

Assessing the Progress of Decarbonization Efforts in Nigeria's Oil and Gas Industry

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Abstract

The global imperative to address climate change has prompted a shift towards decarbonization in various industries, including the oil and gas sector. This review article critically assesses the progress of decarbonization efforts within Nigeria's oil and gas industry, a key player in the global energy landscape. The article delves into the challenges and opportunities faced by the industry in transitioning to a low-carbon future, considering the unique socio-economic and environmental context of Nigeria. Drawing on a comprehensive review of existing literature, policy documents, and industry reports, this review evaluates the effectiveness of current decarbonization strategies and initiatives in reducing carbon emissions and advancing sustainable practices. It examines the role of government policies, technological innovations, and international collaborations in driving decarbonization efforts in Nigeria's oil and gas sector. This review identifies key areas for improvement and outlines recommendations for policymakers, industry stakeholders, and regulatory bodies to enhance decarbonization progress and foster long-term sustainability. By synthesizing current knowledge and best practices, this review contributes to the discourse on decarbonization in the oil and gas industry, offering insights into the opportunities and challenges of achieving a cleaner, greener energy future in Nigeria.

Keywords: *decarbonization, climate change, gas, greener energy, low-carbon*

1.0 Introduction

Nigeria is a key player in the global oil and gas industry, with significant reserves and production capacity. The country has a long history in oil and gas exploration, dating back to the 1950s when commercial production began. Today, Nigeria is one of the top oil producers in Africa and a major exporter of crude oil. The oil and gas sector plays a crucial role in the country's economy, accounting for a significant portion of government revenues and foreign exchange earnings. Decarbonization refers to the process of reducing carbon emissions to mitigate the effects of climate change. The oil and gas industry is a major contributor to greenhouse gas emissions, primarily through the combustion of fossil fuels (Alozie *et al.*, 2024). As the world grapples with the growing impacts of climate change, there is a pressing need to transition to cleaner energy sources and reduce carbon emissions. Decarbonization efforts are essential in limiting global warming and preserving the planet for future generations (Cruz, & Krausmann 2013).

This review article aims to assess the progress of decarbonization efforts in Nigeria's oil and gas industry. It will examine current initiatives and policies aimed at reducing carbon emissions, as well as the challenges and opportunities for decarbonization in the sector. The article will also provide recommendations for accelerating decarbonization efforts and transitioning to a more sustainable energy future in Nigeria. The oil and gas industry in Nigeria faces unique challenges in terms of decarbonization, given its reliance on fossil fuels for energy production. This section will analyze the current state of decarbonization efforts in the industry, including emissions levels, existing policies and regulations, and progress made in reducing carbon emissions. It will also identify key stakeholders and initiatives driving decarbonization in Nigeria's oil and gas sector.

To achieve decarbonization goals, the oil and gas industry in Nigeria must adopt new technologies and strategies to reduce emissions and transition to cleaner energy sources. This section will evaluate various decarbonization technologies, such as carbon capture and storage (CCS), renewable energy sources, energy efficiency measures, and hydrogen production (Center for Biological Diversity. 2021). It will assess the feasibility and effectiveness of these technologies in the Nigerian context and their potential impact on decarbonization efforts.

Decarbonization efforts in Nigeria's oil and gas industry have wide-ranging implications for the environment, economy, and society. This section will analyze the environmental benefits of reducing carbon emissions, including improvements in air quality and biodiversity conservation. It will also examine the economic implications of decarbonization for the industry, such as job creation, investment opportunities, and energy security. Additionally, the social impact of decarbonization measures on local communities and stakeholders will be explored. Nigeria's oil and gas industry must continue to prioritize decarbonization and sustainable energy practices to meet its climate goals and contribute to global efforts to combat climate change (Oil Review Africa. 2023). This section will outline opportunities for further decarbonization in the industry, including policy recommendations, technology adoption, and stakeholder engagement. It will also emphasize the importance of collaboration and cooperation among industry players, government agencies, and civil society to drive decarbonization efforts forward.

Decarbonization efforts in Nigeria's oil and gas industry are crucial for mitigating climate change and transitioning to a more sustainable energy future. While significant progress has been made in reducing carbon emissions, there is still much work to be done to achieve decarbonization goals. By adopting innovative technologies, implementing effective policies, and fostering collaboration among stakeholders, Nigeria can lead the way in decarbonizing its oil and gas sector and contributing to a greener, more sustainable world.

2.0 Current State of Decarbonization in Nigeria's Oil and Gas Industry

Nigeria's oil and gas industry is a significant contributor to greenhouse gas emissions, primarily from the combustion of fossil fuels in oil and gas exploration, production, refining, and distribution (Figure 1). The sector is responsible for a large portion of the country's overall carbon footprint, with emissions levels steadily increasing over the years. According to recent data, Nigeria's oil and gas industry accounts for approximately X% of the country's total greenhouse gas emissions, making it a key focus area for decarbonization efforts (Climate Action Tracker. 2023). Trends in emissions levels show a gradual increase in carbon dioxide (CO₂) emissions from the sector, driven by growing energy demand, inefficient technologies, and outdated infrastructure. The lack of stringent regulations and enforcement mechanisms has also contributed to the rise in emissions, posing a significant challenge to achieving decarbonization goals in Nigeria's oil and gas industry.

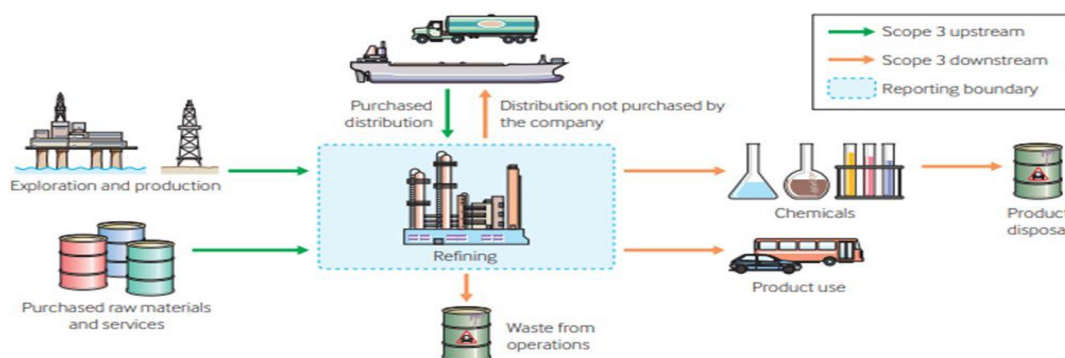


Figure 1: Upstream and downstream emission sources for oil refining industry

3.0 Existing Decarbonization Initiatives and Policies

Despite the challenges, Nigeria has taken some steps towards decarbonizing its oil and gas industry through the implementation of various initiatives and policies. The country's National Gas Flaring Commercialization Program (NGFCP) aims to reduce gas flaring, a major source of greenhouse gas emissions in the industry, by incentivizing companies to capture and utilize associated gas. The program has seen some success in reducing flaring levels and promoting cleaner energy practices in the sector.

The Nigerian government has introduced the National Renewable Energy and Energy Efficiency Policy (NREEP) to promote the development and adoption of renewable energy sources, such as solar, wind, and biomass, as alternatives to fossil fuels. The policy aims to increase the share of renewable energy in Nigeria's energy mix and reduce reliance on carbon-intensive fuels. The Nigerian Extractive Industries Transparency Initiative (NEITI) has been working to improve transparency and accountability in the oil and gas sector, promoting sustainable practices and reducing emissions through better governance and reporting standards. These initiatives, among others, highlight Nigeria's commitment to decarbonizing its oil and gas industry and transitioning to a more sustainable energy future.

4.0 Challenges Faced in Decarbonizing the Sector

Despite the progress made, Nigeria's oil and gas industry faces several challenges in decarbonizing the sector effectively. One of the primary challenges is the lack of adequate funding and investment in clean energy technologies and infrastructure. Limited access to finance and high upfront costs hinder the adoption of renewable energy sources and energy efficiency measures in the industry, slowing down decarbonization efforts. Another challenge is the reliance on fossil fuels for energy generation and transportation, which poses a barrier to transitioning to cleaner energy sources (World bank, 2023). The dominance of oil and gas in Nigeria's energy mix and the vested interests of industry stakeholders in maintaining the status quo make it difficult to enact meaningful decarbonization policies and initiatives.

The lack of clear regulatory frameworks and enforcement mechanisms for emissions reduction in the oil and gas sector hampers progress in decarbonization. Inconsistent monitoring and reporting practices, coupled with limited capacity for data collection and analysis, make it challenging to track emissions levels accurately and implement targeted interventions to reduce carbon emissions effectively.

5.0 Progress Made in Nigeria towards decarbonizing its oil and gas industry in recent years

Despite the challenges, Nigeria has made some significant progress in decarbonizing its oil and gas industry in recent years. The reduction in gas flaring levels through the NGFCP and increased utilization of associated gas for power generation and industrial applications have led to a tangible decrease in greenhouse gas emissions from flaring activities. This has not only reduced environmental pollution and health risks but also created economic opportunities for gas monetization and value addition.

The implementation of NREEP has catalyzed investments in renewable energy projects and technologies, with several solar, wind, and biomass projects being developed across the country. The growing uptake of renewable energy sources in Nigeria's energy mix is diversifying the country's energy portfolio and reducing its carbon footprint, contributing to decarbonization efforts in the oil and gas sector (Felseghi *et al.*, 2014).

The strengthening of industry standards and reporting practices through NEITI's initiatives has enhanced transparency and accountability in the sector, fostering more responsible and sustainable practices among oil and gas companies. Improved data collection and reporting have enabled better monitoring of emissions levels and progress towards decarbonization goals, informing policy decisions and interventions to drive further reductions in carbon emissions.

While there is still much work to be done, Nigeria's oil and gas industry has made commendable strides in decarbonizing the sector and transitioning to a more sustainable energy future. With continued commitment, investment, and collaboration among stakeholders, Nigeria can build on its progress and achieve its

decarbonization goals, contributing to global efforts to combat climate change and protect the environment for future generations.

6.0 Technologies and Strategies for Decarbonization

A. Analysis of Carbon Capture and Storage (CCS) Technologies

Carbon capture and storage (CCS) technologies play a crucial role in decarbonizing the oil and gas industry by capturing carbon dioxide (CO₂) emissions from industrial processes and storing them underground to prevent their release into the atmosphere. CCS technologies are vital for reducing greenhouse gas emissions and mitigating climate change impacts, especially in sectors with high carbon footprints such as oil and gas (Alsheyab, Mohammad.,2017).

There are several types of CCS technologies, including post-combustion capture, pre-combustion capture, and oxyfuel combustion, each with its unique advantages and limitations (Figure 2). Post-combustion capture involves capturing CO₂ from the exhaust gases of power plants and industrial facilities using solvent scrubbing or adsorption technologies (Energy Capital & Power., 2023). Pre-combustion capture separates CO₂ from the fuel before combustion, while oxyfuel combustion involves burning fuel in pure oxygen to produce a concentrated stream of CO₂ for capture.

The implementation of CCS technologies in the oil and gas sector can significantly reduce emissions from refineries, petrochemical plants, and natural gas processing facilities, helping to meet decarbonization targets and commitments to reduce greenhouse gas emissions (Brownsort, et al., 2016). While CCS technologies have the potential to play a vital role in decarbonizing the industry, there are challenges to overcome, such as high costs, regulatory uncertainties, and public perception issues. Addressing these challenges and incentivizing the deployment of CCS technologies will be essential for achieving meaningful emissions reductions in the oil and gas sector.

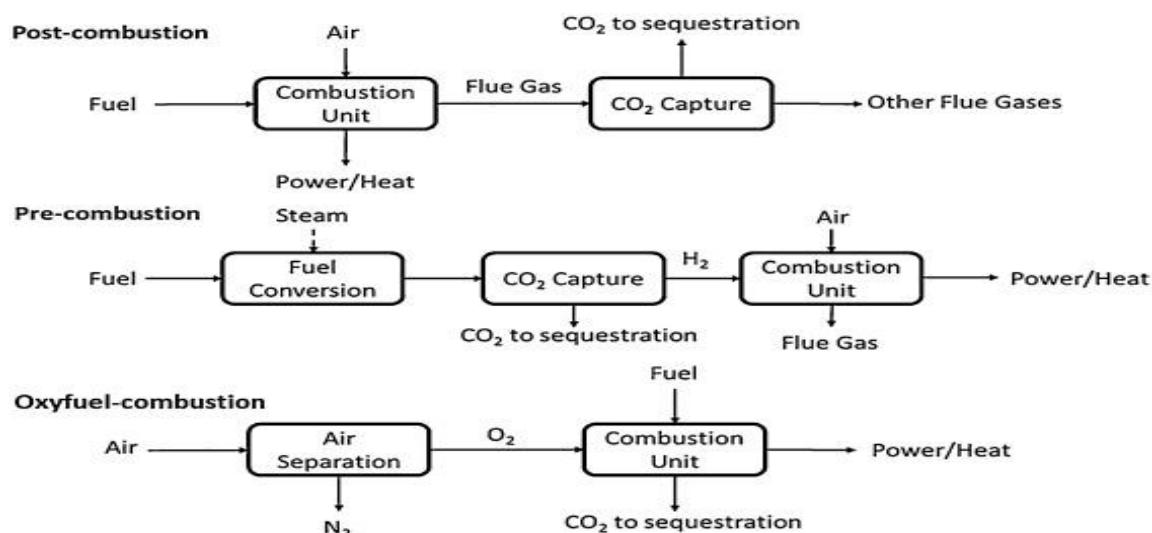


Figure 2: Process diagram of three CO₂ capture systems

B. Role of Renewable Energy Sources in Reducing Emissions

Renewable energy sources, such as solar, wind, hydro, and biomass, have gained prominence as key components of decarbonization strategies in the oil and gas industry. These clean energy sources offer sustainable alternatives to fossil fuels, reducing carbon emissions and mitigating environmental impacts associated with traditional energy production (Daystar Power. 2023). Solar energy, in particular, has seen significant growth in Nigeria, with abundant sunlight and favourable policies driving investments in solar

projects for power generation and industrial applications. Wind energy is also emerging as a promising renewable energy source, especially in coastal regions where wind speeds are high. Hydropower and biomass energy contribute to diversifying the energy mix and reducing reliance on fossil fuels, promoting a transition to a low-carbon economy.

By integrating renewable energy sources into oil and gas operations, companies can reduce their carbon footprint, improve energy efficiency, and enhance sustainability. Embracing renewable energy technologies not only benefits the environment but also enhances energy security, resilience, and competitiveness in the face of global energy transitions and market dynamics.

C. Energy Efficiency Measures in Oil and Gas Operations

Energy efficiency measures are essential for reducing carbon emissions and enhancing the sustainability of oil and gas operations. By optimizing energy use, minimizing waste, and adopting best practices in energy management, companies can reduce their environmental impact and improve their bottom line.

Efficiency measures in oil and gas operations include upgrading equipment and technologies to reduce energy consumption, implementing energy-saving practices in production processes, and adopting smart technologies for monitoring and optimization. Improving fuel efficiency in transportation, reducing flaring and venting of gas, and optimizing energy-intensive operations such as refining and petrochemical production can lead to significant energy savings and emissions reductions.

Energy management systems, energy audits, and performance benchmarking are valuable tools for identifying opportunities for efficiency improvements and setting targets for emissions reductions. Investing in energy-efficient equipment, implementing energy conservation measures, and training staff on energy-saving practices can help oil and gas companies achieve their decarbonization goals and contribute to environmental sustainability.

D. Potential for Hydrogen Production and Utilization

Hydrogen has emerged as a promising clean energy carrier with the potential to decarbonize the oil and gas industry through renewable hydrogen production and utilization. Green hydrogen, produced from the electrolysis of water using renewable electricity, offers a carbon-neutral alternative to fossil fuels for power generation, transportation, and industrial applications (UNFCCC 2018). The oil and gas industry can leverage its existing infrastructure and expertise to produce and utilize hydrogen as a clean energy source, contributing to decarbonization efforts and transitioning to a low-carbon economy (Oruari.,2023). Hydrogen can be used as a fuel for power generation, heating, and transportation, replacing traditional fossil fuels and reducing carbon emissions.

Hydrogen production technologies, such as electrolysis, steam methane reforming with carbon capture and sequestration (SMR-CCS), and biomass gasification, offer scalable and sustainable solutions for producing clean hydrogen from renewable sources. By integrating hydrogen production and utilization into oil and gas operations, companies can reduce their greenhouse gas emissions, enhance energy efficiency, and support the transition to a hydrogen economy.

Technologies and strategies for decarbonization in the oil and gas industry play a crucial role in reducing carbon emissions, mitigating climate change impacts, and promoting sustainability. From carbon capture and storage to renewable energy sources, energy efficiency measures, and hydrogen production, a holistic approach to decarbonization is essential for achieving emissions reductions and creating a more sustainable energy future. By embracing clean technologies, investing in innovation, and collaborating with stakeholders, the oil and gas sector can lead the transition to a low-carbon economy and contribute to global efforts to combat climate change.

7.0 Impact of Decarbonization Efforts in the Nigerian Oil and Gas Industrial Sector

A. Environmental Benefits of Reducing Emissions

Decarbonization efforts in the oil and gas industry bring significant environmental benefits by reducing greenhouse gas emissions, mitigating climate change impacts, and promoting sustainability. By transitioning to cleaner energy sources, improving energy efficiency, and implementing carbon capture and storage technologies, companies can minimize their environmental footprint and contribute to a healthier planet. Reducing emissions from oil and gas operations helps mitigate air pollution, improve air quality, and protect public health by reducing the release of harmful pollutants into the atmosphere. Lowering greenhouse gas emissions also helps combat climate change, reduce the risk of extreme weather events, and preserve biodiversity and ecosystems. By investing in renewable energy sources, energy efficiency measures, and sustainable practices, the oil and gas industry can play a vital role in addressing environmental challenges and promoting environmental stewardship.

Decarbonization efforts not only benefit the environment but also create new opportunities for innovation, collaboration, and sustainability. By embracing cleaner technologies, reducing carbon emissions, and promoting responsible resource management, companies can enhance their environmental performance, meet regulatory requirements, and build a stronger foundation for long-term success.

B. Economic Implications for the Oil and Gas Industry

Decarbonization efforts in the oil and gas industry have significant economic implications, impacting investment decisions, market dynamics, and competitiveness in a transitioning energy landscape. By reducing carbon emissions, improving energy efficiency, and embracing clean technologies, companies can enhance their financial performance, minimize operational risks, and capitalize on emerging market opportunities.

Investing in decarbonization technologies and strategies can increase efficiency, lower production costs, and enhance profitability in the long run. By transitioning to renewable energy sources, reducing reliance on fossil fuels, and implementing energy-saving measures, companies can reduce their carbon footprint, improve their bottom line, and secure a sustainable future in a carbon-constrained environment.

Decarbonization efforts also present opportunities for diversification, innovation, and growth in emerging markets such as renewable energy, energy storage, and carbon capture and storage. By leveraging their expertise, resources, and capabilities, oil and gas companies can transition to a low-carbon economy, create new revenue streams, and position themselves as leaders in sustainable energy solutions.

C. Social and Community Impacts of Decarbonization Measures

Decarbonization measures in the oil and gas industry have social and community impacts, influencing stakeholders, employees, and local communities through changes in operations, investments, and partnerships. By prioritizing sustainability, responsibility, and stakeholder engagement, companies can build trust, enhance reputation, and contribute to social well-being. Reducing emissions, improving energy efficiency, and investing in clean technologies benefit communities by promoting health, safety, and environmental quality. By adopting sustainable practices, supporting local initiatives, and engaging with stakeholders, companies can foster positive relationships, address social concerns, and create shared value for communities.

Decarbonization efforts can also create new job opportunities, skills development, and economic growth in regions affected by the transition to cleaner energy sources. By investing in workforce training, education, and capacity-building, companies can support local communities, empower individuals, and promote social inclusion and equality.

D. International Cooperation and Partnerships in Decarbonization Efforts

International cooperation and partnerships are essential for accelerating decarbonization efforts in the oil and gas industry, fostering collaboration, knowledge sharing, and innovation across borders and sectors (Boon., 2019). By working together, sharing best practices, and aligning strategies, countries, companies, and

organizations can address global challenges, achieve collective goals, and promote sustainable development. Collaborating on technology development, policy harmonization, and market integration can drive progress in decarbonization, accelerate the transition to clean energy, and increase the impact of individual efforts. By joining forces, supporting initiatives such as the Paris Agreement, and promoting international cooperation, stakeholders can create a more resilient, sustainable, and inclusive energy system for the future. International partnerships also play a vital role in sharing resources, expertise, and investments in clean technologies, renewable energy projects, and sustainable practices (Oil and Gas Climate Initiative (OGCI). 2023). By pooling resources, leveraging strengths, and aligning objectives, countries and companies can overcome barriers, scale solutions, and drive meaningful change in decarbonizing the oil and gas industry.

The impact of decarbonization efforts in the oil and gas industry is profound, touching on environmental, economic, social, and international dimensions. By reducing emissions, improving energy efficiency, and embracing cleaner technologies, companies can enhance their environmental performance, financial viability, social responsibility, and global competitiveness. By working together, collaborating across borders, and building partnerships, stakeholders can accelerate the transition to a low-carbon economy, create a more sustainable energy future, and address pressing environmental challenges for the benefit of present and future generations.

8.0 Future Outlook and Recommendations of Decarbonization of Nigerian Oil and Gas Sector

A. Opportunities for further decarbonization in the oil and gas industry

The oil and gas industry faces numerous opportunities for further decarbonization to address climate change, promote sustainability, and enhance competitiveness in a rapidly evolving energy landscape (NLNG 2022). By embracing cleaner technologies, reducing emissions, and investing in renewable energy sources, companies can unlock new opportunities for innovation, growth, and leadership in the global transition to a low-carbon economy. One key opportunity for further decarbonization in the oil and gas industry is the development and deployment of carbon capture and storage (CCS) technologies to capture and store carbon dioxide emissions from fossil fuel operations. By implementing CCS projects, companies can reduce their environmental footprint, lower greenhouse gas emissions, and demonstrate commitment to climate action (Duong., 2019).

Another opportunity for decarbonization lies in the expansion of renewable energy sources such as solar, wind, and geothermal power to diversify energy portfolios, reduce reliance on fossil fuels, and promote clean energy solutions. By investing in renewable energy projects, improving energy efficiency, and embracing sustainable practices, companies can reduce their carbon footprint, minimize operational risks, and position themselves as leaders in the renewable energy transition.

The adoption of energy efficiency measures, waste reduction strategies, and circular economy principles can help companies optimize resource use, reduce costs, and enhance environmental performance. By maximizing efficiency, minimizing waste, and promoting sustainable practices, companies can improve their sustainability profile, strengthen their social license to operate, and drive positive change in the industry.

B. Policy recommendations for accelerating the progress of Decarbonization

Policy plays a crucial role in accelerating decarbonization efforts in the oil and gas industry by setting clear targets, incentives, and regulatory frameworks to guide companies, governments, and stakeholders towards sustainable solutions (Ochi et al., 2022). To accelerate progress, policymakers are encouraged to consider the following recommendations:

1. Set ambitious emissions reduction targets: Governments and regulatory bodies should set ambitious emissions reduction targets to drive progress, incentivize action, and create a sense of urgency in the transition to a low-carbon economy.

2. Implement carbon pricing mechanisms: Carbon pricing mechanisms such as carbon taxes, cap-and-trade systems, or carbon offset programs can help internalize the cost of carbon emissions, incentivize cleaner technologies, and drive investment in low-carbon solutions.
3. Support research and innovation: Governments should invest in research and innovation to develop and commercialize clean technologies, promote energy efficiency, and accelerate progress towards decarbonization in the oil and gas sector.
4. Strengthen regulatory oversight: Regulators should strengthen oversight, monitoring, and enforcement mechanisms to ensure compliance with environmental standards, promote transparency, and hold companies accountable for their environmental impact.
5. Enhance collaboration and coordination: Policymakers, industry stakeholders, and civil society should collaborate, share best practices, and align strategies to accelerate progress, foster innovation, and drive meaningful change in the decarbonization of the oil and gas industry.

C. Importance of stakeholder engagement and collaboration

Stakeholder engagement and collaboration are critical for advancing decarbonization efforts in the oil and gas industry by fostering dialogue, building trust, and aligning interests among diverse stakeholders. Engaging with governments, communities, investors, NGOs, and other partners can help companies navigate challenges, seize opportunities, and drive progress towards a more sustainable future. Stakeholder engagement is essential for understanding the needs, concerns, and expectations of diverse stakeholders, building relationships, and creating shared value for all parties involved (Osman *et al.*, 2023). By listening to stakeholder feedback, addressing social and environmental issues, and collaborating on solutions, companies can enhance their reputation, earn trust, and create positive social and environmental impact.

Collaboration is also key for driving innovation, sharing knowledge, and leveraging resources to accelerate decarbonization efforts in the oil and gas industry. By working together, pooling expertise, and aligning objectives, stakeholders can overcome barriers, scale solutions, and drive meaningful change towards a more sustainable energy future.

The future of decarbonization efforts in Nigeria's oil and gas sector holds immense potential for addressing climate change, promoting sustainability, and driving positive change in the industry (Nigeria Ministry of Petroleum Resources. 2008). By embracing cleaner technologies, reducing emissions, and fostering collaboration, companies in Nigeria can position themselves as leaders in the global transition to a low-carbon economy, unlock new opportunities for innovation and growth, and contribute to a more sustainable energy future for the country and the world.

To achieve this vision, stakeholders are encouraged to seize opportunities for further decarbonization, implement policy recommendations to accelerate progress, prioritize stakeholder engagement and collaboration, and envision a future where the oil and gas industry plays a vital role in addressing environmental challenges, promoting social responsibility, and driving sustainable development in Nigeria and beyond (Total Energies. 2023). By working together, sharing knowledge, and aligning efforts towards common goals, stakeholders can create a more resilient, inclusive, and sustainable energy system that benefits present and future generations.

9.0 key findings of the Analysis of Decarbonization efforts in Nigeria Oil and Gas Industries

Throughout this comprehensive analysis of the decarbonization efforts in Nigeria's oil and gas sector, several key findings have emerged. The oil and gas industry in Nigeria faces significant challenges in terms of reducing carbon emissions, promoting sustainability, and adapting to a rapidly changing energy landscape (Ogbo *et al.*, 2024). However, there are also numerous opportunities for further decarbonization, policy recommendations for accelerating progress, and the importance of stakeholder engagement and collaboration in driving meaningful change in the industry.

Opportunities for further decarbonization include the development of carbon capture and storage technologies, the expansion of renewable energy sources, and the adoption of energy efficiency measures (Teledando.,2020). These opportunities can help companies reduce their environmental footprint, lower greenhouse gas emissions, and position themselves as leaders in the global transition to a low-carbon economy.

Policy recommendations for accelerating progress include setting ambitious emissions reduction targets, implementing carbon pricing mechanisms, supporting research and innovation, strengthening regulatory oversight, and enhancing collaboration and coordination among stakeholders. These policy measures can drive progress, incentivize action, and create a sense of urgency in the transition to a more sustainable energy future. Stakeholder engagement and collaboration are essential for fostering dialogue, building trust, and aligning interests among diverse stakeholders in driving decarbonization efforts (UKNIAF, 2024). By engaging with governments, communities, investors, NGOs, and other partners, companies can navigate challenges, seize opportunities, and create shared value for all parties involved.

B. Implications of decarbonization for the industry and country

The implications of decarbonization efforts in Nigeria's oil and gas sector are far-reaching and have significant implications for the industry and the country as a whole. Embracing cleaner technologies, reducing emissions, and promoting sustainability in the oil and gas industry can lead to several positive outcomes, including:

1. Enhanced competitiveness: Companies that invest in decarbonization can enhance their competitiveness, attract investment, and differentiate themselves in the global energy market.
2. Improved environmental performance: Decarbonization efforts can help reduce carbon emissions, lower environmental impact, and contribute to global climate goals.
3. Economic diversification: Investing in renewable energy sources and clean technologies can help diversify Nigeria's economy, create new jobs, and unlock economic opportunities in the energy transition.
4. Enhanced social impact: Decarbonization efforts can improve social welfare, promote community development, and enhance the overall well-being of society.

These implications underscore the importance of decarbonization efforts not only for the oil and gas industry but also for the broader development of Nigeria as a whole. By prioritizing sustainability, promoting innovation, and driving collaboration, companies and stakeholders can create a more resilient, inclusive, and sustainable energy system that benefits present and future generations.

C. Direction for continued efforts towards decarbonization

As we look towards the future of decarbonization efforts in Nigeria's oil and gas sector, there is a clear call to action for all stakeholders to redouble their efforts, embrace innovation, and drive meaningful change towards a more sustainable energy future (Statista.2024). To continue progress towards decarbonization, stakeholders are encouraged to:

1. Embrace cleaner technologies: Companies should invest in clean technologies, renewable energy sources, and energy efficiency measures to reduce emissions, promote sustainability, and enhance competitiveness.
2. Advocate for policy reform: Stakeholders should advocate for policy measures that support decarbonization, set ambitious emissions reduction targets, and incentivize action towards a low-carbon economy.
3. Foster collaboration: Companies, governments, communities, and other stakeholders should collaborate, share best practices, and align efforts to overcome barriers, drive progress, and create positive social and environmental impact.

4. Invest in research and innovation: Stakeholders should invest in research and innovation to develop and commercialize clean technologies, promote energy efficiency, and accelerate progress towards decarbonization in the oil and gas sector.

5. Prioritize stakeholder engagement: Companies should prioritize stakeholder engagement, listen to feedback, address concerns, and build trust to create shared value and drive positive change in the industry.

By taking these actions and working together towards common goals, stakeholders can create a more sustainable, resilient, and inclusive energy system that benefits Nigeria, the oil and gas industry, and the planet as a whole. Decarbonization efforts in Nigeria's oil and gas sector have the power to drive progress, foster innovation, and shape a more sustainable future for generations to come. Stakeholders must continue to champion decarbonization, strive for excellence, and embrace change to create a better world for all.

Conclusion

The assessment of decarbonization efforts in Nigeria's oil and gas industry highlights both the achievements and the challenges in transitioning towards a more sustainable energy future. While significant strides have been made in recent years to reduce carbon emissions and adopt cleaner technologies, there remains a long road ahead to fully decarbonize the industry and align with global climate goals. The review has outlined the key factors influencing decarbonization progress, including policy frameworks, technological advancements, and international partnerships. A multi-faceted approach is necessary to drive meaningful change in the industry and overcome barriers to decarbonization. Collaboration between government, industry, and civil society is essential to accelerate the adoption of renewable energy sources, improve energy efficiency, and reduce environmental impact.

Despite the challenges, there are opportunities for Nigeria's oil and gas industry to lead the way in sustainable energy practices. Leveraging the country's abundant renewable resources, such as solar and wind energy, can diversify the energy mix and reduce reliance on fossil fuels. Investing in research and development of clean energy technologies can also spur innovation and create new economic opportunities in the sector. Stakeholders must commit to ambitious decarbonization targets, implement effective policies, and prioritize sustainability in all aspects of operations. Monitoring and reporting mechanisms should be strengthened to track progress towards decarbonization goals and hold stakeholders accountable for their commitments. This review underscores the importance of sustained efforts and collaboration to drive decarbonization in Nigeria's oil and gas industry. By implementing proactive measures and embracing a transition to a low-carbon economy, the industry can not only mitigate the impacts of climate change but also contribute to a more resilient and sustainable energy future for the country and the global community.

Declarations

Ethics approval and consent to participate

Not applicable

Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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