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IMPACT OF MANAGEMENT PRACTICES ON GREENHOUSE GAS EMISSIONS IN THE CHEMICAL INDUSTRY

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Abstract. This article provides insights on how management practices impact greenhouse gas (GHG) emissions in the chemical industry. Semi-structured interview results revealed that management practices such as business strategy, top management commitment, cross-functional employee engagement, functional units tasked with GHG reduction and supply chain management influence GHG emissions indirectly through other factors. The study aims to investigate interlinkages between these factors, while also identifying moderating factors such as pressure from customers, the cost of greener produced products, financial benefits, nuances of production processes and workforce competencies. These findings highlight the complexity of elements affecting GHG emission reduction prioritization and implementation in the chemical industry companies. A conceptual model is presented to summarize the findings.

Keywords: GHG emissions, chemical industry, decarbonization management.

JEL Classification: Q56.

1. Introduction

To avoid the dangerous impacts of climate change, it is inevitably necessary to reduce greenhouse gas (GHG) emissions in all sectors of the global economy.

Model trajectories of pollutant emissions show that to limit warming to 1.5 °C, the amount of GHG's in 2050 must be reduced to zero (Intergovernmental Panel on Climate Change, 2018). The issue of emission reduction is highly relevant to the chemical industry both globally and regionally as this sector accounts for 7% of global GHG emissions (World Economic Forum, 2023). The chemical industry consumes about 28% of all energy produced in the industry and about 10% of global final energy (Fiorentino et al., 2019). It is estimated that by 2030 global chemical production will double compared to the year 2020 (European Commission, 2020), making specific actions necessary from both a technological and business management perspective to reduce GHG emissions.

Most scientific articles which intersect the chemical industry and GHG reduction provide insights into the importance of improving energy efficiency in production processes and transitioning to renewable energy sources (Fiorentino et al., 2019; Zuberi & Patel, 2018).

This is reasonable, as a large share of GHG emissions in chemical product manufacturing result from energy use in processes (European Chemical Industry Council, 2024). Improving energy efficiency alone cannot enable companies to achieve the required level of GHG reductions, and the use of renewable energy alone is also insufficient for hard-to-abate industries such as the chemical sector (Broeren et al., 2014). In the chemical industry, GHG emissions are largely driven by the need to use high-temperature heat and fossil fuels as raw materials, for example in processes like plastic production. Therefore, to achieve GHG reduction, it is necessary to combine carbon-free energy supply with CO_2-neutral carbon-based raw materials and seek other management solutions (Gabrielli et al., 2023). However, limited scientific literature examines the reduction of GHG emissions in the chemical industry from a managerial perspective.

Achieving transformational changes to meet carbon reduction goals requires the chemical sector to adopt new solutions and effective management practices. However, the role and applicability of managerial measures in influencing emissions remain insufficiently explored. Therefore, this study addresses the following research question:

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– How do the management measures applied in chemical industry companies affect the reduction of GHG emissions?

This paper aims to provide a new perspective on how the application of management practices can directly or indirectly contribute to reducing GHG emissions in the chemical industry. The study identifies key managerial practices that support emission reduction efforts and highlights their role in addressing environmental challenges within chemical industry organizations. By linking environmental issues with management science, this research contributes to the growing body of literature on corporate climate action and provides a basis for further studies exploring managerial approaches to GHG emission reduction.

In this paper an overview of the available management practices for GHG emissions reduction in the chemical industry is provided in literature review (Section 2), research methods are described in Section 3. The findings from the interviews are presented in Section 4, the conclusions of this study are discussed in Section 5 and Section 6 discusses limitations and areas for future research.

2. Literature review

Reducing greenhouse gas (GHG) emissions refers to human interventions that reduce the sources of GHGs or enhance their sinks, through actions such as energy efficiency improvements, increased use of renewable energy, carbon capture and storage, or changes in industrial processes (Intergovernmental Panel on Climate Change, 2014). This process is not isolated but involves a coordinated sequence of interconnected steps, including planning, initiation, execution, monitoring, and control. Consequently, the successful deployment of technological measures to reduce GHG emissions depends on the application of suitable management strategies and methodologies (Lewandowski & Ullrich, 2023). Emissions management practices are systematic tools and practices that organizations use to methodically monitor, manage, and reduce GHG emissions (Sullivan, 2009; U.S. Environmental Protection Agency, 2024). These measures help companies identify sources of pollution, setting reduction targets and implementing effective mitigation strategies. With increasing requirements related to GHG emissions, company representatives need sufficient information, adaptability and appropriate tools to be able to transform their businesses towards carbon neutrality (Alves et al., 2017).

Reducing GHG emissions in the chemical industry requires the use of diverse management tools, reflecting the need for systemic approaches. To achieve meaningful emission reductions, companies must ensure top management commitment, align business strategies, apply circular economy principles, foster employee engagement, establish organizational units directly responsible for GHG management and actively manage supply chain (Jeswani et al., 2007; Lozano, 2012; Leppelt et al., 2013; Dixon-Fowler et al., 2017; Cucciniello & Cespi, 2018; Dahlmann et al., 2024; Mobarakeh & Kienberger, 2025). This study investigates not only how these management measures affect GHG reduction in chemical industry companies but also how the measures are interdependent and function as a connected system.

3. Methods

This study employs a qualitative methodology, as quantitative data on GHG reduction in the chemical industry from a managerial perspective remains limited. To explore how management measures contribute to emission reduction, semi-structured interviews were conducted with representatives of chemical industry companies to gather insights relevant to the research question. Qualitative content analysis was conducted using MAXQDA Analytics Pro 2022. Interview data were categorized into subcategories to identify key concepts and their relationships (Tamaševičius, 2015).

The interviews were conducted in March 2025.

Research instrument. A questionnaire was developed to ensure that all topics necessary to achieve the research objectives were covered during the semi-structured interviews (see Appendix). Semi-structured interviews followed basic guidelines while allowing additional questions to emerge, deepening understanding of the research topic (Adeoye-Olatunde & Olenik, 2021). Questions on the impact of management practices on emission reduction were derived from a review of the scientific literature. The main managerial measures were summarized in Chapter 2 of this article.

Participants. Participants were selected using a non-random sampling method, based on characteristics relevant to the study. The target group comprised experts in chemical industry companies holding positions related to GHG emissions management, environmental protection, or sustainable development, with a minimum of three years of professional experience. The study initially

Table 1. Characteristics of the study participants

Code of Expert	Education	Position	Work Experience (years)
R1	Social sciences	Sustainability manager	12
R2	Chemical engineering	Corporate responsibility manager	18
R3	Environmental engineering	ESH manager	12
R4	Chemical engineering	Process improvement manager	11
R5	Energy engineering	Manufacturing technical manager	26
R6	Chemical engineering	Environmental and manufacturing technology expert	25

aimed to interview 10–12 experts, gradually adding participants until information saturation was reached. The planned number of experts was not achieved, as some potential participants declined to comment on the topic. Despite this, in-depth perspectives were obtained from 6 experts across 5 companies, providing valuable insights into management measures for GHG reduction in the chemical industry. The respondents' professional experience ranged from 11 to 26 years in the field of sustainability or environmental management. Table 1 presents the detailed characteristics of the study participants.

4. Results and discussion

In this section expert insights are integrated and if any new measures are discussed during the interviews, they are included in the appropriate categories. External factors having influence on management practices are briefly addressed within each subsection.

4.1. Business strategy

Achieving positive results in reducing GHG emissions from chemical industry companies requires transformational changes, which can be achieved by developing integrated strategies (Mobarakeh & Kienberger, 2025). The experts' responses were divided into 3 subcategories based on content, revealing how business strategy influences GHG emission reduction.

Setting goals and planning actions. The way strategies enable achieving the desired emissions reduction is by including specific goals and action plan into the strategies (R2: "<...> our climate-related transition plan is an action plan that clearly sets the company's climate strategic goals, actions and resources for shifting toward lower carbon operations"; R3: "<...> the goals and level of goals <...> come from the strategy. A strategy without its implementation is meaningless").

Strategies must be precise enough to clearly reflect areas for improvement and enable the fulfilment of targets: R4: "<...> the strategy highlights the areas where we aim for improvements. Of course, there are also exact goals. The targets are aimed at direct emissions (Scope 1, 2) and indirect emissions (Scope 3)". When planning the direction of the strategy, it is necessary to examine the company's ability to continue operating in terms of the market, finance, as well as the impact on the environment. Therefore, team-based strategy development can provide a comprehensive understanding of the company's current business position and long-term future.

Feasibility of strategy and practical implementation. Clarity for strategic planning comes from appreciation of organizational abilities. Experts emphasized that for successful strategy implementation, it is necessary to set goals that correspond to the company's capabilities (R3: "<...> it is better to achieve less but in accordance with what is set"; R5: "<...> you can have any strategy you want but the output is either produced or absent. For example, if the raw materials come from Africa and that is the only material at hand they must still be processed and manufactured"). It can be emphasized that the appropriate indicators for assessing goals and objectives could be successfully employed to measure progress, reveal problems and adjust business strategies (Cunha et al., 2023).

Action through investments and technologies. Strategies to reduce GHG emissions often involve large capital investments. While these investments in technologies are essential to achieve long-term carbon neutrality, financial barriers make their widespread implementation difficult. The implementation of technologies such as green hydrogen, low-carbon industrial heating systems, electrification processes and infrastructure renewal was highlighted by experts as key technological elements to achieve the goals set in the strategies (R1: "<...> company had a plan to install a green hydrogen production facility. The project was stopped while in the development stage due to changes in the certification requirements for green hydrogen in the EU. The company also plans to switch from natural gas to highly efficient steam and heat production using green heat module technology. So, the main measures that would help reduce CO_2 by approximately 50–90% are included in the business strategy"; R5: "<...> a lot of investment has been made for a long time already to utilize waste heat"). The ability to adopt such technologies is largely determined by the company's financial strength, given that chemical industry projects are extensive and financially demanding (R1: "<...> we had huge investments in production facilities and storage methods such as hourly electricity metering. Changing the production process requires large investments in new infrastructure: both electricity equipment and energy itself. Overall, it brings many challenges."; R6: "<...> but when it comes to goal implementation, strategy alone is not enough. Everything relies on finances and whether a company can allocate resources for it. Perhaps the most practical goal in the strategy is energy saving because in this way we also save resources in general"). Strategies aimed at pollution prevention, energy savings and the use of cleaner technologies can lower production costs (Barba-Sánchez & Atienza-Sahuquillo, 2010). Consequently, investments should be assessed from both environmental and economic perspectives.

Overall, business strategy plays a crucial and complex role in determining the reduction of GHG emissions in the chemical industry. Although strategies define essential directions, their effectiveness largely depends on external and internal factors. Business strategies play a key role in reducing GHG emissions through goal setting and action planning. It is important for companies to consider both the practical feasibility and the real-world implementation of their strategies while successful implementation depends directly on available investments and technologies. Moreover, experts added that the formation of strategies is influenced by the following external factors: legal regulation, availability of raw materials and energy prices.

4.2. Top management commitment

Management commitment to reducing GHG emissions means the active involvement of leaders and decision makers in developing, implementing and promoting strategies to reduce the organization's emissions. This includes setting clear climate targets, integrating sustainability into core business strategies, allocating resources, monitoring performance and promoting a culture of accountability and innovation at all levels of the organization (Lozano, 2012).

Based on the content of the experts' responses two subcategories were identified highlighting how management commitment influences GHG emission reduction.

Establishing objectives and priorities through active employee participation. One of the key responsibilities of top management in the field of emissions reduction is to define strategic goals and priority areas. Management is also responsible for progress and assessing the company's current position regarding emissions performance. To effectively monitor change, it is essential to track clearly defined and measurable indicators. (R4: "<...> Through goals, results and monitoring indicators set by top management, it is possible to assess the company's current situation and understand where it stands in terms of emissions performance. However, the final decisions regarding priorities—what the organization is striving for and what are the ultimate goals—remain the responsibility of management"). Management commitment is therefore understood as the ability to influence emissions reductions by mobilizing employees around shared objectives and by clearly defining priorities (R1: "<...> Agreeing on where we will focus and what employees themselves should be engaged in, such as identifying key opportunities, implementing additional technologies and developing green steam solutions"); R2: "<...> Management must also direct the organization's emotional momentum toward achieving defined goals, establish clear long-term objectives and continuously motivate employees. Maintaining management commitment over the long term is particularly important to ensure sustained progress toward emissions reduction." Management's influence on employees in achieving environmental goals is critical, as managers' technical skills and competencies have a positive effect on employees' innovative behavior in the workplace (Van Minh et al., 2017).

Integrating strategy into business processes. One of the most challenging tasks for management is the effective integration of strategy into business processes. In this context, clear communication of goals across different departments is essential as it supports more effective production planning, process optimization and purchasing activities. According to experts, these efforts are closely linked to project financing and return on investment. (R3: "Investment into projects depends on management commitment"; R4: "<...> the task of management is to measure and compare decision-making with profitability"). Also, top management must be able to assess the risks associated with the implementation of emission reduction projects and be guided by reasonable decisions, foreseeing consequences the projects could have. (R1: "The most difficult thing is to find finances for the practical implementation of the goals set by management"). Management commitment is one of the essential internal factors acting as a driving force in companies to achieve GHG emission reduction goals (Jeswani et al., 2007).

Experts, answering the question of how top management commitment affects GHG emissions, added that regulation as an external factor influences how top management is committed to GHG emissions reduction: (R1: "<...> management engagement is encouraged by EU regulations and the Green Deal objectives – everything is related to regulation").

In summary, top management commitment holds decisive authority in the implementation of emission reduction initiatives and without active top management engagement, companies face significant challenges in achieving successful emission reduction outcomes. Such commitment is a necessary condition functioning through the establishment of clear objectives and priorities actively engaging staff and the integration of the strategy into business processes. This adds up to findings of Eleftheriadis and Anagnostopoulou (2017) that management commitment to environmental issues has a positive impact on companies' strategic commitments in this area, but actual results depend on how these commitments are integrated into the organization's risk management and operational processes.

4.3. Fostering employee engagement

Based on content analysis, the experts' responses were categorized into three subcategories, revealing the mechanisms through which employee engagement influences GHG emission reduction.

Monitoring of operational efficiency. Experts revealed that employee engagement most frequently influences emissions through energy efficiency initiatives and equipment modernization aimed at reducing resource consumption: R1: "<...> when it comes to smaller projects requiring lower investment, employees propose energy efficiency measures and equipment upgrades to reduce resource use. This has been implemented for a long time already". Similarly, another expert emphasized that "employees are communicated in clear terms and encouraged to engage in improving inefficiencies. The technical department has significant influence on electricity consumption through monitoring and observing inefficient use" (R4).

According to the experts, however, it is difficult to define the impact of employee engagement on emission reduction. R3: "The impact differs and depends on job position. Therefore, it is very important to generate a large number of suggestions from employees because among many insignificant proposals there may be one with a very substantial effect on emission reduction. The impact is difficult to assess and results require patience;

nevertheless, it is crucial to allow employees to present their ideas".

Cross-functional engagement. All experts expressed a consistent view that employee engagement must be organization-wide, as collaboration across departments and functions constitutes a necessary condition for achieving defined emission reduction targets: (R1: "Both production employees and the sustainability team must be involved"; R3: "Employees are asked to identify the problem and to share their perspective; they are not required to provide the technical solution. It is the responsibility of the technical departments to solve the issue and management's task is to secure financing").

Furthermore, it was highlighted that different departments assume responsibility for distinct emission-related domains (R4: "<...> the procurement department monitors raw material availability and evaluates transportation-related aspects while sales can engage with clients in educating and persuading customers on emission-related topics. R1: "<...> work must proceed in all directions; however, without top management engagement and sustained leadership attention to the topic, progress is unlikely). Additionally, employees directly involved in operational processes often have greater insights for efficiency improvement opportunities than administrative personnel (R5: "If fuel is saved within processes, this directly affects GHG emissions"). Some studies support these findings, indicating a significant positive relationship between employee inclusion, diversity, employee development and an organization's environmental performance (Suárez-Fernández et al., 2024). In addition, by ensuring that the strategy is clear, consistent, and inclusive, companies empower employees to take meaningful action to reduce emissions (Salter, 2009).

Employee competencies. Although the significance of employee engagement for GHG emission reduction is difficult to assess directly and in the short term, the experts emphasized that employee competencies play here a substantial role (R3: "The significance of employee proposals and engagement largely depend on their level of competence in this area"; R4: "Competence is critically important, particularly in the context of employee turnover. Employees including the management team must take training to understand the subject matter as it is not a simple topic"). Initiatives aimed at implementing low-carbon technologies and solutions are more likely to materialize in organizations where employee competency is of high importance (Kocot et al., 2024).

In summary, employee engagement contributes to the reduction of GHG emissions primarily through the optimization of operational processes, particularly energy efficiency improvements. Cross-functional engagement was identified as a critical element, as collaboration across departments and functions constitutes a necessary condition for achieving established emission reduction targets. Employee competence also represents an important role of how much impact engaged employees can have in emission reduction objectives.

4.4. Organizational units directly responsible for GHG reduction

An environmental committee on the company's board can have a particularly positive impact on achieving environmental goals (Dixon-Fowler et al., 2017). On the other hand, the position of the company's sustainability manager is viewed in two ways in the literature: some studies confirm that the sustainability manager can influence better environmental performance of the company due to their understanding and commitment to this area (Thun & Zülch, 2023), while other researchers argue the opposite—that the importance of sustainability managers for environmental commitment may be only symbolic (Kanashiro & Rivera, 2019; Peters et al., 2019).

Based on content analysis, the experts' responses were categorized into three subcategories, revealing the mechanisms through which organizational units responsible for GHG reduction influence emissions.

Data collection and systematization. Experts indicated that employees directly involved in GHG emission management make a significant contribution to data collection and systematization. Specialists responsible for emission management, the collection, analysis and presentation of emission-related data are of critical importance. R4: "Everyone in the company is responsible for generating emissions. However, there is a person who collects and systematizes the information, organizes processes to ensure that everything runs smoothly and works more closely with data and proposals regarding areas for improvement". R5: "These colleagues monitor emissions, provide reports and issue warnings when certain thresholds are approached". An internal organizational structure dedicated to the management of GHG reduction projects is associated with the capabilities that a company must develop to effectively promote actions aimed at GHG emission control (Renukappa et al., 2013).

Coordination and support of operational areas. Experts emphasized that the efforts of organizational units alone are insufficient to achieve emission reduction targets. One of the key elements identified was the importance of interdisciplinary collaboration: the involvement of all company employees is essential rather than limiting responsibility to specific positions directly involved in GHG reduction projects (R1: "The agreement on priorities is reached within the team. For example, some projects are postponed and engagement may be parallel"; R1: "Both production employees and the sustainability team are involved in projects"; R4: "Different departments will still be responsible for different emission related areas. However, there must be a person who coordinates the process, gathers information and ensures ongoing support").

Environmental initiatives often require multi-level coordination across different organizational layers as such initiatives compete internally with other strategic business areas that demand investment and resources (Aguilera et al., 2021).

Convincing management and influencing management decisions. Although the responses suggest that employees in environmental or sustainability departments often do not have formal authority to make decisions, the power of structural units is noted through their expertise and ability to influence senior leadership on strategic emissions reduction priorities (R3: "<…> the power of structural units lies in persuading management that achieving emissions reduction targets is important and necessary for the company. Employees can shape and have a significant influence on management decisions on this matter"; R6: "<…> sustainability managers prepare strategies and present them to top management, aiming to reduce emissions and ensure compliance with global reporting standards").

Based on these expert comments, it can be concluded that individuals working in positions responsible for GHG emissions reduction cannot be considered the only employees able to influence emissions. However, such structural units and positions in chemical industry companies are important because they integrate information, collect data, can provide insights to other departments regarding emissions reduction and monitor progress. Another important aspect of how structural units responsible for GHG management influence emissions is influencing management decisions that affect achieving these targets.

It is proved that the existence of sustainability positions, the number of board members and their level of independence in companies have a positive effect on orientation toward more environmentally friendly business strategies (De Villiers et al., 2011).

4.5. Application of circular economy principles

Based on content analysis, the responses were categorized into 2 subcategories, revealing how the application of circular economy principles impacts GHG emission reduction.

One of the main ways circularity is applied in the chemical industry includes changing the type of energy used by purchasing more green energy and acquiring raw materials with a lower emissions impact. The reuse of waste energy was highlighted as having a significant positive effect on emissions reduction. Additionally, the use of secondary raw materials through collaboration within the supply chain (with organizations that require the waste as raw material) was mentioned. However, such use of secondary materials must comply with legal regulations, which can be challenging (R1). The use of secondary raw materials offers significant potential in the plastics sector of the chemical industry where technological possibilities to increase plastic circularity are being intensively explored (Cucciniello & Cespi, 2018).

Specificity of production processes. The application of circular economy principles can be integrated into the production process if the specifics of the production activity allow it (R3: "<…> To minimize losses, technological solutions are needed—everything through the latest technologies, strategies and management tools"). For some experts circularity was emphasized as one of the priority goals but requiring certain production technologies (R4: "<…> circularity is one of the priority areas, especially for large corporations. It is the ideal target everyone strives for. To minimize losses, technological solutions are required, everything to be achieved through the latest technologies"). Other experts noted that, due to the specific nature of their production processes, applying circular economy principles is extremely difficult or almost impossible (R2: "<…> there is little circularity due to the specifics of the production processes, yet we try to reduce emissions in other ways").

Economic value. A very important factor determining whether a company applies circular economy principles is the financial gain (R1: "<…> green production has a higher cost, which is later reflected in the final product price"; R3: "…Companies must choose—to use more sustainable raw materials or cheaper ones. The decision is imposed on the company by external circumstances, rather than chosen freely"). Economic payback also influences investments in lower-emission energy sources (R5: "<…> our main way of implementing circularity is through the reuse of waste energy. This arose due to economic reasons. When energy use is minimized, emissions drop leading to a reduced need for emission allowances").

Analysis of the responses indicates that circularity is integrated into company operations if emissions reduction results are economically viable and in many cases economic return is given more weight than the idea of sustainability alone. By implementing circular economy principles, chemical industry manufacturers can reduce resource consumption and optimize economic resources (Cucciniello & Cespi, 2018).

4.6. Supply chain management

Research shows that European chemical companies invest heavily in building sustainable relationships with suppliers in order to manage sustainability even beyond their own company boundaries (Leppelt et al., 2013). However, it is challenging for chemical companies to integrate supply chain management into their sustainability strategies (Shohan et al., 2019). Based on content analysis, the experts' responses were categorized into three subcategories, revealing the essential aspects.

Raw materials supply. Emissions from the supply chain are significantly influenced by decisions related to the supply of raw materials, in particular transport distances and modes of transport (land, sea, or rail). However, the amount of GHG emissions associated with transport is not yet a dominant criteria in decision-making – economic costs are one of the main factors (R1: "<...> it is possible to purchase raw materials produced using carbon capture technology but green production has a higher price which turns into higher price of the final products"; R3: "<...> emissions in the supply chain depend on the company's strategy—where do the raw

materials come from and where the final products are sold. The geographical location and access to infrastructure have a significant impact on Scope 3 emissions"; R5: "<...> the purchase of raw materials and how they are transported along with the transportation of the final product have the greatest impact"). R3: "These conditions limit companies' ability to make flexible decisions and freely choose transportation alternatives which affect transportation related emissions".

Higher prices for greener manufactured products. Efforts to decarbonize supply chains often increase production costs. This increases the final price of the product and changes the conditions of competitiveness (R1: "<...> decarbonization of the chemical industry has a significant impact on the final price of products. Ensuring competitiveness in the EU on the path to climate neutrality – there are too little incentives. End users often buy the cheapest fertilizers (or other chemical products, respectively) in order to remain competitive in the market. There is a lack of buyers in the final chain who would be interested in purchasing green products at a higher price. It is difficult for European chemical industry players to compete with imported fertilizers (or other chemical products, respectively) given the EU requirements to decarbonize and reduce emissions"; R5: "<...> the transport of raw materials and products have an impact. Most companies look at the economic side and do not consider whether this may affect emissions. If a mode of transport is cheaper, they will choose it without considering the emissions generated").

Implementation of innovation and circular economy principles. According experts, the application of circularity principles is a good practice that can help reduce emissions throughout the supply chain if a systematic approach is taken and trust is placed in other stakeholders (R4: "<...> technological solutions are changing in the supply chain, e.g., the recycling of secondary raw materials will soon be possible not only physically but also chemically. This makes the use of secondary raw materials easier and their use will likely increase while reducing emissions in the supply chain. We seek such innovations, participate in joint projects, conduct pilot studies together and engage in scientific innovation projects"; R5: "If a secondary raw material is unsuitable for us, we sell it to another company (e.g. defective material becomes raw material)". Closed-loop supply chains can contribute to GHG emissions reduction; however, they are currently difficult to implement, requiring strong supply chain management and the involvement of a broader business ecosystem (R1: "<…> For example, in Lithuania, storing coal underground has been banned since 2019. Yet CO_2 capture and utilization has its importance: once purified, it can even be used in the food industry—as carbon dioxide in beverages. However, most of the captured CO_2 have nowhere to go. Whereas export is extremely expensive." The application of circularity principles is also influenced by regulations (R3: "<…> Waste can become a secondary raw material if it complies with legal requirements, yet this is challenging"). Pressure from customers acts as an incentive to achieve emission reduction targets (R6: "<...> external pressure comes from customers, they inquire about our climate targets and sometimes depending on this you can lose a customer"). Engaging suppliers require considerable effort, investment, and internal approval within the company; however, collaborative stakeholder processes can generate learning and feedback effects that facilitate broader climate action among participating actors (André et al., 2023). It is also revealed that better supply chain coordination practices, value chain awareness, and greater supplier involvement in supply chain GHG analysis lead to a relative decrease in GHG emissions in area 3 in the long term (Dahlmann et al., 2024).

The experts' responses also reveal that supply chain management is influenced by the following external factors: legal regulation, globalization, and geopolitics.

Supply chain management has a significant impact on GHG emissions mainly through raw material procurement and sales of final products. The higher price of greener manufactured products has a negative impact on efforts to reduce GHG emissions. Whereas globalization and geopolitical challenges limit the influence of companies in reducing emissions. Nevertheless, there are areas where companies can have a positive impact on the supply chain: the application of circular economy principles and innovations can stimulate companies to reduce both their own emissions and those generated by their supply chain. The key aspects of how management practices influence GHG emission reduction are summarized in Table 2.

Table 2. Summary of the factors through which management practices affect GHG emissions

No.	Management practice	Factors
1.	Business strategy	Setting goals and planning actions
		Feasibility of strategy and practical implementation
		Action through investment and technologies
2.	Top management commitment	Establishing objectives and priorities through active employee participation
		Integrating strategy into business processes
3.	Fostering employee engagement	Monitoring operational efficiency
		Cross-functional engagement
		Employee competencies
4.	Organizational units directly responsible for GHG reduction	Data collection and systematization
		Coordination and support of operational areas
		Convincing management and influencing management decisions

End of Table 2

No.	Management practice	Factors
5.	Application of circular economy principles	Specificity of production processes
		Economic value
6.	Supply chain management	Raw materials supply
		Higher prices for greener manufactured products
		Implementation of innovation and circular economy principles

Based on the results of the study, a model of the impact of the application of management measures on GHG emissions was developed, which is presented in Figure 1.

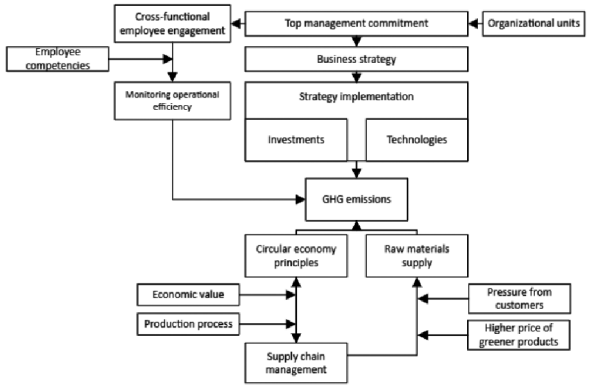

Figure 1. Conceptual model of the impact of management practices on GHG emissions

5. Conclusions

This study analyzes how management practices in particular: business strategy, top management commitment, fostering employee engagement, organizational units for GHG reduction, application of circular economy principles and supply chain management affect GHG emissions in the chemical industry. Results showed how these practices are interrelated determining the managerial mechanism of GHG emissions reduction.

Top management commitment affects GHG emissions through business strategies, which in turn have an impact on GHG emissions through investments and technologies. This link works together, where strategy indicates the direction of action and investments in technologies define the technological solutions by which strategic goals will be implemented. Cross-functional employee engagement influences GHG emission reduction through performance monitoring. The impact of this influence depends on employee competence (moderating factor). The organizational units responsible for reducing GHG emissions influence the commitment of top management. However, employees responsible for systemizing GHG related data and coordinating the areas of activity have the expert power to influence management decisions and provide guidance on the feasibility of the targets set. By monitoring performance indicators and coordinating activities, these employees help manage GHG emissions and contribute to the implementation of the strategy. The application of circular economy principles has a direct impact on reducing GHG emissions. The impact of this measure depends on the economic value it brings and the specifics of production processes (moderating factors). The application of circular economy principles has a reciprocal effect with supply chain management. The possibilities of applying circularity strongly depend on the cooperation of stakeholders operating in the supply chain. Supply chain management impacts GHG emissions through the purchase of raw materials. The impact of this management practice is influenced by the price of greener produced products and pressure from the customers (moderating factors).

In order to achieve the goals of reducing GHG emissions, it is proposed that chemical industry companies should strive for cross-functional employee engagement and ensure employee competence in this area. It is proposed to develop integrated business strategies with goals that correspond to the real capabilities of the company, based on the monitoring of company performance indicators and taking into account the possibilities of investing in technologies with a lower carbon footprint. This study suggests looking for opportunities to apply the principles of the circular economy in cooperation with other interested parties in the supply chain.

6. Limitations and areas for future research

During the literature review, it was challenging to identify which management measures for GHG reduction are most applicable to the chemical industry. Consequently, some important but less-studied management measures may not be captured. The relatively small number of experts limits the completeness of the findings. Future research could build on this study by conducting quantitative analyses to verify the relationships and their strength. Additionally, examining external factors such as legal regulations, raw material availability, energy price fluctuations, globalization and geopolitical dynamics would provide a broader understanding of the implementation of managerial measures for GHG reduction.

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APPENDIX. Interview questionnaire for experts working in the chemical industry

1. What management practices do you apply in your company to reduce GHG emissions? How do these tools contribute to reducing emissions?

2. How are GHG reduction goals stated in business strategies reflected in specific company activities? How does this contribute to reducing emissions?

3. How do the circular economy principles applied in the company (circularity of chemical processes and material use, recycling of raw materials/products) contribute to emission reduction?

4. How does top management commitment influence GHG reduction?

5. How does employee engagement influence emission reduction?

6. What decision-making power do the structural units (positions, departments, working groups, committees, etc.) responsible for GHG reduction have? How does this affect emission reduction?

7. How does supply chain management influence GHG reduction?