Advancing Green Energy in the Petroleum Exploration and Production Space

Anyamkpa D., Oluwalade O., Akande O. and O. M. Hamid-Osazuwa
Asharami Energy Nigeria Limited

ABSTRACT

The transition to green energy in the petroleum exploration and production space is imperative for addressing climate change and achieving sustainable energy security. Such a framework should address key aspects, from renewable energy integration, carbon pricing to regulatory framework and standards. This abstract examines the key considerations and policy frameworks required to facilitate this transition. It emphasizes the integration of renewable energy sources, such as solar and wind power, within the sector and highlights the importance of energy efficiency measures. It also discusses the significance of implementing carbon pricing mechanisms and emissions trading systems to incentivize companies to reduce their carbon footprint. It emphasizes the need for robust research and development support to drive innovation in green energy technologies specific to the petroleum sector. Furthermore, the abstract emphasizes the importance of establishing clear regulatory frameworks and standards to ensure compliance with sustainable energy objectives. It highlights the value of industry collaboration, partnerships, and a just transition approach that considers the impacts on workers and communities reliant on the petroleum sector. Overall, the abstract emphasizes the need for a comprehensive and collaborative approach involving governments, industry stakeholders, and communities to achieve a sustainable energy future in the petroleum exploration and production space. Implementing a policy framework for sustainable energy security in the petroleum exploration and production space requires a balanced approach that considers environmental, economic, and social dimensions. Governments, industry stakeholders, and communities must collaborate to design and implement policies that drive the necessary changes while ensuring a reliable and sustainable energy future.

Keywords: Renewable energy, Climate change, Carbon footprint, Carbon pricing, Green energy, Energy security, sustainability

INTRODUCTION

The petroleum exploration and production (E&P) industry is undertaking a radical transition towards sustainability, while being historically associated with carbon-intensive operations. The sector is actively looking for ways to promote green energy within its operations due to several factors, including regulatory demands, environmental imperatives, and changes in the global energy consumption landscape in recent years. The E&P sector can accomplish these objectives with the aid of green energy technologies.

The petroleum exploration and production (E&P) sector supplies the gas and oil needed to run our electrical plants, run our transportation networks, and make many daily goods. But these also contribute significantly to greenhouse gas emissions, which highlights the pressing need for environmental responsibility. The petroleum exploration and production industry's move to green energy is a calculated response to the changing energy scene, which includes technological advancements, modifications to regulatory frameworks, and cross-sector cooperation.

The role of fossil fuels in a shifting energy economy and the place of oil and gas businesses in the communities in which they operate are complex issues brought up by the mounting social and environmental demands on several oil and gas companies. The oil and gas industry faces increasing pressure to explain the consequences of energy transitions for their operations and business models, as well as the contributions they can make to decreasing greenhouse gas (GHG) emissions and meeting the Paris Agreement goals.

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The purpose of this study is to present a thorough understanding of the ways in which green energy technologies can significantly aid the Nigeria's exploration and production sector in achieving its targets for lowering greenhouse gas (GHG) emissions. The study's methodological framework included document analysis and a review of the literature. The paper outlined how green technology supports the long-term, sustainable growth of the oil and gas industry. Norway, one of the leading countries in the implementation of renewable energy will be used as a case study, with examples taken with a view to improve Nigeria's greenhouse gas emission status. This case study underscores the potential for widespread adoption of renewable energy in industry.

The paper outlines some of the advantages of green technology, including significant reductions in waste and pollution, a decrease in the impact of global warming, and a need for fewer resources. The report promotes joint efforts by the public sector, private sector, and individuals to carry it out.

BACKGROUND TO THE STUDY

A greenhouse gas is a gas in an atmosphere that absorbs and emits radiant energy within the thermal infrared range. They are gases capable of trapping the earth's emitted radiation, which otherwise escapes back to space (Nadine Borduas *et al,* 2018). A country's carbon footprint is the total amount of greenhouse gases it emits into the earth's atmosphere. The primary compounds that make up greenhouse gases are carbon dioxide, nitrous oxide, and methane. Though naturally occurring, large quantities of greenhouse gases are dangerous to the environment because they absorb and emit thermal radiation, trapping heat under the atmosphere and warming the Earth.

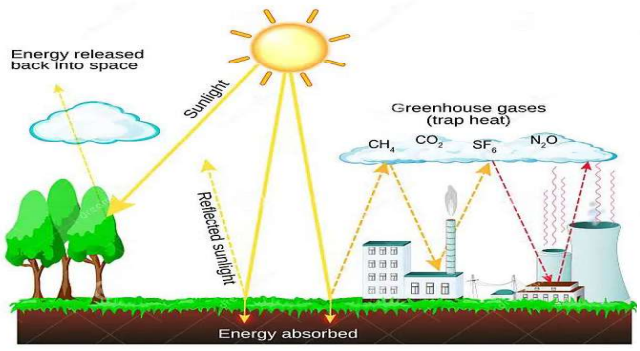

Figure 1.1: The Greenhouse Effect.

Greenhouse gas emissions are majorly caused by human factors such as industrial activities, generating power, cutting down forests, transportation etc. Fossil fuels: coal, oil and gas are by far the largest contributor to global climate change, accounting for over 75 per cent of global greenhouse gas emissions and nearly 90 per cent of all carbon dioxide emissions (United Nations, 2023). Developing countries often have a higher footprint than developed countries due to their industrialization, the same that other countries have already gone through in the 19th and 20th centuries. However, developed countries have sought to lower their greenhouse gas emissions through international treaties and agreements, as well as enacting laws that cap how much carbon a person or entity may emit each time.

Global greenhouse gas emissions have grown by around 70% from 1970 to 2018 and continued to rise today despite significant efforts over recent years to reduce them. This is largely due to increased energy demand for transportation, industry, buildings, and households in growing economies such as China and India. The total amount of greenhouse gas emissions varies significantly between countries; China remains the largest emitter globally, followed by the U.S. and India. However, when looking at per-capita emissions, which takes population size into account smaller countries like Qatar or Luxembourg often top the list (Wisevoter, 2023).

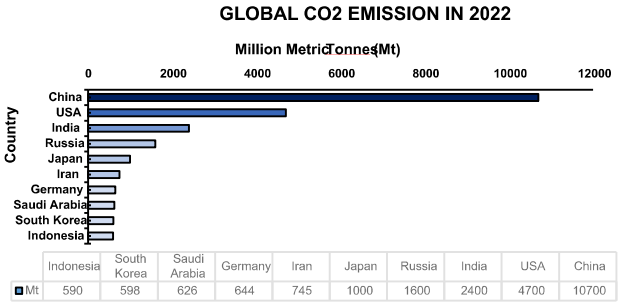

Figure 1.2: Plot showing the largest emitters of CO2 and the amount of CO2 emitted.

Nigeria is at a key juncture in time; with a growing population and a range of socio-economic challenges, it requires sustainable energy sources to meet the growing needs for all the sectors of its economy and achieve universal access to modern energy services. For Nigeria, achieving the maximum ambition of its new regulations would reduce methane emissions from flaring by 100% by 2030, and fugitive methane from leaks by 95% 2050 (Business Day, 2023).

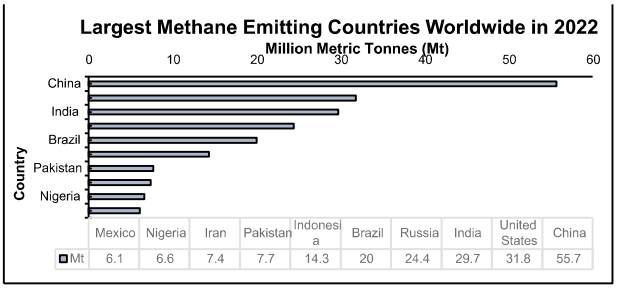

Figure 1.3: Plot showing the largest emitters of Methane Worldwide.

Renewable energy has gained significant momentum in countries around the world as a sustainable alternative to fossil fuels. Some countries have made progress in generating renewable energy. Iceland leads the way with an impressive 86.87% of its energy generated from renewable sources. Norway follows closely at 71.56%, while Sweden stands at 50.92%.

Table 1.1: Top Ten Countries with the most Renewable Energy (Wisevoter, 2023).

S/N	Country	Renewable Energy Generation
1	Iceland	86.87%
2	Norway	71.56%
3	Sweden	50.92%
4	Brazil	46.22%
5	New Zealand	40.22%
6	Denmark	39.25%
7	Austria	37.48%
8	Switzerland	36.72%
9	Finland	34.61%
10	Colombia	33.02%

The high percentages in these nations are primarily due to the abundance of natural resources like wind, hydro, and geothermal energy. Because of its potential for geothermal energy, Iceland can produce a sizable percentage of its power sustainably. In a similar vein, Norway can rely mostly on renewable energy sources due to its enormous hydroelectric power capacity. Furthermore, the ranking prominently features nations such as Brazil, New Zealand, and Denmark, demonstrating their dedication to utilizing renewable energy.

In Nigeria, gas flaring has been a controversial issue in the society. Most gas resources in Nigeria had been flared due to the lack of a nationwide gas infrastructure. However, both economic and environmental imperatives have informed concerted efforts mustered by policy makers in Nigeria to embark on gas utilization and commercialization projects, culminating in the exportation of gas through the Nigerian Liquefied Natural Gas (NLNG) and the West African Gas Pipeline (WAGP) projects. More gas has also been piped to major industrial estates in Nigeria as alternative fuel. According to National Oil Spill Detection and Response Agency (NOSDRA), from data gleamed as of July 2023 from the Nigeria Gas Flare Tracker (GFT), a satellite-based technology, Nigeria's gas flares rose by 9.97 percent in the same period of 2022, flaring 138.7 billion standard cubic feet (scf) of gas from January to June 2023 (BusinessDay, 2023).

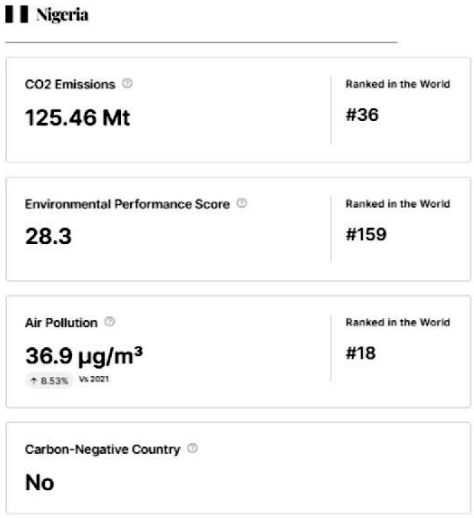

Figure 1.4: Nigeria's Emission tracker.

Three countries, Nigeria, Mexico, and the United States, accounted for most of the decline in global gas flaring in 2022. Two other countries, Kazakhstan and Colombia stand out for consistently reducing flaring volumes in the last seven years (World Bank, 2023).

According to the global gas flaring tracker report, the top nine flaring countries continue to be responsible for most of the flaring. Russia, Iraq, Iran, Algeria, Venezuela, the United States, Mexico, Libya, and Nigeria account for nearly three-quarters of flare volumes and just under half of global oil production. This wasted gas could displace dirtier energy sources, increase energy access in some of the world's poorest countries, and provide many countries with much-needed energy security. If put to productive purposes, the amount of gas flared in 2022 could generate as much electricity as Sub-Saharan Africa currently produces in a year.

According to the International Energy Agency's (IEA) report, around 140 bcm of natural gas is flared globally each year. This is a major source of CO_2 emissions, methane, and black soot, and is damaging to health. In 2022, the volume of gas flared worldwide fell by around 5 billion cubic meters (bcm) to 139 bcm (about 3% reduction). Flaring resulted in 500 Mt CO_2 equivalent annual GHG emissions in 2022. Around 70% of gas flared goes to flares that operate on a near continual basis. In the Net Zero Emissions by 2050 (NZE) Scenario, all non-emergency flaring is eliminated globally by 2030, resulting in a 95% reduction in flared volumes and avoiding 365 Mt CO_2-eq (IEA, 2023).

Norway set an ambitious target to reduce greenhouse gas GHG emissions by 40% of 1990 levels by 2030. It was one

of the first countries to introduce regulations requiring operators to meter gas and taxing flaring-related CO_2 emissions. These policies have been effective, and Norway has reduced flaring emissions by more than 80% since the mid-1990s.

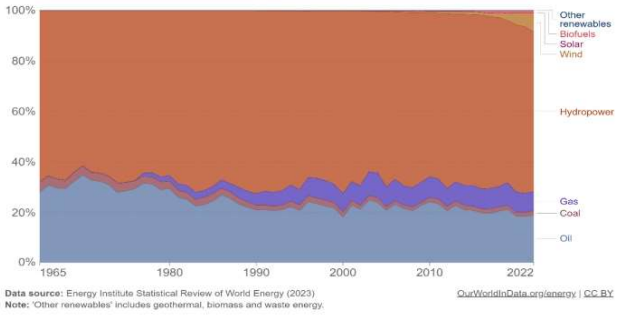

Figure 1.5: Plot showing the Energy Consumption by Source in Norway (1965 – 2022).

The plot above it is observed that in Norway, most of the electricity production come from renewable energy sources. Hydropower is the source of most of the production. Nigeria has a high potential for renewable energy development, being endowed with abundance of renewable energy (RE) resources. However, there are some problems that need to be addressed, such as the lack of investment in renewable energy infrastructure. Despite these challenges, there is a growing commitment to developing renewable energy in Nigeria, which is a positive sign for the future (Ezugwu, 2015).

METHODOLOGY

Green energy is a key component of efforts to address climate change and transition to a more sustainable and low-carbon energy system. Some of the most common methods to promote green energy used in the oil and gas industry include:

i i. Technological Innovations.
ii Policy Framework and Regulatory Implications.
iii Industry Initiatives and collaborations.

In addition to these methods, oil and gas companies are also investing in research and development of new green technologies that can be used in the E&P sector. For example, some companies are developing new ways to produce hydrogen from renewable energy sources, and others are developing new CCS technologies. This section will go over the typical strategies for promoting the use of green energy, as mentioned above, and it will include some examples from Norway as well as other players in the industry.

I. Technological Innovations

i. Renewable energy integration:

Renewable energy integration in the oil and gas industry is a critical component of the transition to a clean energy future. Nigeria has significant renewable energy potential, including solar, wind, biomass, hydroelectricity, and minerals such as lithium, graphite, and cobalt, which are needed for renewable energy technologies. There are several ways that renewable energy can be integrated into E&P operations:

I Generate electricity for E&P operations using solar and wind power.
ii Use renewable energy to directly power equipment, such as pumps and compressors.
iii Produce hydrogen using renewable energy and use it as a fuel for E&P operations.
iv Charge batteries or other energy storage devices using renewable energy and use them to provide power to E&P operations when renewable energy sources are not available.

Renewable energy integration can help oil and gas companies reduce their emissions, improve their energy efficiency, and enhance their resilience. It is also a sound economic strategy, as it can optimize energy consumption, reduce waste, and increase the overall efficiency of exploration and production processes. In Nigeria, there are pioneering projects that are showcasing successful implementations of renewable energy integration in the oil and gas sector.

Renewable energy integration in the oil and gas industry offers several benefits, including:

- Reduced emissions: The oil and gas sector can lower its emissions of greenhouse gases and other pollutants with the use of renewable energy. By doing this, the sector may be able to comply with regulations and enhance its environmental performance.
- Improved energy efficiency: The oil and gas sector can lower operational costs and increase energy efficiency with the use of renewable energy.
- Enhanced resilience: Renewable energy can help to make E&P operations more resilient to power outages and other disruptions.
- Social benefits: Renewable energy integration can help to create jobs and boost the local economy.

There are also several challenges that need to be addressed to advance renewable energy integration in the oil and gas industry. These challenges include:

- Cost: Technologies utilizing renewable energy sources may be more costly than those utilizing conventional fossil fuels. Oil and gas corporations may find it challenging to make investments in renewable energy as a result.
- Infrastructure: To facilitate the use of renewable energy in the oil and gas industry, greater infrastructural development is required. For instance, additional facilities are required to store and transport hydrogen as well as more capacity to generate renewable energy.

- Regulation: Government policies and regulations can play a significant role in promoting the adoption of renewable energy in the oil and gas sector.

Despite the challenges, the integration of renewable energy into the oil and gas industry is underway. Several oil and gas companies have set ambitious targets for reducing their emissions and increasing their use of renewable energy. In addition, governments around the world are developing policies and regulations to support the transition to a clean energy future. There are examples of the many oil and gas companies that are integrating renewable energy into their operations. As the transition to a clean energy future continues, we can expect to see even more innovation and investment in renewable energy integration in the oil and gas industry.

Here are some specific examples of how renewable energy is being integrated into the oil and gas industry today:

- **Equinor:** By 2050, the Norwegian oil and gas corporation Equinor wants to have zero net emissions. In addition to making significant investments in renewable energy, Equinor has also created renewable energy projects, such as the Dogger Bank offshore wind farm and the Hywind Tampen offshore wind farm. The Hywind Tampen wind farm consists of 11 wind turbines that are anchored to the seafloor. This allows them to be installed in deeper waters than traditional fixed-bottom wind turbines. The wind farm is expected to generate

- emissions by 200,000 tonnes per year, that is 0.4 percent of Norway's total CO_2 emissions in 2022 (EuroNews, 2023). Dogger Bank just got connected to Britain's national grid and has started exporting electricity for the first time to British homes and businesses. This is a major milestone in the development of industry and the transition to a cleaner, more secure energy system.
- **Shell:** The Dutch-British oil and gas corporation, Shell has likewise committed to have net-zero emissions by the year 2050. Shell is making investments in wind, solar, and hydrogen energy among other renewable energy technologies. Using renewable energy sources and other efficiency improvements, Shell is also attempting to lower the emissions from its current activities.
- **BP:** The British oil and gas giant BP has set a target of having net-zero emissions by 2050. BP is also making investments in a range of renewable energy technologies, such as the Empire and Beacon wind project, and solar powered energy integration (BP, 2023). By employing efficient techniques and renewable energy, BP is also attempting to lower the emissions from its current operations.
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ii Carbon Capture and Storage (CCS)

- In Nigeria, there is no existing legal framework regulating CCS, however the Petroleum Industry Act, 2021 envisages the need for decarbonization, and thus provides a legal basis for deploying CCS. The Act requires every concessionaire of a petroleum licenses and leases to include an environmental management plan in its field development plan that sets out how the concessionaire intends to mitigate the negative environmental impacts of its operations (Pacer et al, 2023). Carbon Capture and Storage (CCS) is a critical technology aimed at reducing greenhouse gas emissions from industrial processes, particularly in the oil and gas sector. CCS involves capturing carbon dioxide (CO_2) emissions from industrial sources, transporting it, and securely storing it underground, such as a depleted oil and gas reservoir, deep saline aquifer, or unmineable coal seam to prevent its release into the atmosphere. This technology is vital for mitigating climate change and achieving net-zero emissions goals.
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- CCS in oil and gas operations has its benefits, including:
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- Reduced emissions: Emissions of greenhouse gases from the oil and gas sector can be decreased with the usage of CCS. This can lessen the industry's environmental effect and help it reach climate targets.
- Enhanced oil and gas recovery: CCS can also be used to enhance oil and gas recovery (EOR). It can be used to inject CO_2 into a reservoir, which helps to displace the oil and gas and make it easier to extract.
- Job creation: CCS can create jobs in the oil and gas industry and in the renewable energy sector.
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- There are also a few challenges associated with CCS in oil and gas operations, including:

- Cost: It can be costly to deploy CCS. Nonetheless, there are several government initiatives and subsidies that might assist in offsetting the cost, and the price of CCS technology is starting to decrease.
- Infrastructure: There is a need to develop more infrastructure to support CCS in oil and gas operations. For example, there is a need for more CO_2 pipelines and storage sites.
- Regulation: Government policies and regulations can play a significant role in promoting the adoption of CCS in the oil and gas sector.

- In the oil and gas sector, CCS is being implemented despite the difficulties. A few gas and oil firms have set high goals for cutting emissions and utilizing more CCS. Furthermore, governments worldwide are formulating legislation and guidelines to facilitate the implementation of CCS technology.
- Here are some important CCS elements for the oil and gas sector, along with some examples:
- **Depleted Oil and Gas Fields:** CO_2 storage can be

achieved by reusing depleted oil and gas fields. The Weyburn-Midale project in Canada injects captured CO_2 into a depleted oil field, enhancing oil recovery while securely storing the captured carbon. The CO_2has given the Weyburn field, discovered 50 years ago, a new life: 155 million gross barrels of incremental oil are slated to be recovered by 2035 and the field is projected to be able to store 30 million tonnnes of CO_2 over 30 years (Global CCS Institute, 2023).

- **Petra Nova, Texas:** Petra Nova is a pioneering project that integrates CCS with a coal-fired power plant. The captured CO_2 is used for enhanced oil recovery, and the project demonstrates the technical feasibility of retrofitting existing facilities with CCS technology. The Petra Nova project in Texas is an example of CCS combined with EOR.
- **Sleipner, North Sea:** The Sleipner project in the North Sea is one of the earliest and most successful examples of CCS. It captures CO2 from natural gas processing and injects it into a deep saline aquifer. The project has been in operation since the late 1990s and is a testament to the long-term viability of CCS technology.
- **U.K. CCS Cluster:** The U.K. government has announced funding for the development of CCS clusters. These clusters aim to connect multiple industrial facilities to shared CO_2 transport and storage infrastructure, promoting cost-effectiveness and widespread adoption of CCS (Global CCS Institute, 2023).

- To reach the worldwide net-zero aspirations of the Paris Agreement, efforts are currently underway to deploy carbon capture and storage (CCS) in Nigeria. Wherever it is successfully deployed, CCS will assist in lower the carbon intensity of industrial processes.

iii. Reduced Emissions and Flaring

- Gas is burnt off, or 'flared', as part of the oil production process. Gas has been flared in Nigeria since the 1950s, releasing carbon dioxide and other gases into the atmosphere. It is a continuing source of environmental and health concerns in the Niger Delta, despite efforts to reduce it. Lowering emissions and minimizing flaring in oil and gas operations are critical aspects of sustainable and environmentally responsible practices. Flaring, the controlled burning of natural gas during oil extraction, is a significant source of greenhouse gas emissions. Efforts to reduce emissions and flaring involve technological advancements, regulatory measures, and industry initiatives. This can be done through a variety of measures, such as:
- Reducing methane emissions: Methane is a potent greenhouse gas that is emitted from oil and gas operations during drilling, production, and transportation. Oil and gas methane is responsible for 37% of human-derived methane emissions but can easily be eliminated at low or net negative costs (Business Day, 2023). Different measures can be taken to reduce methane emissions, such as using methane capture and utilization (MCU) technologies, repairing leaks, and upgrading equipment.
- • Leak Detection And Repair (LDAR): LDAR programs are used to identify and repair leaks of methane and other volatile organic compounds (VOCs) from oil and gas equipment. LDAR programs can be very effective in reducing emissions, with some studies showing that they can reduce methane emissions by up to 90%.
- Venting reduction: Venting is the intentional release of natural gas into the atmosphere. Venting can be reduced by using technologies such as vapor recovery units (VRUs) and closed loop systems. VRUs capture the vented gas and compress it for reinjection into the reservoir or for sale. Closed loop systems prevent the release of gas to the atmosphere by using it to power equipment or for other purposes.
- Improving energy efficiency: Improving the energy efficiency of oil and gas operations can help to reduce emissions and costs. A few measures can be taken to improve energy efficiency, such as using more efficient equipment, optimizing processes, and reducing waste.

Reducing emissions and flaring in oil and gas operations has its benefits, including:

- Reduced environmental impact: Reducing emissions and flaring can help to reduce the environmental impact of the oil and gas industry. This can help to improve air quality, reduce greenhouse gas emissions, and mitigate climate change.
- Improved operational efficiency: Reducing emissions and flaring can also improve the operational efficiency of oil and gas companies. This can lead to lower costs and improved profitability.
- Enhanced social standing: Reducing emissions and flaring can help to improve the social standing of the oil and gas industry. This can lead to greater public support and make it easier for oil and gas companies to operate in communities.
- There are also challenges associated with reducing emissions and flaring in oil and gas operations, including:
- Cost: Some of the technologies and measures that can be used to reduce emissions and flaring can be expensive to implement.
- Infrastructure: There is a need to develop more infrastructure to support the reduction of emissions and flaring in oil and gas operations. For example, there is a need for more MCU facilities and gas pipelines.
- Regulation: Government policies and regulations can play a significant role in promoting the reduction of emissions and flaring in the oil and gas sector.

- Here are key elements along with examples of activities aimed at reducing flaring and emissions in oil and gas operations:

- **Equinor's Johan Sverdrup Field, North Sea:** The Johan Sverdrup oil field in the North Sea utilizes advanced flare gas recovery systems. The entire field is now on stream, and accounts for roughly a third of Norway's oil production. It also has some of the lowest CO2 emissions of any oil field in the world (Equinor, 2023). Instead of flaring excess gas during routine operations, Equinor has implemented systems to capture, compress, and reinject this gas back into the reservoir for enhanced oil recovery. This approach minimizes emissions while maximizing resource utilization.
- **Nigerian Gas Flare Commercialization Programme (NGFCP):** Nigeria, recognizing the environmental and economic impacts of gas flaring, implemented the Nigerian Gas Flare Commercialization Programme (NGFCP). This initiative aims to end gas flaring by capturing and utilizing the gas for economic purposes. The programme is an opportunity for Government, industry, State Government, ethnic nationalities, and local communities to work together to resolve an oil field unacceptable practice. Regulations and financial incentives encourage oil companies to adopt technologies that minimize flaring.
- **BP's Khazzan Gas Project, Oman:** BP's Khazzan project in Oman is an example of minimizing flaring by developing infrastructure to capture and utilize associated gas. To eliminate emissions, BP Oman introduced green completions to Khazzan Field. The green completions technique redefines well testing from a GHG-producing activity to one that prevents GHG emissions by routing the hydrocarbons to the production facility. Instead of flaring, the project processes this gas for use in power generation and other industrial applications, contributing to emission reduction.
- **TotalEnergies** has set a target of reducing its flaring intensity by 75% by 2025. The company is using a variety of measures to achieve this goal, including using MCU technologies, reinjecting associated gas into the reservoir, and connecting to gas markets.

- In summary, reducing emissions and minimizing flaring in oil and gas operations involves a combination of advanced technologies, regulatory frameworks, and industry collaborations. These efforts are essential for mitigating the environmental impact of the oil and gas industry and aligning with global sustainability goals.

II. Policy Framework and Regulatory Implications

Oil and gas companies are pursuing green energy, but the regulatory landscape and policy framework are dynamic and multifaceted. Governments all throughout the world are creating laws and policies to facilitate the shift to clean energy in the future, since there is a rising awareness of the need to lower greenhouse gas emissions from the oil and gas sector. Nigeria, for instance has gas flaring and venting policies which helped achieve the recognized flare reduction in 2022. Some of the key policy and regulatory implications for advancing green energy in oil and gas include:

- **Carbon pricing:** A market-based strategy for lowering greenhouse gas emissions is carbon pricing. By placing a cost on carbon emissions, it encourages businesses to cut back on their emissions. A carbon tax or a cap-and-trade scheme can be used to achieve carbon pricing.
- **Renewable energy targets:** Energy firms are mandated by renewable energy targets (RETs) to produce a specific percentage of their electricity from renewable sources. By encouraging investment in renewable energy sources, RETs can lessen dependency on fossil fuels.
- **Subsidies and tax breaks:** Governments can encourage the development and application of green energy technology in the oil and gas industry by offering tax incentives and subsidies. This may contribute to the affordability and competitiveness of green energy.
- **Performance standards:** Governments have the authority to impose performance requirements on the oil and gas sector, such as caps on flaring or methane emissions. This may lessen the negative environmental effects of the sector.

In addition to these general policy and regulatory implications, there are also specific policies and regulations that can be implemented to support the advancement of green energy in the oil and gas sector. Here are some examples of policy and regulatory initiatives that are being implemented around the world to advance green energy in the oil and gas sector:

- **Norway:** Norway has implemented a carbon tax on oil and gas companies. The tax is designed to incentivize companies to reduce their greenhouse gas emissions.
- **The European Union (EU):** The European Union has set a target of generating 27% of its energy from renewable sources by 2030. This target is driving investment in renewable energy projects on oil and gas sites in the EU.
- **The United States:** The United States has implemented several policies to support the development and deployment of green energy technologies in the oil and gas sector. These policies include tax breaks for renewable energy projects and performance standards for methane emissions.

- These are just a few of the many policy and regulatory initiatives that are being implemented around the world to advance green energy in the oil and gas sector. As the transition to a clean energy future continues, we can expect to see even more innovative and ambitious policies and regulations emerge.

III. Industry Initiatives and collaborations

Green energy is also being advanced in the oil and gas industry through industry efforts and partnerships. A few gas and oil firms have set high goals for cutting greenhouse gas emissions and boosting the usage of renewable energy sources. Furthermore, to develop and implement green energy technology, oil and gas firms are working together with governments, other stakeholders, and one another. Some of the key industry initiatives and collaborations in advancing green energy in oil and gas include:

- **World Bank's Global Gas Flaring Reduction Partnership (GGFR):** The World Bank's GGFR is a public-private initiative that encourages oil-producing countries and companies to reduce flaring. It provides a platform for knowledge sharing, technical assistance, and financial incentives to support projects that reduce gas flaring.
- **Oil and Gas Climate Initiative (OGCI):** The OGCI is an Aramco led initiative of 13 oil and gas companies that are committed to reducing their greenhouse gas emissions. The OGCI has set a target of reducing methane emissions by 0.2% per year and of investing $10 billion in low-carbon technologies by 2025.
- **Clean Energy Ministerial Oil and Gas Methane Partnership:** The Clean Energy Ministerial Oil and Gas Methane Partnership is a public-private partnership that is working to reduce methane emissions from the oil and gas sector. The partnership has set a target of reducing methane emissions by 45% by 2025.

In the oil and gas industry, industry initiatives and partnerships are critical to the advancement of green energy. Oil and gas corporations, governments, and other relevant parties can collaborate to expedite the advancement and implementation of sustainable energy technology, therefore mitigating the environmental ramifications of the business.

DISCUSSIONS

Norway is one of the richest countries in the world with a gross domestic product (GDP) per capita of about ninety thousand dollars ($90,000). The Norwegian oil and gas sector is responsible for about 73% of its exports with an average oil production of about 2.026 Million barrels per day (ranked 11th in the world).

Norway earned $50.2bn (528 billion kroner) from direct oil and gas licenses in 2022, according to an announcement made by state-owned petroleum company Petoro. This is more than five times the amount earned in an average year, although it is mostly after Russia's invasion of Ukraine caused countries across Europe to cut down on imports of Russian gas. In 2021, Norway earned about $18 bn from direct oil and gas licenses (Offshore Technology, 2023).

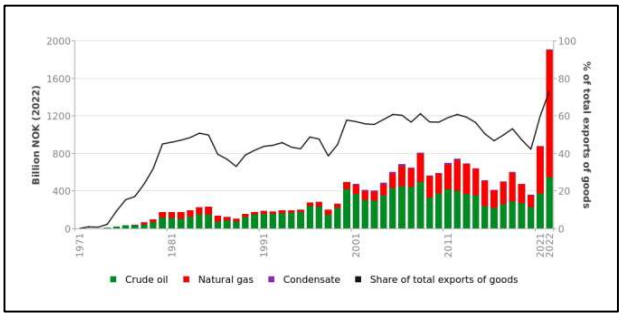
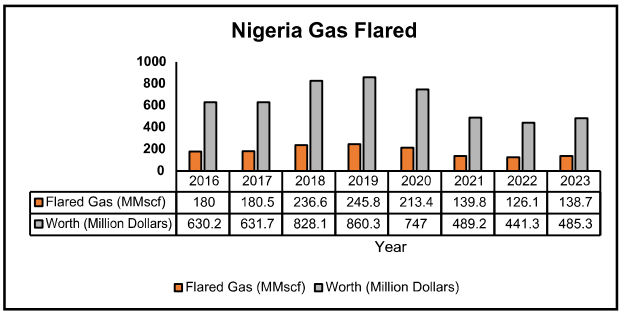


Figure 3.1: Norway's Earnings from Oil and Gas Export.

Nigeria is ranked 15th in the world of oil producers, with an average production of about 1.6 million barrels per day. Nigeria is a member of OPEC and has been working to reform its oil sector to attract more investment and improve transparency.

Oil and gas companies in Nigeria have flared gas worth $485.3 million in the first six months of 2023, a development hinged largely on improved crude oil production.

Data gleaned from the Nigeria Gas Flare Tracker (GFT), a satellite-based technology, shows that Nigeria's gas flares rose by 9.97 percent from $441.3 million in the same period of 2022 to $485 million this year. Nigeria flared 138.7 billion standard cubic feet (scf) of gas from January to June, according to the GFT.



	2016	2017	2018	2019	2020	2021	2022	2023
Flared Gas (MMscf)	180	180.5	236.6	245.8	213.4	139.8	126.1	138.7
Worth (Million Dollars)	630.2	631.7	828.1	860.3	747	489.2	441.3	485.3

Figure 3.2: Nigeria's Gas Flared, 2016-2023.

Investment in clean energy technologies is significantly outpacing spending on fossil fuels as affordability and security concerns triggered by the global energy crisis

strengthen the momentum behind more sustainable options, according to the IEA World Energy Investment 2023 report. The plot below shows a higher clean energy investment over fossil fuel investments since 2019.

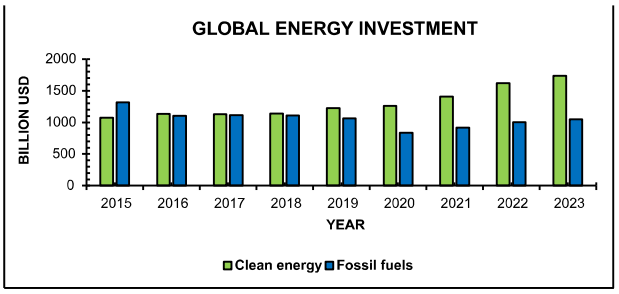


Figure 3.3: Global Energy Investment in Clean Energy and Fossil Fuels, 2015-2023.

This entails the steady transition into clean energy on a global scale. The belief is that the use of clean energy is more cost effective than fossil fuels. The projected growth in clean energy investment in 2023 will be driven by renewables, namely solar power, and electric vehicles. This indicates that the market for renewable energy sources is robust. The plot below shows the annual clean energy investment from 2015 to 2023 (2023 values are estimated).

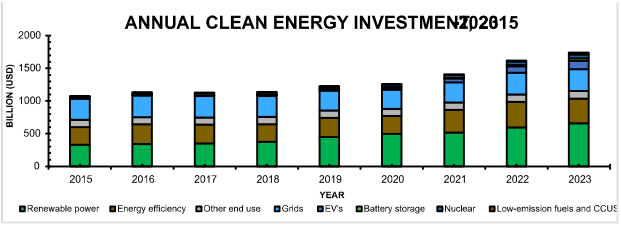


Figure 3.4: Annual Clean Energy Investment in Renewables, 2015-2023.

Norway has remained a global pillar of energy security, providing the world with stable supplies of oil and gas produced in an environmentally conscious manner. Norway has updated its already ambitious targets to reduce greenhouse gas emissions, with plans to achieve 90-95% reductions (excluding sinks) from 1990 levels by 2050.

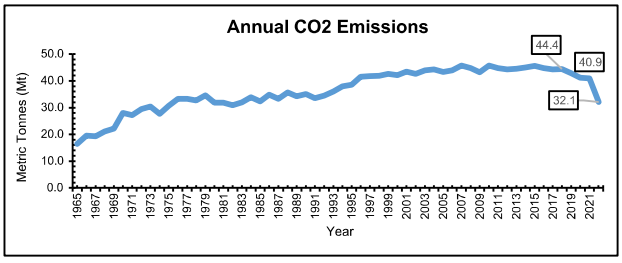


Figure 3.5: Plot showing Norway's CO_2 Emission (1965 – 2021).

The plot shows a steady drop in annual CO2 emission from 44.4 Mt in 2018 to 40.9Mt in 2021. In 2022, Norway had a significant decline, emitting 32.1Mt in the year. This is the effect of investing in renewable energy. The same is seen for Methane emissions as shown in the plot below.

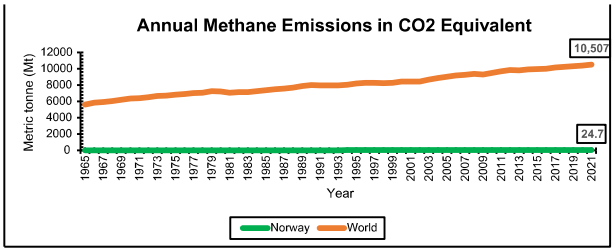


Figure 3.6: Plot showing Global Methane Emissions against Norway's Methane Emissions.

The plot shows how about 10Bt of methane was emitted in 2021, and Norway's emitted 24.7Mt of methane in the same year.

Last year's increase follows two years of exceptional oscillations in energy-related emissions. Emissions shrank by more than 5% in 2020, as the Covid-19 pandemic cut energy demand. In 2021, emissions rebounded past pre-pandemic levels, growing more than 6% in tandem with economic stimulus and the roll-out of vaccines.

The increase in clean energy spending in recent years is impressive but heavily concentrated in a handful of countries. This demonstrates that much work needs to be done to reduce greenhouse gas emissions on a worldwide scale.

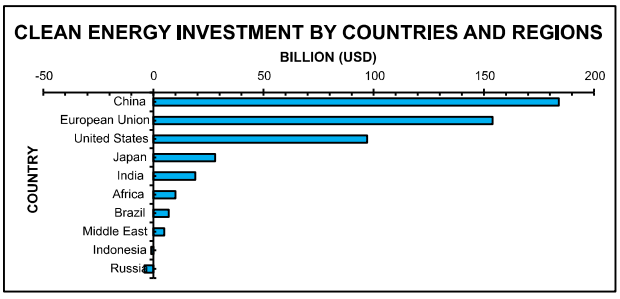


Figure 3.7: Increase in annual clean energy investment in selected countries and regions, 2019-2023.

Several oil and gas companies are currently trying to delve deeper into advancing clean energy in the exploration and production space. Fossil fuels such as oil and natural gas will continue to make up a significant share of the energy mix by 2050, partly because of how they combine affordability and security of supply (McKinsey & Company, 2022). Nonetheless, it is believed that oil and

gas companies are well positioned to play a meaningful role in the energy transition. Reasons for this include their global scale, the risk appetite of their investors, their large balance sheets and cash positions, and their long-standing relationships with energy customers and stakeholders.

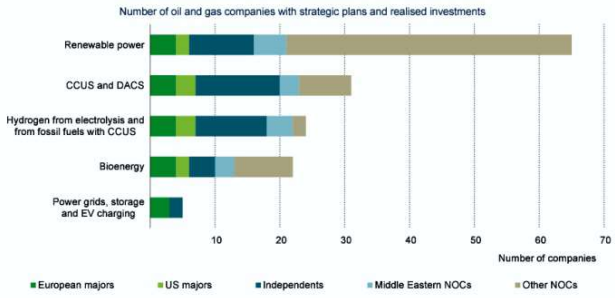


Figure 3.8: Number of Oil and Gas Companies with Strategic Plans and Realized Investments.

Oil and gas companies' investment in clean energy is increasing but remains small relative to overall capital investment; bioenergy investment rose significantly in 2022. The cost of clean energy increased slightly in 2022, but in 2023 pressures are decreasing and established clean technologies are still highly affordable in the current fuel-price climate.

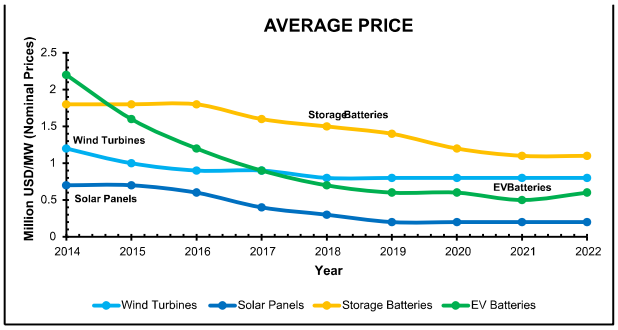


Figure 3.9: Average Prices for Selected Technologies, 2014-2022.

Clean energy investments often require high upfront spending, making the cost of financing a crucial variable for investors, even if this is offset over time by lower operating costs. Renewable power remains the main outlet for non-core oil and gas company spending, but investment in clean fuels, such as bioenergy, hydrogen and CCUS, is picking up.

The plots display a market for renewable energy and indicate that investment in green energy is essential to reducing greenhouse gas emissions. Also, it is noted that the shift to green energy has been going on for a while, with numerous production and exploration firms actively working with the governments of their respective nations (like Norway) to develop business models that include the generation and consumption of cleaner energy.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the oil and gas industry generally face several challenges as it transitions to a clean energy future. However, the industry is also making significant progress in advancing green energy technologies and practices.

Renewable energy integration, reduced emissions and flaring, and industry initiatives and collaborations are all playing a role in advancing green energy in exploration and production (E&P). These efforts are essential for reducing the oil and gas industry's environmental impact and meeting climate goals.

The results of advancing green energy in E&P are significant. By reducing its reliance on fossil fuels, reducing its greenhouse gas emissions, and improving its energy efficiency, the oil and gas industry can reduce its environmental impact and meet climate goals. In addition, advancing green energy can help the oil and gas industry to improve its financial performance and enhance its reputation.

Despite the challenges, the Nigerian oil and gas industry is committed to advancing green energy in E&P. By working together, the oil and gas industry, governments, and other stakeholders can accelerate the transition to a clean energy future.

Here are some additional thoughts on the future of green energy in the oil and gas industry:

- We can expect to see even more investment and innovation in green energy solutions for E&P in the years to come.
- Nigeria oil and gas companies can start by paying more attention to renewable forms of power generation like solar and wind energy.
- The cost of green energy technologies will continue to decline, making them more affordable for the oil and gas industry.
- Governments will implement more policies and regulations to support the adoption of green energy in the oil and gas sector.
- The oil and gas industry will play a vital role in the transition to a clean energy future, but it will need to continue to reduce its emissions and invest in renewable energy technologies.

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