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USING BUSINESS ANALYSIS TO ENHANCE SUSTAINABILITY AND ENVIRONMENTAL COMPLIANCE IN OIL AND GAS: A STRATEGIC FRAMEWORK FOR REDUCING CARBON FOOTPRIN

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ABSTRACT

The oil and gas industry has been identified also as a major source of greenhouse gases and contributes approximately 42% of the total global CO_2 emissions. As the world continues to strive towards sustainable development goals including those of the Paris accord, this industry is under pressure to decrease its emission of carbon. This review discusses the application of business analysis tools on a strategy that supports sustainability and aligns oil and gas companies with environmental standards. The framework is centred on the deployment of next-generation technologies as carbon capture and storage, on establishing global standards of corporate climate policies, on engaging stakeholders, on optimizing business processes, on facing climate risks and on experimenting with new forms of biofuels. Some of the problems include high costs, complications due to state regulations, and negative attitudes from the public and stakeholders.These issues can be overcome through effective public-private partnerships, sharing of information, and diversification of research spending. In addition to mitigating emissions the envisaged framework is designed for companies to derive strategies that will keep them competitive and socially responsive. The present review also underlines the necessity to use a complex approach to increasing the sustainability of the oil and gas industry.

I. INTRODUCTION

The oil and gas industry is the major emitter of greenhouse gases contributing to nearly 42% of the global emission of CO_2. and is therefore a major contributor to climate change [1]. These emissions result from various processes, including the extraction, refining, and combustion of fossil fuels, as well as routine practices like flaring and methane leaks during production [2]. As the primary contributor to global emissions, the industry's activities have a profound impact on climate change, driving global warming, rising sea levels, and extreme weather events [1]. Given its central role in the climate crisis, the oil and gas sector faces increasing pressure to adopt more sustainable practices to reduce its carbon footprint [3]. Similarly, due to globalisation and the signing of the Paris Accord among other international acts, this sector has no option but to cut its footprint when it comes to the environment to meet international emission targets [4],[5]. Industry's pressures on those issues have been varied, some firms are advanced in sustainable practices integration, while others have not been able to adopt sustainable practices without compromising the firm's performances, [6],[7].

The concept of sustainability in the oil and gas industry involves two key dimensions: environmental sustainability and the economic or social sustainability of companies in the sector [8,9]. Achieving a balance between these aspects is critical, as companies must minimize their environmental impact while ensuring their long-term economic viability and maintaining social responsibility

toward the communities in which they operate [8]. The sector's capital intensity, extensive value chain, and reliance on non-renewable resources pose challenges to meeting sustainability goals [10],[11]. The industry's dependence on fossil fuels conflicts with the principles of sustainable development, which prioritize long-term resource conservation and minimizing environmental harm [3]. As oil and gas operations require significant investments in infrastructure, the capital intensity of the sector makes transitioning to sustainable practices more complex [10]. Additionally, the global economy's reliance on oil and gas for energy security further complicates the industry's efforts to reduce its environmental footprint [1]. Growing energy demands, driven by population growth and industrialization, increase the pressure on companies to balance environmental sustainability with energy supply [12].

To achieve sustainability, oil and gas companies must adopt strategies that integrate environmental, economic, and social dimensions [12]. This includes reducing carbon emissions, improving energy efficiency, and transitioning to renewable energy sources [9]. However, these environmental measures must be aligned with the companies' profitability and investments in cleaner technologies [8]. Social sustainability involves ensuring equitable benefits for local communities while mitigating social harms like displacement and health risks [13]. The implementation of sustainability strategies is also complicated by varying regulatory requirements and geopolitical factors [11].

This manuscript aims at formulating a strategic framework that adopts business analysis techniques to tackle these issues thereby promoting sustainability and compliance with environmental standards in the oil and gas sector [6-8]. In this way, the industry will be able to reposition its business models in harmony with the SDGs and contribute to lowering carbon intensity without compromising economic rationality and social standards [14],[15].

II. THEORETICAL REFERENCE

II.1 OVERVIEW OF THE GLOBAL NEED FOR SUSTAINABILITY IN THE OIL AND GAS SECTOR

Sustainability in the oil and gas sector requires balancing environmental impacts, economic growth, and people's welfare in the sector. The industry has come to the stage of a cross-road of providing solutions to global economic growth, while at the same time upholding the Social Responsibility Safety Management about environmental conservation [10],[16],[17]. Due to awareness of environmental protection, the oil and gas industry is continuously evolving towards sustainable development goals, and is linking its further discussion with climate change, emission and sustainable energy for the world [13]. Currently, there is a noticeable trend towards increasing sustainability in the global oil industry on the part of both the global oil and gas sector and governments, with goals set for emission reductions, energy efficiency, and the shift to clean energy [18],[19]. This is based on International Climate Policies, including the Paris Agreement, which calls for emission reduction measures to raise the global temperature by only one degree. In this regard the global temperature should not exceed 5°C above the level of pre-industrialization [3],[20].

The oil and gas sector operates at the intersection of complex geopolitical and societal dynamics, where energy security, economic stability, and environmental sustainability are deeply intertwined [21]. As global concerns about climate change intensify, the industry faces mounting pressure to align with sustainability goals and reduce its carbon footprint [22]. This pressure stems from both international agreements, such as the Paris Agreement, and shifting societal expectations. Business analysis, particularly through strategic frameworks, can play a crucial role in enhancing sustainability and ensuring environmental compliance within this sector [23]. Geopolitically, the reliance on fossil fuels has far-reaching implications for national and global stability [21]. Oil-rich countries often experience economic volatility due to fluctuations in global oil prices and geopolitical conflicts. For example, nations like Venezuela and Nigeria have faced economic instability linked to their heavy dependence on oil revenues. This economic vulnerability highlights the need for these countries to diversify their economies away from fossil fuels. The shift towards cleaner energy sources and the adoption of sustainable practices are becoming essential strategies for maintaining economic stability and reducing vulnerability [24].

Societal implications are equally significant. As governments implement policies aimed at reducing carbon emissions, oil-dependent economies must adapt to avoid socio-economic disruptions. For instance, Saudi Arabia's Vision 2030 represents an ambitious effort to reduce its reliance on oil by investing in diverse sectors such as tourism and technology. Similarly, Kazakhstan is focusing on renewable energy projects to create new economic opportunities and lessen its dependence on fossil fuels. These examples underscore the necessity for oil-dependent nations to foster economic resilience through diversification and innovation [25].

From a business analysis perspective, developing a strategic framework for reducing the carbon footprint involves several key components. First, integrating renewable energy technologies into oil and gas operations can substantially lower emissions and enhance sustainability [23]. For instance, companies can adopt solar, wind, and geothermal energy to power their facilities and reduce reliance on conventional fossil fuels. The use of photovoltaic solar panels on infrastructure, wind turbines near facilities, and geothermal heat pumps can significantly contribute to energy diversification and emissions reduction [26],[27]. Moreover, effective waste management and recycling practices are essential for minimizing the environmental impact of oil and gas operations. Implementing source reduction, material substitution, and process optimization can help reduce waste generation at facilities [28]. Recycling materials such as metal scrap and drilling muds can divert waste from landfills and promote a circular economy. Additionally, converting organic waste into renewable energy sources through technologies like anaerobic digestion and biogasification can offset fossil fuel consumption and reduce greenhouse gas emissions [21].

The strategic framework also emphasizes the importance of compliance with environmental regulations and standards. Companies must regularly monitor environmental parameters, emissions, and adherence to permit conditions to ensure regulatory compliance [26]. Environmental management systems [EMS], such as ISO 14001, can help establish proactive measures for identifying and mitigating environmental risks. Engaging with local communities and stakeholders is crucial for building trust and ensuring the successful implementation of sustainability initiatives [23].

II.2. INTERNATIONAL AGREEMENTS AND REGULATORY FRAMEWORKS: IMPACTS ON THE OIL AND GAS SECTOR

International agreements like the Paris Agreement have played a crucial role in shaping global climate policies by setting ambitious goals to curb greenhouse gas emissions and control global temperature increases. Since its adoption in 2015, the Paris Agreement has sought to limit the rise in global temperatures to well below 2°C above pre-industrial levels, aiming for an even more stringent 1.5°C limit [28],[29]. This framework has driven governments to adopt stricter environmental regulations and to encourage the transition to renewable energy sources. Governments worldwide are responding with increasingly stringent environmental standards. For example, the European Union Emissions Trading System [EU ETS] imposes a cap on total emissions and allows for trading of emission allowances, creating economic incentives for companies to reduce their emissions [30]. Similarly, national carbon taxes are designed to reduce carbon emissions by making high-emission activities more costly [28]. In response to these regulations, there has been a notable shift towards renewable energy. Policies like Germany's Energiewende are promoting significant investments in renewable energy sources, such as wind and solar power [31] Major oil and gas companies, including BP and TotalEnergies, are adapting by investing in these cleaner technologies to comply with regulatory expectations and lessen their environmental impact [32].

Maintaining a social license to operate is increasingly important. Companies must navigate these evolving regulations to retain public trust and avoid financial penalties. Enhanced reporting and ESG disclosures are becoming essential, as illustrated by ExxonMobil's improved climate disclosures following shareholder demands [33]. This regulatory environment compels oil and gas firms to integrate sustainability into their core strategies and operations. This pressure emanates from governments, investors, and civil society who are demanding companies to be more responsible in the manner they deal with their impact on the environment. Different governments in the world are coming up with even tighter restrictions on emissions and environmental conservation thus forcing industries to become environmentally tolerant to meet their set standards [7],[34].

Integrating sustainability into key business operations is now widely recognized as a significant competitive edge [35]. Companies that take the initiative to implement eco-friendly practices, such as cutting down emissions, enhancing energy efficiency, and investing in renewable energy sources, are better prepared to comply with future regulations, attract investors, and enhance their corporate image [36]. Sustainability has shifted from being a peripheral issue to becoming a central element of strategic decision-making, particularly in the oil and gas sector. Business analysis provides the tools needed to measure the financial returns of sustainable investments, ensuring these efforts support both environmental objectives and financial success [37]. Oil and gas companies are experiencing global investors' attention due to Environmental, Social, and Governance [ESG] considerations, which influence the business' sustainability and market capitalization [17],[38].

II.3. IMPORTANCE OF REDUCING CARBON FOOTPRINT IN THE INDUSTRY

Minimizing carbon emissions helps with sustaining oil and gas by lessening greenhouse emissions, advancing along the globe's climate objectives, and promoting sustainable actions in the long term [39]. Currently, the oil and gas sector is one of the highest emitters accounting for about 42% of total global CO_2 emissions [1],[3]. If these emissions are not significantly lowered, the world cannot achieve the existing climate goals, like the Paris Agreement that intends to limit global warming to 1. 5°C above pre-industrial levels [2],[4],[7]. In addition, when the limit of the usage of carbon is set and the cost of carbon increases, firms unable to decrease their emissions will be at a higher risk of suffering financially and could even lose market advantage. While carbon pricing mechanisms like carbon taxes and cap-and-trade systems are in place, they operate to increase the operating costs of oil and gas firms and thereby make capital-intensive projects less economically feasible for investors [17,38]. Digital emission estimation minimizes the carbon footprint of the oil and gas sector providing accurate real-time estimation, and efficient design changes at lower costs: as a result, enhancing the sustainability goals [32]. Organizations that develop a strategic approach to decreasing carbon emissions, including allocating resources to low-carbon technologies as well as increasing the efficiency of energy usage, not only address climatic risks but also strengthen their economic performance and competitive advantage [5].

Integrating renewable energy sources into oil and gas operations offers a promising route to reducing carbon emissions and enhancing sustainability. Technologies like solar, wind, and geothermal power can offset the energy-intensive processes of extraction, transportation, and refining [40]. Solar panels installed on infrastructure such as drilling rigs and refineries can generate electricity, reducing reliance on fossil-fuel-based grid power [41]. Wind turbines, both onshore and offshore, can supplement energy needs and lower greenhouse gas emissions. Geothermal systems, utilizing heat from the Earth, can provide essential power and thermal energy, especially in remote areas with limited grid access. To mitigate climate change, reducing greenhouse gas emissions is crucial. Advanced technologies and practices can minimize methane leaks, flaring, and venting, and enhance energy efficiency throughout the oil and gas value chain [40]. Advanced detection methods, including optical gas imaging and drones, can improve leak identification and repair [41]. Alternatives to flaring, such as gas-to-power conversion and gas reinjection, can help recover resources and reduce emissions. Carbon capture and storage [CCS] technologies can capture and store CO_2 emissions from industrial processes, including oil and gas operations, preventing atmospheric release [40]. Minimizing waste generation and encouraging recycling are key components of sustainable resource management in oil and gas operations [42]. Companies can lessen their environmental impact, conserve natural resources, and improve operational efficiency by reducing waste streams, recycling [43] materials, and implementing waste-to-energy technologies. Strategies such as source reduction, material substitution, and optimizing processes help reduce waste generation at oil and gas facilities [37]. Designing products and packaging for durability, recyclability, and reusability also minimizes waste throughout a product's life cycle [44]. Recycling programs for materials like metal scrap, plastic containers, and drilling muds can divert waste from landfills, decreasing the need for raw materials. Recycling facilities can extract valuable resources from waste, reintegrating them into production and fostering a circular economy [41].

Additionally, organic waste, such as biomass and wastewater sludge, can be converted into renewable energy, reducing fossil fuel consumption and greenhouse gas emissions. Technologies like anaerobic digestion and biogasification convert waste into biogas, biofuels, and heat for onsite energy generation

[45]. Ensuring compliance with environmental regulations is vital for maintaining social license to operate. Environmental management systems [EMS] such as ISO 14001 provide a structured approach to identify and manage environmental risks. Moreover, engaging local communities and stakeholders enhances transparency, builds trust, and enables collaboration on minimizing environmental impacts [45].

The objective of this review is to identify the application of business analysis in increasing sustainability and Conformity to the environmental standards in the Oil and gas industry. Through business analysis, a company gains a structured model of performing decision-making processes, which eventually helps to determine the most appropriate strategies for minimizing carbon emissions and maintaining the company's profitability [6],[7]. Furthermore, it endeavours to present a conceptual framework for managing the carbon reduction strategy within the industry with an emphasis on informed decision-making processes and best practices.

Business analysis is crucial in advancing sustainability and ensuring environmental compliance in the oil and gas industry. By relying on data-driven approaches, companies can enhance operational efficiency, cut down emissions, and boost profitability. Through the use of real-time data and predictive analytics, firms are able to make smarter decisions about energy consumption and emissions control, helping them meet their environmental targets [46]. Additionally, business analysis aids companies in evaluating regulatory risks, allowing them to anticipate changes in environmental policies and adapt strategies to ensure compliance [38]. This foresight minimizes risks while enhancing the company's overall sustainability efforts. Business analysis further informs investment in low-carbon technologies by assessing the cost-effectiveness of such investments, ensuring that the most sustainable solutions are also economically viable [6]. Moreover, optimizing supply chains through business analysis helps companies identify inefficiencies in logistics and production processes, leading to reduced emissions [3]. Business analysis also aligns Corporate Social Responsibility [CSR] efforts with stakeholder expectations, promoting transparency and strengthening trust through clear sustainability reports [20]. Business analysis equips oil and gas companies with the necessary tools to confront environmental challenges, cut their carbon footprint, and remain sustainable while maintaining profitability. Despite these advancements, there remains a gap in integrating business analysis with strategic frameworks specifically tailored for reducing carbon footprints. This journal aims to bridge this gap by proposing a comprehensive framework that leverages business analysis to address sustainability challenges, offering actionable insights for enhancing both environmental performance and economic viability in the oil and gas industry.

III. MATERIALS AND METHODS

The steps used in this review reflected rigorous and efficient identification and synthesis of data. The sources of data collection were academic and peer-reviewed journals, business reports, and case studies that revolved around sustainability, environmental standards, and business reporting on the oil and gas industry. The literature review was conducted by searching multiple databases like Scopus, Web of Science, and Google Scholar using such keywords as "business analysis in oil and gas", "sustainability", "environmental compliance", and "carbon footprint reduction". The inclusion criteria were articles published in the last decade, devoted to global and gas sectors and written in English, which analyzed the role of business analysis for sustainability in the given industry. Studies that did not contain features of any of these articles were dropped out of the review process.

Besides journal articles, several industry reports developed by key oil and gas companies as well as by the International Energy Agency [IEA] and the World Bank were reviewed to identify the current best practices and trends in the industry. Information from these sources was subjected to thematic analysis to find out various themes, strategies and challenges on sustainability and environmental compliance within the industry. The analysis was also identified how various business analysis tools and techniques have been employed in the process of solving these challenges.

To ensure a thorough review, data was categorized based on relevance and impact. Key areas of focus included the effectiveness of various business analysis tools, the influence of technological advances on sustainability, and the strategies that leading firms use to improve environmental compliance. The synthesis process involved cross-comparing findings from different sources to highlight similarities and differences, offering a detailed view of current practices and industry gaps.

The review also assessed the research methods used in the studies, evaluating the strength of research designs, data collection techniques, and analysis methods to ensure the conclusions were credible and sound. Additionally, the review took into account the geographic and sectoral diversity of the studies to provide a well-rounded perspective on sustainability practices in various contexts. The resulting framework, derived from academic research, industry reports, and thematic analysis, offers a comprehensive strategy for reducing the carbon footprint in the oil and gas sector. It provides actionable recommendations and best practices that can be tailored to different operational scenarios within the industry.

III.1 FRAMEWORK DEVELOPMENT

The literature and case study analysis used to inform the development of the strategic framework for lowering the carbon footprint of the oil and gas industry also guided the development of the strategic framework. The above framework was built in several phases. First, the general tools that are applied to business analysis in sustainability practices, including SWOT analysis, PESTEL analysis, and value chain analysis, were described and compared in the context of the oil and gas sector. These tools were then incorporated into a coherent framework specific for improving the decision-making and operational processes about sustainability and environmental management.

The development of the framework was also an iterative process where feedback from other experts and professionals would be incorporated. This feedback played an important role of making certain that the framework is not only theoretical, but it is also realistic and implemental. The framework was intended to be rather general so that it could be easily customized to the peculiarities of individual companies operating in the industry.

III.2 CRITERIA FOR SELECTING CASE STUDIES

When choosing cases, several factors were taken into nconsideration to make sure that only relevant and appropriate cases were included in the review. First, the study had to include eight cases of companies within the global oil and gas sector that have applied business analysis strategies to enhance sustainability and decrease carbon footprint, and are located in the United States of America. Second, these cases had to show some market impact:

emission changes, upgraded compliance, or improved efficiency. The cases were selected from different geographical locations to capture variations in the regulation and the market covering that stream of the profession to get a feel of how business analysis comprehensively can be deployed in several settings.

Additionally, where the description of the problem encountered, the tools used for business analysis, and its outcome were well captured, such cases were considered first. This selection criterion ensured that the case studies presented recommendations which could be applied or could be borrowed by other firms in the industry. The last choice of cases was carried out by comparing the theoretical literature and numerous reports of successful and failed strategies.

Table 1: Key Components of the Framework.

Strategic Framework Component	Description	Business Analysis Tool	Application of the Tool
Policy Alignment	Ensuring company policies are aligned with international environmental regulations and sustainability goals.	PESTEL Analysis	Analyzes the Political, Economic, Social, Technological, Environmental, and Legal factors affecting policy alignment.
Technology Integration	Adoption and integration of advanced technologies to minimize emissions and improve energy efficiency.	SWOT Analysis	Assesses the Strengths, Weaknesses, Opportunities, and Threats related to adopting and integrating new technologies.
Stakeholder Engagement	Engaging with stakeholders, including governments, communities, and investors, to support sustainability initiatives.	Stakeholder Analysis	Identifies and prioritizes key stakeholders and their interests to develop engagement strategies that align with sustainability goals.
Operational Optimization	Streamlining operations to reduce energy consumption and emissions throughout the value chain.	Value Chain Analysis	Examines each stage of the value chain to identify opportunities for reducing carbon footprint and enhancing operational efficiency.
Risk Management	Identifying and mitigating risks associated with environmental compliance and sustainability.	Failure Models and Effects Analysis [FMEA]	Evaluates potential failure points in processes and systems to prioritize risks and implement preventive measures to enhance environmental compliance.
Sustainability Reporting and Monitoring	Implementing systems for tracking and reporting sustainability metrics and progress towards carbon reduction goals.	Balanced Scorecard	Provides a framework for tracking performance across financial, customer, internal process, and sustainability perspectives.
Innovation and Research Development	Investing in R&D to develop new methods and technologies for reducing emissions and enhancing sustainability.	Innovation Mapping	Identifies areas for innovation and tracks the development and implementation of new technologies and practices.
Continuous Improvement	Implementing processes that ensure ongoing improvement in sustainability and operational efficiency.	Lean Six Sigma	Applies Lean Six Sigma methodology to reduce waste, improve efficiency, and enhance sustainability in operations.
Problem Solving and Process Improvement	Identifying and addressing underlying issues that impede environmental compliance and sustainability.	Root Cause Analysis	Investigates the root causes of problems related to environmental performance, enabling targeted solutions that enhance sustainability and compliance.

Source: Authors, (2024).

Table 2. Characteristics of Included Case Studies.

Author & Year	Objective	Case Study	Methodology	Description	Potential Challenges	Suggested Solutions
Tonge [2019]	To examine sustainability trends and technology integration in the oil and gas sector.	BP's Technology Integration for Emission Reduction	Case Study Analysis	BP implemented advanced carbon capture and storage [CCS] technology to reduce emissions in its oil and gas operations.	**High Initial Costs:** Implementing CCS technology involves significant upfront investment.	**Public-Private Partnerships:** Collaborate with governments to secure funding and subsidies for CCS projects.
Alnuaim [2019]	To explore the alignment of corporate policies with international climate goals.	ExxonMobil's Policy Alignment with Paris Agreement	Policy Review and Case Study	ExxonMobil adjusted its internal policies to align with the Paris Agreement's goals, focusing on reducing scope 1 and 2 emissions.	**Regulatory Compliance:** Variations in local regulations across different countries may complicate implementation.	**Global Standardization:** Advocate for more consistent international regulatory standards to simplify compliance.
Intykbayeva [2021]	To assess the impact of stakeholder engagement on sustainability initiatives,	Shell's Stakeholder Engagement in the Netherlands	Stakeholder Analysis and Case Study	Shell engaged local communities and stakeholders in the Netherlands to support its transition to renewable energy.	**Community Resistance:** Some stakeholders may resist changes due to perceived economic or social impacts.	**Transparent Communication:** Develop clear communication strategies to inform stakeholders of long-term benefits.

Mojarad et al. [2018]	To optimize operations for reducing energy consumption and emissions in the oil and gas industry.	Chevron's Operational Optimization in Downstream Operations	Value Chain Analysis and Case Study	Chevron streamlined its downstream operations to reduce energy consumption and emissions using value chain analysis.	**Operational Disruption:** Optimizing operations may temporarily disrupt existing processes.	**Phased Implementation:** Gradually implement changes to minimize disruptions and maintain operational continuity.
Menéndez et al. [2022]	To explore innovation in biofuels as a sustainable alternative in the energy sector.	TotalEnergies' Innovation in Biofuels Development	Innovation Mapping and Case Study	TotalEnergies invested in R&D to develop biofuels as part of its sustainability strategy, reducing reliance on fossil fuels.	**Technological Uncertainty:** The success of new technologies like biofuels is not always guaranteed.	**Diversified R&D Portfolio:** Invest in multiple technologies to mitigate the risk of any single project's failure.
Garbie [2016]	To evaluate risk management practices in ensuring environmental compliance in the oil and gas industry.	Saudi Aramco's Risk Management for Environmental Compliance	Risk Assessment and Case Study Analysis	Saudi Aramco developed a comprehensive risk management framework to ensure compliance with environmental regulations.	**Complex Risk Assessment:** Identifying and mitigating environmental risks can be complex and resource-intensive.	**Advanced Analytics:** Utilize data analytics and AI to enhance risk identification and mitigation processes.
Alnuaim [2019]	To investigate the effectiveness of sustainability reporting in tracking environmental goals.	Eni's Sustainability Reporting and Monitoring System	Sustainability Reporting and Case Study	Eni implemented a robust sustainability reporting system, tracking progress towards carbon reduction goals.	**Data Accuracy:** Ensuring the accuracy of sustainability data across multiple operations can be challenging.	**Integrated Reporting Tools:** Implement integrated software solutions that consolidate and verify data from different sources.

Source: Authors, (2024).

III.3 STRATEGIC FRAMEWORK FOR REDUCING CARBON FOOTPRINT

The following are the elements of the proposed Strategic Framework for Reducing Carbon Footprint namely; policy and regulation matching, incorporation of superior technology, stakeholder involvement, operation optimization, risk management, sustainable assessment, and investment in innovation (Table 1). All the components incorporate tools for business analysis such as PESTEL, SWOT, Value Chain Analysis, Failure Models and Effects Analysis [FMEA], Balanced Scorecard, Stakeholder Analysis, Innovation Mapping, Lean Six Sigma and Root Cause Analysis to enhance effectiveness in attaining sustainable outcomes. As can be evidenced by the case studies presented in this paper, the sustainability effort in the oil and gas industry varies (Table 2). BP engaged in the use of carbon capture and storage which was however characterized by high initial costs through public-private partnerships. ExxonMobil adjusted the policies to the Paris Agreement and promoted the standards for internationalization. Shell was focused on identifying Paths Towards Renewables to involve stakeholders. Through phased implementation, Chevron improved downstream operation efficiency. Biofuels were another important investment for TotalEnergies; it addressed the technological risks by having balanced research and development programs. The participants' actions include Saudi Aramco, which initiated the creation of the framework for risk management, integrated with big data, and also Eni, which focused on improving sustainability reporting, using integrated tools.

IV. RESULTS AND DISCUSSIONS

In the case of the oil and gas industry, there are several effects of the framework in the achievement of the sustainability goals as the following cases have shown. For instance, BP has adopted more refined carbon capture and storage [CCS] technology as an illustration of how technology holds the potential to lower emissions, albeit at a greater start-up cost, which may be moved by PPPs [47]. This approach highlights the role of innovative technology in achieving long-term sustainability goals, demonstrating that while initial costs may be high, the benefits of CCS in significantly reducing emissions can be substantial when supported by strategic partnerships. Such collaborations can help distribute the financial burden and facilitate the scaling of CCS technology across the industry.

Similarly, while addressing the policies of the organization, namely, ExxonMobil, on the requirements of the Paris Agreement, which indicate the importance of the regulation alignment to achieve the objective of sustainability, the variations of the local regulations noticed in this case show that there is a need for international standardization. The variations in local regulations observed in this case underscore the necessity for international standardization. A unified global framework could streamline compliance and foster more consistent implementation of sustainability practices, thereby enhancing the overall effectiveness of regulatory measures. Standardization would reduce the complexity faced by multinational corporations operating in diverse regulatory environments, enabling more coherent and widespread adoption of sustainable practices [10]. Furthermore, Shell's interaction with the stakeholders in the Netherlands shows the need to involve the locals in the support of a shift to renewable energy as the main resistance hinders communication [48]. The other significant factors for sustainability improvement in the oil and gas industry are operational improvement and innovation. Chevron, therefore, sues downstream optimization to minimize energy usage as a

demonstration of how value chain analysis reduces emissions, though operational changes impact continuity and are manageable through a phased approach [15].

The resistance encountered in engaging local stakeholders illustrates the importance of effective communication and collaboration. Involving local communities early in the decision-making process and addressing their concerns can mitigate resistance and enhance support for renewable energy projects. This engagement is crucial for successful implementation and acceptance of sustainability initiatives, as demonstrated by Shell's experience [48]. Another significant factor for sustainability improvement in the oil and gas industry is operational enhancement and innovation [44]. Chevron's use of downstream optimization to minimize energy consumption is a prime example of how value chain analysis can contribute to emission reductions. The phased approach to implementing operational changes demonstrates the feasibility of incremental improvements in reducing emissions while maintaining operational continuity. Such strategic optimization not only lowers energy usage but also enhances overall operational efficiency, thereby aligning with sustainability goals [15].

TotalEnergies' commitment to biofuels as a sustainable option shows how variation in the portfolios can help manage risks arising from the issues of technological volatility to improve the robustness of sustainability approaches [20]. By investing in biofuels, TotalEnergies addresses the challenge of technological uncertainty and demonstrates how a diversified approach to sustainability can enhance resilience. This strategy not only supports sustainability objectives but also provides a buffer against market fluctuations and technological changes, reinforcing the robustness of sustainability efforts [49].

In addition to defensive capabilities, there are more effective risk management practices, including the one in Saudi Aramco, to ensure compliance with the environmental standards whereby risk management enables the application of advanced analytics to tackle complexities of risk assessments [8]. Advanced analytics and risk management strategies enable companies to navigate the complexities of environmental compliance more effectively. By leveraging sophisticated analytical tools, companies can better assess and manage environmental risks, thereby enhancing their ability to meet regulatory requirements and achieve sustainability objectives [50].

The outlined approaches, which could present some problems, contribute to the improvement of the oil and gas sector's performance of sustainable development objectives altogether. The strategic initiatives reflected in these examples highlight the importance of integrating technological innovations, policy alignment, stakeholder engagement, and risk management into a comprehensive framework for enhancing sustainability and minimizing carbon footprints. These elements, when combined, provide a robust foundation for advancing sustainability efforts across the industry [51].

The following are some of the strategic initiatives, which are included in the development of the proposed framework for enhancing sustainability and minimising carbon footprint in the oil and gas industry: For example, BP has employed the best CCS technology that shows that technology is a key factor in addressing emissions even though it might entail high initial costs, which may be eased with public-private partnerships aimed at sourcing capital [47].

Despite the high initial costs, CCS technology represents a critical tool for reducing carbon emissions. The involvement of public-private partnerships can help mitigate these costs and facilitate the broader adoption of CCS, thus contributing to long-term sustainability goals [52]. Similarly, the fact that ExxonMobil changed its internal policies to abide by the Paris Agreement speaks to the power of policy as the crucial factor affecting sustainability; if the policies were more standardized around the world, the company would be more likely to adhere to them and engage in more sustainable practices across different regions [10]. The need for international standardization is evident, as consistent global policies would simplify compliance and encourage more widespread adoption of sustainable practices across different regions [36].

When comparing the proposed framework with several similar strategies in the oil and gas industry that are not included in the analysis, it is possible to identify differences that could provide a better understanding of how to improve sustainability and minimize carbon footprints. For example, [1] focuses on renewable hydrogen as one of the promising options to address the carbonization problem of the oil and gas industry. Unlike the BP's reliance on CCS technology to cut down emissions, renewable hydrogen is a low-carbon fuel which does not have much distance to travel in terms of integration due to its compatibility with existing infrastructures, without the high initial investments that are required for CCS [1],[47]. Also, some companies have ventured into different types of renewable technologies, meaning that they are not concentrated in one particular kind of technology like ExxonMobil's single-focused strategy of policy commitment to the Paris Agreement outlined in this work by [20]. Moreover, this is further demonstrated by [3] on how digital twins and predictive analytics can design and manage the oil and gas industry in a way that maximises operations while also minimising emissions rather than just performing a 'value chain' analysis. This technology provides a dynamic and comprehensive view of operations, allowing for optimized performance and reduced emissions. Unlike traditional value chain analysis, digital twins and predictive analytics offer real-time insights and enhanced efficiency, thereby contributing [53] to more effective sustainability management [38]. This approach differs from the operational improvement strategies that have been embarked on at Chevron particularly because they feature more on the efficiency of current processes and the optimal use of digital tools, whereas the use of big data is still in an enhanced stage [15]. Furthermore, one form of partnership has seen manufacturers like Equinor seek to own certain assets to integrate renewable energy in their operation plans while lowering carbon footprints in a more consistent manner than through the use of posted emissions reduction technologies like CCS or biofuels [54]. These comparative examples emphasize the fact that a more synergistic approach is required to integrate av sophisticated technology, renewable energy investments, and policy changes to achieve overall carbon reduction and sustainability goals in the oil and gas industry. A more integrated and multifaceted strategy, incorporating various elements of technology, policy, and stakeholder engagement, is essential for addressing the complex challenges of sustainability in the oil and gas industry [49]. The strategies for increasing sustainability and decreasing carbon intensity within the oil and gas industry are long-term and have scalability potential across the sector. For example, BP as a company integrates efficient carbon capture and storage or CCS as a form of addressing emissions although the technology is large scale at the start it is costly thus the need for involvement of partner funding [10],[47]. Likewise, ExxonMobil's policy collaboration with the Paris Agreement is evidence of integrated business and climate objectives that can generate a uniform business model that makes compliance more manageable and perhaps more extensive

[8],[10]. Moreover, the practice of engaging stakeholders and coming up with innovative solutions for sustainable options also increases the possibility of expanding these sustainability efforts. Shell's lessons in engaging stakeholders for renewable energy transition show that traditional communications management practice also helps to negate community opposition to sustainable projects and thus increase the acceptance and implementation of such projects in a wide area [20],[48]. Furthermore, the investment in biofuels at TotalEnergies also demonstrated how the diversified research and development offset the risks associated with new technologies for fossil fuel use reduction in the energy sector as a scalable model as mentioned in [15],[20]. These strategies stress about the applicability on a large scale and long-term returns for the industry that fuels the change towards a more sustainable and compliant manner in the oil and gas sector**.** By adopting a synergistic approach that combines technological advancements, policy alignment, stakeholder engagement, and diversified investments, the industry can more effectively achieve its sustainability goals and reduce carbon footprints over the long term.

V. CONCLUSIONS

This review responds to the research questions showing the importance of the business analysis approach in improving sustainability and compliance to environmental conditions in the oil and gas industry. Some major research findings suggest that the use of modern technologies and the integration of corporate policies with international climate goals can significantly decrease emissions; meanwhile, high costs and bureaucratic obstacles can hinder these efforts [10],[47]. Engagement of stakeholders and efforts towards the development and utilization of other renewable energy sources such as bio-fuels are also found to be potential solutions for sustainability and low carbon footprint within this industry, especially when implemented with communication transparency and diverse investment in research and development [20],[48]. Strategic management, focusing on operational excellence, risk management and sound sustainability reporting are integral parts of a strategic management model that provides guidelines for improving organisational performance and targeting global sustainability goals without compromising on economic viability [8].

To reach sustainable and scalable development in the oil and gas industry, it is better to use several strategies: First and foremost, initial strategies include prioritizing the use of more advanced technologies, like CCS; however, it is crucial to find solutions to financial difficulties through public and private financing to reduce the overall costs, which is carried out through the development of funding mechanisms [8,47]. Also, integrating corporate policies with international climate deals including the Paris Agreement is important in lateral harmonization of sustainability regimes, thus minimizing compliance risks across jurisdictions [10]. Stakeholder communication and the involvement of stakeholders within sustainability processes can improve sustainability and easier transition towards renewable energy [48] However, risk management strategies are required to minimize the technological risks involved with newer technologies and rising environmental standards to achieve a diversified portfolio of renewable energy technologies [20]. Further studies should therefore consider examining the applicability of innovation tools like digital twin and predictive analytics for achieving better practical and environmental outcomes than conventional tools [3],[15]. It is also essential to analyse how other novel renewable energy resources such as renewable hydrogen and offshore wind affect the central idea of sustainability and carbon-cutting initiatives in the oil and gas industry [1],[54]. Further, it is necessary to study the community effects of sustainability transition, which involves how local communities can participate actively in this change and how knowledge regarding best practices in public involvement and communication can be shared in different countries [48]. Finally, researchers must assess the impacts of the policy initiatives that seek to synchronise regional and global regulation of sustainability practices seeking to achieve further improvements in the implementation of sustainable practices across the industry [10].

VI. AUTHOR'S CONTRIBUTION

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