A Comprehensive Study on Environmental Impacts of Offshore Platforms Abandonment and Decommissioning in Malaysia

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ABSTRACT

PETRONAS intends to significantly escalate the abandonment and decommissioning of offshore platforms between 2024 and 2026. An offshore platform is outfitted with the necessary equipment to extract petroleum and natural gas beneath the seabed. Malaysia's oil and gas sector is significantly influenced and plays a significant role in the country's economy by contributing around 20% of the annual GDP. Abandonment and decommissioning are crucial processes that necessitate environmentally conscious methods to protect maritime environments from the adverse effects of the industry. This study focused on analysing sustainable dismantling procedures, carefully evaluating the pros and cons of the process. The study shows an impartial assessment that considered both economic feasibility and ecological sustainability to ensure the protection of marine habitats for future generations. It is crucial to comprehend and address the environmental effects of the growing offshore activities in Malaysia.

Keywords: Offshore platforms; Environmental impacts; Abandonment and decommissioning; Sustainable dismantling; Marine habitats

INTRODUCTION

This study aims to comprehensively analyse the environmental impacts of the abandonment and decommissioning of offshore platforms in Malaysia. To properly comprehend this study, it should be known that it is part of an offshore platform's lifecycle to be either abandoned or decommissioned upon its expiry date, lack of oil or gas being produced or even economic viability. This has been the practice where the reasons are based on the mixtures between those grounds. Abandonment occurs whenever an offshore platform is declared abandoned and thus no longer in use, including permanently decommissioned and plugged-up wells. The wellhead must be removed and declared safe and secure by the regulators (Vrålstad et al., 2019). Nevertheless, the process can cause significant environmental risks of pollution resulting from potential leakages due to inadequate maintenance or gradual deterioration, leading to environmental concerns, health issues, and public nuisance if unchecked (Ogeer, 2022).

On the other hand, decommissioning is a process which involves the removal of the offshore platform infrastructure to a feasible extent. As the Bureau of Safety and Environmental Enforcement states, decommissioning refers to removing such infrastructure from the ocean's seafloor and restoring it to pre-lease conditions (Wan Abdullah Zawawi et al., 2023). Malaysia has a dedicated set of guidelines for decommissioning planning and management. These guidelines outline the necessary needs and procedures, such as environmental evaluation, stakeholder consultation, and regulatory compliance. Despite a comprehensive guideline, it is not being adhered to properly and lacks vigorous enforcement with penalties for inappropriate practices. Wan Abdullah Zawawi et al. further reported that around 350 offshore sites have been subject to examinations about decommissioning strategies.

In general, the international law that governs this matter would be the IMO Guidelines and Standards for the

Removal of Offshore Installations and Structures (Resolution A.672 (16)), which outline principles and procedures for decommissioning, emphasising navigation safety and environmental protection, and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, which aimed to control movements of hazardous wastes. The employment of inappropriate decommission methods has led to environmental consequences, including using explosives to dismantle offshore platform infrastructure. For instance, the vast majority of offshore platforms in the Gulf of Mexico (GOM) have employed explosives as a convenient method to dismantle sections of their infrastructure. Despite the environmental concerns, a lack of legislation or enforceable regulations explicitly prohibits these actions.

The affordability and efficiency of explosives have established them as a favoured technique for dismantling infrastructure on offshore platforms. Many studies have noted that the conditions in the Gulf of Mexico are similar to those in Malaysia, making it a widespread practice globally (Zawawi et al., 2012). There is a risk of faulty procedures leading to significant environmental consequences when offshore platforms are abandoned and decommissioned. This concern is seen in the plans of companies like Petronas. Therefore, this research article has evaluated the substantial environmental consequences linked to the abandonment and decommissioning of offshore platforms as a matter of concern. This involves the analysis of current legislation and regulations to assess the sufficiency of the law in governing this matter.

This research is significant as it served multiple aims to raise awareness, initiate legal reforms, and propose solutions. One of the objectives of this study was to enhance awareness regarding the environmental consequences arising from the abandonment and decommissioning of offshore projects in Malaysia. This study has identified and discussed the limitations in the current regulatory frameworks that prioritise the need for immediate policy reforms and institutional initiatives to ensure adequate environmental protection. The importance of using sustainable practices to improve environmental protection measures is highlighted throughout this study. In addition, alternate solutions are proposed to mitigate the abandonment and decommissioning of offshore sites. These solutions aim to reduce environmental results from these practices and encourage repurposing offshore platforms for diverse applications. Offshore platforms could be converted into aquaculture facilities, instrumentation facilities, or power-generating platforms for renewable energy sources.

Offshore Platforms

Maxwell (2023) states that an offshore platform is a stationary structure anchored to the seabed to extract oil or gas. However, Lamb and Bowie (2023) highlighted the necessity to conduct exploratory drilling before constructing an offshore platform. This process entails the extraction of a core sample by drilling into the layers believed to contain petroleum to ensure its presence and quantity are sufficient. Once the offshore drilling platform has been set up, there will be difficulty in transporting the petroleum reserves from point A to point B in a highly efficient manner without loss or ocean pollution. According to Lamb & Bowie (2023), it is emphasised that the drilling process must be precise, sinking the production wells miles into the Earth's crust beneath the sea. Smith (1993) states that a subsea drilling template is a vital tool used to aid in the drilling process and determine the positions of producing wells. Its purpose is to prevent water entering or oil from being released into the ocean. Finally, following the drilling operation, a production casing equipped with a cap is utilised to regulate the movement of petroleum. This valuable resource is often retrieved using natural pressure or pumps and delivered to onshore facilities for additional processing.

Hu (2024) classifies platforms into many groups based on characteristics such as the type of site and weather conditions. Only fixed and floating platforms will be addressed, as they are the prevalent varieties utilised in Malaysia. As Wilson Sons (2021) described, fixed platforms are distinguished by their anchoring to the seabed using steel piles deeply embedded in the ground. According to Caralb News (2021), the platform is physically installed at a significant depth in the seabed due to its construction in shallow water, which is why it is referred to as a fixed platform. An advantage of it is its stability, which is ensured by its solid anchorage to the sea floor. In addition, it is cost-effective because of its reduced construction material requirements. According to A.B.M. Saiful Islam et al. (2012), floating platforms function differently than permanent platforms because they are constructed in deeper water. Unlike a stationary platform, floating platforms are not entirely anchored to the seabed but are connected through wires, chains, or cables. One benefit is its capacity to be dismantled and reused in response to unexpected circumstances, such as extreme weather.

The typical lifespan of an average offshore plan ranges from 20 to 30, but they may increase to 40-50 years or more with proper maintenance, upgrades, and inspections. Factors like environmental conditions, economic viability, maintenance practices, technological advancement and regulatory requirements determine the lifespan of offshore (Knights, 2024). The Environmental Guidelines for Decommissioning of Oil and Gas Facilities in Malaysia (2019) maintain that decommissioning relates to platforms with longer lifespans due to less severe environments with good and rigorous maintenance than those facing harsh conditions. Thus, decommissioning depends on technical, economic, and regulatory factors.

Abandonment

Hallak (2017) argues that abandonment is a stage in the decommissioning project due to the lack of economically recoverable reserves based on the production cash flow. This indicates a significant change in the overall operation stage leading to the decommissioning stage. According to Torbjørn Vrålstad et al. (2019), this stage is referred to as Permanent Plug and abandonment, where the wells of offshore platforms are permanently sealed, and all operations are ceased. This involves fixing multiple cement plugs in the wellbore to separate the reservoir from other fluids from the surface or seabed. This process is costly, especially involving offshore wells, because it is time-consuming and critical for decommissioning efforts.

Due to the criticalness of such a stage, the offshore platform is subjected to all relevant legislation in that area. Wells that become obsolete and their connected platform, whether adequately plugged, and the abandonment process must be within the laws. During this time, the operator must notify the regulator of their intention and plan to abandon such wells and adhere to all relevant requirements. Hence, it is imperative to obtain prior written authorisation from the regulatory body before proceeding to stringent regulation by international and regional legislation, as well as the internal rules of the corporation. However, the decision to pursue the abandonment option may be impacted by the location with the closure, plugging, or abandonment of a well.

In Malaysia, the Environmental Guidelines for Decommissioning of Oil and Gas Facilities in Malaysia (2019) provide a comprehensive outline of the essential aspects of well plug and abandonment activities. These include addressing spillage and gas leakages, mitigating risks of marine water pollution, and ensuring adherence to standard operating procedures (SOP), among other considerations. Nevertheless, this guidance lacked a comprehensive elucidation on the exact abandonment phase. PETRONAS Procedures and Guidelines for Upstream Activities (PPGUA 3.0) (2013), Vol. 8: Drilling and Well Operations, Section 9 contains comprehensive regulations for deeper understanding. This encompasses the essential criteria for ensuring the successful separation of formation fluids, confirming the appropriate depth and sealing capability, and presenting abandonment and suspension proposals to PETRONAS for authorisation. Regrettably, this provision lacks any endorsement from relevant Malaysian legislation concerning this particular issue.

Decommission

Longstaff (2024) defines decommissioning as the set of administrative and technical activities to remove regulatory constraints from an authorised facility, making it possible to reuse it in the future. It involves returning a formerly functioning facility in the oil and gas field to a secure and ecologically sustainable condition (Skrine, 2019). Longstaff further stated that the process commences with careful planning to determine the project's scope, resource needs, and a thorough approach. Afterwards, physical and radiological evaluations are performed to examine the condition of the facility and any presence of radiation contamination. Subsequently, the Department of Environment in Malaysia claims that the decommissioning phase encompasses dismantling and decontamination activities. The post-decommissioning phase mainly concerns site closure, assuring thorough decontamination and certifying preparedness for unrestricted usage (MESTECC, 2019).

Decommissioning is a post-activity that started with the under-commissioning ageing platform infrastructure. In July 2024, the Center for Biological Diversity filed a lawsuit against the U.S. Interior Department for failing to assess environmental harms caused by which remain undercomissioned. Over 2,700 wells and 500 platforms

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within the Gulf of Mexico are overdue for decommissioning, causing potential ecological and public health risks. Thus, the legal framework for the overall process of decommissioning activities must be able to regulate the process of decommissioning the platform itself.

The legal framework for decommissioning offshore oil and gas installations in Malaysia is spread across several statutes, such as the Fisheries Act 1985, the Environmental Quality Act 1974, the Continental Shelf Act 1966, the Exclusive Economic Zone Act 1984, the Petroleum (Safety Measures) Act 1984, and Occupational Safety and Health Act 1994. In addition, the Department of Environment has developed environmental standards relating to the decommissioning process for oil and gas installations in Malaysia. An example is PETRONAS, Malaysia's national oil corporation, which has included the decommissioning principles into their PETRONAS Procedures and Principles for Upstream Activities (PPGUA). These standards are essential for firms engaging in production-sharing contracts (PSC) with PETRONAS in Malaysia. PETRONAS and the Government of Malaysia are responsible for reviewing and approving all decommissioning activities by PSC parties using the abandonment review process.

RESEARCH METHODOLOGY

This study adopts a doctrinal methodology to critically examine Malaysia's legal and regulatory framework governing offshore platform abandonment and decommissioning. Primary legal sources such as the Petroleum Development Act 1974 (PDA), the Environmental Quality Act 1974 and the Fisheries Act 1985 were analysed alongside subsidiary legislation, including PETRONAS Procedure and guidelines for Upstream Activities. International legal instruments such as IMO Guidelines and Standards for the Removal of Offshore Installations and Structures and the Basel Convention on Hazardous Waste were also reviewed to identify best practices and benchmark Malaysia's regulations against global standards. The doctrinal analysis focuses on uncovering gaps, inconsistencies, and overlaps in the existing framework while highlighting the need for comprehensive and enforceable legal reform to address the environmental, economic, and operational challenges of decommissioning offshore platforms. Through this approach, the study aims to provide a robust foundation for advancing sustainable and effective regulatory practices in Malaysia.

RESEARCH FINDINGS AND DISCUSSION

Principle of Utility

The main topic of our discussion is the potential outcomes that would occur after fully utilising the offshore platform, namely regarding the abandonment and decommissioning of the platform. The discussion will focus on the benefits and drawbacks of each of these techniques. This journal's primary objective is actively exploring and striving for energy justice. Hence, the concept of utility proposed by Jeremy Bentham would be the most relevant principle for this issue. According to this view, the moral value of an action is defined by its capacity to limit suffering and maximise joy for the most significant number of individuals touched by the action.

This theory applies to this subject, as its primary goal is to balance the two main considerations: economic profit and environmental harm caused by offshore platforms. Hence, assessing the level of joy and pain that this procedure elicits is imperative.

The principle of utility proposed by Jeremy Bentham evaluates actions based on their ability to minimise harm and maximise benefits for the most significant number. This approach has been applied to offshore platform decommissioning in various studies. Bull and Love (2019) highlighted the ecological and economic benefits of the "rig-to-reef" program, which repurposes decommissioned platforms as artificial reefs, enhancing marine biodiversity and reducing costs.

Similarly, Macreadie et al. (2011) emphasised the balance between environmental preservation and cost efficiency in partial removal, aligning with utilitarian ethics. Curtis (2021) explored the trade-offs between ecological harm from abandoned structures and their potential benefits as artificial habitats, proposing a utilitarian framework to evaluate long-term environmental and economic outcomes. These studies collectively demonstrate how the principle of utility informs decisions that balance economic, environmental and societal interest in offshore platform decommissioning.

Effects of Abandonment

Abandonment activities of an offshore platform do have an impact on the environment. Its positive effect would be that it becomes an artificial reef, a technique gaining popularity in places where many installation platforms exist, like those in the Gulf of Mexico. Out of approximately 1,892 offshore oil and gas platforms, about 200 platforms were decommissioned over the last decade. These abandoned offshore platforms are becoming popular for fishing and scuba diving activities, contributing as much as 30% of the Gulf's "reef" habitat (Bull & Love, 2019). This rig-to-reef programme, by converting abandoned offshore platforms and converting them into artificial reefs, is a successful observed practice (Pereira et al., 2023). Isabelle Garretsen (2021) states that the converted offshore platforms tend to offer a better diversity of marine ecosystems with the ability to provide nourishment, protection and security for marine life. Scientists even consider them as better than natural reefs. Studies have also discovered that offshore platforms significantly contribute to enhancing biodiversity. One study even found that the decommissioning and removing these platforms are more detrimental to the ecosystem (Karasalihović Sedlar et al., 2019).

Likewise, abandonment has negative consequences, which lead towards potential risks. The possibility of leaks from the abandoned well has become an environmental concern (Ogeer, 2022). It could cause substantial damage to the marine ecosystem it initially promoted. This contamination can cause significant damage to marine habitats like coral reefs, mangroves and salt marshes (Curtis, 2021). These are some incidents concerning abandonment. The case of ExxonMobil's Bass Strait Pipeline Rupture in 2023 is an example where Australia's National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) is investigating ExxonMobil for the gas pipeline rapture occurring at the Kingfish A platform, which was decommissioned, raises concern over the integrity of abandoned platform infrastructure. This can cause environmental problems like the potential for pollution harming local ecosystems and marine life and eroding public trust in the regulatory procedures and enforcement, which demands greater transparency of the operations and decommissioning processes.

Any spill can cause disruptions to the food webs, destroy biodiversity, and prevent critical environmental processes like photosynthesis and nutrient cycling, affecting the well-being of marine organisms. It can cause detrimental effects on species and habitats over a long period, and the restoration can take several years, causing impartible harm. Furthermore, Keith (2022) asserts that disruptions can still occur through the erosion of the metal framework and anodes, releasing harmful substances into the ecosystem. Therefore, offshore platforms can still pose an environmental danger.

Effects of Decommission

Decommissioning offshore platforms would signify potential environmental benefits in habitat restoration and biodiversity enhancement at the given location. One main benefit of decommissioning offshore facilities is the potential regeneration and repair of maritime ecosystems. Whenever a platform is being decommissioned, the disassembly of its infrastructure allows for the resumption of natural processes, which aids in gradually restoring the surrounding environment to its original natural state. The absence of impediments in rivers and the flow of ocean currents make it easier to recover marine ecosystems that the platform's presence may have damaged.

Furthermore, Ashley Fowler et al. (2018) emphasised that offshore platforms boost biodiversity by changing their structures into artificial reefs through partial removal decommissioning. These reefs are a magnet for many marine animals and are vital in maintaining ecological balance and resilience. This strategy promotes the health of marine ecosystems, contributes to the restoration of environmental balance, sustains a variety of species and increases the number of local fish populations, helping commercial and recreational fishing.

An example of an early and sizeable rigs-to-reef initiative is Baram-8, today referred to as the Kenyalang Reef in Malaysia. A Shell specialist said that a sequence of marine examinations found that the sunken Baram-8 platform supported a complex ecology of soft coral and fish. The rigs-to-reef program is alleged to have boosted biodiversity by providing additional habitat for marine species in regions with flat and sandy seabed that offer limited cover (personal communication, June 10, 2024). Consequently, decommissioning protects against destructive bottom trawling, safeguarding critical habitats and allowing marine life to flourish undisturbed, thus ensuring minimal environmental impact and promoting habitat restoration (Macreadie, Fowler, & Booth, 2011).

Nevertheless, the drawback of decommissioning these structures is that they can disrupt the existing marine ecosystem, leading to possible detrimental impacts on the marine environment. Over time, the deserted platform becomes increasingly vulnerable to oil and pollutant leakage due to corrosion and deterioration. Additionally, it can present navigational risks to waterborne vessels, potentially leading to accidents and spills. The platform's structure can also disturb the natural contours of the ecosystem (Hulme, 2012). It is vital to acknowledge that decommissioning might lead to soil modification and the removal of habitats, thereby causing long-lasting harmful effects on neighbouring ecosystems. Moreover, the use of explosives to remove offshore facilities is a common practice that leads to environmental harm because of insufficient decommissioning techniques. This method is preferred since it is both cost-effective and efficient. Statistics indicate that explosive and other mechanical severance utilities have been used in over 35% of offshore platform decommissioning efforts since 2019.

Analysis of the Effects of Abandonment and Decommission

When evaluating abandonment, it is essential to examine the act's economic benefit and environmental impact by the principle of utility. If the decommissioning process were carried out, the entire dismantling of the structure would need a substantial workforce and incur huge expenses. However, there would be no possibility of any environmental consequences, such as disturbance to marine life or the risk of discharge. Alternatively, if the decommissioning process is not carried out, the structure could remain intact and function as an artificial reef, providing habitat for particular marine animals.

Nevertheless, any leftover residue on the platform can harm the ecosystem. The most suitable course of action in assessing the benefits and drawbacks of abandoned offshore platforms depends on elements such as the seabed's depth and the facility's dimensions and age. Younger and smaller platforms would be better suited for decommissioning than older and bigger platforms. Although turning abandoned platforms into artificial reefs seems interesting, maintaining them presents significant difficulties because of the considerable financial cost and lack of legal rules controlling their development and maintenance. Therefore, choosing abandoned platforms is a more logical choice since their great possibility of causing environmental damage should be avoided.

From a utilitarian standpoint, it is clear from looking at offshore platform decommission that environmental and financial benefits exist. One might similarly use this strategy, which aims to maximise general well-being and lower stress related to the act of desertion. Decommissioning expenditures for the disassembly and removal of the platform include equipment, labour, and environmental remedial action expenses. Still, this operation removes the potential long-term ecological risks associated with abandoned platforms, including structural decay and well leaks. From a utilitarian aspect, decommission limits the risk of future environmental damage, thereby lowering the overall impact of environmental degradation. Despite the high expense of decommissioning, the long-term gains in ecological preservation and sustainability transcend the original financial expenditure. Hence, the utility principle advocates decommissioning as the optimal choice, as it reduces future environmental harm and guarantees the sustained welfare of the ecosystem and its people. Although decommission may be feasible, it must be carried out correctly and without using explosives, as they harm the environment. Inadequate decommissioning practices and protocols provide substantial barriers that must be addressed to attain overall well-being and environmental sustainability.

The Inadequacies of Malaysian Law

Generally, a single statute does not encapsulate the current regulatory framework regarding offshore platform decommissioning. Instead, it is a fragmented entity in various laws, including the Fisheries Act 1985, the

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Environmental Quality Act 1974, and the Continental Shelf Act 1966. Nevertheless, Petronas has established a subsidiary legislation that serves as the primary regulatory authority for decommissioning oil and gas facilities by the PDA. Consequently, PETRONAS Procedures and Guidelines for Upstream Activities (PPGUA) are essential for delineating and navigating the standard policies and requirements throughout the offshore platform's entire lifecycle. In addition, the Department of Environment has published an environmental guideline titled "Environmental Guidelines for Decommissioning of Oil and Gas Facilities in Malaysia." The Department of Environment's (DOE) rules strongly focus on ecological management elements, such as the need for an Environmental Impact Assessment (EIA) and the requirements for approval. The PPGUA, on the other hand, places more focus on technical elements, such as the offshore facility's lifetime, which includes decommissioning. Complying with these various laws and regulations is essential while decommissioning.

Petronas is responsible for reviewing and approving all offshore activities, as stipulated by PPGUA. PPGUA even mandated that the decommissioning plan be submitted during the field development stages. This guarantees that these processes' Health, Safety, and Environment (HSE) components are not overlooked. Petronas conducts monthly assessments of its health, safety, and environmental (HSE) performance during the completion of initiatives. A post-decommissioning inspection is performed within a few months of completion to guarantee that the marine and land environments are not adversely affected by any improperly disposed detritus. PPGUA realistically approaches the options available after the offshore platforms have reached the end of their lifecycle. Initially, it is necessary to eliminate all unused installations. Nevertheless, if it is determined that non-removal or partial removal is more appropriate, it will not be removed entirely. A case-by-case assessment of each circumstance determines the proper course of action.

Nevertheless, the current regulations on offshore decommissioning and abandonment processes in Malaysia have few weaknesses despite the numerous acts and guidelines that have been established. Initially, the issue of which act would take precedence is ambiguous due to the multiple statutes scattered throughout the area. Consequently, the consequences of neglecting the obligation are uncertain, encouraging individuals to engage in the opposite behaviour. In other words, these regulations lack a distinct penalty structure and a strict enforcement mechanism. Following that, the law prioritises a single aspect only. It places a greater emphasis on the execution of decommissioning activities. Alternatively, they could focus on the initial stages of the project's life cycle. This is because early planning is more efficient, which can significantly reduce the cost and any severe environmental consequences.

Comparative Analysis

This research has compared Malaysia with other countries to determine the international standards for legislation requirements in decommissioning programs. According to a study conducted by the Society of Petroleum Engineers (2021), Malaysia was compared to the United States of America, United Kingdom, Norway and Thailand to assess their existing regulatory structures for criteria as seen in the table below:

TABLE 1: Comparison of Decommissioning Regulations

Factors	Criteria	Countries				
		Norway	UK	USA	Thailand	Malaysia
Decommissioning Preparation	1.Submission Timeline	✔	✖	✔	✔	✔
	2.Decommissioning Options Assessment	✔	✔	✔	✔	✔
	3.Workflow Optimization	—	✔	—	—	—
	4.Information Management System	✔	✔	—	✔	✔
Decommissioning Technical Execution Procedures	5.Well P&A	✔	✔	✔	✔	✔
	6.Seabed Deposit Management	✔	✔	✔	✔	✔
	7.Pipelines & Associated Structures	✔	✔	✔	✔	✔
	8.Structures & Facilities	✔	✔	✔	✔	✖
	9.Reuse Standard	—	—	✔	✔	✖
	10. Waste Management	✔	✔	✔	✔	✔
	11. Safety Standards	✔	✔	✔	✔	✔
	12. Debris Survey	—	✔	✔	✔	✔
	13. Post-Decommissioning	✔	✔	✔	✔	✔
	14. 3rd Party Validation	—	—	—	✔	✖
	15. Liability & Residual Risk Management	✔	✔	✔	✔	✖
Additional Environment	16. Rig to reefs	—	—	✔	✔	✔
	17. Post-Environment Monitoring	✔	✔	✔	✔	✖
	18. Impact Assessment	✔	✔	—	✖	✔
Financial Security Framework	19. Financial Security Requirement	✖	✔	✔	✔	✖
	20. Residual Risk Fund	✔	—	—	—	—
Key: ✔ = Mentioned specifically		14	15	15	17	12
✖ = Not specific		1	1	0	1	6
— = Not Mentioned		5	4	5	2	2

Source: Shaleni Kumar, Mohd-Akmal Sidek, Augustine Agi et al. (2021)

Based on this study's analysis, Thailand was identified as having the best decommissioning regulations because they have the strictest rules and cover the most criteria. However, there is no specific regulation on impact assessment under an additional environment, which is present in Malaysia's regulations. Although there are no regulations for impact assessment, Thailand still conducts environmental impact assessment (EIA) reports, which include public participation supported by existing legislation, and there are proposals to enhance public participation to achieve meaningful civil involvement. This showed that Thailand emphasises stakeholder engagement in high regard and prioritises public involvement to review and provide feedback during the scoping phases. Audits and verifications are also conducted to assess compliance with DEA and EMP. Consequently, Thailand's decommission processes are recommended as a benchmark for other Southeast Asian regions to emulate.

Meanwhile, Malaysia has the most lenient regulations because decommissioning is a recent practice for the country's oil and gas industry. There are many expected criteria for decommissioning which are either not explicitly mentioned or not at all in the Malaysian regulations. For decommissioning preparation, Malaysia is most covered by the absence of rules for workflow optimisations, which is required for better management. For decommissioning, technical execution procedures, regulations on structure and facilities, reuse standards, third-party validation and liability and residual risk management are not explicitly mentioned. This is concerning because these criteria ensure that the decommissioning process is conducted to the utmost best standard and hold the operators accountable when conducting these processes. Although Malaysia exceeds Thailand in impact assessment within the decommissioning regulations, there are no specific regulations for post-environment monitoring under additional environments, which is still a significant step in preventing environmental risks. The most lacking criteria would be on financial security framework with no specific regulation for financial security requirements, and residual risk fund is not mentioned.

This highlights the beginning of Malaysia's decommissioning regulations, which lacked many expected criteria because only a few fixed offshore platforms in the country's waters have been decommissioned without a well-established localised regulatory framework. Based on the interview with a professional engineer with extensive experience in the oil and gas fields, Malaysia's decommissioning laws are not as mature as those of other countries such as North Sea UK, as seen from Table 1 and New Zealand, which have stringent regulations. He also recommended that Malaysia follow examples from these countries because they critically consider public perception, and their lawmakers empower other agencies to monitor, control and enforce regulations during decommissioning.

For instance, Environment Protection Authority Te Mana Rauhī Taiao provided that New Zealand's decommissioning plans must first be accepted by the Environmental Protection Agency (EPA) before consent can be obtained for activities required for decommissioning in their field. Also, their decommissioning plans and regulations are subjected to public consultation before being accepted, as seen in the Exclusive Economic Zone and Continental Shelf (Environmental Effects Decommissioning Plans) Regulations 2021.

RECOMMENDATION

Legal Reformation

Addressing the inadequacies of law in Malaysia for the abandonment and decommissioning of offshore platforms, this study identified an absence of a specific legal framework tailored to regulate these processes. Instead, any authorities concerned about these processes are spread across various statutes, which are unreliable for effectively enforcing the abandonment and decommissioning process. The primary regulatory guideline for these processes in Malaysia is a guideline established by PETRONAS that functions as a subsidiary legislation under the PDA. However, this guideline does not possess the requisite legal authority for comprehensive enforcement. Thus, a critical issue persists due to the absence of a primary regulatory authority explicitly empowered by legislation to oversee and enforce regulations specifically tailored for the abandonment and decommissioning of offshore platforms in Malaysia.

Henceforth, legal reform is urgently imperative because the current ambiguity and inadequate enforcement mechanisms pose significant risks to environmental management during the abandonment and decommissioning processes. By analysing the international comparative table, Malaysia should adopt a better regulatory framework like that of Thailand, which has been seen as the benchmark leader for Southeast Asia. Given that Thailand is a neighbouring country, Malaysia can closely emulate Thailand's success in decommissioning. It is essential to be able to learn from countries that have extensive experience in decommissioning activities.

Alternative Use for Offshore Platforms

Thermal-Ocean Energy Conversion

Ocean thermal energy conversion (OTEC) can be seen as a potential energy source for generating energy and electricity, which uses the temperature differences between the hot surface of the sea and the cold deep ocean waters. Repurposed offshore platforms for OTEC usage can be a means of energy and freshwater production while reducing environmental impact and being cost-effective without building new facilities. This leveraging effect could encourage the development and deployment of OTEC even faster than anticipated in Malaysia (Abdul Rani et al., 2021).

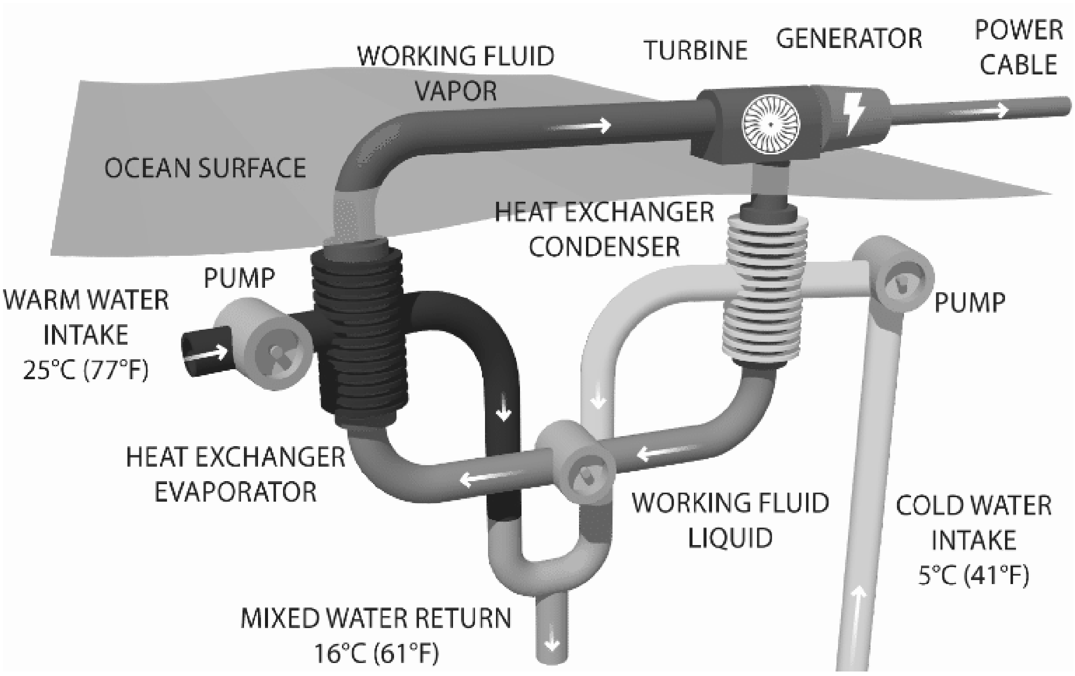

FIGURE 1: Working Principles of OTEC

Source: Makai Ocean Engineering Inc

Figure 1 demonstrates the current working of the OTEC system, which utilises warm ocean surface water by pumping it into a process which uses the differential temperature to generate steam from a working fluid (ammonia) to convert such fluid into vapour and eventually spin turbines, creating electricity.

Abdul Rani et al. (2021) highlighted that OTEC is effective only when utilising deep seawater at depths exceeding a hundred metres, as a substantial temperature gradient is necessary to generate electrical power. Supported by a response by an expert from Shell, it was noted that utilising offshore platforms for OTEC or hydrokinetic energy has a low environmental impact, as these systems do not emit greenhouse gases or other pollutants. Moreover, OTEC technology provides baseload power, generates fresh water, and supports marine cultures by integrating deep water. However, specific technical studies are essential to assess the feasibility of this approach.

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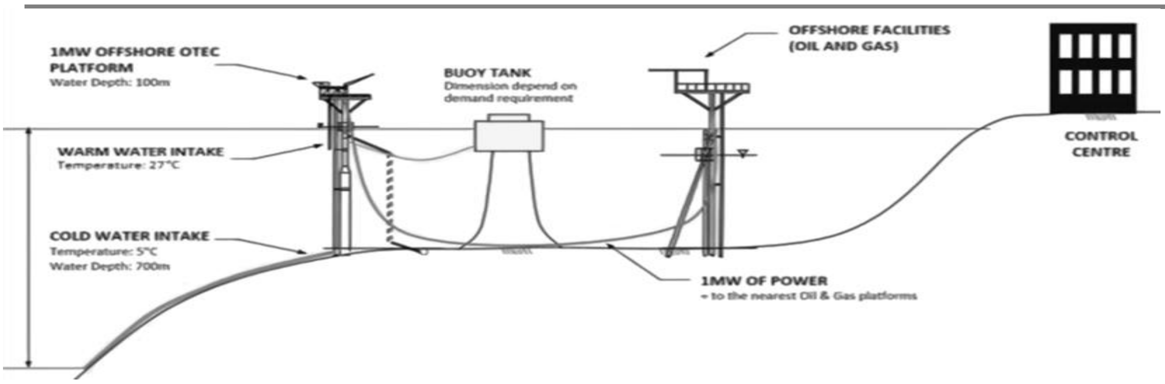

FIGURE 2: Conceptual Design of Fixed OTEC Power Plant

Source: M A R Zulkifli et al. (2022).

As shown in Figure 2, utilising offshore platforms for OTEC eliminates the expensive decommissioning process and prolongs their usefulness. The illustrated Figure displays the topside structure, which supports the machinery of the OTEC plant on its two decks. The system comprises many components: a functional fluid evaporator and condenser, a water output evaporator and condenser, a turbine, and a generator. The system generated 1 MW of electricity and produced up to 2 million gallons of clean water daily, resulting in substantial savings in carbon dioxide emissions.

In the long term, OTEC plant ships could supply electricity to shore stations via submarine power cables. OTEC factories in equatorial waters could produce sustainable fuels like ammonia and hydrogen, supporting the transition to a post-petroleum era. Deploying OTEC plants on these offshore platforms can generate continuous revenue and economic viability. Repurposing offshore platforms is a more friendly approach that maintains sustainability by promoting renewable energy production and facilitating the transition from dependence on fossil fuels.

Seasteads

Through the interview, the participant brought into this study mentioned the repurposing of offshore platforms into Seasteads. He refers to research on repurposing offshore platforms into structures for an eco-friendly, self-sustaining permanent dwelling at sea. Given the anticipated decommissioning of numerous offshore platforms, an initiative to repurpose them into habitable hubs is a viable option. However, critics argue that this concept may only support temporary occupation and self-sufficiency.

Furthermore, this concept has been refined by Patri Friedman, the executive director of The Seasteading Institute (STI), aiming to establish "next-generation governance" in international waters, free from national jurisdictions. The initiative has received substantial backing, including $1.25 million from Peter Thiel, co-founder of PayPal. Plans have been drafted to construct a prototype Seasteads in the Pacific Ocean near San Francisco, designed akin to a modified cruise ship inspired by offshore oil rigs with essential modifications.

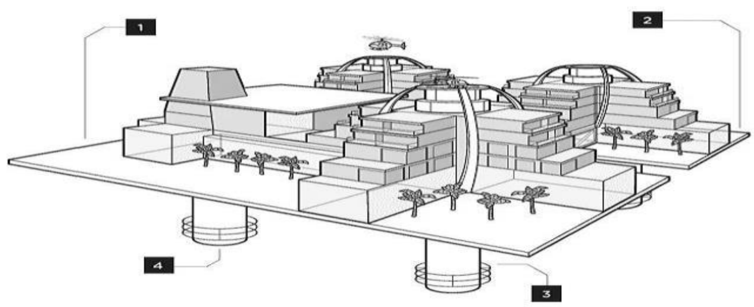

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FIGURE 3: Conceptual design of Seasteads

Source: A. Chin & L.R., Mohd-Khairi. (2011)

Figure 3 illustrates the ideal architecture of Seasteads as a modular structure that enables the extension and development of a city. The design of this submission was created by Morris Architects, which was awarded the 2008 Radical Innovation in Hospitality Awards for its innovative offshore hotel idea that is both self-sustaining and eco-friendly. The design depicted in Figure 3 incorporates various characteristics, including The dwelling platform spans an area of 160,000 square feet; the water distribution networks; the foot tanks serve the purpose of supporting the Seasteads above water and reducing the effects of unpredictable large waves; the engine room contains four diesel engines.

CONCLUSION

Our study has found numerous significant environmental factors resulting from Malaysia's abandonment and decommissioning of offshore platforms. As highlighted in this study, the regulatory frameworks and practices in Malaysia's oil and gas sector must address these issues to achieve sustainable and responsible decommissioning operations.

Upon closer examination of Malaysia's approach, it becomes apparent that although praiseworthy components are in place, there are also notable issues and deficiencies within the regulatory structure. It has implemented regulations and protocols to oversee the overall lifespan of offshore platform installations by mitigating environmental effects and impacts while maintaining and promoting sustainable methodologies. However, with the absence of some specific regulations, lack of enforcement mechanisms, and the existing gaps in facing critical matters such as financial security and environmental studies, the problems still linger.

Progress for Malaysia is through continuous improvement and enhancement of the existing legal framework to upgrade enforcement protection at every decommissioning stage. Exploring possible alternative uses of offshore platforms like reefs or repurposing them for other uses could enhance economic viability and promote environmental responsibilities. Through this balance, we can foster continuous national growth while preventing destruction and preserving marine ecosystems for future generations.

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