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Shaping Sustainability Strategies: A Comprehensive Analysis of Greenhouse Gas Reporting in the Oil and Gas Sector and its Strategic Implications

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Abstract

The oil and gas (O&G) industry is one of the major contributors to greenhouse gas (GHG) emissions. Some companies voluntarily disclose their carbon footprint and environmental impact in their annual sustainability reports. We investigate the emission targets, reporting boundary used, and the scope of emissions reporting by eight O&G companies, ranging from large multinational firms to smaller regional companies. There is a lack of comparability in emission reporting, especially concerning emissions across the value chain (also known as Scope 3, in which the use of sold products is the largest category). A Strength, Weakness, Opportunities, and Threats (SWOT) analysis is conducted to unpack companies' motivations in reporting the value chain emissions. This research contributes to the limited literature on the comparability of emissions reporting of the O&G industry. Our study creates an inventory of GHG emission reporting of O&G companies, highlighting the need to harmonize reporting practices to facilitate comparability and enable informed decision-making by stakeholders. This thesis aims to inform reporting practices, align targets, and enhance transparency. The findings promote accountability and progress towards a sustainable energy future.

Keywords: GHG emissions; Oil and Gas Companies; Net Carbon Intensity; Value Chain

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Contents

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

BP	British Petroleum
CAT	Climate Action Tracker
CCS	Carbon Capture and Storage
CDP	Carbon Disclosure Project
CI	Carbon Intensity
ESG	Environmental, Social and Governance
EU ETS	European Union Emission Trading Scheme
GHG	Greenhouse Gas
GHGRP	Greenhouse Gas Reporting Program
GRI	Global Reporting Initiative
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
IEA	International Energy Agency
IOCs	International Oil Companies
IPCC	Intergovernmental Panel on Climate Change
ISSB	International Sustainability Standards Board
LCFS	Low Carbon Fuel Standard
NCI	Net Carbon Intensity
NGO	Non-governmental Organisation
NOCs	National Oil Companies
O&G	Oil and gas
OGCI	Oil and Gas Climate Initiative
PFC	Perfluorocarbon
PPA	Power Purchase Agreement
RECs	Renewable Energy Certificates
RQ	Research Question
SBTi	Science-based Target Initiative
SWOT	Strengths, Weaknesses, Opportunities and Threats
TCFD	Task force on Climate-related Financial Disclosures
3BL	Triple Bottom Line

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Introduction

1.1 Background

Climate change is one of the most urgent and pressing issues of our time, and it requires immediate action from all sectors of society. More than 110 countries responsible for nearly 65 percent of the global greenhouse gas (GHG) emissions have pledged to be carbon neutral by 2050 to limit the global increase in temperature well below 2 degrees Celsius [7]. GHG emissions are a major contributor to climate change [8], as these gases trap heat in the atmosphere, leading to a rise in Earth's temperature. This can lead to a range of negative impacts, including sea level rise, more frequent and severe weather events, and loss of biodiversity [9, 10]. To address these concerns, industries started reporting GHG emissions to identify and quantify their major emissions and accurately monitor progress toward emission reduction targets. Governments rely on accurate emissions data to set national targets, making it all the more important for companies to report their emissions accurately and transparently.

Firms have a variety of reasons for reporting their GHG emissions. The main reason is regulatory compliance. Under certain schemes, such as the European Union Emission Trading Scheme (EU ETS), businesses that exceed certain GHG emission thresholds must report them as part of their compliance obligation under this scheme. Under the US Greenhouse Gas Reporting Program (GHGRP), large emitters such as power plants, refineries, and industrial facilities must report their GHG emissions. Outside the realm of regulatory compliance, companies may voluntarily report their GHG emissions for other reasons. Reporting emissions has become an essential practice and way for businesses to demonstrate their dedication to environmental stewardship and sustainability. Reporting emissions can help companies to identify opportunities to cut emissions and streamline operational efficiencies resulting in cost savings and improved environmental performance [11]. Notably, stakeholders and investors have grown more concerned with how businesses perform on environmental matters in recent years; open reporting can build their confidence and support [12]. Furthermore, some companies may require suppliers to report emissions as part of their supply chain management processes to identify opportunities for emissions reductions and manage supply chain risk more efficiently [13].

Oil and gas (O&G) companies are among the largest and most powerful players in the global energy market, accounting for roughly 15% of global emissions from

human activities [14]. Despite growing interest in renewable energy sources, fossil fuels remain dominant in meeting global energy demand, accounting for over 80% of global primary energy consumption in 2020 [15]. The production and use of oil and gas also have other significant environmental impacts. Given the urgent need to address climate change, O&G companies have a responsibility to take action to reduce their emissions and to support efforts to transition to a low-carbon energy system. With new regulations such as the Fit for 55, strategic frameworks like the European Green Deal, and national-level targets and policies, the O&G sector is continuously evolving its emission reduction targets, reporting criteria, and emission categories. Consequently, there is a need for updated research to closely examine the disclosure practices and performance of O&G companies in this regard. There is also a lack of research exploring the reporting of different emission categories by O&G companies and how their reporting practices have evolved. Understanding these aspects is critical for achieving net-zero targets and implementing effective measures across all emission categories.

1.2 Goals

This thesis aims to review the current practices of GHG emission reporting from O&G companies, identify gaps, and provide recommendations to minimize the risks associated with inconsistent reporting practices, if any. To the best of our knowledge, there are no studies regarding comparing approaches chosen by different O&G companies.

This thesis has two main objectives. First, it compares the emission reporting practices of selected O&G companies and identifies potential inconsistencies. Specifically, we conduct detailed analyses of the reporting across the value chain and identify deviations following GHG Protocols' standards [2]. Secondly, we explore the motivations of these companies to report value chain emissions. These motivations could include but are not limited to, the potential for improving emissions reporting to address the urgent need for climate action, thereby reducing the financial, climate, and regulation risks.

By identifying best practices and areas for improvement, this thesis aims to provide an objective evaluation of GHG emission reporting in the O&G industry and increase transparency, which ultimately can contribute to the ongoing efforts to address climate change. This led to the following two research questions:

RQ1: How do O&G companies report GHG emissions in their sustainability reports? Are there inconsistencies and gaps in their reporting?

RQ2: What are companies' motivations for reporting emissions across the value chain? What are the challenges, weaknesses, and opportunities for O&G companies?

This thesis is organized as follows. Chapter 2 discusses the literature on voluntary GHG reporting, with a particular focus on the O&G sector. This chapter also examines emission reporting of the value chain. Chapter 3 describes data, including collection method and processing. Chapter 4 describes the methodology, including the analytical techniques and qualitative methods. Chapter 5 presents the results of the analysis, with a focus on the O&G companies' GHG reporting practices. Finally, Chapter 6 provides a comprehensive discussion of the findings and conclusions and highlights the limitations of the study.

2
Literature

The O&G sector is a significant source of GHG emissions, with industry's operations accounting for 9% of all human-made GHG emissions, and it produces the fuels that create another 33% of global emissions [16]. Due to the growing concerns about climate change and its environmental and societal effects, this industry has come under increasing pressure to cut emissions and adopt more sustainable practices. As a result, many O&G companies began disclosing their GHG emissions and sustainability performance to show their commitment to sustainability and fulfill stakeholder expectations.

This chapter reviews the literature on sustainability reporting and GHG emissions reporting by industry, specifically the O&G sector. We look at the reporting of the largest emission category across the value chain. Finally, we review the strategies used by O&G companies for low-carbon transition. We also identify the research gap in the present studies and show how the gap can be bridged.

2.1 Sustainability reporting

The concept of sustainability has gained significant attention from regulatory bodies, industries, and research communities worldwide [17]. As a result, there has been an increased implementation of sustainability practices [17] and the publication of annual sustainability reports by companies operating in various sectors, including the O&G industry. Sustainability reporting refers to disclosing the company's environmental, social and governance (ESG) performance information to stakeholders. These reports provide detailed information about an organization's sustainable practices, impacts, strategies, and long-term plans toward sustainable development [18].

Sustainability reporting typically encompasses three dimensions: economic, environmental, and social sustainability. These dimensions, collectively known as the triple bottom line (3BL), are essential for comprehensively assessing a company's sustainability efforts [19]. The economic dimension of the 3BL focuses on economic prosperity, profit-making, competitive advantage, and sustaining the overall economic value of the business. The environmental dimension involves factors such as climate change, global warming, pollution, and depletion of the ozone layer. Lastly, the social dimension addresses issues related to social progress, including health and safety, community well-being, employment opportunities, charity, and organi-

zational behavior [20]. This thesis focuses only on the environmental dimension, specifically the GHG emission reporting practice.

The O&G industry has a long-standing tradition of sustainability reporting, dating back to the early 1990s [21]. The initial focus was primarily on health and safety issues but has expanded to include a broader range of sustainability issues. Nowadays, most major O&G companies produce annual sustainability reports, providing stakeholders with detailed information on their ESG performance [22].

A study [23] suggests that effective sustainability reporting offers several benefits to O&G companies by enhancing their reputation and strengthening their relationships with stakeholders. Studies also show that companies with transparent and comprehensive sustainability reporting practices are more likely to gain the trust and support of local communities, governments, and non-governmental organizations [24, 25, 26]. This, in turn, can lead to improved regulatory compliance, reduced reputational risks, and increased social acceptance of the company's operations.

Investor demands often drive sustainability reporting in the O&G industry. Often, O&G companies recognize the importance of sustainability reporting in maintaining investor confidence and attracting sustainable capital flows. A study [27] shows that shareholders increasingly consider ESG factors when making investment decisions. Another research [28] found that companies with robust sustainability reporting practices attract more investment and enjoy lower capital costs.

Additionally, many studies [29, 30, 31] suggest sustainability reporting enables companies to identify and manage risks effectively. By reporting on ESG performance indicators, O&G companies can identify potential vulnerabilities and proactively address them [32]. For instance, reporting on water consumption and wastewater management allows companies to implement measures that reduce water usage and minimize environmental impacts [33]. Sustainability reporting also facilitates better decision-making by providing management with the necessary information to integrate sustainability considerations into strategic planning and operational processes [34].

Despite its benefits, various studies found that sustainability reporting in the O&G industry faces several challenges and limitations. Research from studies [35, 36] identifies the lack of standardization in reporting practices as one of the key challenges, making it difficult for stakeholders to compare the ESG performance of different companies. This lack of comparability limits stakeholders' ability to make informed decisions based on sustainability performance metrics [37].

Another study [38] mentions that the O&G industry encounters challenges in effectively measuring and reporting GHG emissions due to the complexity of its value chain, which involves extraction, refining, and distribution processes. According to a study [39], inconsistencies in reporting practices across different O&G companies also hinder comparability and benchmarking of sustainability performance.

2.2 GHG reporting

There exist numerous GHG reporting standards, frameworks, and protocols. The Intergovernmental Panel on Climate Change (IPCC), well-known for providing periodic scientific consensus on the impacts of climate change and measures needed to mitigate them, also produces guidelines for national governments to create national greenhouse gas inventories [40]. There are also industry- or NGO-led GHG emissions reporting standards that quantify and disseminate information regarding GHG emissions to inform corporate operations and offer solutions [2].
For example:

1. The Greenhouse Gas (GHG) Protocol: the most widely used GHG accounting standard by the World Resources Institute and the World Business Council for Sustainable Development [2].

2. The Global Reporting Initiative: guidance on sustainability reporting, including GHG emissions [41].

3. The Carbon Disclosure Project (CDP): collects information on GHG emissions and climate change strategies from thousands of companies worldwide [42].

4. Task Force on Climate-related Financial Disclosures (TCFD): an initiative that encourages companies to disclose climate-related financial information to help investors, lenders, and other stakeholders assess the risks and opportunities associated with climate change [43].

In the last decade, the GHG Protocol has become a recognized framework for a firm's GHG reporting [44]. For instance, TCFD has recommended the adoption of GHG Protocol standards for assessing and disclosing climate-related risks and opportunities in financial reporting [43]. Additionally, the European Parliament has enacted a new sustainability reporting directive, incorporating the European Sustainability Reporting Standards, which explicitly incorporates the GHG Protocol as a reference framework for GHG emissions reporting [45]. Furthermore, the International Sustainability Standards Board (ISSB), an institution with newfound financial backing [46], has mandated the adoption of the GHG Protocol within its standards. These decisions highlight the relevance of the GHG Protocol as the cornerstone of GHG emissions reporting.

The GHG Protocol requires companies to report six GHGs, namely, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Most sustainability reports report these gases in terms of CO_2 equivalent (CO_2e). The GHG Protocol defines each GHG's global warming potential (GWP) relative to carbon dioxide based on the amount of heat a unit of each gas traps in the atmosphere over a specific period (usually 100 years) [47]. This GWP converts the emissions of each GHG into a CO_2e equivalent, representing the amount of CO_2 emissions that would have the same impact on the climate as the emissions of the other gases.

According to the GHG Protocol [2], entities' obligations regarding GHG emissions reporting hinge on two key determinants: (1) the scope of emissions and (2) the organizational boundaries, as shown in Figure 2.1.

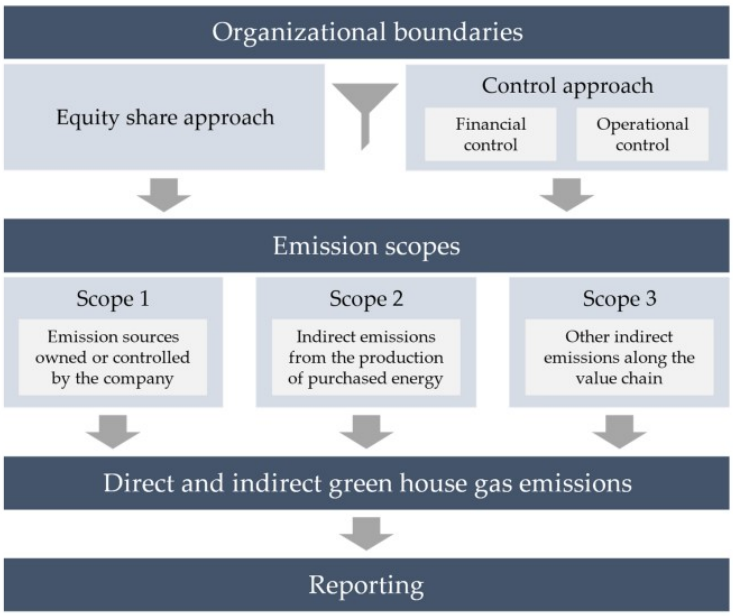

Figure 2.1: Flowchart illustrating reporting entity's emission reporting mechanism [1].

2.2.1 Organizational/System boundary

The allocation of emissions by a firm's equity investments is based on the selected consolidation approach, which determines a firm's organizational boundaries regarding reporting. According to GHG Protocol Standards, businesses can choose the system boundary of their emissions among three alternatives: equity share, financial control, and operational control [2, 1].

Under the **equity share approach**, a firm allocates the emissions from its investments based on its equity stake in the investee, without considering the level of influence associated with these holdings [1].

Employing the **control approach** for emissions reporting entails the inclusion of 100% of emissions from entities over which the reporting firm exercises control. The control criterion is further classified into two: financial and operational control. The financial control criterion is met when a firm possesses the capacity to direct both financial and operational policies [48] within its investments. Typically, this entails majority ownership and voting rights in subsidiary firms. Consequently, emissions of these firms are encompassed in the reporting, irrespective of shareholding proportions. Operational control, in contrast, is satisfied when a firm, either directly

or indirectly through subsidiary entities, has complete authority to enforce its operational policies [48]. Under the operational control paradigm, GHG emissions are reported comprehensively or not at all. In cases such as joint ventures, where no participating partner possesses control, emissions from the joint venture are excluded from the reporting.

A recent study [49] looks at the sustainability reporting of 237 large New Zealand entities and found that only 74 report their GHG emissions. Of the 33 entities that disclose their system boundary method, 32 use operational control. Also, another study [50] evaluating GHG reporting in higher educational institutions in Columbia also points out that they use the operational control approach to defining organizational boundaries as it is the most suitable approach for this sector due to its organizational structure and control of operations.

2.2.2 Emission reduction targets

Companies establish short and long-term emission reduction targets to align with national and continental-level emission goals and work towards achieving net zero emissions. These targets are crucial in promoting accountability for GHG emissions and driving sustainable practices within organizations [2]. By setting clear targets, companies can effectively monitor their progress, identify areas for improvement, and showcase their commitment to sustainability [51]. A study [52] suggests that these targets can lead to operational cost reductions, increased efficiency, and positive environmental outcomes. Moreover, public disclosure of emission reduction targets enhances a company's reputation and fosters stakeholder engagement [51]. These targets vary across companies and evolve, reflecting the dynamic nature of emissions reduction efforts in response to changing environmental priorities. Moreover, stakeholders use these targets to compare the performance of the companies [53]. In the subsequent chapters, we examine the emission reduction targets set by the selected companies and analyze their progress toward achieving these goals.

A report [54] analyzing the data collected by 75 organizations in 2015 from over 7,800 suppliers through CDP reveals that only 45% of them have active emission reduction targets. In a study [55] analyzing corporate emissions reports of 50 global food and beverage companies, 64% of those companies had one or more GHG emissions reduction targets for target years between 2020 and 2035. Another recent report [56] found that only 13 companies out of 100 of the world's biggest O&G firms have low carbon transition plans that extend at least 20 years into the future. Studies [57, 58] also highlight that these targets are tracked by independent trackers, including Climate Action Tracker (CAT) and initiatives like the Science-based Target initiative (SBTi). Furthermore, a report [59] indicates that NGOs and stakeholders utilize these targets to assess the climate change performance of companies and determine whether to invest in them.

2.2.3 Net carbon intensity (NCI)

In addition to emission reduction targets, companies often report a net carbon intensity (NCI) metric in their annual sustainability reports, which measures their environmental performance. It is expressed as the ratio of GHG emissions relative to another business metric, such as production, total energy delivered (sales), or revenue. This metric quantifies GHG emissions associated with specific activities or processes, such as product manufacturing or electricity generation. For instance, one study [60] used GHG emissions intensity expressed in gCO_2e/kWh to compare the change in emission intensity from the electricity sector between 2001 and 2017, while another study [61] compared the passenger car emissions intensity in gCO_2e/km. Additionally, researchers have also used carbon intensity expressed in gCO_2e/dollars in a study [62] to calculate and compare the GHG intensity of new production in different sectors to avoid warming above 2 degrees Celsius. Previous studies [63, 64] have used GHG intensity expressed in $kgCO_2e$/boe and gCO_2e/MJ to compare the emission performance of various companies in the O&G sector.

Low-Carbon Fuel Standard (LCFS) is a regulatory framework that employs GHG intensity to govern the reporting and use of transport fuels, including gasoline and diesel. Different versions of LCFS are in use in California, Oregon (U.S.), Europe, and British Columbia (Canada) [65], but California first adopted this standard in April 2009 [66]. It sets specific GHG intensity targets for these fuels to reduce their carbon footprint and promote cleaner alternatives. Under current regulation, the goal is to achieve a 20% reduction in carbon intensity (CI) of transportation fuels by 2030 [67]. According to an LCFS study [67], the CI benchmark for gasoline and its substitutes ranges from 93.23 gCO_2e/MJ in 2019 to 88.25 gCO_2e/MJ in 2023 and diesel and its substitutes range from 94.1 gCO_2e/MJ in 2019 to 89.15 gCO_2e/MJ in 2023. The LCFS incentivizes lower-carbon alternatives like biofuels (20 to 50 gCO_2e/MJ), landfill gas (10 to -20 gCO_2e/MJ), and electricity, facilitating a transition to greener options [66, 68, 69].

A recent report [70] by a group of researchers from Pembina Institue, Canada, found that the GHG intensity of grey, blue, and green hydrogen ranges from 94-102 gCO_2e/MJ, 19-35 gCO_2e/MJ and 0-5 gCO_2e/MJ respectively and emphasizes the role of low carbon hydrogen in decarbonizing the Canadas' energy system. Another study [63] reported that the GHG intensities of forty-six O&G companies range from 60 to 90 gCO_2e/MJ based on emission data in 2018.

2.3 Value chain emissions

GHG Protocol categorizes the emissions into Scope 1, Scope 2, and Scope 3, as shown in Figure 2.2. The first two categories (Scopes 1 and 2) are mandatory, while the last one (Scope 3) is voluntary.

Scope 3 emissions, also known as "value chain emissions" , encompass indirect GHG

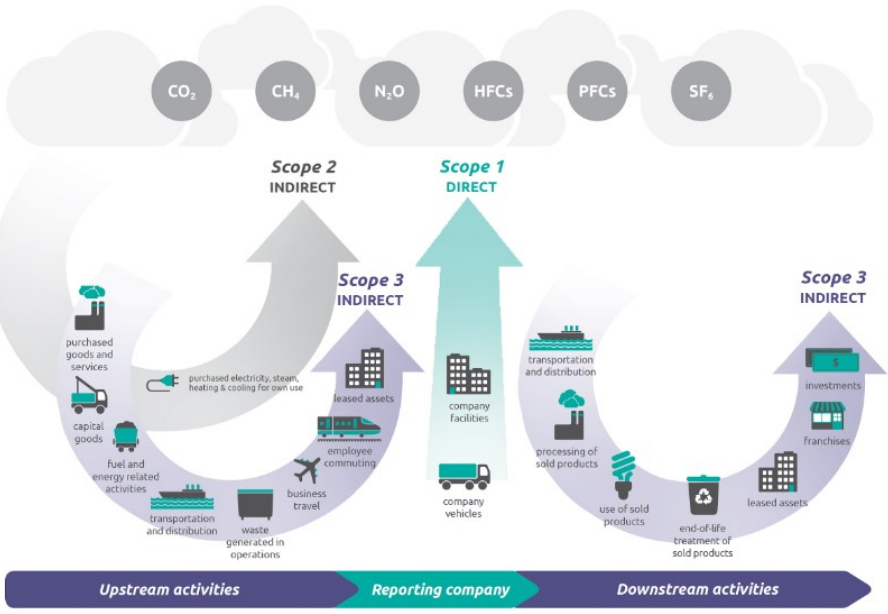

Figure 2.2: An overview of scopes and emission categories along the value chain according to GHG Protocols' standards [2].

emissions associated with a company's value chain, extending beyond its operational boundaries. These emissions account for the entire life cycle of a product or service, including activities such as raw material extraction, production, distribution, use, and disposal. The GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard categorizes Scope 3 emissions into 15 distinct categories, as outlined in Table 2.1.

It is found that Scope 3 emissions make up the majority share of total emissions across most sectors [71, 72], particularly amounting to 90% of emissions in the energy companies such as O&G industry [73] and the motor industry [74]. Most climate-related risks are found within the supply chain rather than within a company's operational boundaries [75]. A recent report [56] compares the Scope 3 emissions of O&G companies to those of entire nations. For example, in 2019, ExxonMobil's Scope 3 emissions exceeded Canada's total emissions. The report also highlights deficiencies in emission disclosure, with only one-third of companies in the sector disclosing their Scope 3 emissions. Moreover, even among the disclosing companies, the completeness of coverage remains low. The report [76] suggests that firms report, on average, only 22% of their complete supply chain emissions.

Existing guidelines and frameworks, including GHG Protocol standards and CDP, offer frameworks for assessing Scope 1 and 2 emissions. However, these guidelines do not provide a comprehensive and clear framework for quantifying and establishing benchmarks for Scope 3 emissions [77, 78]. Many studies [79, 80, 81] found that inadequacies in Scope 3 emissions reporting include inconsistencies in reporting methodologies, lack of transparency, and incomplete coverage of emissions sources, and they suggest that identifying the sources of these gaps is a crucial initial step

Table 2.1: Categories of Scope 3 emissions under corporate value chain accounting and reporting standard of GHG Protocol [3].

Cat.	Emissions considered	Examples
1	Purchased goods and services	CO_2 emissions associated with production and transport of raw materials used to manufacture products
2	Capital goods	Emissions associated with equipment produced for use within an organization's operations
3	Fuel- and energy-related activities (not included in scope 1 or scope 2)	CO_2 emissions associated with extracting, producing and transporting the fuel used by an organization
4	Upstream transportation and distribution	CO_2 emissions related to transporting raw materials directly to its facilities
5	Waste generated in operations	CO_2 emissions from organization waste disposal
6	Business travel	CO_2 emissions from air and ground transportation used for business travel
7	Employee commuting	CO_2 emissions associated with employee transportation to/from work
8	Upstream leased assets	Organization's use of leasing assets as a source of emissions
9	Downstream transportation and distribution of sold products	CO_2 emissions from shipping of finished goods to customers
10	Processing of sold products	CO_2 emissions produced when customers utilize sold products
11	Use of sold products	CO_2 emissions from customer
12	End-of-life treatment of sold products	Disposal of sold products by the organization
13	Downstream leased assets	Customers utilization CO_2 emissions from leasing assets
14	Franchises	Emissions generated from operating franchises owned by an organization
15	Investments	CO_2 emissions related to investments made by an organization

toward enhancing transparency and the accuracy of emissions data, ultimately facilitating informed decision-making and the improvement of sustainability practices.

2.4 Strategies for low carbon transition

O&G companies employ various strategies to report their GHG emissions and contribution toward green transitions effectively. Many studies have examined these strategies and how they contribute to the industry's sustainability.

2.4.1 Target setting

One key strategy is setting ambitious emission reduction targets, demonstrating companies' commitment to addressing climate change and mitigating GHG emissions [63, 82, 53]. By establishing goals, companies express their intentions to position themselves as industry leaders in sustainability. A study [4] comparing the strategies of International oil companies (IOCs) and national oil companies (NOCs) as a part of energy transition reveals that setting up emission reduction targets and taking measures to achieve those targets is a main strategy among both sets of companies. Aligning GHG reporting strategies with internationally recognized frameworks and standards, such as the GHG Protocol and CDP, is a crucial strategy that enhances the credibility and comparability of emissions data [83, 84]. Studies [85, 86] indicate that adhering to established reporting frameworks demonstrates transparency and accountability, fostering stakeholder trust and facilitating meaningful comparisons with industry peers. A recent study [87] compares more than 2200 firms having science-based emission-reduction targets (SBTs) and finds that their decarbonization efforts resulted in financial gains.

2.4.2 Investing in clean technologies

Investing in renewable energy projects and energy efficiency initiatives is a proactive strategy that helps O&G companies reduce their carbon footprint [4, 82, 88, 89]. Previous studies [82, 89] suggest that companies can minimize reliance on fossil fuels and decrease emissions by diversifying energy sources and optimizing energy consumption. These investments can contribute to environmental sustainability and position companies as leaders in transitioning to a low-carbon future. According to studies [4, 88], IOCs are focusing their strategies on diversifying their product portfolios, investing more in clean energy technologies, and trying to be a significant player in the electricity market.

The adoption of carbon capture and storage (CCS) technologies is an innovative strategy employed by O&G companies to mitigate GHG emissions [4, 82, 89, 90]. CCS technologies capture CO_2 emissions from industrial processes and store them underground, effectively preventing their release into the atmosphere. Research from studies [4, 88, 90] indicate that companies can significantly reduce their carbon footprint and contribute to global emission reduction efforts by implementing CCS. A study [4] found that all major IOCs are investing in CCS technologies, and this is a strategy involving strong partnerships among them. However, the percentage of investment is higher in O&G companies that get support and funding from the government. For example, Equinor sets strategies with an aim to have 25% market share in the European CCS market by 2025 and specifically mentions the importance of government policies and funding to help achieve this goal [91].

2.4.3 Supply chain management

Engaging suppliers and implementing supply chain emissions management strategies is another aspect of GHG reporting for O&G companies. Studies [53, 92] suggest that collaborating with suppliers and implementing measures to reduce emissions throughout the supply chain allows companies to achieve more comprehensive emission reductions. Furthermore, other studies [76, 93] convey that this approach strengthens relationships with suppliers and fosters sustainable practices across the industry. In a study [94], a group of 53 firms in Alberta, Canada, actively addressing climate change, replied to a survey that there is a strategic requirement for actions in the supply chain for effective GHG emission reduction.

2.4.4 Managing climate associated risks

Incorporating climate-related risks and opportunities into strategic decision-making is essential for O&G companies [43, 95, 96]. According to a study [97] and a report [43], considering the potential impacts of climate change, such as regulatory changes and physical risks, enables companies to make informed decisions that enhance their resilience and long-term viability. Another publication [98] mentions that this strategy empowers companies to navigate the evolving business landscape and identify new opportunities in the transition to a low-carbon economy. In a study [96], researchers investigate the relationship between carbon emissions and TCFD-aligned climate-related information disclosure using annual reports of selected companies and found that companies with higher carbon emissions tend to disclose more climate-related risks and management strategies in their yearly reports than companies with lower levels.

2.5 SWOT analysis

Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis is the most commonly used tool for strategic planning processes and strategic management in organizations [99]. It is a tool for identifying internal (Strengths and Weaknesses) and external (Opportunities and Threats) factors that may impede organizational performance or decision-making [100, 101].

A survey conducted as a part of a study [102], which gathered responses from Chief Executive Officers of 149 organizations, including both public and private sectors in the UK, finds that SWOT analysis is the predominant strategic tool employed by organizations in the UK. Similarly, another survey carried out as a part of a study [103] collected responses about analytical methods used by enterprises in South Africa for environmental scanning, and it also shows that SWOT analysis is the most frequently used analytic tool, with 283 out of 325 respondents adopting it as their preferred method.

According to studies [104, 105], the SWOT analysis serves as a tool for businesses to shape strategies to combat climate change and navigate the intricate path toward achieving sustainability goals. For instance, one study [106] focused on assessing GHG emissions associated with municipal solid waste in Indonesia and, based on the insights gained from a SWOT analysis, proposed strategies that emphasized the enhancement of GHG reporting data quality. Another study [107] concentrated on evaluating GHG emissions within the built environment sector, utilizing a SWOT analysis to identify pathways for emission reduction, suggests the significance of adopting a circular economy approach for curbing emissions in this sector.

Furthermore, various other studies have harnessed the power of SWOT analysis to scrutinize GHG reporting practices across diverse sectors, encompassing domains including healthcare [108], electricity generation [109, 110], and transportation [111, 112]. These studies have employed SWOT analysis to formulate strategies to manage emissions within these sectors effectively. However, a noticeable gap exists in the research on utilizing the SWOT analysis tool in GHG reporting in the O&G sector, particularly in value chain emission reporting. To bridge this gap, we carry out extensive analysis in the upcoming chapters of our study.

3
Data

We select case-study companies based on the availability of publicly available sustainability reports in which we collect data for further analysis. This is an important aspect in ensuring the reliability and accuracy of the analysis. We select eight O&G companies on the basis of their size, scope of operations, and significance in the oil and gas industry. Four companies are among the largest and most well-known IOCs globally: Royal Dutch Shell, British Petroleum (BP), Chevron, and Total Energies. They are likely to impact the industry significantly, and their sustainability performance is likely to be closely scrutinized by stakeholders. We also include four smaller companies with significant regional importance: Aker BP, Equinor, Preem, and Neste.

The eight companies selected operate in different parts of the world, including Europe, North America, and Asia. This geographic diversity allows for a more comprehensive sustainability performance analysis across different regions. Table 3.1 lists the key attributes of the selected O&G companies.

Table 3.1: Key attributes of the selected O&G companies. Investment in renewables is the disclosed low-carbon investment as a proportion of total CAPEX (2010–Q3 2018) reported in [4]. "–" means data not reported.

Company	**Headquarter**	**Size** (billion$, 2022)	**Commitment to zero emissions**	**Investment in renewables** (%)
Shell	The Netherlands	$381	Net-zero by 2050	1.33%
BP	United Kingdom	$255	Net-zero by 2050	2.30%
Chevron	United States	$236	Net-zero by 2050	0.23%
Total Energies	France	$281	Net-zero carbon by 2050	4.30%
Aker BP	Norway	$12.9	Net-zero emissions by 2050	–
Equinor	Norway	$74.9	Net-zero carbon by 2050	1.80%
Preem	Sweden	$13.0	Carbon-neutral value chain by 2035	–
Neste	Finland	$17.0	Carbon neutrality by 2035	–

All the selected companies have set net zero emission targets by 2050 or earlier. These companies have taken different approaches to sustainability, with some prioritizing renewable energy and others focusing on reducing emissions from their core operations. Some are known for their comprehensive reporting of Scope 3 emissions. This unique combination of different characteristics allows us to compare different sustainability strategies within the industry.

This chapter describes the data sources and collection methods (Section 3.1). Section 3.2 lists the challenges and limitations in our data. Section 3.3 describes the ethical considerations and how we ensure data reliability.

3.1 Data sources and collection methods

The main source of the data is the companies' annual sustainability reports for 2021, which also contains data from previous years and prior years if available. Sustainability reports from the other years and other relevant reports are also collected when available. These reports are listed in Table 3.2.

For the data used to address RQ1, we employ keyword-based search methods to find it from the case-study companies sustainability reports. For example, we identify the GHG emissions data by keywords including "GHG emissions," "Scope 1," "Scope 2," "Scope 3," and "category." Similarly, we identify information on emission targets data by keywords such as "emission targets," "net-zero," "long-term," and "short-term."

We use the same keyword-based approach as above to address RQ2. For example, to find literature related to Scope 3 reporting from academic search engines including Google Scholar, Scopus and Semantic Scholar , we use words such as "emission reduction", "energy efficiency", "accountability", "transparency", "value chain", "data quality", "supplier engagement", "stakeholder trust", "supply chain", "low-carbon products", "innovation", "lack of methodology", "regulatory requirement", "accurate emission baselines" along with "Scope 3 reporting". We also apply the same keywords in sustainability reports to find data reported by the case-study companies.

3.2 Limitations and challenges

There are many challenges during the data collection process. We only collect data from publicly available sources and reports. However, this approach has limitations as not all data is publicly disclosed.

The main challenge during data collection of RQ1 is to map different categories of Scope 3 emissions from the GHG emission data in sustainability reports. For example, Preems' sustainability report does not mention the Scope 3 emission data

Table 3.2: Company's sustainability reports used in this study. All reports contain clickable links.

Company	Reports and links
Shell	• Greenhouse Gas and Energy Data, 2021 • Shell Plc Sustainability Report 2021 • Sustainability Report 2017
BP	• ESG datasheet 2021 • Sustainability Report 2021 • Sustainability Report 2017
Chevron	• Climate change resilience Report 2021 • Sustainability Report 2021 • Sustainability Report 2015
Total Energies	• Universal Registration Document 2021 • Sustainability and Climate 2022 Progress Report • Integrating Climate into our Strategy Report 2016
Aker BP	• Sustainability Report 2021 • Sustainability Report 2020
Equinor	• Sustainability Report 2021 • Sustainability Report 2016
Preem	• Sustainability Report 2021 • Sustainability Report 2018
Neste	• Sustainability Report 2021 • Sustainability Report 2017 • Sustainability Report 2015

category number. We use the GHG Protocol standard [3] to map the given data and find the correct category number to solve this issue.

Some companies use different units. For example, Aker BP reports its net carbon intensity in $kgCO_2e$/boe (boe = barrel of oil equivalent) while most companies reported it in gCO_2e/MJ. We use the conversion factors in Appendix 1 A.1, converting boe to energy in MJ.

Calculating the total energy delivered or sold by each company is another challenge. Many companies do not report the data for energy delivered or sold annually. For instance, Preem only provides the annual sales of each product in volumes in their

report. Therefore, we use standard energy density conversions, as shown in Appendix 1 A.1, for their products to calculate the total energy delivered. In the case of Neste, the total energy delivered annually in MJ is calculated using equation 4.1 given in the methodology (Chapter 4).

To ensure data integrity and reliability, multiple sources of documents and websites for each company are utilized to cross-check and verify the accuracy of disclosed data. In addition, calculations are conducted to confirm that the results in their report match the calculated results. For instance, companies provide the equation for net carbon intensity (NCI) calculation, and the data are also available in their documents, allowing us to perform cross-checking and validation. The NCI calculations are repeated to verify that they align with the data presented in the reports (Chapter 5). Our assumptions, such as the conversion factors, are documented in Appendix A.1.

The data collection process RQ2 also possesses several challenges and limitations. To address RQ2, we use a relatively small number of approximately 20 literature sources. This limited sample size may have implications for the comprehensiveness of the findings. Another limitation is the limited scope of keywords used in the search process. By using only a restricted set of keywords, there is a possibility that some pertinent literature may be overlooked, leading to gaps in the analysis and potential biases in the findings.

Additionally, the study's reliance on English-based literature introduces a language bias. This restriction may exclude valuable insights and data from non-English sources, limiting the study's cross-cultural and global perspective. Furthermore, the data collection process is restricted to three academic search engines and databases. While these sources are reputable and widely used, they may not encompass all relevant literature related to RQ2.

Finally, we rely on manual reading to extract relevant data. It is time-consuming, leading to searching only a limited number of literature, and may introduce human error, potentially impacting the efficiency and accuracy of the data collection process.

3.3 Ethical considerations

The data gathered are publicly accessible and do not contain any confidential or private information. This aligns with research ethics, allowing anyone to access the documents and utilize the data.

4
Methodology

To answer RQ1, a systematic approach is developed to consolidate data from our case-study companies. First, we identify the base year of the companies, and their short-term and long-term emission targets for achieving carbon neutrality are noted down. Then, we collect the data for the scopes of emissions, their reporting boundaries, the total energy delivered, and the reported NCI. Finally, we calculate carbon intensities and net carbon intensities to compare them. The emission reporting of the O&G companies is consolidated using the step-by-step procedure described below:

1. Collect the emissions data of the selected eight companies from the sustainability reports.

2. Identify the companies' base year, short-term and long-term scope-based absolute emission targets, net carbon intensity targets, and net-zero emission targets. This gives us an overview of their reports' ambitious goals and strategies to achieve carbon neutrality by 2050 or sooner.

3. Identify data for all three scopes of emissions and their respective system boundary approaches from the reports mentioned in Table 3.2 (Chapter 3). Also, gather the data for total energy delivered in a year.

4. Categorize the companies based on the system boundary approaches they employ.

5. Record all the categories of emissions reported in the Scope 3 category, along with the starting year of reporting those categories for each company.

6. Convert the scope of emissions collected in step 3 into a standard unit, million tonnes of CO_2e, and total energy delivered to MJ.

7. Gather the data for NCI from the reports. This is used to find missing data, including the total energy delivered in a year, using equation 4.1.

8. Calculate carbon intensities using equation 4.2 and net carbon intensities based on product mix using equation 4.3.

The terminologies and calculation methods are described in Sections 4.1 - 4.7. The

research methodology for addressing RQ2 is explained in Section 4.8.

4.1 Base year

A base year or baseline year refers to a specific reference year chosen by a company to establish a starting point for measuring progress in reducing greenhouse gas emissions. It serves as a benchmark against which future progress is measured. For instance, if a company sets a goal to reduce greenhouse gas emissions by 30% between 2020 and 2030, they choose 2020 as their starting point (i.e., 2020 is the base year). According to [2], companies should choose the earliest relevant point in time for which they have reliable data as a base year. By setting a base year, O&G companies can track their performance, evaluate the effectiveness of their actions, and determine whether they are on track to meet their climate targets.

4.2 Emission reduction targets

O&G companies establish emission targets to address their climate change impact and minimize their carbon footprint. These targets, outlined in their sustainability reports, fall into two broad categories [2]:

1. Absolute targets: These targets set specific emission reduction goals in absolute terms. For example, a company may aim to reduce total GHG emissions (in metric tons, Mt) by 50% by 2030 compared to the emission levels of a base year.

2. Intensity targets: These targets are expressed as a reduction in the ratio of GHG emissions relative to another business metric, such as production or revenue. For instance, a company aims to reduce net carbon intensity (expressed in gCO_2e/MJ) by 20% by 2030 relative to a base year.

Within the absolute target category, two commonly mentioned targets in the sustainability reports of O&G companies are scope-based emissions targets and net-zero emission targets. A scope-based emission target outlines goals to reduce emissions within specific scopes. For example, a company could establish an emissions goal to lower Scope 1 (direct emissions) and Scope 2 (indirect emissions from energy consumption) by a certain percentage by 2030.

The most common target, yet often poor-defined and non-transparent, is the net-zero emissions target that aims to achieve a state of net-zero emissions by a specific year. This goal involves offsetting any remaining emissions through various methods such as carbon capture and storage, investments in renewable energy, or other offsetting mechanisms.

Our analysis includes the net carbon intensity targets of the companies, short-term and long-term scope-based targets, and net-zero emission targets. These indicators capture the ambitious goals and strategies these companies stated in their reports to reach carbon neutrality by 2050 or sooner.

4.3 System boundary

A key step in corporate GHG accounting is defining the organizational boundary. This step determines which operations are included in the company's organizational boundary and how the company consolidates emissions from each operation. The GHG Protocol provides companies with a framework to track and report GHG emissions, with its boundary calculation method as an integral element. As introduced in Section 2.2, two distinct approaches for corporate reporting can be used to consolidate GHG emissions: **the control approach** and **the equity share**.

4.3.1 Control approach

In this approach, the companies consider 100% of the emissions from operations that the company has control while excluding emissions from operations in which the company has an ownership interest but no control. They are two types of control:

1. *Financial control* This criterion measures a company's ability to direct an operation's financial and operating policies for maximum economic benefit. A company exercising financial control holds majority rights over benefits, majority ownership risks, and rewards of ownership. For instance, owning majority shares and having the authority to make critical financial decisions constitutes exercising such control.

2. *Operational control* This criterion addresses who has the authority to introduce and implement operating policies at an operation. A company or one of its subsidiaries with full authority over establishing and enforcing policies at an operation is considered to have operational control. For example, if a company operates a facility and can make operational decisions, it exercises such control.

4.3.2 Equity share

A company accounts for GHG emissions from operations in this approach according to its equity share. The equity share reflects economic interest, the extent of a company's rights to the risks and rewards flowing from an operation. The Equity share approach assesses a company's share of emissions from joint ventures or partnerships based on ownership percentage in those joint ventures or partnerships, reporting emissions based on this ratio. For example, if one owns 50% of a joint venture operating a coal mine, they would report 50% of its emissions under this

approach.

4.4 Scope of emissions

As introduced in Section 2.2, three "scopes" of emissions are defined for GHG accounting and reporting purposes to help delineate direct and indirect emission sources. These scopes are as follows:

Scope 1 emission: Emissions generated directly from sources controlled or owned by an organization. Examples of Scope 1 emissions are the air emissions generated during fuel combustion in manufacturing or transportation facilities or from its fleet of delivery trucks.

Scope 2 emission: Emissions stem from the consumption of purchased electricity, steam, or other forms of energy used by an organization [2]. There are two types of Scope 2 emissions:

- *Location-based Scope 2 emissions* are emissions created physically from electricity or heat generation sources used by a company, such as power plants or boilers. Calculations are based on emissions factors for grid average electricity consumed without considering specific contracts or purchases. In other words, location-based emissions represent actual emissions from production facilities that supply the company's energy needs [2]. For example, if a company uses electricity generated from renewable and non-renewable sources, their location-based Scope 2 emissions would be calculated according to an average emissions factor of the two sources [113].

- *Market-based Scope 2 emissions* consider any contracts or agreements a company may have for purchasing renewable energy or carbon credits, which allows it to claim emissions reductions even though its grid still produces power from non-renewable sources [2]. For instance, if a company purchases renewable energy certificates (RECs) or enters into a power purchase agreement (PPA) with a renewable energy provider, their Scope 2 emissions would be determined based on their emissions factor rather than being calculated as part of the grid average - giving companies more flexibility when it comes to claiming emissions reductions from using greener sources of power and encouraging cleaner energy sources, in general, [113].

In this study, all eight companies in our study have reported market-based Scope 2 emissions but not all companies provided data on location-based Scope 2 emissions. To ensure consistency and comparability across the analyzed companies, we focus on market-based Scope 2 emissions allowing for a comprehensive analysis of the companies' carbon footprints.

Scope 3 emissions: Emissions involve any other indirect emissions produced in an organization's value chain, including purchased and sold goods and services, trans-

portation emissions, waste disposal emissions, and employee commuting emissions. According to the GHG Protocol, there are 15 categories of Scope 3 emissions, including purchased goods/services, transportation, employee commuting emissions, etc., which is already described in Chapter 2 in Table 2.1.

Organizations employ three approaches to calculate Scope 3 emissions: the sales method, the throughput method, and the production method. Among the case-study companies, only Chevron mentions these three approaches used for its Scope 3 calculation, while others haven't mentioned any specific approach chosen. We are considering Scope 3 emissions reported only by the sales method by Chevron for calculations in this study as this method reports the highest Scope 3 emissions in Chevron's 2021 sustainability report.

We first collect all these three scopes of emissions and the respective system boundary approaches chosen from the reports and documents mentioned in 3.2 (Chapter 3). Then we convert all these emissions into the same unit in million tonnes of CO_2e. Finally, we note down all the categories of emissions reported in the Scope 3 category and the starting year of reporting those categories by each company.

4.5 Total energy delivered

For some companies (Chevron, Total Energies, Neste), the annual total energy delivered (E) is not reported in the sustainability reports. Therefore it is calculated based on equation 4.1 by dividing total GHG emissions across Scope 1,2, and 3 by the reported net carbon intensity (NCI_R). It is given by:

$$\mathrm{E} = \frac{\mathrm{GHG} - \mathrm{CO}_{2\_r}}{\mathrm{NCI}_R} \tag{4.1}$$

where
E = Total energy delivered by sold products (TJ per year).
GHG =Total Scope 1,2, and 3 GHG emissions (metric ton CO_2e per year).
CO_{2_r} = CO_2 removals by carbon sinks and carbon capture and storage (CCS) technologies (metric ton CO_2e per year).
NCI_R = Reported net carbon intensity (gCO_2e/MJ).

4.6 Carbon intensity of scope emissions

We calculate the carbon intensity of Scope 1, 2, 3 emissions (CI_i where $_i$ = 1, 2, 3, or r) using equation 4.2 given below. CI_i is the ratio of GHG emissions of i in a given year to the total energy delivered.

$$\mathrm{CI}_i = \frac{\mathrm{GHG}_i}{\mathrm{E}} \tag{4.2}$$

where
CI_i= Carbon intensity of Scope i (gCO_2e/MJ).
GHG_i= Scope 1,2,3 or CO_{2_r} emissions (metric ton CO_2e per year).

CI of the Scope 1-3 emissions is positive, whereas CI_r is negative per definition.

4.7 Net carbon intensity(NCI_P)

We calculate NCI_P to compare and cross-check with the NCI_R reported by companies in their sustainability reports. Net carbon emissions based on product mix, carbon intensities of products, total energy delivered, and carbon removals are given by equation 4.3.

$$\mathrm{NCI}_P = \frac{(\sum_j \mathrm{CI}_j \times \mathrm{P}_j) \times \mathrm{E} - \mathrm{CO}_{2-r}}{\mathrm{E}} \tag{4.3}$$

where
NCI_P = the net carbon intensity calculated based on product mix P (gCO_2e/MJ).
CI_j = the carbon intensity of product j (gCO_2e/MJ).
P_j = the product mix of product j (%).

4.7.1 Uncertainty range of NCI_P

We calculate the uncertainty range of NCI_P as follows. The CI of each product is shown in Appendix Table A.2. We use a range of CI values to calculate the NCI_P. The highest and lowest value for the CI of each product is chosen based on the CI values reported by Shell, BP, and Chevron in their 2021 NCI calculations. Figure 5.4 in Chapter 5 shows each company's product mix percentage. Using these data and equation 4.3, we calculate the maximum, minimum, and average NCI_P and plot it in a graph. The maximum and minimum values give us the ranges of uncertainty and are plotted as error labels, which depict the uncertainty range of NCI_P.

4.8 SWOT analysis

We utilize SWOT analysis to identify the motivations, challenges, weaknesses, and opportunities for O&G companies in reporting value chain emissions, particularly the Scope 3 emissions. We carry out the SWOT analysis using the four steps given below:

1. Strengths: identify the internal strengths related to Scope 3 reporting of the organizations under study. Such strengths include well-established reporting systems, reliable data collection mechanisms, or strong commitment from leadership toward sustainability.

2. Weaknesses: assess the internal weaknesses related to Scope 3 reporting. These include difficulties with data collection, a lack of standardized reporting frameworks, and inadequate resources dedicated specifically for Scope 3 reporting.

3. Opportunities: identify external opportunities available to organizations by their Scope 3 reporting. Such opportunities include emerging reporting standards, evolving stakeholder expectations, or potential cost savings through emission reduction initiatives.

4. Threats: assess any external factors which can impede or impact the Scope 3 reporting, such as regulatory changes, reputational risks, or competitive pressures.

We grade each identified SWOTs with a grade of 0-3 based on whether companies have explicitly mentioned the point in their reports or not. The grading scale and what it signifies are shown in Table 4.1. A grade 0 is given to the points in which no company has reported these positions, but they were nonetheless identified in the literature of roughly 20 studies on Scope 3 reporting. This multi-method approach ensures an in-depth examination of the Scope 3 emission reporting landscape in these O&G companies' sustainability reports and the literature. This serves as a more solid basis for answering RQ2.

Table 4.1: Grading scale used in the SWOT analysis for analyzing RQ2.

Grading	**Explanation**
∘ (0)	Not mentioned by any companies but is identified in the literature
• (1)	Mentioned by 1-3 companies
• • (2)	Mentioned by 4-6 companies
• • • (3)	Mentioned by more than 6 companies

5

Results

This chapter presents the results of the analysis of the two research questions. Section 5.1 delves into the emission targets set by O&G companies. Section 5.2 presents the results of system boundary approaches chosen by companies, followed by detailed value chain emission reporting in 5.3. Section 5.4 offers a brief overview of the product mix of the O&G companies. Section 5.5 presents the carbon intensity of the scope of emissions, each category of Scope 3 emissions reported by the companies, and a comparison of net carbon intensities in Section 5.6. Finally, Section 5.7 explains the SWOT analysis for Scope 3 reporting.

5.1 Emission reduction targets

Figures 5.1 and 5.2 show Scope 1+2 and NCI targets set by companies in sustainability reports 2021. Figure 5.1 suggests that Shell, BP, Chevron, Total Energies, Aker BP, and Equinor all show commitments to achieve net zero emissions by 2050 concerning their Scope 1+2 emissions, while Neste set targets for carbon-neutral production by 2035. However, these companies started from different base years and have distinct intermediate targets. For instance, Shell is committed to a 50% reduction by 2030 compared to its emission levels in 2016. BP and Neste have set the same reduction target relative to their 2019 emission levels. Equinor and Aker BP have established similar targets, but their baselines differ, with Equinor using 2015 and Aker BP using 2005. In 2030, Total Energies aims to reduce Scope 1+2 emissions from its operated activities by at least 40% compared to 2015.

Chevron, on the other hand, has specific targets for its oil and gas production, with a 40% reduction goal for upstream oil production activities and a 26% reduction goal for gas production by 2028. Lastly, Preem has not specified any interim targets but aspires to achieve carbon neutrality by 2035.

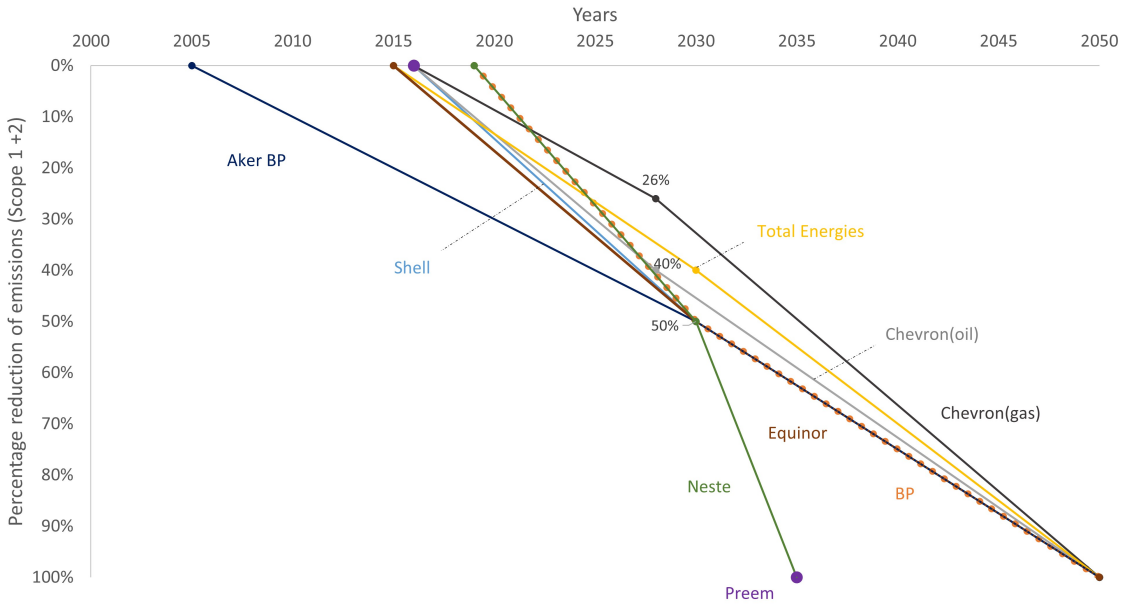

Figure 5.1: Scope 1 + Scope 2 emission targets set by the companies in sustainability reports 2021. Preem's target is shown as a point as it only set the target to become carbon neutral by 2035 without any intermediate targets.

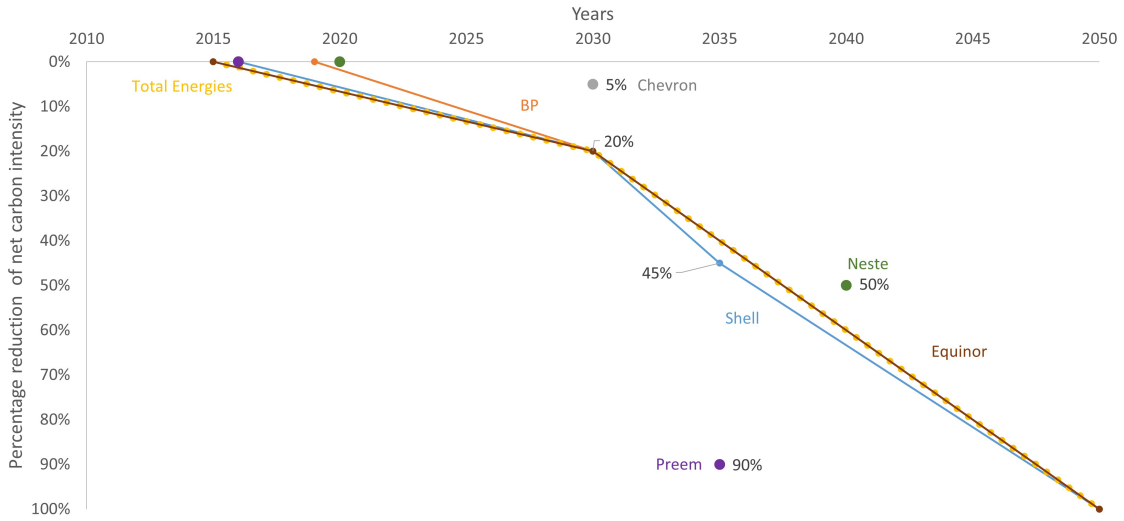

Figure 5.2: Net carbon intensity targets set by the companies in sustainability reports 2021. The targets of Preem, Neste, and Chevron are shown as points, as they only set one target relative to their base year.

The NCI targets set by the aforementioned companies are shown in Figure 5.2. Four of these companies (Shell, BP, Total Energies, Equinor) have established a short-term target of a 20% reduction by 2030. It is worth noting that this reduction target aligns with the low carbon fuel standard target set by the California Air Resources Institute for 2030 [114]. Shell and Equinor have set intermediate targets to be achieved before reaching net zero in 2050. Shell aims to reduce NCI by 20%

by 2030 and 45% by 2035 compared to the 2016 baseline. Equinor, on the other hand, targets a 20% reduction by 2030 and a 40% reduction by 2035 relative to the 2015 baseline. BP and Total Energies have set an NCI target of a 20% reduction for the products they sell by 2030. Neste aspires to decrease the use phase emission intensity of its sold products by 50% by 2040 compared to the 2020 levels, while Preem set a target of 90% reduction by 2035. Chevron has a short-term target of achieving a greater than 5% reduction by 2028. Notably, Aker BP does not mention specific NCI targets in its reports.

5.2 System boundary

The O&G companies use different system boundary approaches to report their scope of emissions, which are listed in Table 5.1. In 2021, IOCs reported Scope 1 and 2 emissions using both operational control and equity share approaches. However, only Chevron reports all scope of emissions using both operational control and equity share approaches. Operational control is the most commonly adopted system boundary approach among these companies, with the exception of Neste, which uses a financial control approach. Equinor employs the operational control approach to report Category 4 & 6 of Scope 3 emissions while utilizing the equity share approach for reporting Category 11 of Scope 3 emissions.

Table 5.1: System boundary approaches used by companies to report emissions in 2021. "–" means no company reported using that system boundary approach.

Scope	**Operational control only (1)**	**Equity share only (2)**	**Both (1) & (2)**	**Financial control only (3)**
Scope 1	Aker BP Equinor Preem	–	Shell BP Chevron Total Energies	Neste
Scope 2	Aker BP Equinor Preem	–	Shell BP Chevron Total Energies	Neste
Scope 3	Shell BP Total Energies Aker BP Equinor (Cat. 4 & 6) Preem	Equinor (Cat.11)	Chevron	Neste

Figure 5.3 illustrates the total emissions of Chevron using both the operational control and equity share approaches. The results show that the operational control approach yields higher emissions compared to the equity share approach. These findings highlight the chosen system boundary approach's significance in influencing a company's reported emission levels.

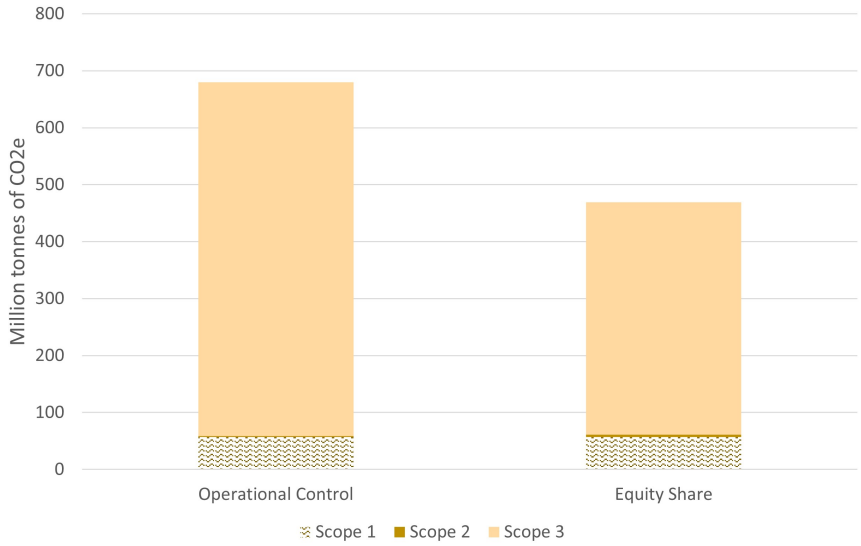

Figure 5.3: Emissions reported by Chevron in 2021 using two different system boundaries: operational control and equity share approaches.

5.3 Scope 3 reporting by category

Table 5.2 illustrates the companies' starting years of reporting different categories of Scope 3 emissions in their sustainability reports. Among these eight companies, BP and Neste were the pioneers initiating Scope 3 category-wise reporting in 2015, with Neste already reporting four categories from the start (Category 1, 9, 11, 12). Total Energies, Equinor, and Preem began reporting in 2016. Equinor reports Category 4, 6, and 11, while Preem reports Category 1, 6, 9, and 11. Shell started reporting in 2017, and Chevron began in 2019. Aker BP is the last among these companies to commence reporting, which starts in 2020. It is also evident that the reporting of Scope 3 categories by companies such as Neste, Aker BP, and Shell has progressed over the years as they have started reporting new categories, while others remain reporting the same categories.

Every company, except Aker BP, reports Category 11 emissions related to the use of sold products. Category 11 is the largest emission category within Scope 3 emissions, constituting approximately 90% of Scope 3 emissions. It is observed that none of the companies report all categories of Scope 3 emissions. Categories 8, 10, 13, 14, and 15 are not considered by any of these companies. Aker BP reports the highest number of categories (eight), followed by Neste (seven). Shell and Preem report four

Table 5.2: Reporting of Scope 3 emissions categories by company. The earliest starting years of reporting is 2015(red) and the latest in 2021(light peach). Empty cells imply no reporting from the company.

Category	Shell	BP	Chevron	Total Energies	Aker BP	Equinor	Preem	Neste
1	2017				2021		2016	2015
2					2021			
3	2017	2019			2020			2017
4					2020	2016		2017
5					2021			2017
6					2020	2016	2016	
7					2020			
8								
9	2021				2021		2016	2015
10								
11	2017	2015	2019	2016		2016	2016	2015
12								2015
13								
14								
15								

of them. From Table 5.2, it is evident that Categories 3 and 9 are the next most reported emissions after Category 11. Category 3 represents emissions from fuel- and energy-related activities (not included in Scope 1 or Scope 2), while Category 9 represents emissions from downstream transportation and distribution of sold products.

5.4 Product mix

Figure 5.4 shows the product mix of the selected O&G companies. The product mix encompasses a range of energy products, including oil, gas, liquefied natural gas (LNG), biofuels, and power. Power products are referred to as the electricity sold by these companies, and when assessing their carbon intensity, they are represented as fossil equivalence of sold energy.

It is also evident from Figure 5.4 that IOCs (Shell, BP, Chevron, and Total Energies) possess a more diversified product mix than smaller companies. Neste has the highest share of biofuels in its product mix, whereas Preem only has a 2% share of non-oil products. Shell has the largest share of power in its product mix, accounting for 12%, followed by Total Energies with 7% and BP with 4%. Oil is the dominating product of all O&G companies except BP and Total Energies, have gas contributes to the largest share within their product mix. The product mix's composition significantly impacts the NCI_P, which will be further explored in subsequent analyses.

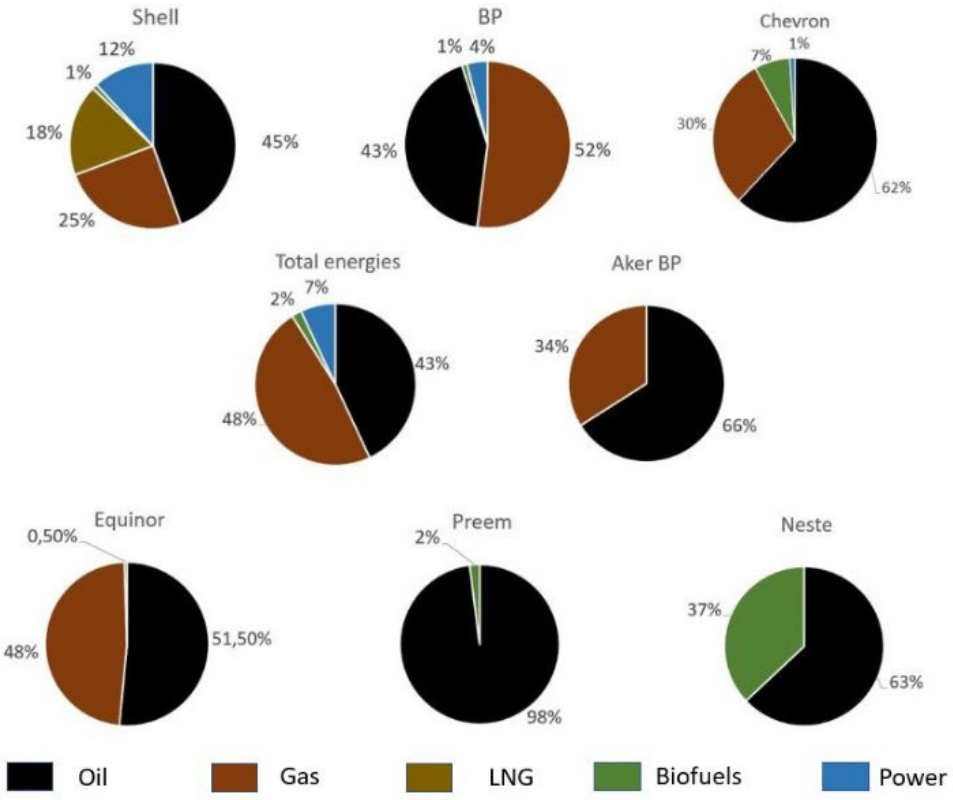

Figure 5.4: Product mix of the selected eight O&G companies.

5.5 Carbon intensity of scope emissions

The contrast of the *reported* carbon intensity (CI) of Scope 1, 2, and 3 emissions from eight O&G companies is shown in Figure 5.5. The results again illustrate that Scope 3 emissions dominate the overall emissions and, therefore, CI of this sector. These numbers highlight the substantial variations in reporting practices among companies. Scope 2 emissions and its CI are typically negligible among all categories, with Preem reporting the lowest intensity of 0.14 gCO_2e/MJ.

Total Energies reported the highest CI at 91 gCO_2e/MJ. This may be due to its heavy reliance on carbon-intensive products. In contrast, Aker BP reported the lowest CI at 3 gCO_2e/MJ, primarily due to inadequate reporting concerning Scope 3 emissions. Among the IOCs, Total Energies reported the highest CI at 91 gCO_2e/MJ, while Chevron reported the lowest at 73 gCO_2e/MJ. Neste's product mix consists of around 37% of biofuel, and it can be noticed from the lowest reported CI (55 gCO_2e/MJ) among all the companies.

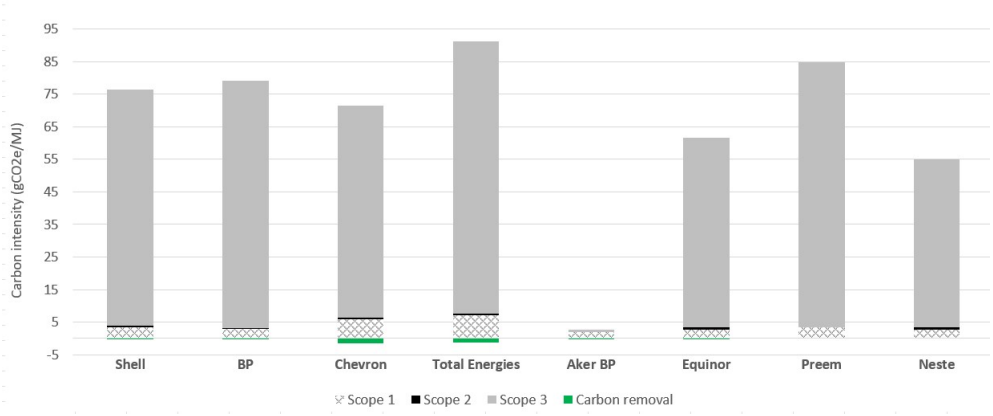

Figure 5.5: Reported GHG emissions and the corresponding carbon intensity by company in 2021. Carbon removals are CO_2 removals with carbon sinks and CCS technologies.

Figure 5.5 also includes carbon removal intensity (CI_r) reported by these companies, shown as negative values. In 2021, Preem and Neste reported zero carbon removals. Chevron reports a CI_r of -1.63 gCO_2e/MJ, while Total Energies has the highest reported carbon removals of a CI_r of -1.26 gCO_2e/MJ. Shell, BP, Equinor, and Aker BP show negligible CI_rs of -0.08, -0.14, -0.07, and -0.05 gCO_2e/MJ, respectively.

5.5.1 Scope 3 emissions by category

We further look into the largest emission category, Scope 3 emissions, and compare the reported emissions within Scope 3 subcategories, as shown in Figure 5.6. Category 11 (use of sold products) is the dominant contributor to CI across all firms, underscoring the rationale behind their reporting of this category across all companies except Aker BP, which has notably not reported Category 11 emissions.

Category 1 (purchased goods and services) and Category 3 (Fuel- and energy-related activities (not included in Scope 1 or Scope 2)) have the next largest reported CIs. Shell, Preem, and Neste reported CIs of 8.22, 6.89, and 7.16 gCO_2e/MJ, respectively, for Category 1. For Category 3, Shell, BP, Aker BP, and Neste reported CIs of 7.60, 27.4, 0.29, and 0.15 gCO_2e/MJ, respectively. Category 9, emissions from downstream transportation and distribution of sold products, is the next most reported category. However, it has a negligible reported CI ranging from 0.03 to 0.95 gCO_2e/MJ compared to the other reported categories.

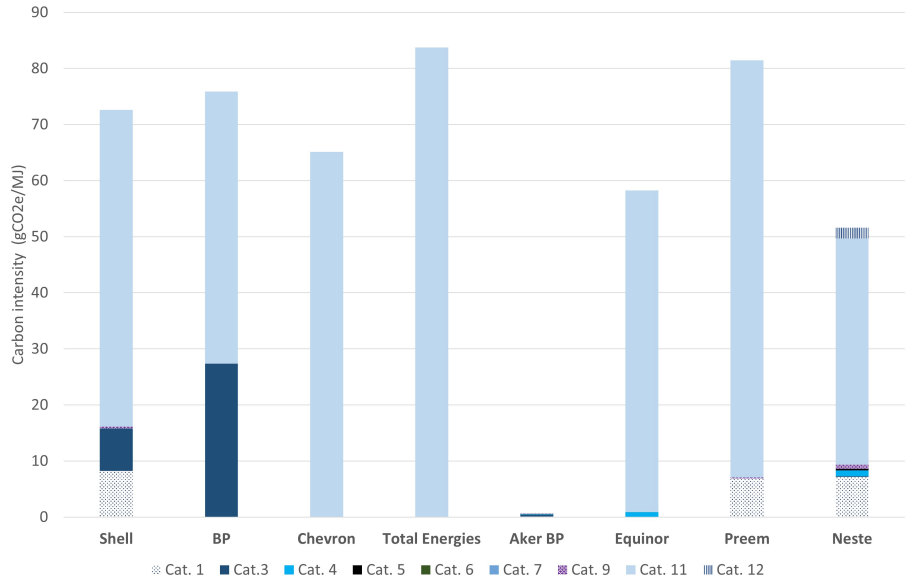

Figure 5.6: Carbon intensity of reported Scope 3 emissions by category for 2021.

5.5.2 Validation of reported net carbon intensities

To cross-check the validity of the reported net carbon intensities, we compare the net carbon intensity reported by the companies in their sustainability reports (NCI_R) and our calculated net carbon intensity using an approach that is based on their product mix (NCI_P)(Figure 5.7). We also calculate the uncertainty range of NCI_P, represented by the error labels in Figure 5.7. This lower and upper uncertainty range varies within and between the companies. For instance, the lower and upper uncertainty range of Shell is -6.73 and 5.39 gCO_2e/MJ, respectively, while the upper uncertainty range of Preem and Neste is 4.54 and 6.32 gCO_2e/MJ respectively. We observe that the NCI_R values for Shell, BP, and Chevron are 77, 79, and 71 gCO_2e/MJ, respectively, and fall within the range of their corresponding NCI_P values. This suggests the reported net carbon intensities align closely with the calculated values based on the companies' product mix.

Total Energies has a higher NCI_R (91 gCO_2e/MJ) compared to its NCI_P. This can be attributed to our assumptions of the carbon intensities of the products. Preem, on the other hand, does not report NCI_R. Equinors' NCI_R is 67 gCO_2e/MJ, which is also lower than its NCI_P. Aker BP reports a relatively small NCI_R value of 0.78 gCO_2e/MJ, primarily due to excluding Category 11 emissions. However, the NCI_P of Aker BP indicates high emissions from its products, emphasizing the necessity for comprehensive reporting.

These results highlight the variations in reporting practices among the companies and underscore the challenges associated with comparing them based on the reported data. The disparities between the NCI_R and NCI_P values emphasize the importance of consistent and comprehensive reporting methodologies to enable accurate comparisons and assessments of companies' net carbon intensities.

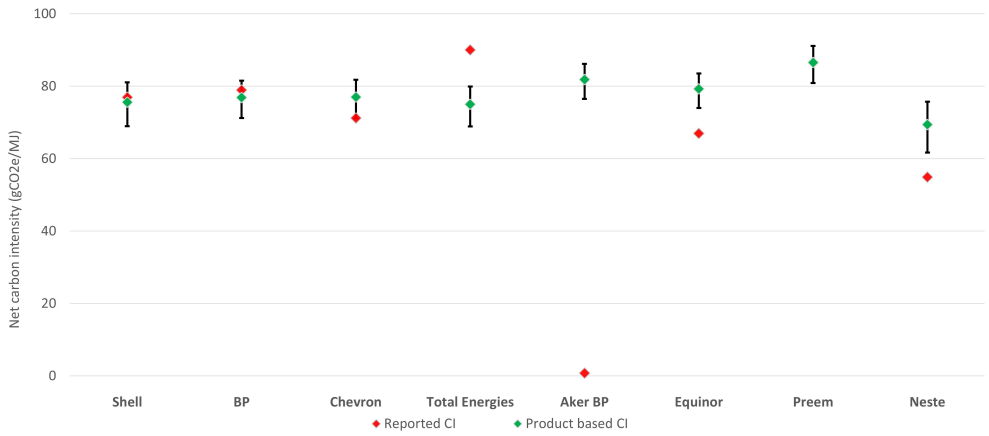

Figure 5.7: Net carbon intensity comparison of NCI_R and NCI_P. The error labels depict the uncertainty range of NCI_P, calculated using the method explained in Section 4.7.1. Preem does not report NCI; Aker BP's reported NCI is negligible.

5.6 SWOT analysis

We summarize the results of the SWOT analysis below. Some of those strengths, weaknesses, opportunities, and threats are described in detail with examples:

Strengths: According to the sustainability reports of the companies in this study, one of the key strengths of Scope 3 reporting lies in its ability to showcase the companies' commitment to addressing climate change and promoting sustainability. All eight companies describe in their sustainability reports and stated multiple times clear commitments to reaching the goals outlined in the Paris Agreement and reducing emissions. For example, Total Energies states in its report that "Total Energies supports the pledges made by nations worldwide to combat global warming as part of the Paris Agreement. In support of those commitments by the European Commission, they have set a target in Europe of reducing Scope 1+2+3 emissions [115]."

Another commonly reported strength is the increased awareness and implementation of energy efficiency and emission reduction measures across the value chain. For instance, Aker BP reported that they have implemented emission-reducing upgrades, such as equipping the NS Frayja platform supply vessel with a new battery system and exploring the retrofit installation of ammonia fuel cell technology on offshore support vessels in collaboration with Alma Clean Power and Eidesvik Offshore. Aker BP also reported that they plan to fit batteries on five platform supply vessels starting in 2022, resulting in an annual CO_2 reduction of 10% [116].

Weaknesses: According to the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard [3] and the guidance documents of the Task Force on Climate-related Financial Disclosures [43], one major challenge and weak-

ness of Scope 3 reporting lies in the quality and availability of data. Estimates of Scope 3 emissions are often based on different and sometimes incomparable methods, as organizations have the discretion to set organizational boundaries and choose which products to include in these calculations [63]. As a result, comparing Scope 3 reporting across companies becomes difficult [76]. For instance, Shell calculates its GHG using locally regulated methods or the industry-standard 2009 API Compendium. However, there are inherent limitations to the accuracy of such data, and uncertainties can contribute to the overall uncertainty of a corporate emissions inventory. Shell estimates the overall uncertainty of its direct GHG emissions to be around 4% for 2021 in their report [117].

Opportunities: The reports of all eight companies highlight their interest and innovations in transitioning to low-carbon products. IOCs are diversifying their portfolios by incorporating low-carbon products such as biofuels, hydrogen, wind power, and solar energy [117, 118, 119, 115] as per their reports. Companies like Preem and Neste are investing in the development of low-carbon fuels, including biogas and hydrogen [120, 121].

The companies also report that identifying Scope 3 emissions presents an excellent opportunity for increased collaboration and a stronger commitment to emission reduction [117, 118, 115, 120, 121]. Shell, for example, has created the "Shell Supplier Energy Transition Hub," a digital platform offered free of charge to their supply chain and other interested companies. This platform enables participants to set emission ambitions, track performance, share best practices, and exchange emissions data. By the end of 2021, 258 suppliers had joined the platform [117]. Similar efforts to enhance collaboration with suppliers are evident in the reports of other companies.

Threats: The threats are mainly identified from the literature regarding Scope 3 emissions. A study [122] suggests that reporting Scope 3, Category 11 emissions in sectors without clear transition plans can lead to underperformance by respective firms. Another study [123] highlights the limited implementation of the standard due to challenges in obtaining emissions data from vendors and customers. Shareholders are pressurizing these companies to disclose these emissions and demonstrate how they are managing them [12]. These findings underscore the potential threats and obstacles associated with Scope 3 reporting and the need for effective strategies to address data availability and industry-wide transition plans.

Table 5.3 summarizes the results of the SWOT analysis with scales from 0 (No companies mentioned but are found in the literature reviews) to 3 (Mentioned by more than six companies) to indicate the shared visions and challenges. One interesting observation is the lack of discussions in the company's sustainability report regarding the weaknesses and threats associated with GHG reporting.

Table 5.3: Strengths, weaknesses, opportunities and threats of Scope 3 emission reporting.
Grading scale:- ∘ = No companies mentioned but are found in the literature reviews, • = Mentioned by 1-3 companies, • • = Mentioned by 4-6 companies, • • • = Mentioned by more than 6 companies.

Strengths	**Weaknesses**
• • • Shows commitment to addressing climate change and sustainability. • • • Drives emission reduction and energy efficiency across the value chain. • • • Helps identifying high-impact activities across the value chain. • • Increases accountability and transparency.	• • • Challenge of proper data availability and quality. • • Resource intensive to gather and analyse data from a large number of suppliers. ∘ Difficulty in establishing accurate emission baselines and tracking progress over time. ∘ Reporting Scope 3 is not a regulatory requirement in all regions, leading to inconsistency.
Opportunities	**Threats**
• • • Potential for improved supplier engagement and collaboration in emission reduction. • • • Encourages innovation and development of low-carbon products and services. • • Cost savings and operational efficiencies through improved emission tracking and management. • • Builds stakeholder trust and enhances brand reputation.	• • • Limited control over emissions from end-use customers. • • • Complexity of supply chain networks. ∘ Lack of uniformity in reporting and methodology. ∘ Increased scrutiny from stakeholders and investors on emissions performance.

6
Discussion and Conclusion

This chapter provides a discussion and conclusion of our study. Section 6.1 delves into a detailed analysis and interpretation of our research results, followed by key contributions in Section 6.2. In Section 6.3, we critically address the limitations inherent in our study, acknowledging any constraints or challenges encountered during the research process. We also highlight potential avenues for future research that can further contribute to the field and extend the knowledge gained from this study. Building upon this analysis, Section 6.4 presents the conclusions drawn from our study, providing a synthesized understanding of the research outcomes and their significance in relation to the research objectives and broader context.

6.1 Discussion

The findings from this study underscore the notable lack of comparability and inconsistencies among the sustainability reports of the case-study O&G companies. This observation is consistent with previous research, such as the study [22], which also highlights the non-comparability of ESG reporting within the O&G industry and [124] pointing out that there is a lack of standardization and consistency in the reporting of GHG emissions which makes it difficult to compare the performance of different companies. Our investigation delves deeper into these findings in the subsections below, revealing crucial insights into emission-reduction targets set by the companies, system boundary approaches used to report emissions, Scope 3 reporting, CI of the scope of emissions, and NCI.

6.1.1 Emission reduction targets

The analysis of emission-reduction targets reveals a mix of short-term and long-term goals among the companies. All the case-study companies have set some emission-reduction targets, and the IOCs in our case study may belong to those companies in the study [56] having low transition plans mentioned in the literature review (Section 2.2.2). While all companies, except Chevron and Preem, have established short-term targets for Scope 1+2 emissions to be achieved by 2030, Chevron aims to achieve its target by 2028, and Preem has not set a short-term target. It is worth noting that Preem stands out with its ambitious goal of attaining a carbon-neutral value chain by 2035, far more ambitious than Swedens' national-level objective [125], and Neste

aims for carbon-neutral production by the same year, consistent with Finlands' carbon neutrality target [126]. On the other hand, companies like Shell, BP, Chevron, Aker BP, and Equinor have set their sights on achieving carbon neutrality by 2050, reflecting the broader carbon neutrality objectives of Europe and the United States [127, 128]. These findings align with the previous studies [129, 130] suggesting that these targets are significantly influenced by regional factors and the specific carbon neutrality / net zero goals of their respective countries.

Considering NCI targets, it is notable that not all companies have specified targets in this category. However, all IOCs have established targets. Chevrons' target of just over 5% reduction by 2028 contrasts with the 20% reduction targets set by other companies for 2030. This 20% target is similar to the low carbon fuel standard target set by the California Air Resources Institute for the same year [114]. Moreover, these targets undergo regular updates due to dynamic changes in national-level targets, policies, and ambitious continental goals to achieve carbon neutrality. For instance, Shell reported achieving a net carbon intensity target of 20% by 2030 in its 2021 sustainability report, while a previous study in 2016 revealed Shells' aim to achieve the same target by 2035 [82]. This indicates that these targets are constantly evolving in response to changes in country-level targets and agreements, creating complexities for NGOs and investors seeking comparability. Another crucial observation is the disparity in base years used by companies to set emission-reduction targets. For example, Equinor and Aker BP have both set Scope 1+2 targets of 50% reduction by 2030, but their respective base years are 2015 and 2005. This non-standardization of base years may hinder comparability for stakeholders such as NGOs and investors.

6.1.2 System boundary

The operational control approach emerges as the predominant choice of system boundary approach among the companies, while Chevron stands out as the sole company utilizing both the operational control and equity share approaches for reporting all three scope emissions. This prevalence of the operational control approach aligns with previous studies [1, 131] on GHG reporting and studies mentioned in the literature review that have identified it as the dominant method. This suggests that O&G companies may have more subsidiaries where they can control their operating policies rather than equity shares.

We also find a striking comparison of emission levels reported by Chevron when employing the operational control and equity share approaches. In 2021, Chevron reported total emissions of 680 million tonnes of CO_2e and 469 million tonnes of CO_2e using the operational control and equity share approaches, respectively. This discrepancy is consistent with the findings of a previous study [84] on Shell's GHG reporting in 2009, which also observed notable differences in emission levels depending on the chosen system boundary method. These observations raise important considerations, suggesting that companies when granted the freedom to choose their system boundary method for emissions reporting, may strategically adjust their or-

ganizational boundaries by excluding facilities with higher emission levels in order to meet their emissions targets. These findings underscore the critical significance of carefully selecting the appropriate system boundary approach in emissions reporting. The GHG Protocol specifically mentions the exceptional case of O&G industries where the approach chosen will considerably impact GHG inventory as they have complex ownership [48]. It highlights the need for accurate and comprehensive assessments of a company's environmental impact, as the choice of system boundary method can significantly influence reported emission levels. To ensure transparency and reliability in emissions reporting, these findings suggest that it is crucial for companies to adopt a consistent and robust approach that encompasses all relevant emission sources within their value chain, minimizing the potential for strategic boundary manipulation.

6.1.3 Product mix

From the analysis of the product mix of the selected O&G companies, we find a notable trend in diversification strategies. IOCs stand out by including power as a significant share within their portfolios, indicating a shift towards investments in renewable energy sources and positioning themselves as players in the electricity market. Conversely, the smaller companies (Neste, Preem) focus more prominently on low-carbon fuels such as biofuels and hydrogen, showcasing their commitment to cleaner energy alternatives. This finding aligns with previous studies [132], [133] and [134], which also observed a similar trend among IOCs as they increasingly invest in renewables and expand their presence as electricity sellers, effectively diversifying their operations in the energy sector. In a recent report [135], ten major O&G companies in the Oil and Gas Climate Initiative (OGCI) invested £11.4 billion in clean/low carbon energy technologies. So, as explained in our literature review, this could be a major strategy for low carbon transition by the O&G companies.

However, recent news reports from [136] and [137] have raised concerns regarding the profitability and market performance of investments in renewable energy by BP and Shell. These reports reveal that BP and Shell are considering reducing their investments in renewable energy projects. This potential shift in strategy prompts questions about their future product mix and the CI of their products. The uncertainty and volatility observed among these companies are evident, and the constantly changing country-level targets and policies further contribute to the complexity of their strategies. Amidst these uncertainties, it becomes imperative for these companies to carefully assess and adapt their strategies to align with evolving market dynamics, technological advancements, and shifting regulatory landscapes. As they navigate through the energy transition, the strategic decisions made by these companies may have significant implications for their long-term sustainability and the broader energy industry. The balance between traditional fossil fuel products and low-carbon alternatives could play a crucial role in shaping their product mix and carbon intensity, influencing their environmental impact and market competitiveness. This underscores the need for agility and strategic foresight to navigate the

dynamic energy landscape and respond effectively to emerging challenges and opportunities.

6.1.4 Detailed Scope 3 reporting categories

The detailed analysis of Scope 3 reporting finds the reporting patterns of different emission categories within the sustainability reports of the case-study companies. It is worth noting the pioneering efforts by BP and Neste in 2015, alongside the progressive reporting over the years by Neste, Aker BP, and Shell, which underscores their commitment to comprehensive emissions reporting.

However, a significant observation is that none of the companies reported all the Scope 3 emission categories during 2015 - 2021, with Category 11, which represents emissions from the use of sold products, emerging as a prominent focus across the reporting companies. Shell, Neste, Preem, and Aker BP demonstrated a more comprehensive approach by reporting multiple categories and providing detailed accounts of measures already taken and planned actions to reduce these emissions in their sustainability reports. This emphasizes the importance of including diverse emission categories in reporting, as it may enable companies to identify specific measures and strategies to address emissions effectively, thereby enhancing their competitive position in the climate crisis landscape and fostering stakeholder trust. The distinctive focus of Aker BP on reporting upstream categories is notable, possibly explaining their emphasis on implementing emission reduction and energy efficiency measures in upstream transportation and commuting, as already explained in the SWOT analysis results. These findings underscore the significance of comprehensive and transparent Scope 3 reporting, as it offers valuable insights into the emissions profiles of companies' value chains and unveils opportunities for emissions reduction and sustainability initiatives.

Furthermore, the discrepancy in Scope 3 reporting between European companies and the US-based Chevron highlights regional variations in reporting practices, suggesting that regulatory and market factors may influence the extent of reporting. A previous study [138] finds that institutional pressures, such as compliance with EU emissions trading scheme regulations and adherence to GRI guidelines, positively influence the GHG reporting practices of multinational O&G companies, leading to improved reporting quality and more detailed reporting.

6.1.5 Carbon intensity of scope emissions

The observed patterns in CIs of Scope 1,2,3 and CI_r among the eight O&G companies give insights into their emission profiles and mitigation efforts. The dominance of Scope 3 emissions in overall CI aligns with previous research explained in Chapter 2, underscoring the significance of addressing emissions throughout the value chain.

The negligible Scope 2 CI across the companies suggests that Scope 2 emissions are relatively minor contributors to their overall CI in the O&G sector. Preems' exceptionally low Scope 2 CI can be attributed to efficient energy management practices or the utilization of low-carbon energy sources. This suggests that understanding such practices could offer valuable insights for other companies to adopt more sustainable energy consumption strategies.

Examining the reported CI_rs unveils varying degrees of carbon removal efforts among the companies. Chevron and Total Energies stand out with relatively high CI_r in 2021. This demonstrates their proactive approach to offsetting carbon emissions, potentially through CCS projects or reforestation initiatives. However, the negligible CI_rs of Shell, BP, Equinor, and Aker BP imply that their reported carbon removal efforts are relatively minor. This signals the need for these companies to explore and implement more robust carbon offsetting strategies to align with global sustainability goals.

Furthermore, the notably low CI_r of Equinor in 2021 presents a contrast to the findings discussed in subsection 2.4.2 of the literature review. This previous report [91] highlights Equinors' strategic emphasis on substantial investments in CCS. However, the reported low level of CCS deployment in Equinors' 2021 sustainability report raises concerns about their ability to attain the projected market share mentioned in the aforementioned report. The incongruity between their reported CI_r and the anticipated role of CCS in their strategy prompts questions about their alignment with the outlined sustainability goals.

The variations in CIs of Scope 1,2,3, and CI_r among the selected O&G companies highlight the diversity in their reporting practices and emission reduction efforts. By comprehensively addressing Scope 3 emissions and enhancing transparency in reporting, companies could accurately assess their environmental impact and develop targeted strategies to drive sustainability in the energy sector. The findings underscore the importance of harmonized reporting methodologies and proactive carbon removal initiatives for the O&G industry to transition towards a low-carbon future.

A closer look at the CIs of different categories of Scope 3 emissions reported in 2021 by these companies also reveals a more detailed overview. Category 11, encompassing emissions from the use of sold products, emerges as the dominant contributor to CI across all firms, emphasizing its critical role in the overall environmental impact of the industry. This finding suggests that the rationale behind the diversification strategies applied to the product mix within these companies might be rooted in the aspiration to curtail emissions originating from Category 11. Significantly, this trend diverges from findings in other sectors. For instance, a report [139] and a study [140] highlight Category 1 emissions (pertaining to purchased goods and services) as significant contributors to emissions in the manufacturing sector and the educational sector (universities), respectively. Furthermore, as revealed by another study [141], the tourism sector differs by demonstrating higher emissions attributed

to Category 13.

Following Category 11, Category 1 and 3 exhibit relatively high CIs among the reported emission categories. These results suggest that companies should pay close attention to managing emissions from these categories to achieve effective emissions reduction. Additionally, Category 9, which represents emissions from downstream transportation and distribution of sold products, emerges as the next most reported category. However, the negligible carbon intensity ranging from 0.03 to 0.95 gCO_2e/MJ for Category 9 indicates that emissions associated with downstream transportation and distribution are relatively low compared to other prominent categories. Nonetheless, these emissions may still be significant in the context of a company's overall carbon footprint, and strategies for emissions reduction in this category remain relevant for achieving sustainability goals. Understanding the significant role of Category 11 emissions and identifying areas of higher carbon intensity, such as Categories 1 and 3, is crucial for formulating targeted and effective emissions reduction strategies. This analysis contributes to the growing body of knowledge surrounding emissions reporting and management within the O&G sector and may help in supporting companies in their transition toward a more sustainable and environmentally responsible future.

6.1.6 Findings from the comparison of reported and calculated net carbon intensities

The comparison of NCI_R reported by the O&G companies in their sustainability reports and the corresponding NCI_P that we calculated also gives insights into the importance and comparability using NCI. The range of NCI_R from these findings falls within the range of NCI specified in Section 2.2.3, except for Aker BP. The findings indicate a close alignment between the reported NCI_R values and the calculated NCI_P for Shell, BP, and Chevron, with values of 77, 79, and 71 gCO_2e/MJ, respectively. This consistency suggests that these companies' reported NCIs are reliable based on our assumptions and reflect the emissions associated with their product mix.

However, a notable discrepancy arises for Total Energies, where the reported NCI_R of 90 gCO_2e/MJ exceeds the calculated NCI_P. This difference may be attributed to assumptions made during the calculation process, particularly regarding the CIs of specific products used. On the other hand, Preem does not report NCI_R. These variations in reporting practices highlight the need for standardized and comprehensive reporting methodologies to ensure consistency and comparability among companies.

The discrepancies observed between NCI_R and NCI_P values emphasize the challenges of comparing emissions data among O&G companies. To ensure accurate assessments and informed decision-making, it is imperative for companies to adopt standardized reporting practices and provide transparent and comprehensive emissions data.

Furthermore, the high NCI values observed in the O&G companies raise the pertinent question of whether their ambitious targets to achieve net zero or carbon neutrality by 2050 are attainable. Equally significant is the consideration of whether their existing strategies are adequate to facilitate this transition. A study [142] has discovered that the readiness for a low-carbon transition varies substantially among the sampled companies. European-based firms generally demonstrate a higher level of preparedness compared to their North American counterparts within the industry. This prompts the query: Can the industry truly claim to be fully prepared for the intricate challenges of the low carbon transition and the pursuit of exceptionally ambitious emission reduction objectives through their current status and strategies? Or could these strategies potentially be perceived as green-washing, as suggested by previous research? [143, 144].

6.1.7 SWOT analysis

The SWOT analysis of Scope 3 reporting suggests that this type of reporting could be a valuable tool for companies that are committed to addressing climate change and sustainability. It provides a comprehensive evaluation of the strengths, weaknesses, opportunities, and threats associated with this reporting approach. The analysis sheds light on the potential benefits and challenges faced by companies undertaking Scope 3 reporting, offering valuable insights into the industry's strategies for sustainable development.

Among the strengths identified, Scope 3 reporting demonstrates its significance in showcasing companies' commitment to addressing climate change and sustainability. Various studies [123, 145, 77] highlight the growing importance of Scope 3 emissions for the same goals. By driving emission reduction and energy efficiency throughout the value chain, Scope 3 reporting enables companies to strategically tackle high-impact activities, contributing to a lower overall carbon footprint. Previous studies by [55, 123, 146, 76] also found the same. Moreover, the increased accountability and transparency fostered by Scope 3 reporting enhance stakeholder trust and promote a culture of environmental responsibility within the industry. By shedding light on these areas, companies may strategically target emission reduction efforts and align their sustainability goals more effectively.

On the other hand, the analysis also identifies key weaknesses in Scope 3 reporting. Proper data availability and quality are significant challenges, already mentioned in studies [55, 123], as emissions data are dispersed across multiple suppliers and stakeholders. This hinders the ability to consistently and accurately compare emissions across companies. Additionally, the resource-intensive nature of data gathering and analysis from a large number of suppliers demands considerable time and effort, potentially straining companies' capabilities. Establishing accurate emission baselines and tracking progress over time also poses challenges due to the complexity and varying methodologies involved. Furthermore, the lack of regulatory requirements

for Scope 3 reporting in some regions results in inconsistency in reporting practices among companies.

Scope 3 reporting also presents promising opportunities for companies committed to sustainability. The analysis identifies the potential for improved supplier engagement and collaboration in emission reduction efforts. By working closely with suppliers, companies can collectively reduce their carbon footprint in the supply chain. This opportunity is similar to the strategies of these companies for low carbon transition already explained in Chapter 2. Scope 3 reporting also fosters a culture of innovation, incentivizing the development of low-carbon products and services that align with emission reduction goals. Moreover, the implementation of Scope 3 reporting may lead to cost savings and operational efficiencies through better emission tracking and management. These cost-saving measures may contribute to the financial performance of companies while advancing environmental objectives. Additionally, Scope 3 reporting has the capability to enhance brand reputation, as companies demonstrating transparency and proactive emission reduction efforts gain credibility and recognition in the marketplace.

However, the analysis also reveals certain threats associated with Scope 3 reporting. Limited control over emissions from end-use customers poses a significant threat, as Scope 3 emissions predominantly arise from the use of sold products by customers. This limitation necessitates a broader collaboration between companies and customers to reduce downstream emissions collectively. The complexity of supply chain networks also poses a threat to accurate and standardized reporting. Companies must navigate the intricacies of diverse supply chains to gather comprehensive and consistent emissions data. The lack of uniformity in reporting and methodologies across the industry can lead to information gaps and hinder accurate assessments. A study by [55] about the status of GHG reporting in the food sector suggests the need for an easy and clear methodology. The authors of another study [72], who conducted a small-scale sector-based study of about 22 firms on Scope 3 emissions in Australia, underline the lack of proper methodology. Additionally, increased scrutiny from stakeholders and investors emphasizes the need for companies to adopt comprehensive and transparent Scope 3 reporting practices.

6.1.8 Advantages and disadvantages of SWOT analysis

Incorporating a SWOT analysis as a research tool in the second research question of this study offers several advantages and considerations for strategic planning and decision-making. Studies and reports [99, 101] suggest that the SWOT analysis is one of the most recognized strategic tools that enables a systematic evaluation of internal (strengths and weaknesses) and external (opportunities and threats)factors influencing a specific domain. This methodological approach facilitates a systematic and structured assessment, providing valuable insights into the research question. By identifying the strengths and weaknesses of Scope 3 reporting, the analysis offers a holistic understanding of the reporting practices and challenges faced by compa-

nies. Moreover, the analysis of opportunities and threats sheds light on potential pathways for improvement and potential risks that may influence decision-making in the context of emission reduction strategies.

However, it is essential to recognize certain limitations associated with the application of SWOT analysis in research and decision-making. While the SWOT framework offers a structured approach, it may oversimplify complex issues and fail to capture nuances in the data. As a qualitative tool, the analysis heavily depends on subjective judgment and researcher interpretation, which can introduce bias into the findings [99]. Additionally, the SWOT analysis may not provide quantitative metrics for prioritization and comparison, limiting its ability to quantify the significance of each factor. Therefore, complementary quantitative methods should be employed to support and validate the SWOT analysis results [101].

Verification of data accuracy and reliability is crucial to ensure the credibility of the findings. Furthermore, researchers should be aware of potential cognitive biases that may influence their interpretation of the results. While the analysis highlights potential strengths and opportunities in Scope 3 reporting, it does not guarantee a definitive pathway for all companies [101, 147]. The context-specific nature of the findings necessitates considering individual company characteristics and strategic objectives when implementing the insights gained from the analysis. Collaborative efforts involving multiple stakeholders could enrich the SWOT analysis by providing diverse perspectives and insights, enhancing the comprehensiveness of the assessment [99].

6.2 Key contributions

This thesis offers insights into how GHG reporting practices impact the O&G sector's journey toward sustainability. It brings attention to crucial factors that shape emissions reduction strategies and highlights the inconsistencies in reporting practices. For instance, the study highlights the differences in the years companies choose as a starting point (base years) for their emission reduction goals. This discovery raises concerns about comparing these targets, particularly for organizations, NGOs, and investors.

Moreover, the research looks at how O&G companies report their Scope 3 emissions and its 15 categories and bridge the gap as discussed in Chapter 2. This uncovers that reporting patterns vary, especially those in Nordic countries, the rest of Europe, and a US company. This underlines how regional differences play a role in emissions transparency.

In addition, the study sheds more light on the limitations of inconsistent reporting practices. For example, comparing companies like Neste, BP, and Preem reveals how detailed Scope 3 reporting impacts apparent carbon intensity differences.

Clarifying the GHG Protocol's Scope 3 standard is another crucial point. The study argues for a more standardized approach to enhance comparability among reporting entities and avoid confusion.

Lastly, a thoughtful SWOT analysis helps to find the motivations of Scope 3 reporting of the eight O&G companies. It outlines a practical road map for them to navigate the challenges of Scope 3 emissions and work towards net-zero targets. One example is the emergence of collaboration within supply chains as a key theme. The study underscores how involving various stakeholders in data collection can help pinpoint emission sources accurately and develop effective reduction strategies. This collaborative approach seems promising for making real changes in the industry. By pulling these insights together, this thesis provides a comprehensive guide for companies aiming to align with today's sustainability demands.

6.3 Limitations and areas of future research

Despite the valuable insights gained from our study, there are several limitations to consider. Firstly, our research focused on a selected group of O&G companies, including IOCs and smaller regional players. While these companies represent significant players within the industry, the findings may not fully capture the entire spectrum of emissions reporting practices in the O&G sector. Future research may extend the scope to include a more extensive and diverse sample of companies, encompassing various geographical regions and operational sizes, to provide a more comprehensive understanding of emissions reporting practices.

Secondly, the quality and accuracy of emissions data remain a key challenge in GHG reporting. The discrepancies in reporting methodologies and data availability among the studied companies may introduce uncertainties in the comparative analysis. Employing third-party verification or independent auditing of emissions data can enhance the reliability and credibility of the reported information. Additionally, exploring innovative technologies such as blockchain-based platforms to track and verify emissions data in real time may offer new opportunities to improve the accuracy and transparency of reporting.

Another limitation lies in the dynamic nature of emission reduction targets and reporting practices, influenced by evolving national and international policies, regulatory frameworks, and market trends. Our study provides a snapshot of the companies' emissions reporting at a specific time (2021), and future research should consider conducting longitudinal studies to track the changes and progress in emissions reporting practices over time. Longitudinal research would provide valuable insights into the adaptability and responsiveness of companies in aligning their strategies with evolving sustainability goals.

In addition, our research primarily concentrated on evaluating how these companies report their emissions in accordance with GHG Protocol frameworks. Despite

this, there are various other standards and frameworks that these companies apply in their sustainability reports, as mentioned in Section 2.2. Future research can explore the extent to which they conform to emission reporting based on those standards and frameworks.

Finally, while our SWOT analysis offered valuable insights into the strengths, weaknesses, opportunities, and threats surrounding Scope 3 emissions reporting, additional research with more in-depth interviews with company representatives and stakeholders to gain a more nuanced understanding of the drivers and barriers influencing reporting strategies. Such qualitative data can provide valuable context and enrich the interpretation of our findings.

6.4 Conclusion

Our study delved into GHG emissions reporting practices of eight O&G companies, comprising both IOCs (Shell, BP, Chevron, Total Energies) and smaller regional players (Aker BP, Equinor, Preem, Neste). This exploration of GHG emissions reporting practices within the O&G industry has provided significant insights into the carbon footprint and environmental impact disclosures of these companies in their sustainability reports. The central aim is to assess the comparability of emissions reporting, with a particular focus on Scope 3 emissions. Through a comprehensive analysis of emission targets, reporting boundaries, and the scope of emissions reporting, our research makes a substantial contribution to the existing literature, providing an essential inventory of GHG emission reporting practices in the O&G sector and underscoring the need for harmonization and standardization to enhance comparability and to enable informed decision-making by stakeholders. Moreover, the SWOT analysis gives valuable insights into the motivations driving diverse Scope 3 reporting strategies within the industry.

The implications of our findings are far-reaching. Standardization of reporting methodologies and the establishment of ambitious, transparent emission reduction targets are essential for fostering sustainability and addressing the environmental challenges posed by the O&G industry. The evolving emission reduction targets and product mix strategies reflect the transformative nature of the sector, driven by a global shift toward sustainability and market dynamics. As the climate crisis escalates, companies must adapt their strategies to navigate the rapidly evolving energy landscape successfully. It also indicates that the O&G industry exhibits diverse practices in reporting GHG emissions, leading to a lack of comparability among the studied companies. Notably, the Scope 3 emissions emerged as a key concern, with significant variations observed in the reported categories across the companies. The analysis reveals that BP and Neste have been pioneers in Scope 3 reporting. At the same time, Shell, Aker BP, and Neste demonstrated progressive reporting practices, expanding the number of Scope 3 categories over time. However, none of the companies reported all the Scope 3 emission categories, and Category 11, involving emissions from the use of sold products, emerged as a prominent focus among the

reporting entities.

The SWOT analysis in our study emphasizes the importance of holistic Scope 3 reporting and the need for proactive measures to mitigate environmental impacts. It also sheds light on the motivations and strategies driving different Scope 3 reporting practices. It is evident that regulatory and market factors play a significant role in influencing the scope and extent of emissions reporting among companies. The findings emphasized the importance of comprehensive and transparent Scope 3 reporting, as it not only identifies opportunities for emissions reduction but also fosters stakeholder trust and informed decision-making. The SWOT analysis also highlighted the potential for improving reporting practices and addressing challenges related to data quality and availability.

By promoting accountability and transparency, our research supports the industry's progress toward a sustainable energy future. Going forward, it is crucial to address the identified limitations and continue exploring opportunities for future research. Efforts in this direction will not only enhance the understanding of emissions reporting practices but also contribute to the development of effective strategies to combat climate change and promote sustainable development within the O&G sector. As the industry continues its journey toward sustainability, ongoing vigilance, and adaptability will be key in navigating the challenges and opportunities that lie ahead.

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A

Appendix

A.1 Conversion factors

- Energy
  1 barrel of oil equivalent (boe) = 6.119 million kJ = 6119 MJ [5]

- Energy density

Table A.1: Energy density based on [5] and [6]. Assumed the energy density of gasoline for fossil products and the energy density of biogas for renewable products of Preem.

Product	**1000 MJ/m^3**
Fossil products	35
Renewable products	25

- Carbon intensity

Table A.2: Carbon intensity of products (gCO_2e/MJ) by company. '–' means no data reported.

Products	**Shell** [117]	**BP** [148]	**Chevron** [149]	**Range used in this study**
Oil Products and GTL	91	92	82	82-92
Gas	66	72	75	66-75
LNG	70	–	60	60-70
Biofuels	41	27	48	27-48
Power	66	38	43	38-66

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