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Cost Analysis of Decommissioning Process of Offshore Structure: A Comparative Study for Removal Options

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Abstract

A good number of offshore oil and gas installations in Nigeria are going towards the end of their production life, which means that the decommissioning activity will be increasing in years to come. Decommissioning of the offshore installation is a costly and challenging task. A proper cost analysis is needed to identify the effective techniques, safety challenges and issues associated with decommissioning activities. This study introduces an approach to assessing the financial and non-financial criteria of each decommissioning option by which the assessment of the feasibility of environmental, health and safety, and public outcomes will be used to strike a balance towards the best removal option with the lowest financial and environmental impacts combined. The costs for effective decommissioning of offshore structure were calculated using complete removal option, partial removal option, and leave-in-place option. From the results Leave-in-place removal option gave a cost of ***$18,560,200****, Complete removal option* ***$106,364,400****, Partial removal option* ***$64,610,800.*** *Striking the balance of costs with other liability will yield further costs for leave in place option which means that the Toppling in Place Partial Removal Option, displayed the best results in this study.*

1. Introduction

Decommissioning of oil and gas platforms offshore Nigeria is an unavoidable issue that will face the oil and gas industry in Nigeria at some point in the near future as the platforms reaches the end of their useful production lifetimes. A number of different decommissioning methods exist and each will result in an array of environmental and socioeconomic impacts, some positive and some negative. These impacts, their cost and benefits, will be perceived and valued differently in this project with different perspectives. For example, some will see the need to decommission platforms that have reached the end of their useful production lifetime as an opportunity to fulfill operators original lease obligations and remove these large structures from the oceans, thereby restoring the seabed to its original, natural state. Decommissioning can also be viewed as an opportunity to derive a greater return on the investment represented by the platforms by converting them to other potentially valuable uses with economic and/or scientific benefits. Yet another perspective is that decommissioning provides a chance to preserve a large part of the biological communities that inhabit offshore platforms, thus conserving an ecological resource that contributes to biological production locally and regionally.

However, Design lifespan of these offshore platforms is usually 25 to 30 years, at the end of these economic periods, these platform needs to be removed and decommissioned in line with international conventions which requires all abandoned platforms be removed in a way that will not cause harm to the environment. This represent the end of the production life cycle of oil and gas installations [1] (Kaisera & Byrd 2007)

Thus, the core objective of this study is to create an analysis and decision framework of techniques that will assist decision makers and other interested parties in understanding the implications of different decommissioning options and making a choice among them. Each of these techniques could potentially be achieved by implementing any of a range of possible decommissioning options. The challenge for decision makers is therefore to evaluate available information to determine whether and how these various techniques could be achieved and the mix of cost and benefits associated with each. Making such judgments is not an easy process because decommissioning is a complex and costly engineering undertaking that involves an extremely wide range of legal, environmental, socioeconomic, and policy issues.

While the option presented by partial removal and rig to reef is in many respects a cost satisfactory way of decommissioning offshore structures, the complete removal makes it a tedious procedure and therefore requires more cost.

Complete or total removal means that everything on and above the seabed must be extracted. This can be done through removal methods like the single lift in which the structure is removed in one piece. Multi-lift means the structure that the structure will be removed bit by bit. Alternatively, the structure could be re-floated, this is the most likely solution for the complete removal of concrete installations.

This option requires to a sufficient depth below the mud line to eliminate any interference with other users of the site, including fishermen, shrimpers, ships, and naval operations. The area around the platform must be cleared of debris and verified clean by trawling. The obvious advantages of complete removal are that the site is returned to a natural condition, there is not interference with shrimping or navigation, and there is no maintenance or liability problem. The disadvantages include cost, possible harm to marine life during removal, and the elimination of reef habitat if the platform is scrapped on shore. (Tubman, M.W & Suhayda N.J, 1976)

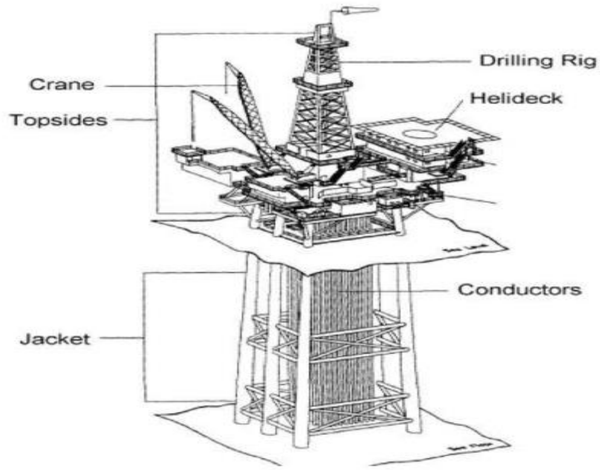

Figure 1: Platform Schematics

The Partial removal of platforms (in a manner that does not create hazards to navigate) provides less extensive habitat but reduces residual liability and maintenance cost for operators. Substantial savings, compared with complete removal, could be realized if this option were permitted in Nigeria, particularly for larger platforms located in deeper water. Shrimpers are the primary opponents of partial removals in waters shallower than 300 feet, because partially removed platforms could create obstructions that decrease trawlable waters. (Haitham K.M & Mokhtar, 2014)

Partial removal involves removing the top section of a platform to between 50 and 150 feet below the water surface. The exact depth depends on state and federal requirements. The Nigerian Navy and NIMASA were contacted by the navigation of commercial and naval ships and federal responsibilities under international agreements. Any modification of current regulations requiring removal to 15 feet below the seafloor must take into account the safety of navigation and the operational needs of the Nigerian Navy, particularly submarine passage. . (MMS 2001; Sapura A & Iwaki P 2010).

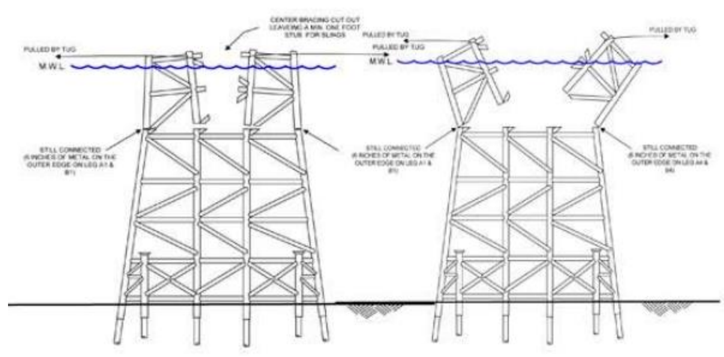

Figure 2: Partial removal step 1 to 2

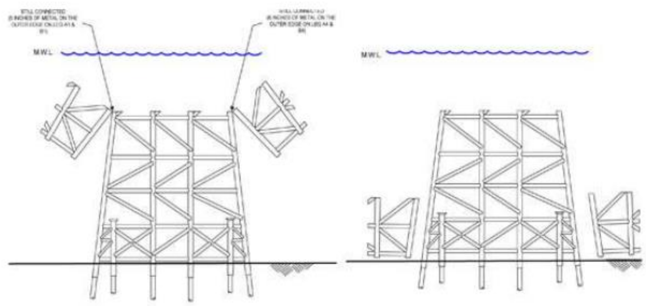

Figure 3: Partial removal step 3 to 4

Commercial and recreational fishermen, environmentalist, and others concerned with maintaining or expanding the habitat that platforms provide (and avoiding the damage they perceive from explosive platform removals) would prefer that platform be left in place as artificial reefs, thus expanding the marine ecosystem by hard bottom habitat. This scenario, however, raises significant problems. Federal law requires that non-operating platforms be removed. But even if the law were changed, problems would still exist. Who would maintain the structure? Who would be liable for accidents, collisions, and other potential hazards? How would conflicts with other users of the ocean- such as shrimpers and commercial fishermen be resolved?

Given all these problems, the leave-in-place option is probably not feasible now, except in a very few cases, such as when a structure has become a popular spot for recreational fishermen. Some way of handling the liability problem, such as an industry financed fund, would have to be established to make leave-in-place a viable option. This research work will deal in a comparative way, the effective techniques in decommissioning of offshore structures as a function of cost, safety, technical feasibility, taking as a base case the option proposed by complete removal and partial removal.

Figure 4: Leave in Place Option

2.0 Materials and Methods

2.1 Research Design

This section presents the methodology adopted for quantifying the effective decommissioning of an offshore platform rig in Field XX located in the Niger Delta. The study compared complete removal options with existing approximate removal options to identify the most suitable approach.

The study follows a comparative analysis approach, considering complete removal, partial removal, and leave-in-place options. Each removal option is described below, along with the techniques involved:

1. Complete Removal: This option involves the comprehensive dismantling and removal of the offshore platform rig, including all infrastructure, equipment, and subsea components. Techniques employed in this option may include cutting the structure into sections, utilizing heavy lift vessels, and employing specialized tools and machinery for disassembly and removal.
2. Partial Removal: The partial removal option focuses on selectively removing specific components or sections of the offshore platform rig. This approach is chosen when certain elements can be safely and economically removed while leaving others in place. Techniques utilized for partial removal may include cutting and lifting designated sections, using remotely operated vehicles (ROVs) for underwater disassembly, and employing lifting equipment for removal.
3. Leave-in-Place: The leave-in-place option involves leaving the offshore platform rig intact without significant removal activities. Decommissioning and securing the structure in a manner that minimizes potential risks to the environment and human safety are essential considerations. Techniques utilized for leave-in-place options may include well plugging and abandonment, sealing and securing infrastructure, and implementing monitoring systems for long-term structural integrity.

A comparative analysis will be performed for these removal options based on predefined acceptability conditions, as outlined in Table 3.1. The conditions will serve as criteria to evaluate the effectiveness of each removal option in the context of the offshore platform rig in Field XX. Data collection will involve gathering information on the rig's current state, structural components, and associated environmental factors. Numerical simulations and modeling techniques will be employed to assess the performance and implications of each removal option.
The research will utilize a combination of qualitative and quantitative data analysis methods. Qualitative analysis will involve evaluating factors such as environmental impact, safety considerations, and regulatory compliance. Quantitative analysis will involve utilizing relevant metrics and indicators to assess the effectiveness of each removal option in meeting the predefined acceptability conditions.
The study will culminate in a comparative analysis that determines the most effective decommissioning option for the offshore platform rig in Field XX, based on the outcomes of the complete removal, partial removal, and leave-in-place options. The findings will provide valuable insights and recommendations for the decommissioning process, contributing to improved decision-making and sustainable practices in the offshore industry.

Table 1: Acceptable conditions (OSPAR 98/3 Regulations with respect to offshore facility removal (Saiful W.A, 2011)

Installation(excluding topsides	Weight (tonnes)	Complete Removal to land	Partial Removal to land	Leave in Place	Re-use	Disposal at Sea
Fixed Steels	<10,000	Yes	No	No	Yes(3)	No
Fixed Steels	<10,000	Yes	Yes(1)(2)	No	Yes(3)	No
Concrete gravity	Any	Yes	Yes(2)	No	Yes	Yes

Floating	Any	Yes	No	No	Yes	No
Subsea	Any	Yes	No	No	Yes	No

2.2 Data Analysis

The data used in this work was obtained from secondary data. In analyzing the data used for the application for the various options, complete removal and partial removal was plotted against cost to illustrate the decommissioning as a function of cost for the offshore structure in Figure 4.5. Since this plot occurs at different costs, they are entirely independent of each other. Thus, the leave-in-place scenario would entail fairly minimal decommissioning cost as a result of reduced technical work, even though the cost would be related to planning for plugging and abandoning wells, removing conductors, removing or abandoning pipelines and power cables and clearing topside or equipment (Culwell 1998). In the case of a partial removal this cost would be somewhat less than the complete removal scenario depending upon the nature and extent of removal (Culwell 1998).

2.3 Design and Implementation of Decommissioning Cost

Each costs analysis are explained below;

Let, Engineering and Planning Cost = C_1
Permitting and Regulatory Compliance Cost = C_2
Platform Preparation Cost = C_3
Plugging and Abandonment Cost = C_4
Conductor Severing and Recovery Cost = C_5
Mobilization/Demobilization Cost = C_6
Platform and Structural Removal Cost = C_7
Pipeline and Power Cable Decommissioning = C_8
Materials Disposal Cost = C_9
Site Clearance and verification Cost = C_{10}
Shell Mounds Cost = C_{11}
Navigation Aids Cost = C_{12}
Total Decommissioning Cost (Tc)
$= C_1 + C_2 + C_3 + C_4 + C_5 + C_6 + C_7 + C_8 + C_9 + C_{10} + C_{11} + C_{12}$

$$\mathbf{T_c(s)} = \sum_{i=1}^{12} C_i(s)$$

Complete Removal Cost Analysis

$C_1 = \$1000 / \text{ton} \times \text{Total Weight(tons)} \times 2\%$

Let, T_{ecc} = Environmental Consultant Costs
T_{mmpc} = Marine Mammal Protection Costs
T_{cfc} = Compensating Fishermen Cost

$C_1 = T_{ecc} + T_{mmpc} + T_{cfc}$

$C_3 = 12\% \text{ of Total Weight (tons) @ } \$1000 / \text{ton}$

$C_4 = \$63{,}300 / \text{well} \times (\text{No of wells to plug})$

$C_4 = 51 \times \$59{,}400$

$C_5 = \$310{,}000 / \text{day} + \$65{,}000 / \text{day} + 10\% \text{ contigency} \times 118 \text{ days}$

$C_6 = 70{,}000 \text{ tons of steel} \times \$325 / \text{ton} + \$700{,}000 \text{ (other materials)}$

$Tc = C_1 + C_2 + C_3 + C_4 + C_5 + C_6 + C_7 + C_8 + C_9 + C_{10} + C_{11} + C_{12}$

$$\mathbf{T_c(s)} = \sum_{i=1}^{12} C_i(s)$$

Partial Removal Cost Analysis

$C_1 = \$1000/\text{ton} \times \text{Total Weight (tons)} \times 2\%$

$C_2 = \$63{,}300\ /\ \text{well} \times \text{No of wells to plug}$

$C_5 = \text{No of conductors} \times \$59{,}400\ /\text{conductors} = \$3{,}029{,}400$

$C_{7i} = (\$150{,}000/\text{day} + \$32{,}500/\text{day} + 10\%\ \text{contingency}) \times 43\ \text{days}$

$C_{7j} = (\$310{,}000/\text{day} + \$65000/\text{day} + 10\%\ \text{contingency}) \times 36\ \text{days}$

$C_7 = C_{7i} + C_{7j}$

$C_{9i} = \frac{1}{7} \times \$23{,}450{,}000 + \$700{,}000(\text{other materials}) = \$4{,}050{,}000$

$C_{9j} = 6000\ \text{tons of steel} \times \$325/\text{ton} + \$4{,}050{,}000(\text{deck and other})$

$Tc = C_1 + C_2 + C_3 + C_4 + C_5 + C_6 + C_7 + C_8 + C_9 + C_{10} + C_{11} + C_{12}$

$$\mathbf{T_c(s)} = \sum_{i=1}^{12} C_i(s)$$

Leave-in-Place Removal Cost Analysis

$C_4 = \$63{,}300 \times (26) = \$1{,}645{,}800$

$Tc = C_1 + C_2 + C_3 + C_4 + C_5 + C_6 + C_7 + C_8 + C_9 + C_{10} + C_{11} + C_{12}$

$$\mathbf{T_c(s)} = \sum_{i=1}^{12} C_i(s)$$

3.0 Results and Discussion

3.1 Data Presentation

Case Study- Rig XX

Total Weight	69920 tons
Depth ft.	1198 ft.
Wells to Plug	26
Conductors	51
Jacket Weight (tons)	42900
Deck Weight (tons)	9839

Table 2: Cost Associated with Leave-In-Place Decommissioning Options

Leave-in-Place Removal Option	
Basic Parameters *C4 = $63,300 x (26) = $1,645,800* $C_1 + C_2 + C_3 + C_4 + C_5 + C_6 + C_7 + C_8 + C_9 + C_{10} + C_{11} + C_{12} = Tc$	
COSTS	**LEAVE-IN-PLACE**
	($)
Engineering and Planning	**699,200**
Permitting and Regulatory Compliance	

Platform Preparation	**600,000**
Plugging and Abandonment	**12,121,200**
Conductor Severing and Recovery	**3,029,400**
Mobilization/Demobilization	**500,000**
Platform and Structural Removal	
Pipeline and Power Cable Decommissioning	**550,000**
Materials Disposal	
Site Clearance and verification	**1,060,400**
Shell Mounds	
Navigation Aids	
TOTAL COSTS	**18,560,200**

Table 3: Cost Associated with Complete Removal Decommissioning Options

Complete Removal Option

Basic Parameters

C1 = $1000/ton x 69920 tons x 2% = $1,398,400 **(Eq. 3.1)**

C2 = $200,000 + $50,000 + $130,000 = $380,000. **(Eq. 3.2)**

C3 = 12% of 69,920 tons @ $1000/ton = $8,390,400 **(Eq. 3.3)**

C4 = $63,300 x (26) = $1,645,800 **(Eq. 3.4)**

C5 = 51 x $59,400 = $3,029,400 **(Eq. 3.5)**

C7=$310,000/day + $ 65,000/day + 10% contingency) x 118 days = $48,675,000 **(Eq. 3.6)**

C9=70,000 tons of steel x $325/ton + $700,000(other materials)=$23,450,000 **(Eq. 3.7)**.

C1+C2+C3+C4+C5+C6+C7+C8+C9+C10+C11+C12 = **Tc** **(Eq. 3.7a)**

COSTS	**COMPLETE**
	($)
Engineering and Planning	**1,398,400**
Permitting and Regulatory Compliance	**380,000**
Platform Preparation	**1,200,000**
Plugging and Abandonment	**12,121,200**
Conductor Severing and Recovery	**3,029,400**
Mobilization/Demobilization	**12,000,000**
Platform and Structural Removal	**48,675,000**
Pipeline and Power Cable Decommissioning	**550,000**
Materials Disposal	**23,450,000**
Site Clearance and verification	**1,060,400**
Shell Mounds	**2,500,000**
Navigation Aids	
TOTAL COSTS	**106,364,400**

Table 4: Cost Associated with Partial Removal Decommissioning Options

Partial Removal Option

Basic Parameters

C1= $1000/ton x 69920 tons x 2% = $1,398,400

C4=$63,300 x 26= $1,645,800

C5 = 51 x $59,400 = $3,029,400

C7i=($150,000/day+$32,500/day+10%contingency)x43days=$8,632,000

C7j=($310,000/day+$65,000/day+10%contingency)x36days=$14,850,000

C7=C7i+C7j

C9i=1/7 x $23,450,000 + $700,000 (other materials) = $4,050,000

C9j=6000 tons of steel x $325/ton + $4,050,000 (deck and other) = $6,000,000

C1+C2+C3+C4+C5+C6+C7+C8+C9+C10+C11+C12 = **Tc**

COSTS	PARTIAL
	($)
Engineering and Planning	**1,398,400**
Permitting and Regulatory Compliance	**760,000**
Platform Preparation	**1,200,000**
Plugging and Abandonment	**12,121,200**
Conductor Severing and Recovery	**3,049,400**
Mobilization/Demobilization	**12,000,000**
Platform and Structural Removal	**23,482,000**
Pipeline and Power Cable Decommissioning	**550,000**
Materials Disposal	**10,050,000**
Site Clearance and verification	
Shell Mounds	
Navigation Aids	
TOTAL COSTS	**64,610,800**

Table 5: Total Cost Associated with Decommissioning Options

COSTS	LEAVE-IN-PLACE	COMPLETE	PARTIAL
	($)	**($)**	**($)**
Engineering and Planning	**699,200**	**1,398,400**	**1,398,400**
Permitting and Regulatory Compliance		**380,000**	**760,000**
Platform Preparation	**600,000**	**1,200,000**	**1,200,000**
Plugging and Abandonment	**12,121,200**	**12,121,200**	**12,121,200**
Conductor Severing and Recovery	**3,029,400**	**3,029,400**	**3,049,400**

Mobilization/Demobilization	**500,000**	**12,000,000**	**12,000,000**
Platform and Structural Removal		**48,675,000**	**23,482,000**
Pipeline and Power Cable Decommissioning	**550,000**	**550,000**	**550,000**
Materials Disposal		**23,450,000**	**10,050,000**
Site Clearance and verification	**1,060,400**	**1,060,400**	
Shell Mounds		**2,500,000**	
Navigation Aids			
TOTAL COSTS	**18,560,200**	**106,364,400**	**64,610,800**

Table 6: Striking Balance of Cost Between other Criteria for effective decommissioning.

Criteria	**Sub-criteria**	**Removal Methods**							
		SSCV		**SLV**		**HLV**		**BTA**	
		Full	Partial	Full	Partial	Full	Partial	Full	Partial
Safety	Personnel Offshore	**0.3**	**0.7**	**0.4**	**1**	**0**	**0.8**	**0**	**0.5**
	Personnel Onshore	**0.3**	**1**	**0.3**	**1**	**0**	**1**	**0**	**1**
	Fishermen	**1**	**0.3**	**1**	**0.3**	**0**	**0.3**	**1**	**0.3**
Environment	Operations	**0.7**	**0.7**	**0.7**	**0.8**	**0**	**0.6**	**1**	**0.6**
	End Point	**0.7**	**0.9**	**1**	**0.9**	**0**	**0.9**	**1**	**0.9**
	Energy	**1**	**1**	**1**	**1**	**0**	**0.9**	**1**	**0.8**
	Emissions	**1**	**1**	**1**	**1**	**0**	**0.9**	**1**	**0.7**
Technical Feasibility	Technical Feasibility	**0.4**	**0.8**	**0.3**	**0.6**	**0**	**0.8**	**0**	**0.3**
	Recovery	**0.7**	**0.8**	**0.3**	**0.4**	**0**	**0.7**	**0**	**0.2**
	Proven Technology	**0.5**	**0.9**	**0.3**	**0.5**	**0**	**0.8**	**0**	**0.6**
Societal	Fisheries	**0.9**	**0.6**	**0.9**	**0.6**	**0**	**0.6**	**1**	**0.6**
	Amenities	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**0.8**
	Communities	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**
Cost	Capex	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**0.5**
0	Low	Worst performance/outcomes							
↓	Medium								
1	High	Best performance/outcomes							

In the analysis options spreadsheets were developed to solve the total decommissioning cost of the platform rig using the required decommissioning costs (Table 4-1). The results are shown in Tables 4-2 to 4-7. The striking balance between other criteria for effective decommissioning to the base criteria cost is given in Table 4-8. The effectiveness in the decommissioning of offshore platform of each removal option is determined by comparatively evaluating the overall worst performance and best performance of the removal methods from Table 4-8.

4.0 Conclusion

In concluding this research work, it is once again necessary to highlight the aim. The major objectives of this study is to determine which of the existing removal options gives the best approximates for decommissioning of offshore structures. In this study, the effective decommissioning of Rig XX in the Niger Delta was calculated using complete removal option, partial removal option, and leave-in-place option. From the results of the decommissioning costs analysis done, Leave-in-place removal option gave a cost of $**18,560,200**, Complete removal option **$106,364,400**, Partial removal option **$64,610,800.** From the results stated, It is obvious that the Leave-in-place option gave a minimum cost to Partial removal option and Complete removal. Striking the balance of costs with other liability will yield further costs from environmental and safety damages, platform security and community fishing compensations for leaving platform in place.

Hence, the Partial Removal options displayed the best results in this study. It is important to point out that the conclusion and results reported in the present work are applicable to platforms standing in varied water depths in Niger delta years to come.

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