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INNOVATIVE APPROACHES TO CARBON CAPTURE AND UTILIZATION IN NIGERIA'S OIL AND GAS SECTOR:

TRANSFORMING EMISSIONS INTO ASSETS

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Abstract

This study carried out an assessment of innovative approaches to carbon capture and utilization in Nigeria's oil & gas sector: transforming emissions into assets. Nigeria's oil & gas sector is a significant contributor to the country's economy, but its operations also generate substantial greenhouse gas emissions. To address this challenge and align with Nigeria's climate commitments, innovative approaches to carbon utilization in the oil and gas sector are crucial. Findings identified direct air capture technology, carbon capture and storage technology and carbon capture and utilization technology as current innovative technologies adopted in transforming carbon emissions into assets in Nigeria's oil & gas sector, showed the relationship between gas utilization and carbon emissions efficiency in Nigeria's oil & gas sector and final findings identified five challenges of transforming carbon emissions into assets in Nigeria's oil & gas sector namely technology, leakages, capture and storage costs, decision & regulatory strategies and implementation time. This paper recommends the need for collaboration between the Nigerian government, international organizations, and the private sector to develop and deploy the necessary technologies and infrastructure. By embracing these strategies, Nigeria's oil & gas sector can contribute to the country's transition towards a low-carbon economy while creating new revenue streams and aligning with global efforts to combat climate change.

Keywords

Carbon Capture and Utilization, Climate Change, Innovative technologies, Mitigation, Oil & Gas Sector, Sustainable Development

1.0 Introduction

The entire world is experiencing negative changes in physical, biological and human systems. Sea levels, ice and snow cover have fallen by around 15% and the world is warming with an overall increase in the spread of diseases, the onset of droughts and the exposure of fertile soils to desertification (Rosenzweig & Casassa 2007). These are generally associated with an increase in greenhouse gas emissions such as carbon dioxide (CO_2), methane (CH_4), water vapor (H_2O (g)), nitrous oxide, halocarbons and others. Carbon dioxide (CO_2) has been recognized as the most important anthropogenic greenhouse gas, with an annual emissions growth rate of approximately 80% (IPCC 2007; Lewis 2007) and a current atmospheric concentration of approximately 750 gigatons. Previous research studies have revealed that the CO_2 emitted would remain in the atmosphere for hundreds of years (Lewis 2007; GF 2008). The main global concern is how to reduce additional emissions in ways that generate commercial and environmental benefits. Responses from the oil and gas industries, which are major emitters, indicate that gas could be captured and used for tertiary recovery of oil and/or gas from partially depleted reservoirs (Herzog et al. 1997; Herzog 2004; Svensson et al. 2004; GF, 2008).

Carbon capture, utilization and storage (CCUS) is the process of capturing carbon dioxide emissions and using them to make things such as building materials (utilization) or storing them permanently at thousands feet below the surface (storage). Carbon dioxide captured from industrial operations may have chances to enter the atmosphere, help reduce emissions, as well as eradicate it directly from the air. The carbon dioxide is then reused or sent to a deep injection well where it is safely and permanently locked away.

Carbon capture, utilization and storage (CCUS) encompasses techniques and technologies to extract CO_2 from flue gases and the atmosphere, then reuse the CO_2 for various applications while identifying storage options safe and durable. However, before looking at the pros and cons, it is essential to carefully consider the aforementioned energy terms (carbon capture, utilization and storage). Carbon capture requires developing sorbents capable of effectively binding CO_2 present in flue gases or in the atmosphere, although at a high cost. It is the leading large-scale approach to cost-effectively reducing emissions while preserving the importance of fossil fuel resources and existing infrastructure in the power and industrial sectors. Carbon storage serves to prevent widespread emissions of carbon dioxide from contributing further to or making climate change worse. Although this process increases the energy demand of power plants, most experts recognize carbon storage as a transitional solution.

Carbon capture and utilization refers to the various ways in which captured carbon dioxide can be recycled to generate economically valuable products or services, primarily involving the conversion of carbon dioxide or carbon monoxide. Carbon capture and utilization offers a particular opportunity to transform emissions into assets in the context of Nigeria's oil and gas sector, generating new sources of revenue and contributing to the achievement of the country's Sustainable Development Goals. The implementation of procedures and technologies allowing the collection, storage and use of CO2 produced by oil and gas activities can contribute to the realization of these oil and gas operations. This article aims to explore innovative approaches to carbon capture and utilization in Nigeria’s oil and gas sector: turning emissions into assets. This paper is divided into five parts, namely the introduction, literature review, innovative technologies adopted to transform carbon emissions into assets in Nigeria's oil and gas sector, the innovation strategy designed to address the carbon emissions challenges in Nigeria's oil and gas sector, conclusions and recommendations.

Problem Statement

Nigeria is an oil and gas nation and still leading giant in Africa. However, the country has had a chequered history of a heavily polluted and unsustainable petroleum industry with most of its gas either vented or flared rather than being re-injected for economic, healthy and environmental reasons. There were pockets of technologies for the application of CCSU for Enhanced Oil Recovery due to maturity of the wells particularly onshore basins in Nigeria. Therefore, the specific objective of this paper is to examine the legal and regulatory frameworks that would promote the widespread adoption of carbon capture, storage and utilisation in the oil and gas industries in Nigeria while addressing the liability health, safety and environmental implications that may arise from leaked carbon.

Over the past decades it has become clear that carbon dioxide (CO_2) emissions into the Earth’s atmosphere, resulting from the combustion of fossil fuels, are the main causes of global warming. Several approaches to limit the release of CO_2 have been investigated and are gradually being implemented. One approach is the introduction of renewable energy, such as solar or wind power. However, as fossil fuels will still remain the mainstay of energy production over the next few decades, carbon capture and storage (CCS), the capture and sequestration of CO_2 under the sea or in disused gas and oil wells, is viewed by many as an important way to limit man-made climate change. Notwithstanding, the permanence of stored CO_2 in the Earth's crust for many thousand years is problematic, as the whole process is very energy consuming and the risk of deadly accidental leaks is very high. An alternative to sequestration is presently being investigated at the IASS (Institute for Advanced Sustainability Studies).

2.0 Literature Review

Conceptual Clarification

Carbon capture is the technology of capturing/extracting CO2 emitted from electrical and industrial installations, thereby preventing it from escaping into the atmosphere (Bandilla, 2020) and is more economical and technically feasible compared to direct capture of air (DAC). Carbon can be captured and stored, where applicable, in carbon capture and storage (CCS) or used, where applicable, in carbon capture and utilization (CCU). Carbon capture and utilization is not a new technology and its use dates back more than two decades for enhanced oil recovery through injection into geological formations and industrial processes (Bandilla, 2020; Climate, 2005; Demirel, Matzen, Winters, & Gao, 2015). There are several enhanced oil recovery programs in Brazil, Canada and the United States, and approximately 75% of the world's captured carbon is used in the United States for this purpose. Carbon (CO2) capture technology is currently possible via one of the following methods: chemical absorption, physical absorption, physical adsorption, chemisorption, chemical bonding, and phase separation (Gozalpour, Ren, & Tohidi, 2005; High et al. , 2022; Singh & Dhar, 2019), which are carried out via pre-combustion, post-combustion, or oxy-combustion (Bandilla, 2020; Climate, 2005; Finney, Akram, Diego, Yang and Pourkashanian, 2019). Technology provides the economic benefits of reusing infrastructure, creating and maintaining high-value jobs, deferring closure costs, and ensuring a just transition (Climate & Project, 2005).

Pre-combustion capture involves the conversion of greenhouse gas-producing fuel into CO2 and carbon-free fuel (Bandilla, 2020; Climate, 2005).

Post-combustion capture involves capturing CO2 after the combustion of greenhouse gases, producing fuel from the flue gases. The concentration of CO2 determines the energy requirements for its sequestration and correlates with the capture configuration for optimized performance (Keith, 2009).

Low concentration CO2 capture is typically achieved using various methods namely Chemical absorption, physical absorption, physical adsorption, chemical bonding and, at a lesser level, phase separation are used in post-combustion capture. Degradation of solvents by other flue gases adds to the challenge of high cost of the technology due to its high energy requirements for stripping (Liang et al., 2015; Bandilla, 2020; Finney et al., 2019).

The oxycombustion capture technique involves the use of pure oxygen for the combustion of fuel producing greenhouse gases by extracting oxygen from the air, using chemisorption and phase separation methods (Finney et al., 2019; Bandilla, 2020; Climate & Project, 2005).

The advantages and disadvantages of different combustion capture methods are briefly summarized in Table 2.1.

Table 2.1: CO2 Capture methods

Capture methods	Merits	Demerits
Pre-combustion capture	i. The efficiency of capture is higher in comparison to post-combustion capture (Finney et al., 2019; Gazzani, Macchi, & Manzolini, 2013) ii. The technology is mature making the process easy to understand (Jansen, Gazzani, Manzolini, van Dijk, & Carbo, 2015).	i. Requires specialized plant designs (Finney et al., 2019). ii. It is very capital intensive (Bandilla, 2020).
Post-combustion capture	i. The absorbent can be regenerated and this impacts cost. ii. Existing plants can be easily retrofitted to accommodate the technology (Finney et al., 2019).	i. The high energy demands for separation makes it capital intensive to operate (Bandilla, 2020; Climate & Project, 2005). ii. The efficiency of capture is lower in comparison to the other techniques, however an exception is the CaL process (Finney et al., 2019).
Oxy-fuel combustion capture	i. The efficiency of the capture is high due to high concentration of CO_2 in the flue gas. ii. There is a possibility of obtaining a pure stream of CO_2 at conditions favourable for usage/transport (Allam et al., 2013; Boot-Handford et al., 2014; Finney et al., 2019).	i. Requires plant modification especially when chemical looping is employed. ii. The process of separation of Oxygen from air is energy intensive therefore increasing cost (Finney et al., 2019; Jansen et al., 2015).

Source: (Adopted from Towoju & Petinrin, 2023)

Theoretical Framework

Several studies have explored the effect of the oil sector on global growth and development (Akinlo 2012; Brunnschweiler 2009; Rosser 2006). Furthermore, an extensive literature has examined the impact of oil price changes on carbon emissions (Ebaid et al. , 2022; Li et al., 2020, Ullah et al., 2020; Musa 2020; Wei et al, 2022). However, the ecological effects of the oil sector have been largely ignored. The relationship between the oil sector and carbon emissions can be viewed from two perspective. The first view posits that the oil sector leads to increased carbon emissions. The basic argument is that the exploitation of oil through mining, refining and storage leads to increased carbon emissions. Some pollutants identified in the sector include volatile organic compounds (VOCs), methane (CH4), and polycyclic aromatic hydrocarbons (PAHs) (USEPA 2015, Xu and Chen 2016). In addition to pollutant emissions from increased oil production, the sector's huge revenues, when used effectively, can lead to increased revenues and carbon emissions. Previous studies have revealed a positive impact of income on carbon emissions (Ahmed et al., 2017; Hakimi and Hamdi, 2016; Raggad 2018; Saboori et al., 2016). The argument is that increased oil revenues resulting from increased energy consumption and increasing urbanization often lead to increased carbon emissions. Empirically, some studies have revealed the positive effect of urbanization and energy consumption on carbon emissions (Apergis et al., 2010, Chen et al., 2019; Wang et al., 2019; Musa 2020; Bulut 2017; Saboori et al., 2016; Nwani 2017).

The second perspective on the relationship between the oil sector and carbon emissions, however, argues that the oil sector does not necessarily lead to increased carbon emissions. The literature claims that when oil production relies on modern, cleaner technologies, carbon emissions can be reduced. Furthermore, some researchers have argued that oil abundance does not, in most cases, translate into increased income and energy consumption. According to this school of thought, oil abundance tends to harm economic growth (income). The main transmission mechanisms include the Dutch disease theory, the volatility argument, and the income allocation inefficiency argument (Collier and Hoeffler 2004, Rosser 2006). Overall, while there are strong thematic reasons to suspect a broad correspondence between the oil sector and increased carbon emissions, the nature of the relationship is neither simple nor straightforward. In an economy where oil production relies on old technologies, carbon emissions are likely to increase. Similarly, increased oil revenues, which lead to increased urbanization and energy consumption, can lead to increased carbon emissions. However, when a country adopts modern, cleaner technologies for oil extraction, refining and storage, coupled with strict environmental regulations to control carbon emissions, the oil sector will not necessarily increase pollution.

3.0 Innovative Technologies adopted in Transforming carbon emissions into Assets in Nigeria Oil and Gas Sector

Three notable technologies is considered important in transforming carbon emissions into assets in Nigeria Oil and Gas Sector namely Direct Air Capture (DAC), Carbon can be captured and stored as applicable in Carbon Capture and Storage (CCS) or be used as applicable in Carbon Capture and Utilization (CCU).

3.1 Direct Air Capture Technology:

In recent years, direct air capture (DAC) has emerged as a promising negative emissions technology, primarily due to its locational flexibility and ability to absorb CO2 generated from non-localized sources. There are two variants of DAC, namely DAC-1 using liquid solvents and DAC-2 using solid absorbents, in terms of overall emissions generated as a result of the process of removing CO2 from the atmosphere. It was discovered that the majority of overall emissions generated during the DAC life cycle can be attributed to the operational phase. Operational emissions were then categorized into three main stages, namely CO2 capture, CO2 separation and compression. The impact of the choice of energy source on the emissions generated was then analyzed in the cases of DAC-1 and DAC-2, separately for the three classifications. Both variants were found to be reasonably efficient in terms of net CO2 removed from the atmosphere, provided that the energy requirements come from renewable energy resources. Additionally, we analyzed secondary impacts in terms of land use requirements and water loss during the process. In 2020, current CO2 levels in the Earth's atmosphere reached 412 ppm, representing an increase of more than 47% from pre-industrial levels of 280 ppm. The more practical implications of this increase in atmospheric CO2 can be viewed in terms of an increase in Earth's average temperature. This carries serious implications in terms of, but not limited to, sea level rise and changes in weather and ecological patterns. To limit global temperature rise to less than 20°C, atmospheric CO2 levels must be kept below 450 ppm. Given the increase in global greenhouse gas emissions in recent decades and the expected dominance of fossil fuels in the years to come, the path to removing CO2 from the atmosphere is becoming increasingly more relevant. In its review of pathways to reducing consistent emissions to 1.5°C, the IPCC has forecast the use of carbon dioxide removal (CDR) of the order of 100 to 1,000 Gt of CO2 eliminated over the course of the 21st century.

The entire technological process of DAC can be subdivided into four main components, namely CO2 capture, CO2 separation, transportation and sequestration/utilization. CO2 capture represents the process of extracting CO2 from ambient air, either by chemical absorption using liquid solvents or by physical adsorption using solid absorbents. Based on the choice of CO2 capture mechanism used in the process, DAC technology can be classified into DAC-1, which uses liquid solvents, and DAC-2, which uses solid absorbents. This collected CO2 is then separated from the absorbent/adsorbent, to prepare it for the next cycle. Once the CO2 is separated, it is prepared and transported, usually using pipelines, then stored in underground geological formations for sequestration. Alternatively, the captured CO2 can also be prepared for product use such as greenhouse agriculture and beverage carbonation, and transported accordingly to the use facility. Details of the aforementioned subprocesses are provided in advance.

3.2 Carbon Capture and Storage Technology:

Currently, an important carbon dioxide removal technology in use is carbon capture and storage (CCS), where CO2 is collected from large industrial point sources and then transported and stored in underground geological formations. Although the technology has proven effective in terms of CO2 capture, it is limited to large industrial sources in terms of applications. Greenhouse gas emissions from these industrial sources account for approximately 36% of global greenhouse gas emissions, thereby limiting the potential for CCS application.

Carbon capture and storage (CCS) is perceived by many researchers to be the separation of CO2 and its capture from the emitted flue gas mixture, followed by transport and appropriate storage underground, thereby preventing it to enter the atmosphere (Anderson and Newell 2003; Herzog 1997; Ha-Doung and Keith 2003). CCS will be best applied to large stationary emission points such as industrial plants and fossil fuel power plants, where CO2 is emitted in large quantities and can be isolated from flue gases emitted at certain important stages. The process will play an important future role in mitigating climate change if storage can last for hundreds of years. Similarly, captured gas can be injected into partially depleted or less productive oil and gas reservoirs to improve recovery (Williams et al. 2006; Dooley et al. 2006). Carbon dioxide has been injected into more than 11,000 oil wells for tertiary recovery since the late 1970s and the process already accounted for more than 15% of production annual oil production in the Permian Basin of Texas in the United States (Heller & Taber 1986). It was also used for a similar process in the North Sea in the United Kingdom. CCS involved three major stages each involving scientific, technological, significant environmental and economic impacts.

The United Nations Framework Convention on Climate Change (UNFCCC) supports energy innovation that improves sinks, reservoirs and carbon sequestration. This is because the necessary alternative energy sources, such as renewable energy sources, are not yet available, and carbon capture is the necessary alternative to greenhouse gas reduction technology. greenhouse and the promotion of energy efficiency practices. Carbon capture and storage, as a technological innovation under the UNFCCC, has also been strengthened under the Kyoto Protocol through the establishment of a clean development and carbon trading mechanism. broadcasts. Therefore, carbon capture and storage (CCS) has global legal support for further development and legal research for mitigation of greenhouse gases in the air. It has further been claimed that global gas venting and flaring is a significant source of greenhouse gases. However, there are serious legal and regulatory barriers that could hinder the widespread adoption or application of carbon capture. These issues include access to onshore and offshore storage sites, ownership rights to stored carbon and stored sites, transport of carbon by pipeline and third party access rights to pipelines, liability in the event of a leak of carbon, the distribution of risks and the management of its long-term health and safety implications. -long-term stewardship and good management of stored sites, air rights of way, underground permits and measurement, verification and accounting (MVA) of storage sites. These obstacles are predisposing factors for which Mai Bui et al consider CCS as an emerging technological innovation. Apergis et al. (2010) argue that a combination of carbon capture, storage and utilization would achieve the necessary promotion and wide application of the technology, arguing that the deployment of carbon capture, storage and utilization (CCSU) in the industrial food pharmaceutical sector and for enhanced oil recovery (EOR) have been largely beneficial for the dual objectives.

3.3 Carbon Capture and Utilization Technology:

Carbon capture and utilization (CCU) technology manages to capture carbon dioxide produced by the combustion of fossil fuels or as a byproduct of industrial manufacturing processes behind products such as cement and steel. Compressed carbon dioxide are transported through Pipelines or ships for storage in deep underground rock formations such as saline aquifers or depleted oil and gas reservoirs (Ahmed, Rehman, Ozturk, 2017).

Carbon dioxide are prevented from entering the atmosphere and contributing to climate change through the CCU process. The same forces that hold oil and gas in the Earth's crust for millions of years can trap the captured carbon permanently, or other industries can use it in the production of synthetic hydrocarbons, alcohol or durable plastics and adhesives.

The benefits of implementing UCC are also cyclical in nature. For the oil industry, injecting captured carbon into oil reservoirs puts remaining oil under pressure and can help increase production. Captured carbon can absorb carbon dioxide from the atmosphere at a faster rate than any other natural biomass and also help stimulate the strategic growth of large-scale algae. Renewable resources can also power the electrical process used to remove carbon dioxide at its source.

It would be difficult to overstate the value that carbon capture and utilization (CCU) technology offers to the African oil and gas industry. As oil and gas producing countries face enormous pressure to transition to green energy sources and leave their oil assets underground, CCUS can act as a lifeline for their energy industries. This technology offers African states a way to continue to attract international oil companies (IOCs) and prosper from their vast hydrocarbon wealth while simultaneously meeting global emissions reduction targets and setting an example in responsible extraction and use of fossil fuels. CCU is a suite of technologies with a range of applications. CO2 can be captured from electrical and industrial installations (which use fossil fuels or bioenergy), or directly from the air. CO2 is transported for use (including enhanced oil recovery (EOR), chemical or fuel production) or for storage in deep geological formations. These technologies have been used since the 1970s, and in recent years commercial applications have expanded to include biofuel production, electricity generation, and low-carbon hydrogen production. The IEA's Net Zero by 2050 report from May shows that a major push is needed by 2030 if the world is to reach net zero emissions by 2050. This effort must be made across all technologies, including CCUS. By 2030, CCUS primarily supports reducing emissions from existing power and industrial assets (through retrofits) as well as increasing low-carbon hydrogen production. After 2030, deployment will shift towards heavy industry applications and carbon removal in the form of bioenergy with CCS (BECCS) and direct air capture (DAC) with CO2 storage.

4.0 The challenges of transforming carbon emissions into assets in Nigeria Oil and Gas Sector

In Nigeria, the economic, environmental and political situations are the consequent generators of the following potential challenges.

4.1 Technology

Although many countries are particularly interested in transitioning to low-carbon energy sources (especially biofuels), most projections show that current fossil fuels, environmentally undesirable and non-renewable, will continue to play an important role in the medium term (Watson et al. 2007). For example, by 2015 and 2030 respectively, coal demand alone would increase to 4,215 and 5,647 million tonnes for developing countries (IEA 2006). To ensure effective capture of the CO2 that will be emitted during the combustion of these fuels, efficient technology is necessary. For "clean coal technology" to be successful alone, a range of modern technologies that are currently not available in developing countries like Nigeria are certainly required. These technologies will cover coal preparation (washing and briquetting), combustion for example by fluidized bed boilers and gasification, and the purification of unwanted gases by processes such as denitrification of flue gases and desulfurization before the ultimate carbon capture and storage (Watson et al. 2007).

4.2 Leakage

Many studies show that natural underground geological formations can provide adequate storage of carbon dioxide for a very long time (Ha-Doung & Keith 2003). However, the interaction of acid gas with the formation and its stored resources can have serious environmental consequences. Given the nature of storage options in Nigeria, there would be a high possibility of leakage due to low storage capacity formations, unsuitable geological traps and/or low density seals which could allow the gas to escape. Increased environmental concentration of CO2 can lead to acidification of groundwater and soils, killing various plant and animal species and, therefore, impairing soil fertility. In a country where local populations depend on agriculture for their food, this can reduce possible agricultural yields, causing more destruction than benefit.

4.3 Capture and Storage Costs

The costs of capturing, transporting and storing CO2 depend on the country, technology and fuel types (Kallbekken & Torvanger 2004). For example, the cost of capturing coal-fired power plants will be higher than that of gas-fired power plants due to the greater concentration of gas. Likewise, the cost of transportation varies depending on the applicable options. Ships and pipelines are the most potential transportation options in Nigeria. Various cost estimates have been reported by different authors. Analysis by Anderson and Newell (2003) estimated total transport and storage costs between $7 and $19 per 1000 kg CO2, while Hendriks et al. (2000) reported between $13 and $44 per 1000 kg of gas. Both authors assumed a transportation distance of 1,000 km, indicating that for longer distances transportation costs and corrosion risk will increase (especially for offshore pipelines). In Nigeria, costs are likely to be higher due to weather-ocean conditions, requiring advanced pipeline technology and potentially longer transportation distance. This can seriously affect its implementation unless oil and gas companies use the gas under enhanced oil recovery (EOR) or are constrained by the government. The consequence will be an increase in costs for oil and gas consumers and, if added to the current poverty situation, the masses will be seriously disadvantaged.

4.4 Decision and Regulatory Strategies

To successfully implement CCS in Nigeria, major emitters (oil and gas companies) and other companies authorized by the government to engage in electricity distribution and associated services, as well as other stakeholders in the industry, must develop the right approach that integrates important solutions and previous lessons from international sectors like the American Natural Gas Corporation (Mandil 2005). This should include the development of a government regulatory framework that ensures unconditional commitment and national support. Given our current environmental policies which do not address this issue, its implementation will be blocked along the way if the government does not introduce a new regulatory framework that encourages its development or does not amend current regulations to ensure that the responsibilities for capture and storage are assigned to real transmitters.

4.5 Implementation Time

Implementing a CCS system capable of capturing the desired quantities of greenhouse gases will require sufficient time and planning. Each oil and/or gas formation and power generation facility (medium or large) requires unique method innovations to promote effective CO2 isolation and capture (Amey 2008). Transporting gas by pipelines or ships requires that the appropriate technology and equipment are in place and a certain number of capture facilities are fully implemented based on actual capture costs and the agreement of cost sharing finalized between companies and relevant authorities designated by the government. Apart from the lack of efficient technologies suitable for CCS in Nigeria and potential cost inconsistencies, poor planning and implementation policies, complete insecurity in the oil industry and serious corruption issues can delay the project for a long time. longer period. Rapid compliance by oil and gas companies, which are the largest emitters, is another indicator of the speed and success of implementation. However, if these issues are properly addressed, the CCS project could be executed in the short term, producing positive results, but this is very difficult.

5.0 Conclusions and Recommendations

This study examined innovative approaches to carbon capture and utilization in Nigeria's oil and gas sector by transforming emissions into assets. Findings identified direct air capture technology, carbon capture and storage technology and carbon capture and utilization technology as current innovative technologies adopted in transforming carbon emissions into assets in Nigeria Oil and Gas Sector, showed the relationship between Gas utilization and carbon emissions efficiency in Nigeria Oil and Gas Sector and final findings identified five challenges of transforming carbon emissions into assets in Nigeria Oil and Gas Sector namely technology, leakages, capture and storage costs, decision & regulatory strategies and implementation time. This research paper recommends on the following actions to be taken in order to foster carbon capture and utilization technology in Nigeria and are as follows;

- There is need to scale up carbon dioxide removal technology, governments worldwide need to continue to build the market for carbon. Enacting a carbon fee policy will encourage the industry to grow and mature as it provides not only a valuable commodity, but also a service to companies and individuals seeking to comply with either government policies.

- Implement the adoption of carbon capture, storage and utilization technology as evidence-based for mitigation of greenhouse gas in Nigeria which will enable Nigeria to access green fund and CDM under the Kyoto Protocol.
- Introducing a comprehensive gas policy along with a review of the fiscal regime for gas projects and forming a committee to advise the Government on focusing on regulatory changes with the ultimate aim of privatization across the entire spectrum of the economy.
- To enhance Nigeria's oil and gas sector's environmental sustainability, it is recommended to implement post-combustion carbon capture in existing refineries as it easily allows for retrofitting, making it a feasible and efficient upgrade to reduce carbon emissions. For new refineries, incorporating pre-combustion capture and oxy-fuel combustion capture is advised. These methods necessitate specialized designs and modifications but offer higher efficiency in reducing emissions from the outset. Adopting these technologies will position Nigeria as a leader in environmentally responsible oil and gas production, aligning with global sustainability goals.

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