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Extending the Lifespan of Offshore Platforms: Vital Strategies for Durability

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Abstract

This article explores the preventive measures for enhancing the durability and sustainability of aging offshore platforms, focusing on their evaluation, life extension, and potential repurposing. It begins by discussing diagnostic systems that assess structural integrity and safety, highlighting the importance of degradation models and neural networks in predicting corrosion effects on platform longevity. The paper then contrasts outdated Malaysian jacket platforms with emerging renewable energy solutions, particularly Ocean Thermal Energy Conversion (OTEC), emphasizing the environmental benefits of reusing these structures. It delves into life estimation methodologies, including pushover analysis, to assess existing platforms' capacities for continued operation. The complexities of decommissioning are examined, presenting sustainable practices that align with circular economy principles. Additionally, the article reviews the ecological impacts of offshore platforms, demonstrating their role as artificial reefs that enhance marine biodiversity. The concept of the Real Life project is introduced, showcasing innovative models for transitioning oil and gas platforms into renewable energy facilities. As offshore structures reach the end of their operational lives, this study underscores the necessity for strategic planning in decommissioning and reuse, contributing valuable insights into sustainable energy transitions in the context of climate change and economic viability. Overall, the research highlights the potential for aging offshore platforms to support renewable energy initiatives while minimizing environmental and economic impacts.

Keywords: Offshore platform, durability, decommissioning, ocean thermal energy conversion (otec), renewable energy, marine biodiversity

INTRODUCTION

Offshore platforms have long been pivotal in the extraction of oil and gas, significantly contributing to global energy needs. However, as many of these structures approach or exceed their designed operational lifespans, there is an increasing urgency to reassess their viability and potential for reuse. This article delves into the preventive measures aimed at enhancing the durability and sustainability of aging offshore platforms. It examines diagnostic approaches to evaluate structural integrity, explores the opportunities for repurposing these platforms for renewable energy generation, and addresses the ecological impacts of their decommissioning. By investigating the potential for converting outdated infrastructure into sustainable energy sources, this research contributes to the ongoing discourse on energy transitions in the context of climate change and resource management.

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Durability of off-shore Platform: Evaluation

The task of developing diagnostic systems and methods is always present. It is possible to increase the integrity, reliability, and safety of structure maintenance (exploitation) as well as achieve resource efficiency by effectively valuing the condition of structures, identifying the most important factors, making prognoses, etc. The evaluation of durability should be based on degradation models that can be constructed using observations, modeling, and expert knowledge. The corrosion effects were taken into account when developing the sheet piling moorage degradation models. For long-term forecasting, a stochastic model of corrosion was developed.

The neural networks that have been developed to describe the relationships between the primary specifications of the investigated structures (the fishing harbor moorings of Nakhodka port) are based on the information that is currently available. Variability of corrosion velocities that affect wall strength over the course of life have been identified. Models built using neural networks for simulating sheet piling walls have been tested, and they performed well [1].

Competence Between Old and New Version

Malaysian jacket platforms are no longer relevant in terms of design. Other options must be taken into consideration because these outdated platforms have outlived their intended purpose. Numerous offshore oil and gas extraction installations are nearing the end of their useful lives, which opens up a variety of options, including decommissioning and the introduction of new energy sources like wind farms. Investigating the environmental effects of using an aging fixed offshore platform as a source for Ocean Thermal Energy Conversion (OTEC) is the goal of this paper. It is discussed how using an old fixed offshore platform as an OTEC source will affect the environment. OTEC generates energy by using cold-water intake piping to take advantage of temperature differences between the warmer ocean surface water and the colder deep water, which requires a seawater depth of 700 meters. The results of this study demonstrate that OTEC is intended to protect marine life, develop into a fresh and dependable energy source, aid in the production of clean water, and lessen the adverse effects of climate change. OTEC platforms using aging platforms could result in 44% of fish being caught in the ocean, the removal of 13 GW of ocean surface heat for every GW of electricity produced annually, and the production of 1.3105 tons of hydrogen annually for every GW of electricity. In addition, OTEC platforms can provide 2 million liters of water per day for a 1 MW platform and can remove about 5106 tonnes of carbon dioxide from the atmosphere for every GW of electricity produced annually. Malaysia has numerous potentials to profit from the OTEC process because its seawater profile permits the installation of a fixed offshore platform as an OTEC power plant.

The early 1900s saw the start of Malaysia's oil and gas industry, which has since developed over 115 years. The majority of jacket platforms in Malaysia are no longer in production. 191 offshore platforms outlived their design life in 65% of cases in 2014. These platforms have experienced corrosion and fatigue crack failure, which eventually caused them to fail. In Malaysia, more than 300 shallow water-fixed oil and gas platforms have been in use for more than 20 years, with 48% of them having outlived their 25-year design life. These outdated platforms are no longer within their intended life span, so several options need to be reviewed since they have outlived their design life. As a result, as many offshore oil and gas production facilities approach the end of their operational lives, a number of options, such as decommissioning, are becoming a global concern. This study's goal is to look into the environmental effects of using an outdated fixed offshore platform as a source for ocean thermal energy. As these platforms near the end of their useful lives, it is important to comprehend the environmental effects of their decommissioning and potential future uses for them. The effects of using an existing, aging fixed offshore platform as a source of renewable energy are covered in this study. Either the platform should be taken down or left standing. Decommissioning can be done in a variety of ways depending on the needs and conditions. Decommissioning the structure is the first option, and there are two different techniques that can be used: partial removal and complete removal [2]. Furthermore, the difficulty and expense of the decommissioning process may be impacted by the platforms' remote location, varied depths, and weather patterns. The platforms could also be left in place and used as an alternative for power generation using wind, wave, current, and solar potential, an aquaculture facility, instrumentation facilities used for diving, tourism, or LNG terminals. The operators must therefore decide which options are best for their platform.

Life Estimation to Revalidate

Presenting the technical background on structural condition assessment of older fixed-type offshore platforms. Also covered are related works that are not directly related. In the field of requalification for life extension of offshore jacket platforms, numerous studies have been conducted. The pushover analysis, a static nonlinear collapse analysis technique to assess the structure's nonlinear behavior and capacity beyond the elastic limit, is used in many of these studies to reevaluate already-existing platforms. From here, it is possible to determine the truss structure's overall failure mechanism and inherent reserve strength or capacity. The industry-adopted codes and standards, to describe this reassessment methodology. This could be useful for decommissioning or maintaining older fixed offshore jacket structures' structural behavior.

The first offshore oil and gas platform was created in 1947 off the coast of Louisiana in the Gulf of Mexico (GOM), in a depth of about 5 meters. Since that time, offshore platforms have been utilized frequently in the oil and gas sector. Following that, the offshore oil and gas sector experienced rapid growth, accounting for 14% of global production in 30 years. It increased to approximately 33% of the world's production by the year 2010. Over 10,000 offshore platforms have been planned and put into operation to date. The development in the energy-hungry post-World War II countries, the massive industrialization processes in the 1970s, the liberalization, and the phenomenal growth in the economy all contributed to the oil and gas industry's exponential growth. These elements played a role in the offshore oil and gas industry's quick and steady growth as well as the use of offshore platforms. An offshore platform is a structure that must remain secure in all weather conditions and has no fixed access to land. Offshore platforms can be either floating or fixed to the ocean floor. The majority of the earliest offshore oil and gas rigs were fixed-type platforms, also known as "Jackets," that were situated in shallow to intermediate waters at a maximum depth of 500 meters [3]. They support decks and/or useful platform facilities and are piled high. Except for minimal production platforms, which have a 10-year design life, the design life of a typical jacket platform is between 20 and 30 years.

Accuracy of Prototype

A study assessed the planning, design, fabrication, load-out, transportation, installation, and commissioning phases of the project life cycle for the construction of a fixed petroleum platform. The project life cycle must be meticulously planned for a successful execution, just like several offshore structures that are situated in open waters and subject to strong forces. Therefore, it is essential to research and compile all pertinent data on platform construction in order to create a client, consultant, and contractor Work Breakdown Structure (WBS) template in a project planning software. Ultimately, the findings of this study serve as a guide that can be modified according to the soil characteristics, environmental conditions, and operational parameters to suit the planning and management for the construction of a fixed petroleum platform. A sizable building called an oil platform is used to house the personnel and equipment required to drill for and then produce oil and natural gas in the ocean. There are various petroleum platform types, and each type is chosen based on factors such as water depth, intended service, and the amount of deck equipment required to carry out that service. The following issues were looked into in order to create a WBS for the construction of a fixed jacket petroleum platform: It considers operational factors, such as the platform's purpose, location, and orientation, as well as environmental factors, such as winds, tides, currents, ice, shallow gases, earthquakes, and marine growth [4]. It examines the dead loads, or weights, of the platform structure, as well as any fixed equipment and ancillary structures that are not affected by the mode of operation, (i) live loads, or loads placed on the platform while it is in use but which may change either during the mode of use or from one mode of operation to another, and (ii) environmental loads, or loads placed on the platform by natural phenomena such as wind, current, wave, earthquake, snow, ice, and earth movements.

Mode to Avail Decommission

Due to its effects on the environment, society, and economy, the decommissioning of offshore platforms poses a significant and contentious challenge that has drawn attention over time. This research aims to explore sustainability aspects of decommissioning and stakeholders' perceptions of the future of offshore platforms. Two rounds of empirical investigation were used to inform the analysis, which also included a variety of primary data gathered through in-depth interviews and multiple-choice questionnaires. According to the analysis, stakeholders see reuse as a chance to reduce the effects from an environmental, economic, and social standpoint. Although the multipurpose platform offers potential for the future, it also has drawbacks. The study uses only qualitative analysis methods, a small sample size, and a narrow geographic scope. The analysis contributes to the decommissioning discussion by outlining decommissioning programs, stakeholder impacts, and considerations for future planning. It offers several insights into the decommissioning scenario from a sustainable and circularity perspective. The study advances knowledge in the field and offers practical managerial insights by highlighting stakeholders' perceptions in the Italian context, exploring sustainability dimensions, and identifying the key Sustainable Development Goals (SDGs) associated with the problem.

The decommissioning of offshore platforms, a multidisciplinary issue, has received more regional, national, and international attention in recent years. This attention has increased awareness of environmental issues on a global scale. Decommissioning's environmental effects have drawn the industry's attention more and more recently, as has raising public awareness of it. Decommissioning is an essential component of the world energy system and, as such, promotes social and economic advancement. Over 53 countries have constructed over 7500 offshore oil and gas structures. Additionally, an increasing number of oil and gas platforms and facilities have reached the end of their expected life after using up all the oil reserves that could be extracted.

Decommissioning activities require a sizable investment that is not likely to yield a Return on Investment (ROI). Decommissioning seeks to strike a delicate balance between minimizing financial and human costs and safeguarding wellbeing and the environment. It is a relatively new challenge for the majority of producer countries and energy companies. Adopting sustainable practices that involve a circular approach to decommissioning programs in this context presents a game-changing opportunity to manage resources within the limits of the planet. The Sustainable Development Goals (SDGs) can be achieved through the actions outlined in the oil and gas decommissioning sector using a Circular Economy (CE) approach. Designing policies and business strategies for the oil and gas industry requires a thorough understanding of the circularity of products and services (or their contribution to the CE.

The elimination of waste and lifecycle thinking are important aspects of circularity. Programs to reuse outdated facilities for marine research, aquaculture, renewable energy technologies, recreation, or to recycle the building's materials have emerged in recent years [5]. Reducing the negative effects of decommissioning offshore oil and gas platforms enables the development of new business ventures and environmental enhancements. Although the environmental impact of decommissioning was previously obscure, stakeholders have recently shown increased interest as a result of increased public awareness. In the Mediterranean region, decommissioning of offshore platforms is currently a hot topic. It has been suggested as a top priority for the following biennium, 2022–2023. It is necessary to look into the technical assessment of removal techniques, sustainability considerations, environmentally sound management, and best practices for treatment. There are many offshore installations in Italy, and the decommissioning of a number of buildings is imminent. According to national regulations, decommissioning entails tearing down structural elements, removing platforms, and putting the area back to its pre-construction state. However, the high cost of social and economic decommissioning has gradually shifted regulations in favor of a circular and sustainable strategy.

Life derivation in terms of marine life

Understanding how man-made offshore structures serve as artificial reefs and how they alter the surrounding marine environment was the goal of our research at Union Oil Platform, off Huntington Beach, California, USA. In order to determine (1) the abundance, standing stock, and productivity of attached fouling organisms, (2) the density, size-structure, and biomass of eplbenthic populations beneath the platform, and (3) the abundance, species composition, and distribution of eplfaunal and infaunal benthos as a function of distance away from EVA, underwater surveys were conducted. Clusters of sea mussels have taken over the platform's substructure. Every day, an estimated cubic meter of mussels drops from the platform, supporting extraordinarily dense populations of sea stars below. On the base of EVA, bands of stinging sea anemones prevent sea stars from ascending to the platform. The presence of EVA has a significant impact on the nearby sand community, with some species' densities being greatly increased and others being significantly decreased by the structure's proximity. The ecosystem of an oil platform's dominant fauna is represented by a trophic model, which shows that the attached community has high productivity and turnover rates.

Permanent offshore structures for the production of oil and natural gas are becoming more common in coastal marine environments around the world. Since the blowout and oil spill at Platform "A" in the Santa Barbara Channel, California, in 1969, these installations have been the subject of intense public interest and concern. In addition to accelerating the expansion of existing production fields in southern California and the Gulf of Mexico, the North Sea and Beaufort Sea have seen increased exploration and platform construction due to the industrialized world's soaring rates of petroleum consumption. The majority of offshore platforms are positioned on soft sediment bottoms to create artificial reefs that serve as attachment points for marine life and vertical relief that fish find appealing. Algal spores and invertebrate larvae quickly colonize the underwater areas of platform structures, creating a "fouling" assemblage that gives the accompanying fishes food and cover. The focus of earlier studies on the ecology of oil platforms was on describing the fouling communities and fish populations.

The underlying benthic ecosystem hasn't gotten much attention. The discovery of an extraordinary concentration of sea stars beneath Union Oil's production platform EVA in southern California, USA, sparked our interest in furthering research in this area. Volume V of "Marine Ecology" will contain an overview of how oil impacts marine life [6]. Two main objectives of our research at Platform EVA were to describe and explain the distributional patterns of benthic populations on and around the platform, and to demonstrate the potential value of platforms like EVA for quantitative biological research. The animal community that is connected to EVA, the sea stars on the platform, the collection of large echinoderms that live there, and the epifaunal and infaunal communities of the nearby soft bottom are all described here. Descriptive data are used to model trophic relationships between the attached community and the benthic echinoderm aggregation, as well as to estimate the standing stock and productivity of the fouling community.

Adjustment to scheme rejuvenation

Over the next three decades, there will be a number of sub-transitions within the current energy transition. In a scenario involving an energy mix, oil and gas will continue to play a crucial role in conjunction with renewable energy sources. With the primary objective of creating a model for the reuse of offshore Oil & Gas platforms at the end of their useful lives for the production of renewable energy, the authors of the current work developed a project called RELife (Renewable Energy for a New Life of Offshore Platforms) in this context. In this context, various technical scenarios are studied and investigated while taking into account two different types of platforms (4-legged platform with 3 or 4 production wells). For each scenario, the viability from an economic and environmental standpoint is also assessed. All of the sub-models are also contrasted with a typical decommissioning procedure. Both the Adriatic Sea and the North Sea are evaluated because they are geographical regions with different renewable resource availability. All of the scenarios have undergone a discount cash flow analysis and a life cycle assessment in order to evaluate their economic and environmental viability.

Two major challenges currently facing the energy sector are the global climate change and sustainable economic development. Dealing with them is frequently associated with the decarburization of the current energy system brought about by the switch from fossil fuel to renewable energy. In actuality, there is an important energy transition involving sources, structures, scale, economics, and policy that is taking place globally in the energy sector. Germany's shift to decentralized renewable energy and energy efficiency is one example of this transition to sustainable energy, but there are numerous other examples and varieties that can be mentioned. Reusing offshore Oil & Gas platforms at the end of their useful lives could serve as a significant example of an energy transition.

Offshore platforms and installations for oil and gas have a finite operational life. There are currently 6500 offshore oil and gas production facilities located on the continental shelves of about 53 different nations. The Gulf of Mexico is home to over 4,000, while 950 are in Asia, 700 are in the Middle East, and 600 are in Europe, the North Sea, and the North East Atlantic [7]. The Mediterranean basin contains 0.4% of the world's oil and gas reserves, along with 127 offshore platforms that primarily extract gas. These offshore structures are primarily found in the Ionian Sea and the Strait of Sicily, as well as the Northern and Central Adriatic coasts, at depths between 10 and 120 meters.

In the upcoming years, a large number of offshore oil and gas structures will be decommissioned globally as fossil fuel exploration and production come to an end. There will need to be 600 platforms dismantled in the North Sea alone. For instance, the Dutch North Sea structures had an average age of 24 years in 2014. As a result, many of these structures have already reached the end of their useful lives or will in the next ten years. The northern and central regions of the Mediterranean basin have more than 110 offshore gas platforms deployed since the 1960s, which represents the region's highest concentration of fossil fuel extraction platforms. Over the past 50 years, the Italian Oil Company has installed about 80 gas platforms in the Adriatic Sea, which was once a lucrative gas prospect. The staged scenario depicts the Company in the midst of a crucial decision, a plan to decommission the platforms at the lowest cost and risk, as the majority of these structures are approaching the end of their useful lives. Other international oil companies experience the same problem. Figure 1 and 2.

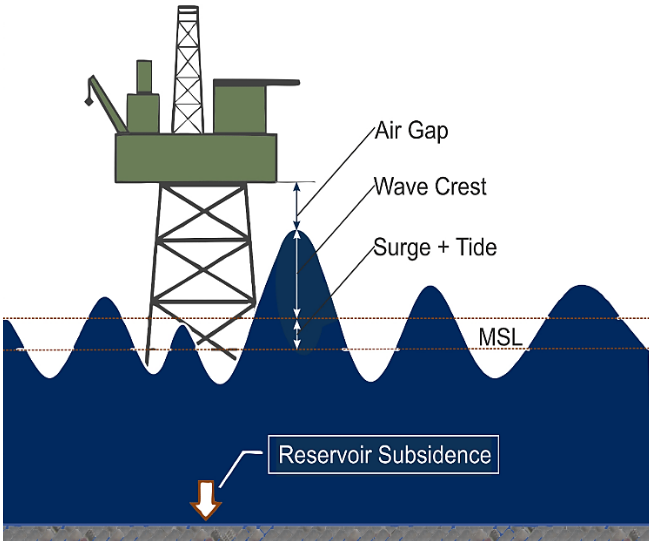

Figure 1. Conceptual model illustrating factors influencing air gap: extreme water level components including wave crest, tide, sea level anomalies (SLAs), and non-tidal residuals (NTRs) relative to mean sea level (MSL).

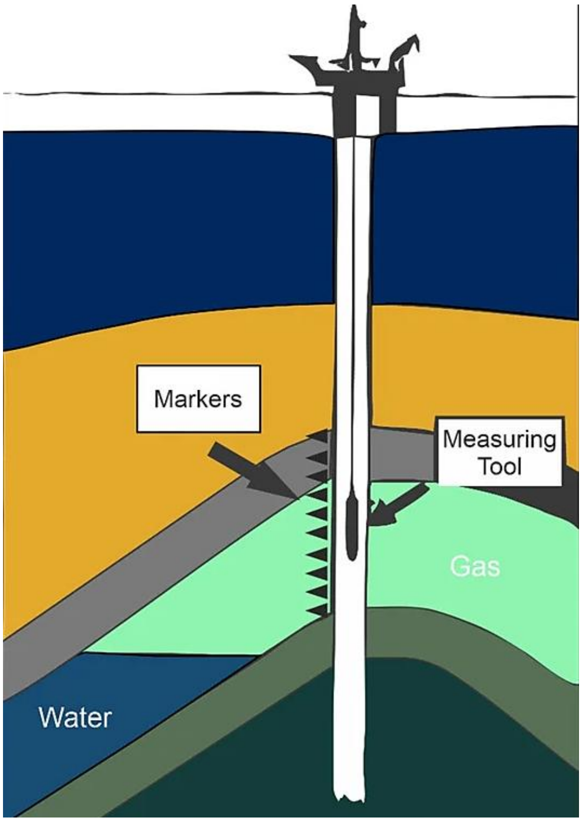

Figure 2. Conceptual model of radioactive marker technique (RMT) for monitoring formation changes via gamma radiation

DISCUSSION

The evaluation of offshore platforms is critical for ensuring their integrity and safety. Diagnostic systems and methods play a vital role in assessing structural conditions, allowing for informed decisions regarding maintenance or decommissioning. The use of advanced modeling techniques, such as degradation models and neural networks, has improved the understanding of corrosion dynamics and structural performance, enabling accurate predictions of platform longevity.

As the oil and gas industry faces pressures from climate change and the need for sustainable practices, repurposing aging platforms for renewable energy generation, particularly through Ocean Thermal Energy Conversion (OTEC), presents a viable solution. This innovative approach not only minimizes waste but also harnesses existing infrastructure to contribute to clean energy production. Moreover, the ecological benefits of utilizing platforms as artificial reefs have shown potential for enhancing marine biodiversity, providing critical habitats for various marine species.

The complexities of decommissioning offshore platforms must also be carefully managed. Stakeholder perceptions highlight the importance of sustainable practices that consider environmental, economic, and social impacts. By exploring circular economy principles, the industry can develop decommissioning strategies that not only mitigate negative environmental effects but also create opportunities for new business ventures and technological innovations. [8-10]

CONCLUSION

In conclusion, as offshore platforms reach the end of their operational lives, a multifaceted approach is necessary to address the challenges and opportunities that arise. The integration of advanced diagnostic techniques for evaluating structural integrity, the exploration of renewable energy applications such as OTEC, and the emphasis on sustainable decommissioning practices are essential for transitioning to a more sustainable energy future. By repurposing aging infrastructure, the oil and gas industry can contribute to environmental conservation while supporting the shift toward renewable energy sources. This article underscores the importance of strategic planning and innovative thinking in ensuring that offshore platforms can continue to play a role in the evolving energy landscape, ultimately benefiting both the economy and the environment.

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