Synthesis of Environmental Sustainability Framework for Modular Refinery in the Nigeria Oil and Gas Sector

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Abstract

This paper discusses the synthesis of environmental sustainability framework for Modular Refinery (MR) in the Nigeria Oil and Gas Sector. Energy, and most importantly oil and gas plays an important role in the economic development. The downstream sector demonstrates a lack of adequate petroleum refining regulation in some countries such as Nigeria, which has resulted in environmental pollution and Green House Gas (GHG) emissions that have continued to impair environmental sustainability in the country. The wastes generated from petroleum refineries are in the form of gases, particles and liquid effluent, which becomes hazardous to the environment and to human health. The development of MR is one of the best, if not the only, option for making global south nations self-sufficient in domestic demand and net exporters of petroleum products. Literature in public domain have narrated various issues in respect of the theme of this paper as noted below. The oil and gas industry is essential to the global economy and the activities of the oil and gas companies have a huge effect on the world and the environment. Oil refineries in Nigeria are responsible for 4% of global CO2 emission and 24% in GHG emissions resulting in health and environmental issues. National Oil Spill Detection and Response Agency (NOSDRA) detects and responds to oil spill according to Government Regulations. Regulatory standing in Nigeria stipulates that environmental impact assessments (EIA) is a prerequisite before, during and after oil and gas refinery projects In order to cut GHG emissions that achieve global temperature rise of 1.5 -2^{0}C, Global North are reducing reliance on oil. Global South (GS) countries including Nigeria plan to increase MR installation in order to increase both domestic availability of oil and the oil sector contribution to Gross Domestic Product (GDP). MR are viable option in inaccessible location or rural areas, especially where oil supply is inadequate to meet daily consumption demand. The methodology for this study uses interpretivism as an innovative research philosophy, allowing for the development of a sustainable environmental framework. The key considerations for developing an environmental sustainability framework for modular refinery in GS can be encapsulated under the indices of stringency, compliance and transparency. One limitation of the indices would be over-reliance of GS on oil revenue. This paper argues the need for urgent diversification in the GS. Summarily, all the three indices needs detailing when adopting the proposed framework in the oil and gas sector of the GS. Future work will include the collection of primary data from key stakeholders in the oil and gas sector to ascertain the effectiveness of the proposed framework for MR. Further study to include financial evaluations for MR framework in terms of its economic feasibility will also be desirable.

1. Introduction

The development of modular refineries is one of the best, if not the only, options for making global south nations self-sufficient in domestic demand and net exporters of petroleum products. However, the history of the downstream sector demonstrates a lack of adequate petroleum refining regulation in some countries such as Nigeria, which has resulted in environmental pollution and GHG emissions that have continued to impair environmental sustainability in the country. In order to combat climate change and its dangers, the world is embracing more sustainable practices such as the circular economy. Sectors such as oil and gas are evolving toward more sustainable practices. At this time, any unregulated environmental hazards can stall the impact of any intended development that is not sustainable in the end. Frameworks are required to propel a sector toward its goal. The current environmental challenges in Nigeria's downstream sector are most likely related to how ineffective the current environmental framework has been in capturing the needed changes to create and maintain sustainability. As the federal republic of Nigeria plans to build more modular refineries, it is necessary to assess the challenges with the current refinery framework and seek out ways to incorporate sustainability into the framework under which these novel refineries will operate. The oil and gas industry is responsible for significant economic prosperity in many countries, including Nigeria [1] providing customers with the energy they require to maintain their standard of living. Oil-producing global south countries rely heavily on oil exports for foreign exchange [2]. Refineries are the instruments used to convert crude oil to desired petroleum products such as Diesel fuels, automobile fuels, asphalt and petroleum jelly. Modular refineries are gaining preference to conventional refineries in global south

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countries due to ease of installation, lower project costs and investments, including cheaper operational costs in terms of labour and running costs. However, the process of converting crude oil into petroleum and petrochemical products produces wastes. These wastes get into the environment in the form of gases, particles and liquid effluent, which becomes hazardous to the environment and to human health. Approximately 4% of all Carbon Dioxide (CO_2) emissions worldwide in 2018 resulted from oil refineries [3]. The IPCC (2011) further stated that the worldwide refining sector increased its capacity by 13% from 2000 to 2018, leading to a total GHG increase of 24%. To cut GHG emissions and achieve global temperature rise of 1.5 -2 C, developed countries are reducing reliance on oil. However, more than 150 new modular refineries planned to be operational throughout Global South countries, that is, Asia, the Middle East, and Africa by 2025 to boost their energy demands. It is only imperative that the global government, national governments, and researchers look for ways to instill frameworks for environmental sustainability from the start of these projects in order to avoid further environmental harm in the future.

2. Literature Review

The oil and gas industry is vital to the global economy, influencing everything from transportation to heating and electricity, to industrial production and manufacturing [4]. The oil and gas industry is responsible for significant economic prosperity in many countries, including Nigeria [1] providing customers with the energy they require to maintain their standard of living. A number of oil exporters, especially in global south countries, rely heavily on oil exports for foreign exchange [5]. Despite increased awareness of climate change and the adoption of renewable energy technologies, oil and gas continue to be the primary sources of global energy. Oil and gas accounted for 34% and 24% of global primary energy consumption, respectively, in 2018 [6]. Furthermore, the primary energy consumption of oil and gas increased by 13% and 28%, respectively, between 2008 and 2018. Although renewables (wind, geothermal, solar, biomass, and waste) account for only 4% of total energy consumption in 2018, their share has grown 4.5 times since 2008.

2.1. Evaluation of Modular Refineries

A modular refinery is one where the components are constructed as modular units that can be swiftly and easily shipped anywhere in the world [7]. They are available globally and in a wide range of sizes and with daily capacity ranging from 500 to 30,000 barrels. In comparison, its modular structure gives it a low investment capital and relatively good margins, thus making modular refinery enticing to upstream and downstream operators, making it a viable option in inaccessible location or rural areas, especially where diesel supply is inadequate to meet daily consumption demand [8]. Table 1. shows the simplistic difference between a modular and conventional refinery, Figure 1 shows the Atmospheric distillation Unit of the Modular refinery. In oil refineries, a variety of chemical and physical separation processes are utilised to split crude oil into more refined products.

Table 1. Basic Comparison between Modular Refinery and Conventional Refinery

	Modular Refinery	Conventional Refinery
Refining Capacity/product ranges	Between 1000-30,000 bpd / Gasoline, Naphtha and lights	30,000 bpd and above / all ranges of products.
Manufacturing	Mounted on skids and transported to site	Fabrication on site.
Environmental Impact	Installation is with minimal impact to the environment	From developmental phase, environmental concerns are raised by regulators
Crude Types	Heavy Crude	All Crude Types
Flexibility	Easy to add more modules	Rigid except by turn around Maintenance

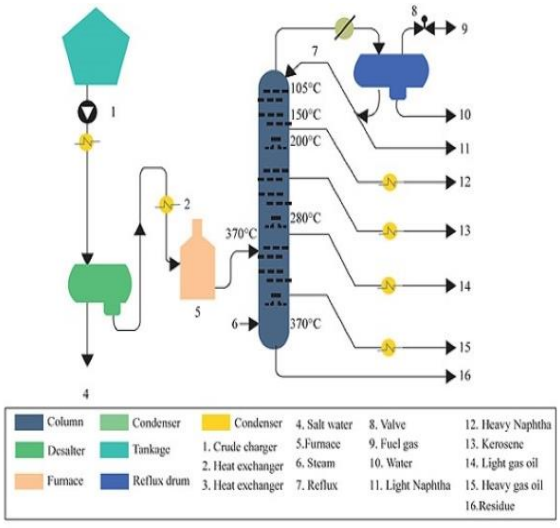

Figure 1. Atmospheric Distillation Unit [9]

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2.2. Health, Safety and Environmental implications of Oil and Gas Refineries

Oil and gas operations involve upstream activities, including all processes before the raw material is refined: exploration, drilling, extraction, storage, shipping, etc., and downstream activities, which involve refining, selling and distributing the product. Due to the nature of these operations, which include substantial risks, organisation's and Government bodies consistently strive to lessen the magnitude of their negative effects on the environment and people [10]. High-profile incidents like the Santa Barbara oil leak in 1969 in California and the Deep-Water Horizon disaster in the Gulf of Mexico in 2010 serve as proof of the industry's difficult past [11]. Additional companies in the industry were at the centre of significant environmental and human rights crises in other parts of the world. Early in the 1990s, the Shell Company's operations in Nigeria's Niger Delta led to river pollution and tensions with the local Ogoni population. Indigenous people living in Ecuador at the time sued Chevron for polluting the Amazon rainforest and harming their health in 2003 [11]. As a result, the sector has moved closer to sustainability during the previous few years. The effects of the pollution from petrochemical and petroleum refinery waste are of great concern because these industries are the most desirable for national growth and improved quality of life [12]. There are many distinct types of waste produced during the conversion of crude oil into petroleum and petrochemical products. These wastes end up being detrimental to both the environment and human health when they are released into the environment as fumes, particles, and liquid effluent. In a petroleum refinery, air emissions can arise from a variety of places, such as equipment leaks (from valves, flanges, pump seals, drains, and compressor seals), high-temperature combustion processes during fuel burning, heating of steam and process fluids, and product transfer. Through regular emissions, fugitive releases, unintentional releases, or plant upsets from various refining operations such separation, conversion, and treatment processes, several contaminants are released into the environment [13]. As a result of equipment malfunction, pipeline deterioration, and other factors, almost 900 accidents involving oil refining and exploration were reported in Nigeria in 2000 [14]. According to earlier research, criteria pollutants can harm plants and humans by causing DNA deterioration in bone marrow cells, respiratory illnesses, and decreased lung function in people [15], and the production of acid rain, which degrades water quality and affects aquatic habitat. It was discovered that 2.5 million deaths per year in rural and urban areas of global south nations are caused by indoor exposure to particulate matter, accounting for 4-5% of the 50–60 million deaths that take place worldwide each year [16]. The activities of oil and gas companies have a significant impact on the world and the environment [17]. Refineries are liable to a set of environmental rules pertaining to air, land, and water because they are essentially regarded as major sources of pollution in the locations where they are situated. Refineries pose significant risks to the air, water, and land environment. In Nigeria, for instance, oil and gas refineries (both conventional and illegal) have been highly responsible for pollution (air, land and water), production of yield cuts with bad specifications, fires and explosion scenarios, community disputes and death of plants and animals [9]. According to the Intergovernmental Panel on Climate Change (IPCC) report [18] there is a need to drastically cut emissions from economic activity while enhancing access to and ensuring energy affordability. The report states that significant reduction of Green House Gas (GHG) emissions is essential for achieving a sustainable global temperature rise of 1.5–2°C. Approximately 4% of all Carbon Dioxide (CO_2) emissions worldwide in 2018 resulted from oil refineries [3]. It further stated that due to its function as a supplier of transportation fuels and chemicals, the worldwide refining sector increased its capacity by 13% from 2000 to 2018, leading to a total GHG increase of 24% [18]. A study on the environmental impact assessment on Nigeria refineries by [14] explained that results from the emission inventory showed that refinery is one of the major sources of air pollution in Nigeria. The environmental and health impacts of these pollutants indicate that adequate control has to be put in place, as more refineries are established, to ensure reduction in the emissions.

2.3. Existing Environmental Frameworks for Modular Refineries

A variety of frameworks regarding environmental sustainability in the oil and gas sector as it pertains to refinery and modular refineries were reviewed during this research. Researchers have used different indicators to develop an environmentally sustainable framework for the energy sector. This paper adopted the Organisation for economic cooperation and development (OECD) indicators of regulatory management systems framework [19] shown in figure 2.2. The components were then adapted to fit into the oil and gas industry. The rationale for using these indicators was their suitability for this study, owing to the fact that they were applied by the developed countries that were used as comparisons in this study. A similar study carried out by the Institute for Oil, Gas, Energy, Environment and Sustainable Development (OGEES Institute), Afe Babalola University, Ado Ekiti, Nigeria applied the same

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indicators to their work when reviewing the Environmental guidelines and standards for the petroleum industry in Nigeria (EGASPIN).

Figure 2. OECD Indicators of Regulatory Management Systems Framework [19]

The three components that serve as indicators for measuring a good and sustainable environmental framework used in this study are Stringency, Compliance, and Transparency [19] and are compiled in Table 2. The Stringency component assessed the elaborative, comprehensiveness of the outlined environmental guidelines. The transparency component assessed the ease of obtaining information on an application while the Compliance component assessed the detailed regulatory standards put in place by the regulator for enforcements of guidelines. The study considered the life cycle stages of a project in the oil and gas industry namely: approval phase, construction phase and closure phase. The countries that were selected to serve as comparative roles in this study are Canada and Norway. The rationale for choosing these countries is based on availability of their robust oil refinery regulatory framework online, and the clearly defined process and methodology followed by these countries in the development of their frameworks.

As a strategy to cut emissions from the petroleum refining industry in Canada, the National Framework for Petroleum Refinery Emission Reductions (NFPRER) was established in 2001. A multi-stakeholder Steering Committee chaired by Environment Canada and Alberta Environment Agency oversaw the creation of the NFPRER. Under the Canada regulatory framework, environmental impact assessments (EIA) must be conducted before, during and after oil and gas projects. The framework also clearly outlines the requirements for approvals for such projects, as well as the discharge limits in the operational stage of the project life cycle. At the closing stage of the life cycle, the framework requires operators to provide plans for decommissioning projects [20].

Table 2. The Three Components used as Indices for our study.

Stringency	Is there a detailed, precise, and legally enforceable legislative framework for pollution from the oil and gas industry? Does project approval mandate an environmental impact assessment (EIA)?
Compliance	Does the regulatory body have the authority to enact and enforce environmental laws? Do non-compliance penalties exist (and if so, what do they entail: fines, confinement, or imprisonment)?
Transparency	How promptly can the general public access data and information?? Is it required to consult with stakeholders? Can stakeholders get involved in project applications?

A well-defined guideline for remediation and methods for reclamation are available. Thereafter, a government certification is then issued to the operator. The framework goes ahead to prescribe a government reclamation program in the event that an operator defaults. It details environmental monitoring guidelines for air, surface and groundwater and sets clear threshold for monitoring team. Another important factor of the guideline is it sets low target values as well as values that calls for interventions, and lists about sixteen toxic poly-aromatic hydrocarbons, as well as other pollutants to be controlled, such as heavy metals that harm the environment. At the approval stage of an Oil and Gas project, the Alberta Energy requires an environmental management plan. After approval, there are measures in place (inspections, audits, monitoring and reporting) to ensure compliance at the operations stage of the project, as well as the decommissioning phase. Environmental monitoring goes on after decommissioning until the satisfactory level has been achieved. Under the framework, the Alberta Energy Ministry issues licenses, while regulation of the three stages of a project's lifecycle is under the jurisdiction

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of the independent Alberta Energy Regulator (AER), which is funded by the oil and gas industry through administrative fees levied on operators in the industry. A number of agencies are involved in the Nigerian environmental regulatory framework. The Department of Petroleum Resources (DPR) is the agency in charge of oil refineries regulations. The Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) , published by the Department of Petroleum Resources (DPR), Ministry of Petroleum Resources, in 1991 and revised in 2002, 2016, and 2018, serves as the regulatory policy in Nigeria's oil and gas industry. To prevent, reduce, and manage pollution from the many components of petroleum activities in Nigeria, EGASPIN sets the environmental and safety requirements that all oil companies, including refinery operators, must adhere to. Other agencies that are also involved include the National Oil Spill Detection and Response Agency (NOSDRA) whose functions include detection and response to oil spill (section 6 (1) of the NOSDRA act. The National Environmental Standards and Emergency Agency (NESREA) which is the governmental body in charge of protection, development and enforcement of environmental standards in line with global bodies and standards (NESREA Act, 2007). The Niger Delta Development Commission (NDDC) that is responsible for tackling ecological and environmental issues that arise from activities associated with oil exploration, including environmental pollutions from oil spillages and gas flaring. Under the EGASPIN policy, environmental impact assessments (EIA) must be conducted before, during and after oil and gas refinery projects. The policy also clearly outlines the requirements for approvals of such projects, as well as the discharge limits in the operational stage of the project life cycle. The target values and intervention values do not however meet up with international standards set by WHO. For instance, at the operational stage of the refinery projects, only ten (10) PAHs as well as other pollutants to be controlled, such as heavy metals that harm the environment, are documented for groundwater value standards evaluation. There are no clear prescribed environmental monitoring procedures; neither are the set threshold at par with global standards, though remediation methods for reclamation are required from operators during the approval stages of the project's lifecycle. At the closing stage of the life cycle, the framework does not set clear requirements for operators to provide plans for remedial and decommissioning projects; neither is there a defined government remedial certification issued to operators. The existing Nigerian framework requires an environmental management plan at the approval stage of an Oil and Gas refinery project to be provided by operators. After approval however, there are no set measures in place to ensure compliance at the operations stage of the project, as well as the decommissioning phase. Though there are audits, inspections, monitoring and reporting carried out, there are a number of agencies involved so no single regulator is responsible. Other agencies such as NOSDRA and NESREA still have similar obligatory regulations. These other agencies cannot enforce regulations. Under the framework, licenses are issued by the Department of Petroleum Resources (DPR), which also oversees regulation of the three stages of a project's lifecycle. In Nigeria, though there are existing laws allowing freedom of information, the environmental framework does not provide the public with details of project approval to communicate a consideration for public and environmental best interests. Regulatory approvals are not readily available to the public, neither are there stakeholders' engagements during the stages of oil and gas refinery projects. Affected parties, concerned people and other categories are not provided a platform or given an audience under the framework. However, the framework makes provision for reporting incidents, monitoring and incident reports are not made available to the audience at any stage of a project's lifecycle, neither in the event of an incident. The DPR is not subject to audit, and there is no transparency in the sector. The Nigeria environmental framework is lacking on Transparency and compliance indices as shown above, there is a need to review the framework to address challenged areas and thus meet up with global standards.

2.4. Existing Environmental Framework for Modular Refineries in Nigeria

A number of agencies are involved in the Nigerian environmental regulatory framework. The Department of Petroleum Resources (DPR) is the agency in charge of oil refineries regulations. The Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN), published by the Department of Petroleum Resources (DPR), Ministry of Petroleum Resources, in 1991 and revised in 2002, 2016, and 2018, serves as the regulatory policy in Nigeria's oil and gas industry. To prevent, reduce, and manage pollution from the many components of petroleum activities in Nigeria, EGASPIN sets the environmental and safety requirements that all oil companies, including refinery operators, must adhere to. The National Environmental Standards and Emergency Agency (NESREA), a governmental organisation responsible for the protection, development, and enforcement of environmental standards in accordance with international bodies and standards (NESREA Act, 2007), and the Niger Delta Development Agency are additional organisation that are also involved. The

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National Oil Spill Detection and Response Agency (NOSDRA), whose duties include detection and response to an oil spill, is also involved.

3. Methodological Approach

Our methodology is based on interpretivism as a research philosophy, enabling the development of a sustainable environmental framework for modular refineries in the global south. Combining an inductive approach with interpretivism enabled the development of a novel understanding strategy. In order to gather specific and in-depth knowledge regarding the application of developing an environmental framework for a modular refinery in the global south in practical scenarios, a case study approach using the case of the Federal Republic of Nigeria was adopted in the research strategy. Additionally, the study examined the varied viewpoints on modular refinery in the global south using qualitative approaches. A cross-sectional study was conducted in a short period. Documentary analysis used to collect data from secondary sources across a wide range of resources within the oil and gas sector and environmental agencies in Nigeria. Thematic analysis was used for data analysis to elicit meaning from the data.

4. Discussion and Results

Oil was discovered in Nigeria in 1956 at Oloibiri in the Niger Delta by Shell-BP. When Nigeria's first oil field began producing 5,100 bpd in 1958, it became a producer of oil. Other foreign businesses were granted exploration rights in onshore and offshore regions bordering the Niger Delta after 1960. Nigeria founded the Nigerian National Petroleum Company (NNPC) in 1977 and became a member of the Organisation of Petroleum Exporting Countries (OPEC) in 1971. By the late 1960s and early 1970s, Nigeria had surpassed 2 million barrels of crude oil production per day despite production levels declining in the 1980s because of the economic downturn, oil production completely recovered in 2004 and reached a record high of 2.5 million barrels per day. Plans to expand production to 4 million barrels per day have been in place since 2004, but the nation's output has been declining ever since.

With an estimated population of over 200 million and a land area of 923,768 sq. km. Nigeria is the most populous nation in African continent. Nigeria, which has the eighth-highest population among the top ten countries in the world, makes up 47% of the population in West Africa. As can be seen in Figure 3 below. Nigeria's ongoing population growth has increased demand for local oil and gas. Due to the present conventional refineries' inability to generate enough of the required products for domestic use, the country now imports more than 80% of its refined goods to satisfy its current demands. Consequently, the development and improvement of modular refineries in the nation would probably boost the domestic supply of oil and gas.

Industry experts posits that the development of scalable or modular refineries as well as the efficient renovation of existing ones can significantly increase the productivity and performance of Nigeria's refining sector.

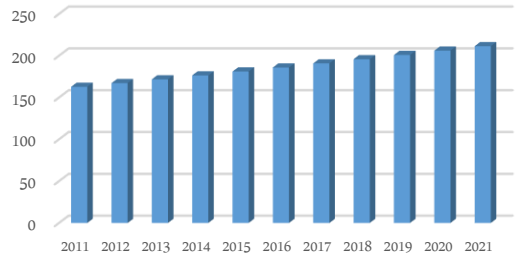

Figure 3. Nigeria's Yearly Population 2011-2021

The upstream sector is responsible for the production of crude oil and natural gas. This sector of Nigeria's oil and gas industry is currently more active than the downstream. This is because the downstream industry currently lacks critical elements such as best practices optimization, dependability, sustainability, and private investor participation. As a result, there is a significant discrepancy between the productivity of the upstream and downstream sectors. However, Crude oil's contribution to foreign exchange low and declining as Nigeria's upstream sector remains unstable (as shown in Figure 4).

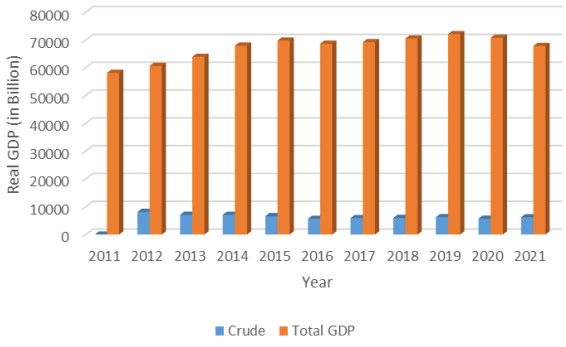

Figure 4. Statistics showing the contribution of oil and natural gas sector to Nigeria's Real GDP from 2011 to 2021 [21]

Since the focus of oil and gas industry in Nigeria has primarily been on upstream sectors, its little impact on the economy and GDP has also decreased. Thus, the need to revitalize the oil and gas industry is essential. One way to achieving this revitalization, is

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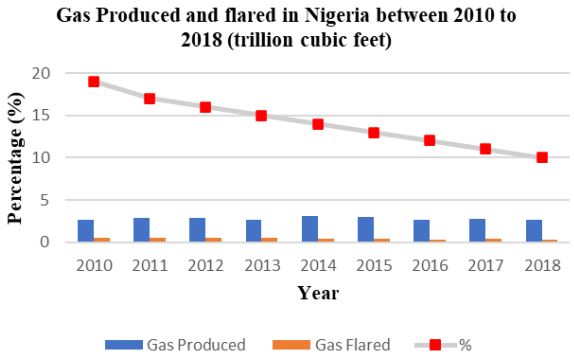
to focus on the downstream sector of the oil and gas industry, and modular refineries can be a key component of this resuscitation. Oil for the past three decades has provided 90 percent of the foreign exchange earnings of Nigeria, financing 80 percent of total government revenue. Importance of oil in Nigerian Economic Development after Nigeria's independence in 1960, oil production for export had risen dramatically as British and American oil corporations recognized increased investment opportunities. When the Mineral Act of 1914, vesting all land and minerals in the Nigerian State, was changed into the Petroleum Act of 1969, the government consolidated its new commitment to the growth of the oil industry. With limited capital and technical resources, however, the state was unable to transform the Nigerian economy into a major petroleum exporter overnight. Increased flows of investment from multinational firms made this transition possible. Through a series of contracts and new laws, Nigeria remodeled its domestic market to become more attractive to foreign investors. In 2019, the oil and gas sector accounted for about 5.8 percent of Nigeria's real GDP and was responsible for 95 percent of Nigeria's foreign exchange earnings and 80 percent of its budget revenues. The petroleum sector in Nigeria must be transformed, from being just a source of rents for the Federal Government to an important contributor to GDP growth. Petroleum production and export play a dominant role in Nigeria's economy and account for about 90% of her gross earnings. This dominant role has pushed agriculture, the traditional mainstay of the economy, from the early fifties and sixties to the background. However, reliance on crude oil production oil alone cannot sufficiently support the Nation's economy especially as production profit is in decline. The downstream sector, with the creation of optimally functioning modular refineries is a means to economic revival.

4.1. Health, Safety and Environmental Management of Oil and Gas Operations

Gas flaring has been a substantial contributor to environmental pollution, energy waste, and loss of money in Nigeria. Globally speaking, gas flaring in the oil and gas industry is a serious environmental issue and a waste of a vital energy source. Around 400 million tonnes of CO_2 or 1.5% of global CO_2 emissions is contributed annually by gas flaring to GHG emissions. About 35 million tonnes of CO_2 and 12 million tonnes of CH4 are released into the atmosphere annually by gas flaring activities in Nigeria; CH4 is believed to have a stronger warming potential than CO_2. The average world temperature has reportedly risen by 0.5 degrees Celsius as a result of these gases over the past 100 years. The creation of the gas, its composition, and the flare efficiency all affect the amount of greenhouse gases (GHG) released during flaring and venting. One of the key issues is the unknown efficiency, which depends on a number of variables such as the gas flow rate, flare stream composition, and wind speed.

The amount of gas burned as CO_2 is determined by efficiency; the remaining gas is vented as methane, a higher greenhouse intensity. In addition, more than 100 flare sites in the Niger Delta continuously release a hazardous mixture of chemicals into the atmosphere. There are significant ambiguities regarding the consequences of flaring on the environment because estimates of efficiency range from 20% to 99%, and 75% was generated and flared in Nigeria, as shown in Figure 5 below:



(Department for Petroleum Resources Annual Oil and Gas Reports)

Figure 5. Graph showing the amount and percentage of Gas flaring (CO2 and GHG) in Nigeria

Due to a lack of enforcement of gas-flaring legislation, Nigeria has not been able to stop gas flaring. The first law to address the broader potential issue of oil extraction and the associated environmental risks was the Petroleum Act of 1969. Aiming to address such environmental risks, this act pushed oil corporations to submit oil-development plans. The Nigerian government introduced the Associated Gas Re-Injection Act No. 99 in 1979, marking its first attempt to deal with the problem of gas flaring. Oil corporations, however, disregarded the rules outlined in the deadline of 1984, stating it was too expensive to re-inject gas. As a result, about 55% of oil fields were excused from taking part in gas re-injection, while oil fields that flare gas were subject to a minimal fine. According to a study conducted by the Nigerian Department of Petroleum Resources in 2007, 117 flare sites were present in the Niger Delta. As oil firms concluded that it would be cheaper to pay the small fines than to re-inject gas, gas-flare practices continued to rise sharply. As a result, only 12% of the gas is reinjected, while around 75% is flared. Although lawmakers passed legislation to stop gas flaring, there is still a problem with gas flaring since

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the law needs to be enforced properly because of the light penalties for violators and the exemptions given to oil corporations that flare gas.

4.2. Challenges and Framework of establishing Modular Refineries in Nigeria

One issue that has impeded the growth and effectiveness of modular refineries in Nigeria is a lack of funding. Only seven of the twenty-five licensees of private refineries passed a technical and financial capacity examination conducted by the Ministry of Countries where refinery sustainability in refining has been improved on with CO_2 emission reduced to an acceptable or barest minimum like Canada and Norway have three major factors that have been linked together and put in motion. These include stringent legislation, monitoring and enforcing compliance, and transparency of regulatory activities to the public. The combination of these three independent components works towards the achievement of a vital aim – sustainability.

4.2.1. Stringent Legislation: Studies by other researchers have shown that gas flaring is arguably the biggest problem that the Nigerian oil and gas industry faces due to its associated impacts. However, it is unfortunate that Nigeria needs effective legislation as well as stringent sanctions that are needed to fight this menace. Although Nigeria has different forms and levels of institutional structures used for the course of oil and gas management such as The Department of Petroleum Resources (DPR), it is yet to be understood clearly how these structures strictly tackle CO_2 emission. Therefore, the government through legislation will have to consider some factors like core reasons that lead to continuous emission of CO_2 and CH4 gases. This legislation provides specific and clear directives/guidelines on maximum volume amount of gas that each organisation in the oil and gas sector is expected to flare (where necessary) as well as stating means of utilisation. These directives will essentially ensure that flaring up to a certain volume of gas becomes an illegal act, thereby declaring the perpetrators as offenders. The legislation also makes provision for fines and penalties for offenders of these directives. In Nigeria currently, the penalties for this offence are meagre when compared with the volume of flared gas, thereby giving the operators the grounds to continue flaring. However, the legislation should carry heavier and stricter fines and penalties to make this work. Providing some incentives such as tax holidays (for a few years) as well as tax reductions to the companies in the oil and gas sector will serve as a good indirect financial support and encouragement towards investing on gas flare reduction. In other words, money meant for tax could be channelled towards investment in technologies that reduces gas flaring. As a recommendation, there should be an Act that restricts waste of petroleum resources (gas inclusive) and directs on the best ways to harness them. This currently operates in Norway. This Act is responsible for the specification on the best means for gas production and of gas utilization. Norway is a known for good management and utilization of gas, therefore the adoption of this Act in Nigeria will encourage gas flare reduction. Furthermore, provision of an Act that regulates exploration licensing, production licensing, and cessation of petroleum activities as well as compensation to the community in the event of pollution such as gas flaring should be promulgated. This exists in Norway as Petroleum Activities Act 1996, and it is responsible for the regulation of all petroleum activities. This could guarantee huge compensation for communities affected by gas flaring and cause the operators to be careful and channel more attention on flare reduction, particularly if the penalty is huge. Fines for defaulting operators should be so exorbitant to deter them. This could be the responsibility of DPR in Nigeria because they are responsible for creating all policies related to the oil and gas industry. Availability of a policy that mandates oil and gas operators to install and operate gas-gathering and transportation facilities such as pipelines. This policy is operational in Qatar and promotes bringing gas ashore. However, a part of the capital cost would be compensated based on separate agreement by both parties. A good example for compensation could be through tax reduction or tax holidays.

4.2.2. Monitoring Compliance: An effective monitoring team is required to effectively enforce the laws that will be enacted by the legislation of the country. Without consistent monitoring, these legislations for gas flare management may not succeed in the oil and gas sector. Currently, the oil and gas downstream sector needs to be better monitored owing to the fact that more than one agency is performing similar roles with none playing a major unique role to the downstream. Although Nigeria currently has some institutional frameworks for the management of refining pollution, but due to a lack of a clear-cut monitoring team, these frameworks are yet to be successfully adopted and implemented. Therefore, to make the legislation successful, there is a need to create a monitory agency unique to the downstream and modular refineries. This team can be from a pool of all the agencies and stakeholders in the industry.

4.2.3. Enforcement Transparency: The duty of the enforcement team is to be unbiased in compelling the oil and gas companies to comply with the directives of the legislation. The team will be entrusted with

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consistent checks as well as non-discriminatory execution of this duty, which will require the licensing body in the oil and gas industry to be separated from the regulatory agency, so that each agency would be acting in accordance to their respective requirements. This framework will improve monitoring efficiency.

4.3. The Sustainable Modular Refinery Framework

After analysing the importance of Modular refineries and the current challenges facing the downstream sector as a whole, as well as the economic significance of establishing modular refineries, this study subsequently developed and proposed an Environmental Framework for Modular Refinery in the Global South as shown in Figure 4.3.

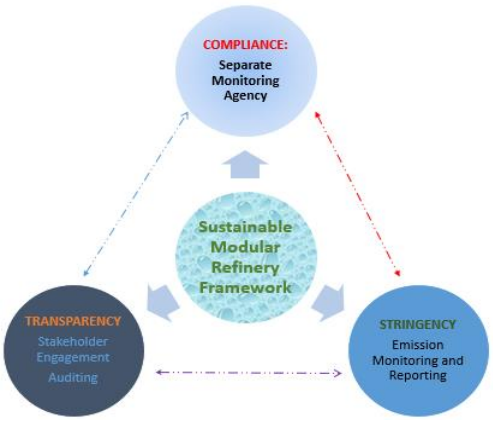

Figure 6. The Sustainable Modular Refinery Framework

The Canadian National Framework guides this framework for Petroleum Refinery Emission Reductions. As explained in the literature review, the framework focuses on flexible approaches that set limits on emission performance that lead to positive environmental and health outcomes, rather than only prescribing specific legislations. It takes into account wherever possible the monitoring and reporting requirements of existing and/or potential initiatives, such as emissions trading schemes, National Pollutant Release Inventory, etc. Furthermore, it provides a consistent level of environmental performance and health protection associated with petroleum refineries across Canada. When these practical steps included in the Canadian framework is combined with the current DPR's General Requirements and Guidance Information for the Establishment of Modular Refineries in Nigeria.

5. Conclusion

The regulatory and environmental monitoring bodies in Nigeria, as shown by EGASPIN are not following current global best practices for transparency and compliance in the oil industry. Though there is a policy demonstration by the regulators to comply with international standards in terms of policy, the existing framework is not compliance-and transparency-tight. In order to bring EGASPIN's established environmental standards into compliance with global best practices, urgent revision is required. It is also past time to change the supervisory policies so that the DPR is not involved in the environmental enforcement processes and that the functions are handled by an independent agency, such as NESREA. Finally, the regulatory bodies should be subject to auditing by external international bodies, which Nigeria is, signatory to, to ensure transparency in the system. Future work will include the collection of primary data from key stakeholders in the oil and gas sector to ascertain the effectiveness of the proposed framework for MR. Further study to include financial evaluations for MR framework in terms of its economic feasibility will also be desirable.

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