, improving energy efficiency, and protecting natural resources. Companies that adopt ESG criteria are also forced to take responsibility for their environmental impact. The Green Deal strengthens this dynamic by requiring companies in the EU to make their production processes, energy consumption, and value chains more sustainable.

A.2.3. The Corporate Sustainability Reporting Directive (CSRD) and the Green Deal

A crucial part of the Green Deal is the CSRD, which is designed to hold companies accountable for their environmental performance and social responsibility. The CSRD will require companies across the European Union to provide detailed reports on their sustainability efforts, with a focus on ESG criteria. This transparency is essential to achieve the goals of the Green Deal, as it allows for more accurate assessment of companies' contributions to a more sustainable economy.

While the Green Deal aims for large-scale structural changes in the economy, the CSRD provides a legal framework to force companies to measure and disclose their progress on sustainability and environmental impact. The CSRD will play an increasingly important role in enforcing the Green Deal's objectives and ensures that companies reduce their environmental impact in line with the goals of the E-pillar of ESG.

Conclusion

The European Green Deal is a policy measure that will bring about fundamental changes in the European economy, with the ultimate goal of climate neutrality by 2050. The Green Deal is deeply rooted in the environmental principles of the E-pillar of ESG and emphasizes reducing the ecological footprint of companies and governments. The implementation of the CSRD is a crucial part of this transition, holding companies accountable for their sustainability performance and ensuring transparency in their ESG reporting.

B

Disclosure Requirements ESRS E1

In this appendix, the remaining six Disclosure Requirements are described, following the discussion of Disclosure Requirements ESRS E1-5 to ESRS E1-7 in Section 4.4. First, Disclosure Requirements ESRS E1-1 to ESRS E1-4 are presented, followed by ESRS E1-8 and ESRS E1-9 after the intermediate section.

B.0.1. E1-1: Transition Plan for Climate Change Mitigation

The first component of ESRS E1, E1-1, falls under the category *"Strategy"*. Unlike other categories within ESRS E1, such as *"Impact, Risk and Opportunity Management"* and *"Metrics and Targets"*, *"Strategy"* focuses on integrating climate-related goals and plans into the overall strategy and operations of an organization. This means that E1-1 should not only provide insight into the transition to a sustainable economy but also explain how these plans are embedded in the organization's long-term policy, financial planning, and decision-making processes (Charluet, 2024).

As E1-1 serves as a strategic foundation, it also requires input from other disclosure requirements such as E1-3 (Actions and Resources), E1-4 (Targets), and E1-6 (GHG Emissions). These requirements are addressed in subsequent sections, but their interconnection with E1-1 highlights the complexity and the necessity of a well-integrated approach.

Reporting Requirements under E1-1

As the name of ESRS E1-1 suggests, a transition plan must be developed. The transition plan that companies are required to present under E1-1 should demonstrate how their strategy and business model are aligned with the goals of the Paris Climate Agreement, with the ultimate objectives of achieving climate neutrality by 2050 and limiting global warming to 1.5°C. This includes not only an overview of current and future actions but also a detailed account of past performance to provide stakeholders with insights into the progress and consistency of climate ambitions. Below are the requirements that the transition plan must meet, according to EFRAG regulations (2024b), to fully comply with the CSRD:

- *GHG Emission Reduction Targets*
  Companies must explain how their reduction targets for Scope 1, 2, and 3 emissions align with the stated goal of limiting global warming to 1.5°C. Both absolute and relative targets must be described, with references to sector-specific benchmarks and pathways.
- *Decarbonization Levers and Actions*
  Companies must detail the strategies and actions they are implementing to reduce

emissions. This includes, but is not limited to:

  - Electrification and use of renewable energy.
  - Efficiency improvements in production and logistics processes.
  - Fuel substitution and phasing out of fossil fuels.
  - Innovations in product portfolios and technology.

- *Investments and Financing*
  The reporting must provide insights into the investments (CapEx) and operational expenditures (OpEx) specifically targeted at implementing the transition plan. This also includes the extent to which these investments align with the EU Taxonomy.
- *Locked-In Emissions*
  Companies must conduct a qualitative and quantitative assessment of the potential locked-in emissions from existing assets and products. The reporting should clarify how these emissions affect progress toward reduction targets and outline plans to manage them.
- *Integration into Strategy and Governance*
  The transition plan must demonstrate how it is integrated into the broader corporate strategy and financial planning. It should also specify whether the plan has been approved by the board and report on the progress made in its implementation.

By thoroughly collecting and analyzing this information, a company can not only comply with the requirements of E1-1 but also establish a strong foundation for the subsequent disclosure requirements within ESRS E1.

B.0.2. E1-2: Policies related to climate change mitigation and adaptation

Disclosure Requirement E1-2 represents the second component of the ESRS E1 requirements and falls under the category of *"Impact, Risk and Opportunity Management"*. Together with E1-3, this component focuses on how companies manage their material impacts, risks, and opportunities related to climate change. Unlike the categories *"Strategy"* or *"Metrics and Targets"*, this section emphasizes operational policies and their practical implementation. Disclosure Requirement E1-2 provides a framework for documenting the policies a company has implemented to systematically address climate change, focusing on both mitigation and adaptation.

This requirement is particularly important as it provides insights into how a company assumes responsibility for reducing greenhouse gas emissions, managing physical and transition risks, and leveraging opportunities arising from the energy transition.

Reporting Requirements for E1-2

Companies are required to provide a detailed description of the policies adopted to manage material impacts, risks, and opportunities related to climate change. This includes (Charluet, 2024):

- Identification and assessment of risks and opportunities.
- Managing and remediating these risks and opportunities.
- The extent to which policies are aligned with the broader sustainability strategy of the company, as described in ESRS 2.

The requirements outlined in the European Sustainability Reporting Standards report (2024b), which the policies must explicitly address, cover the following five areas:

- *Climate Change Mitigation*
  Policies aimed at reducing greenhouse gas emissions (GHG) and leveraging transition opportunities. This includes managing direct emissions (Scope 1), indirect

emissions (Scope 2), and value chain emissions (Scope 3). Examples include electrification, fuel optimization, and investments in emission-free technologies.

- *Climate Change Adaptation*
  Policies focused on managing physical risks, such as damage from extreme weather events. These include measures such as strengthening infrastructure, protecting critical assets, and implementing recovery plans for climate-related incidents.
- *Energy Efficiency*
  Policies to optimize energy consumption within the organization. These include measures to improve operational processes, reduce energy-intensive activities, and implement new technologies that consume less energy.
- *Renewable Energy*
  Policies that promote the adoption and use of renewable energy. This includes the use of solar and wind energy, the installation of charging stations for electric vehicles, and the use of biofuels or hydrogen technologies.
- *Other Relevant Policies*
  Policies that indirectly contribute to mitigation and adaptation, such as procurement policies focused on sustainable suppliers, employee training programs, and investment strategies that prioritize sustainability.

Finally, to ensure compliance with E1-2, companies must explain how they evaluate the effectiveness of their policies. This includes monitoring performance through relevant KPIs that measure the impact and progress of the policies. Additionally, companies must specify the processes and responsibilities established to oversee policy implementation and consistency. Regular reporting, both internal and external, plays a crucial role in ensuring transparency and identifying areas for improvement. This approach not only helps organizations achieve their policy objectives but also strengthens stakeholder trust and enhances their reputation in sustainability.

B.0.3. E1-3: Actions and resources in relation to climate change policies

Disclosure Requirement E1-3, like E1-2, falls under the category of *"Impact, Risk and Opportunity Management"*. While E1-2 focuses on the policy frameworks and strategic principles of climate change, E1-3 emphasizes the operational aspects: which actions are undertaken, which resources are deployed, and what results are expected or have already been achieved.

The purpose of E1-3 is to encourage companies to further operationalize their climate policies and provide transparency on how they translate their strategies into measurable actions. This requires organizations to provide insights not only into their current activities but also into their future plans and the resources allocated for these efforts. By reporting concrete details on matters such as emission reductions, investments in energy efficiency, and adaptive measures, E1-3 gives stakeholders a clear view of how companies contribute to the energy transition and climate goals (Charluet, 2024).

Reporting Requirements for E1-3

Unlike E1-2, which is more strategic in nature, E1-3 requires reports that reflect operational progress and financial allocations. Companies must not only quantify their actions and results but also explain how these align with their broader sustainability strategy and financial planning. The focus is on the resources deployed, such as capital expenditures (CapEx) and operational expenses (OpEx), and the extent to which these investments contribute to emission reductions and adaptations to mitigate physical climate risks. To achieve completeness, the following three policy measures must be described (EFRAG, 2024b):

- *Climate Mitigation and Adaptation Actions*
  Companies must provide detailed descriptions of the actions they are undertaking

to reduce greenhouse gas emissions and adapt their operations to the impacts of climate change. This includes both actions already implemented and plans for future measures. Examples include electrification, energy savings, and adjustments to manage physical risks such as extreme weather conditions. Actions must be linked to specific strategies, such as decarbonization levers or nature-based solutions.

- *Outcomes and Expected Impact*
  Organizations should provide insights into the results of actions taken, such as the amount of emissions reduced in a given year. Additionally, they must report on the expected impact of future actions, including projections of emission reductions and how these contribute to established goals. This helps evaluate the effectiveness of policies and strategies.
- *Financial Resources and Investments*
  Companies are required to specify the financial resources allocated for climate measures, including expenditures for capital (CapEx) and operational costs (OpEx). These data should be linked to relevant financial reports and KPIs, and, where possible, aligned with the EU Taxonomy. This provides insights into how resources are deployed to support transitions to sustainable business operations.

With this requirement, E1-3 builds on the strategic foundations of E1-2 but focuses specifically on the actions and resources essential for achieving climate goals. This makes E1-3 a crucial component of the broader ESRS framework, which supports companies in translating ambitions into measurable and transparent results.

B.0.4. E1-4: Targets related to climate change mitigation and adaptation

ESRS E1-4 is the first component within the *"Metrics and Targets"* category. This category emphasizes the establishment of measurable objectives and the use of related indicators to track progress in climate mitigation and adaptation. Unlike the *"Strategy"* and *"Impact, Risk and Opportunity Management"* categories, this one focuses entirely on quantifiable outcomes. Companies must not only set targets but also demonstrate how these align with their broader policy goals and strategic efforts discussed in earlier sections.

Reporting Requirements for E1-4

Companies must publicly disclose their climate-related objectives. This includes goals for reducing greenhouse gases (GHG) and other targets, such as energy efficiency and the use of renewable energy. These targets should demonstrate how they align with broader climate strategies. Below are three key points that must be addressed when reporting for ESRS E1-4 (Charluet, 2024):

- *Scientific Basis*
  Companies must indicate whether their reduction targets are scientifically grounded and align with the goal of limiting global warming to 1.5°C. This includes specifying the methodologies and scenarios used, such as sectoral decarbonization pathways or internationally recognized standards.
- *Timelines*
  Targets must include at least values for 2030 and, if available, for 2050. From 2030 onward, companies should establish periodic targets for every five-year period. This aids in evaluating progress and adjusting actions as needed.
- *Decarbonization Levers*
  Provide an overview of planned actions and strategies to achieve the targets. Examples include energy efficiency, fuel substitution, the use of renewable energy, and process optimizations. Describe how these levers contribute to achieving the reduction goals.

Data Requirements for E1-4

ESRS E1-4 primarily focuses on establishing reduction targets and planning decarbonization actions to reduce GHG emissions. While actual emission data (such as Scopes 1, 2, and 3) are more comprehensively calculated and reported under ESRS E1-6, ESRS E1-4 provides the strategic framework within which these emissions must be reduced. It serves as the link between the policy frameworks of E1-2 and E1-3 and the quantitative reporting requirements of E1-6 and beyond (EFRAG, 2024b).

Table B.1 provides an overview of the measurable, specific data required for full reporting under ESRS E1-4. The emphasis is on data directly related to reduction targets and decarbonization actions. For example, emission targets are expressed in absolute values (in tons of CO_2 equivalent) and relative reductions (as percentages). Additionally, baselines, base years, and associated financial implications (such as CapEx and OpEx) are listed, as these data are critical for planning and implementing climate strategies.

Table B.1: Specific Data Requirements for Reporting under ESRS E1-4.

Requirement	Required Data
GHG Emissions	• Indicative emission data (Scopes 1, 2, and 3) in tons of CO_2 equivalent (tCO_2eq), based on reduction targets (for actual calculations, see ESRS E1-6 in section 4.4.2).
Reduction Targets	• Absolute reduction targets in tCO_2eq. • Relative reduction targets (% reduction relative to the baseline year). • Baseline emissions (tCO_2eq) and baseline year (year).
Decarbonization Actions	• Expected emission reductions per action (tCO_2eq). • Specific contributions of actions to reduction targets (tCO_2eq).
Financial Implications	• Allocated CapEx and OpEx for emission reductions (€).

In Table B.2, an example table illustrates how EFRAG (2024b) outlines expectations in the European Sustainability Reporting Standards report for documenting targets. Column 1 lists the company's climate-related objectives, which are assigned a reduction percentage. These targets should be set every five years to ensure the ultimate goal of 2050 is achieved. As shown in the fictive example provided by EFRAG (2024b), the company aims for a 10% emission reduction by 2030 through energy efficiency and consumption reduction, as well as a 10% reduction through the use of renewable energy compared to 2025.

Data Requirements E1-5, E1-6, E1-7 are described in Section 4.4

B.0.5. E1-8: Internal Carbon Pricing

Disclosure Requirement E1-8 focuses on how companies utilize internal carbon pricing mechanisms to support climate goals and guide strategic decisions. This requirement is unique within the ESRS guidelines as it links financial instruments, such as carbon prices, to emission reduction targets. The objective is to provide insights into how companies use internal incentives to drive sustainable choices and ensure transparency in the rationale behind these prices (Charluet, 2024).

Table B.2: Fictive Example, GHG Emission Reduction Targets ESRS E1-4 (EFRAG, 2024b, p. 31)

	Base year (e.g., 2025)	**2030 target**	**2035 target**	**…**	**Up to 2050 target**
GHG emissions ($ktCO_2eq$)	100%	60%	40%		
Energy efficiency and consumption reduction	-	-10%	-4%		
Material efficiency and consumption reduction	-	-5%	-		
Fuel switching	-	-2%	-		
Electrification	-	-	-10%		
Use of renewable energy	-	-10%	-3%		
Phase out, substitution or modification of product	-	-8%	-		
Phase out, substitution or modification of process	-	-5%	-3%		
Other	-	-	-		

Reporting Requirements for E1-8

Companies are required to disclose whether and how internal carbon pricing mechanisms are applied and how these contribute to decision-making and achieving climate-related objectives. The key reporting requirements include the following points (EFRAG, 2024b):

- *Type of Carbon Pricing Mechanism*
  Companies must specify the type of internal carbon pricing mechanism used. Examples include shadow pricing for capital investments (CapEx) or research and development (R&D), internal carbon charges, or internal carbon funds.
- *Scope of Application*
  It must be clarified which activities, geographical regions, or entities are covered by the carbon pricing mechanisms.
- *Applied Carbon Prices*
  Companies must disclose the carbon prices applied per mechanism, along with the critical assumptions used to determine these prices. This includes the source of the carbon prices, their relevance to the chosen scope, and whether the prices are based on scientific guidelines. If applicable, companies can also explain how these prices align with science-based carbon price trajectories.
- *Emissions Covered by the Mechanisms*
  The estimated volume of greenhouse gas emissions (expressed in metric tons of CO_2 equivalent) covered by the internal carbon pricing mechanisms must be reported. This should be broken down by Scope 1, Scope 2, and, where applicable, Scope 3. Additionally, the proportion of these emissions relative to the company's total emissions per scope must be disclosed.
- *Consistency with Financial Reporting*
  Companies must explain whether and how the carbon prices used in internal pricing mechanisms are consistent with the carbon prices used in their financial reporting. This includes applications such as asset valuation, depreciation, and impairment analyses.

Data Requirements E1-8

Table B.3 provides an overview of the data requirements for reporting under ESRS E1-8. These requirements pertain to carbon pricing, emission volumes, and future projections, as prescribed by the standard (EFRAG, 2024b).

Table B.3: Data requirements for ESRS E1-8, based on (EFRAG, 2024b)

Requirements	Required Data
Applied Carbon Prices	• Amounts (€ / tCO_2eq)
Covered Emission Volumes	• Emission volumes for Scope 1 (tCO_2eq) • Emission volumes for Scope 2 (tCO_2eq) • Emission volumes for Scope 3 (tCO_2eq)
Total Carbon Emissions per Scope	• Percentage of total emissions per scope (%)
Planned Future Carbon Prices	• Expected carbon price (€ / tCO_2eq)

Table B.4 under Disclosure Requirement E1-8 is designed as a standardized format, developed by EFRAG (2024b), to provide companies with a consistent framework for reporting on internal carbon pricing systems. The table aims to present detailed information on various types of internal carbon prices applied, such as shadow prices for CapEx or R&D decisions, internal carbon fees or funds, and carbon prices used for impairment testing.

The columns in the table include the types of internal carbon prices, the relevant emission volumes (in tCO_2eq), the applied prices (in €/tCO_2eq), and a description of the scope of application. Through this structure, the table offers insights into how companies use internal carbon pricing systems to support decision-making and drive climate efforts.

Table B.4: Types of internal carbon prices (EFRAG, 2024b, p. 66)

Types of internal carbon prices	**Volume at stake (tCO_2eq)**	**Prices applied (€/tCO_2eq)**	**Perimeter description**
CapEx shadow price			
Research and Development (R&D) investment shadow price			
Internal carbon fee or fund			
Carbon prices for impairment testing			
Etc.			

B.0.6. E1-9 Potential Financial Effects from Material Physical and Transition Risks and Potential Climate-Related Opportunities

E1-9 is designed to provide companies with insights into the potential financial effects arising from physical risks, transition-related risks, and climate-related opportunities. The objective is to understand how these factors impact the financial position, performance, and cash flows of a company over the short, medium, and long term. Additionally, it requires companies to identify how climate-related opportunities, such as market growth or cost savings, can generate financial value.

E1-9 stands out for its focus on predicting the external financial implications of climate change. It emphasizes the broader impact of external factors, such as physical risks (e.g., natural disasters) and transition-related risks (e.g., regulations or market changes), and how these could have financial consequences. While E1-8 focuses on internal carbon pricing mechanisms and their role in decision-making (Charluet, 2024).

Reporting Requirements for E1-9

The requirements for ESRS E1-9, as developed by EFRAG, focus on identifying and managing financial risks and opportunities arising from climate change. Companies must demonstrate how these factors influence their strategy and performance. The requirements are detailed below (EFRAG, 2024b).

- *Material Physical Risks*
  Companies must provide insights into the financial effects of physical risks, specified as acute (e.g., extreme weather events) and chronic (e.g., rising sea levels) risks.
- *Material Transition-Related Risks*
  Companies must report on the financial effects of risks arising from the transition to a low-carbon economy, such as regulations, market dynamics, and energy efficiency requirements.
- *Climate-Related Opportunities*
  The standard also requires insights into the financial benefits companies can derive from climate-related opportunities.

Data Requirements E1-9

Table B.5 provides an overview of the specific data points required for reporting under ESRS E1-9. These requirements focus on the financial impact of material physical and transition-related risks, as well as opportunities resulting from climate-related actions. By reporting this data, companies can provide insights into how these factors influence their financial position, performance, and future growth prospects.

The data points include metrics such as the value and share of assets exposed to risks, financial liabilities, and opportunities for market growth and cost savings. These data are essential for ensuring clear and consistent reporting, as required by ESRS (2024b), and for informing stakeholders about the financial resilience and outlook of the company.

Table B.5: Data Requirements for ESRS E1-9, based on (EFRAG, 2024b)

Requirements	Required Data
Physical Risks	• Total value and percentage of assets exposed to risks (in €). • Net revenue related to activities under physical risks (in €).
Transition-Related Risks	• Total value and percentage of assets exposed to risks (in €). • Net revenue dependent on activities with transition risks (in €). • Upcoming financial obligations (in €).
Climate-Related Opportunities	• Cost savings from adaptation and mitigation measures (in €). • Estimated market growth for low-carbon products/services (in € or %).

C

Emission data

Table C.1 contains the 132 data points that resulted from the filtering process in Chapter 5.4. This was done using the SAP interface (SAP, 2024d). Based on the filtering according to ESRS E1 requirements, it can be assumed that these data points are the most relevant for emissions reporting.

Table C.1: Metrics and Emissions Data Table

Metric	Measure	Dimension	DPI
Carbon Credits	Carbon Credits	Emission Data Type	Emissions
Carbon Credits	Carbon Credits	Removal Activity	Emissions
Carbon Credits	Carbon Credits	Scope	Emissions
Carbon Credits	Carbon Credits	Value Chain Stage	Emissions
Energy Intensity Based on Net Revenue	Amount		Energy
Energy Intensity Based on Net Revenue	Energy Consumption	Energy Acquisition	Energy
Energy Intensity Based on Net Revenue	Energy Consumption	Energy Carrier	Energy
Energy Intensity Based on Net Revenue	Energy Consumption	Energy Source Type	Energy
Energy Intensity Based on Net Revenue	Energy Consumption	Is High Climate Impact Sector	Energy
Energy Intensity Based on Net Revenue	Energy Consumption	Type of Purchased Energy	Energy
Energy Intensity Based on Net Revenue	Energy Consumption	Use of Energy	Energy
GHG Emission Intensity, Location-Based per Net Revenue	Amount	Allocation Method	Emissions
GHG Emission Intensity, Location-Based per Net Revenue	Amount	Emission Data Type	Emissions
GHG Emission Intensity, Location-Based per Net Revenue	Amount	Scope	Emissions

Continued on next page

Table C.1: Metrics and Emissions Data Table (continued)

Metric	Measure	Dimension	DPI
GHG Emission Intensity, Location-Based per Net Revenue	CO2e Emissions	Allocation Method	Emissions
GHG Emission Intensity, Location-Based per Net Revenue	CO2e Emissions	Emission Data Type	Emissions
GHG Emission Intensity, Location-Based per Net Revenue	CO2e Emissions	Scope	Emissions
GHG Emission Intensity, Market-Based per Net Revenue	Amount	Allocation Method	Emissions
GHG Emission Intensity, Market-Based per Net Revenue	Amount	Emission Data Type	Emissions
GHG Emission Intensity, Market-Based per Net Revenue	Amount	Scope	Emissions
GHG Emission Intensity, Market-Based per Net Revenue	CO2e Emissions	Allocation Method	Emissions
GHG Emission Intensity, Market-Based per Net Revenue	CO2e Emissions	Emission Data Type	Emissions
GHG Emission Intensity, Market-Based per Net Revenue	CO2e Emissions	Scope	Emissions
GHG Removals and Storage	CO2e Emissions	Activity Type	Emissions
GHG Removals and Storage	CO2e Emissions	Allocation Method	Emissions
GHG Removals and Storage	CO2e Emissions	Emission Data Type	Emissions
GHG Removals and Storage	CO2e Emissions	Emission Source Activity	Emissions
GHG Removals and Storage	CO2e Emissions	Energy Carrier	Emissions
GHG Removals and Storage	CO2e Emissions	Gas Type	Emissions
GHG Removals and Storage	CO2e Emissions	Is Biogenic Emission	Emissions
GHG Removals and Storage	CO2e Emissions	Removal Activity	Emissions
GHG Removals and Storage	CO2e Emissions	Scope	Emissions
GHG Removals and Storage	CO2e Emissions	Scope Subcategory	Emissions
GHG Removals and Storage	CO2e Emissions	Source Category	Emissions
GHG Removals and Storage	CO2e Emissions	Value Chain Stage	Emissions

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Table C.1: Metrics and Emissions Data Table (continued)

Metric	Measure	Dimension	DPI
Gross GHG Emissions - Scope 1	CO2e Emissions	Activity Type	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Allocation Method	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Emission Data Type	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Emission Source Activity	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Energy Carrier	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Gas Type	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Is Biogenic Emission	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Removal Activity	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Scope	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Scope Subcategory	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Source Category	Emissions
Gross GHG Emissions - Scope 1	CO2e Emissions	Value Chain Stage	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Activity Type	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Allocation Method	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Emission Data Type	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Emission Source Activity	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Energy Carrier	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Gas Type	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Is Biogenic Emission	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Removal Activity	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Scope	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Scope Subcategory	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Source Category	Emissions
Gross GHG Emissions - Scope 2, Location-Based	CO2e Emissions	Value Chain Stage	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Activity Type	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Allocation Method	Emissions

Continued on next page

Table C.1: Metrics and Emissions Data Table (continued)

Metric	Measure	Dimension	DPI
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Emission Data Type	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Emission Source Activity	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Energy Carrier	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Gas Type	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Is Biogenic Emission	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Removal Activity	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Scope	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Scope Subcategory	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Source Category	Emissions
Gross GHG Emissions - Scope 2, Market-Based	CO2e Emissions	Value Chain Stage	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Activity Type	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Allocation Method	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Emission Data Type	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Emission Source Activity	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Energy Carrier	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Gas Type	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Is Biogenic Emission	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Removal Activity	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Scope	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Scope Subcategory	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Source Category	Emissions
Gross GHG Emissions - Scope 3	CO2e Emissions	Value Chain Stage	Emissions
Percentage of Fossil Sources in Total Energy Consumption	Energy Consumption	Energy Source Type	Energy
Percentage of Nuclear Sources in Total Energy Consumption	Energy Consumption	Energy Source Type	Energy

Continued on next page

Table C.1: Metrics and Emissions Data Table (continued)

Metric	Measure	Dimension	DPI
Percentage of Renewable Sources in Total Energy Consumption	Energy Consumption	Energy Source Type	Energy
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Activity Type	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Allocation Method	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Energy Carrier	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	ETS Installation Type	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Gas Type	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Emission Data Type	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Emission Source Activity	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Is Biogenic Emission	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Scope	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Scope Subcategory	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Source Category	Emissions
Percentage of Scope 1 Emissions under Regulated ETS	CO2e Emissions from Regulated ETS	Value Chain Stage	Emissions
Renewable Energy Production	Energy Production	Energy Acquisition	Energy
Renewable Energy Production	Energy Production	Energy Carrier	Energy
Renewable Energy Production	Energy Production	Energy Source Type	Energy
Renewable Energy Production	Energy Production	Is High Climate Impact Sector	Energy
Renewable Energy Production	Energy Production	Type of Purchased Energy	Energy
Renewable Energy Production	Energy Production	Use of Energy	Energy

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Table C.1: Metrics and Emissions Data Table (continued)

Metric	Measure	Dimension	DPI
Total Energy Consumption	Energy Consumption		Energy
Total Energy Consumption from Renewable Sources	Energy Consumption	Energy Source Type	Energy
Total Energy Production	Energy Production		Energy
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Activity Type	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Allocation Method	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Emission Data Type	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Emission Source Activity	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Energy Carrier	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Gas Type	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Is Biogenic Emission	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Removal Activity	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Scope	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Scope Subcategory	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Source Category	Emissions
Total Gross GHG Emissions - Location-Based	CO2e Emissions	Value Chain Stage	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Activity Type	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Allocation Method	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Emission Data Type	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Emission Source Activity	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Energy Carrier	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Gas Type	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Is Biogenic Emission	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Removal Activity	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Scope	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Scope Subcategory	Emissions
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Source Category	Emissions

Continued on next page

Table C.1: Metrics and Emissions Data Table (continued)

Metric	Measure	Dimension	DPI
Total Gross GHG Emissions - Market-Based	CO2e Emissions	Value Chain Stage	Emissions

D

Interview Setup

In this study, semi-structured interviews were conducted with experts in ERP systems and emissions reporting from PwC and SAP. The purpose of these interviews was to gain insights into the key challenges and best practices for implementing emissions reporting within ERP systems, with a specific focus on CSRD and ESRS E1 requirements.

To ensure a structured interview process, a PowerPoint presentation was used, covering the following elements:

- **Introduction:** A brief personal introduction.
- **Interview structure:** Explanation of the structure and objective of the interview.
- **Data security and recording:** The Consent Form, in accordance with TU Delft guidelines, was discussed, and permission was requested to record the interview. The data from these interviews has not been included in this thesis due to its extensive length (over 40 pages).
- **Research context:** Explanation of the focus of this study, with an emphasis on ESRS E1 and emissions reporting. Additionally, key findings from Chapters 4 and 5 were briefly summarized.

Following this introduction, the interview commenced, consisting of four main sections. Within these sections, in-depth questions were posed depending on the interviewee's area of expertise. The responses to these in-depth questions were incorporated into the main analysis to strengthen the insights obtained.

This appendix outlines the structure of the interviews and the applied questionnaire, including distinctions in questions per expert group. This helps the reader understand how the interviews were designed and how the collected information contributes to answering the research questions.

D.1. Structure and Objective of the Interview Questions

The interviews were structured into four main sections, each addressing a specific aspect of emissions reporting in ERP systems. Within each section, questions were tailored to the expertise of the interviewee. This allowed for the collection of information from different perspectives, such as sustainability, technology, and business strategy.

A key characteristic of these interviews was their semi-structured nature, meaning that in addition to predefined questions, there was room for follow-up questions. This allowed experts to elaborate on their knowledge and experience, leading to a deeper exploration of practical challenges and possible solutions.

This chapter explains why certain questions were asked, their objectives, and how the responses contribute to answering the research questions.

Part 1. General Insights

The first part of the interview aimed to map out the background and experience of the interviewee. This was important to understand the perspective from which the expert answered subsequent questions.

Why these questions?

- To understand the expert's specific knowledge and experience related to the subject.
- To gain insight into their view of the current status of emissions reporting.
- To understand how companies currently approach CSRD and ESRS E1 compliance.

Specific questions:

1. Can you elaborate on your experience with emissions reporting and/or SAP systems?
2. What general trends do you observe in how companies handle emissions reporting, specifically within ESRS E1?

Expert-specific questions:

For the SAP ESG experts, two specific questions were asked. These experts could provide more details on the ESG Reporting Manager. The additional questions were:

1. Can you explain your experience in setting up the ESG Reporting Manager – CSRD and using SAP, in the context of emissions reporting?
2. How do you see the market development at this moment in the use of ERP systems such as SAP for ESG reporting?

Relevance to this study

This section of the interview provided context on how companies handle emissions reporting within ERP systems and how well they are prepared for ESRS E1 requirements. It helped identify knowledge and implementation gaps, which were later analyzed in the study.

Part 2. Specific Challenges

This section focused on the practical and technological challenges companies face when collecting and reporting emissions data.

Why these questions?

- To identify the key challenges companies currently face in collecting and processing emissions data.
- To uncover cross-sector challenges, such as data consistency, system integration, and internal collaboration.

Specific questions:

1. What do you see as the biggest technical challenges in collecting and reporting emissions data?
2. What do you see as the biggest organizational challenges in collecting and reporting emissions data?
3. Are there challenges in standardizing and comparing emissions data, both internally and externally?

Expert-specific questions:
For the SAP and ESG experts from PwC Germany, PwC Luxembourg, and SAP Netherlands, an additional question was included regarding the challenges of the ESG Reporting Manager.

1. What limitations are currently experienced with the current functionalities of ESG Reporting Manager and SAP?

Relevance to this study:
This section provided critical insights into the biggest obstacles companies face, which were directly used in Chapter 6 (challenges). The information from this section formed an essential basis for analyzing potential improvements and optimizations in ERP systems.

Part 3. Improvements

This section explored potential improvements in ERP systems and emissions reporting. This included both technological innovations and organizational changes that companies could implement.

Why these questions?

- To gain insight into which quantitative data points are difficult to collect from SAP SCT and how this can be improved.
- To identify areas for improvement in existing data processing procedures.

Specific questions:

1. Do you see added value in SAP as an ERP system for companies in supporting ESG reporting, specifically within the context of CSRD and ESRS E1?
2. What improvements would you like to see (potentially with the use of software) to better support companies in achieving completeness in data?
3. Which of the 19 metrics in SAP SCT do companies find most challenging to collect or complete? Please provide a Top 3.

Expert-specific questions:
For the SAP ESG experts, specific questions were formulated that focused more on the ESG Reporting Manager than SAP in general.

1. Are there any specific features within ESG Reporting Manager that you think could be better utilized by companies to achieve ESRS E1 compliance?
2. What improvements, if any, would you like to see in ESG Reporting Manager or other SAP Modules to better support companies in achieving completeness in data?

Relevance to this study:
These questions helped identify concrete improvement points, which were directly used in Chapter 7 (best practices and improvements). This provided valuable input for the roadmap in Chapter 8, where a step-by-step plan was presented.

Part4. Recommendations

The final section focused on successful case studies and strategic recommendations for companies.

Why these questions?

- To gather best practices from companies that have successfully implemented emissions reporting via SAP.
- To develop concrete recommendations for companies preparing for CSRD and ESRS E1 compliance.

Specific questions:

1. Can you share examples of companies that have successfully implemented emissions reporting (via SAP)?
2. What strategies or approaches have they applied?
3. What steps should companies take to more efficiently collect and report emissions data?
4. What would you consider a good step-by-step approach for companies to effectively use ERP systems to comply with ESRS E1 requirements?

Expert-specific questions:
PwC experts specializing in CSRD and ESRS requirements in the Netherlands were asked about their vision for the future of data collection and emissions reporting, as well as the role PwC could play.

For SAP ESG experts, the focus was again placed on the ESG Reporting Manager, as seen in the second question below.

1. What role can consultants, such as those from PwC, continue to play in guiding companies in data collection and emissions reporting?
2. Are there already examples of companies that have successfully used the ESG Reporting Manager for emissions reporting? What were their success factors?

Relevance to this study
This section directly contributed to the roadmap in Chapter 8, which developed a 12-step plan for companies implementing emissions reporting via ERP systems.