Collaborate

Offshore Platform Operational Risk Management in Extreme Weather Conditions

Part of the Book Series "Maritime Engineering"

Regulatory and Policy Barriers to Marine Renewable Energy in Indonesia

Abstract

Indonesia possesses vast potential for marine renewable energy (MRE), including tidal, ocean current, and ocean thermal energy (OTEC). However, its utilization remains significantly below the national energy mix targets. This perspective article examines the gap between Indonesia's energy transition ambitions and the existing regulatory realities. Through a critical review of current policies, we identify three major barriers: (1) overlapping authority among institutions, (2) the absence of a dedicated fiscal incentive framework for marine technologies, and (3) the lack of a comprehensive and integrated national roadmap within the National Energy General Plan (RUEN). We argue that without cross-sectoral regulatory alignment and legal certainty for investors, the potential of MRE will remain largely untapped. This article highlights the importance of establishing a "one-stop" policy framework and developing a technology roadmap that reflects Indonesia's archipelagic characteristics. In conclusion, strengthening regulatory frameworks is not merely an administrative step, but a fundamental prerequisite for positioning marine energy as a pillar of Indonesia's future energy sovereignty.

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1. Introduction

Given Indonesia's geological conditions and geographical location, the country possesses vast, diverse, and widely distributed new and renewable energy (NRE) sources that can be utilized to meet national energy needs. The development and utilization of NRE potential are aligned with the National Energy Policy (KEN) under Government Regulation Number 79 of 2014, which mandates the realization of Energy Independence. This involves ensuring energy availability by maximizing domestic resource potential through efficient and diversified energy management strategies. One of the key sources for this energy diversification is marine energy.

Marine energy is a renewable resource derived from natural phenomena occurring in the ocean, stemming from both water movement and its physical properties. Generally, global marine energy is categorized into:

- Ocean Current Energy: Utilizing kinetic energy from the horizontal or vertical movement of water masses.
- Ocean Wave Energy: Converting the rising and falling motion of waves into electricity.
- Tidal Energy: Harnessing potential energy from the vertical displacement of water caused by the

difference between high and low tides.

- Ocean Thermal Energy Conversion (OTEC): Exploiting the temperature differential between warm surface waters and cold deep waters.
- Salinity Gradient Energy: Utilizing the difference in salt concentration.

In Indonesia, marine energy is specifically divided into four types: ocean currents, waves, tides, and OTEC. This classification aligns with Law Number 30 of 2007 concerning Energy, which includes seawater movement and ocean temperature gradients as types of new and renewable energy. From an existential standpoint, Indonesia is an archipelagic nation where more than 70% of its territory is sea, consisting of 17,380 islands (Geospatial Information Agency, 2024). This geography creates numerous straits between islands and a coastline spanning 99,093 kilometers, making Indonesia the country with the second-longest coastline in the world after Canada.

For decades, Indonesia has relied heavily on fossil fuels for daily activities, often overlooking renewable sources despite their vast potential and positive impacts. These renewable sources have remained largely untapped while fossil fuel consumption continues to rise. Today, this heavy reliance has led to depleting fossil fuel reserves, which could trigger a serious domino effect harming society and, ultimately, threatening national stability. Consequently, a transition from fossil fuels to renewable energy in the near future is imperative.

Beyond domestic policy, European Union nations have also set specific consumption targets for renewable energy as of 2020, as detailed by Westerman et al. (2020). Despite varying targets, EU countries have initiated renewable energy management through various funding schemes, including feed-in tariffs, market premiums, and green certificates (Novico et al., 2021).

Recognizing both the urgency and the potential, the Indonesian government has drafted several legal instruments, schemes, and policies for renewable energy management. However, in practice, these efforts still face complex and structural obstacles. To accelerate the energy transition, these barriers must be deconstructed. Given the complexity of the issue, this process must be inclusive and gradual. Furthermore, stakeholders must understand the core problems embedded within these hurdles. In line with this urgency, this article comprising an Introduction, Research Methodology, Results and Discussion, and Conclusion aims to identify the obstacles faced in implementing renewable energy in Indonesia and to analyze the underlying issues therein (Chen & Huo, 2023).

2. Methodology

The method I used was to reference primary and secondary data to support the arguments in this article. The data collection technique used was a literature study, which involved collecting data through books, articles, laws and regulations, other legal literature, and online sites relevant to the issues discussed. The data analysis technique used in this study was descriptive, providing an overview of the collected data through sentence analysis with the aim of explaining the data studied and drawing conclusions about the answers to the existing problems.

3. Result

In general, offshore platform operations are greatly affected by marine environmental conditions, especially during extreme weather events. The dynamic marine environment causes offshore operational activities to always pay attention to the safety and stability factors of the production system. Extreme weather such as storms, high waves, and strong winds can disrupt production activities, logistics transportation, and work activities on the platform. Therefore, offshore operational management in general must be designed to be able to adapt to changing conditions of the marine environment. In practice, offshore operational management focuses not only on smooth production, but also on efforts to prevent the risk of work accidents and facility damage. Operational systems are usually equipped with strict work safety procedures, equipment condition monitoring systems, and marine environmental condition monitoring systems. With this system, operators can make operational decisions such as reducing production activities or temporarily halting operations if weather conditions are considered to be high risk to the safety and stability of the platform structure (Rahman et al., 2019).

In addition, the readiness of human resources is also an important factor in offshore operations in general. Offshore workers must have the ability to understand work safety procedures, use of personal protective equipment, and the ability to respond to emergency conditions. Work safety training, evacuation simulations, and the implementation of a work safety culture are important parts in supporting the smooth operation of offshore operations. With good worker readiness, the potential for work accidents can be suppressed even if the platform operates in quite extreme environmental conditions. Overall, offshore platform operations require a balance between technical aspects, operational management, and occupational safety. Good operational management will help maintain the continuity of energy production, protect workers, and minimize negative impacts on the marine environment. With the development of increasingly sophisticated monitoring technology and weather prediction systems, offshore operations in the future are expected to be safer, more efficient, and able to face the challenges of changing marine environmental conditions more optimally (Kubacka et al., 2021).

4. Discussion

In general, operational risk management on offshore platforms is an important component in maintaining the sustainability of the marine energy industry amid increasingly complex environmental challenges. Extreme weather conditions not only have an impact on technical operational aspects, but also affect aspects of work safety, operational economics, and sustainability of the marine environment. Therefore, the risk management approach must be carried out in an integrated manner by combining engineering, management, and occupational safety aspects so that the offshore operational system can run optimally in various environmental conditions. From a technical point of view, the development of monitoring technology and weather prediction systems has made a major contribution to improving the operational reliability of offshore platforms. Sensor technology, satellite-based monitoring systems, and real-time data analysis systems allow operators to identify potential operational disruptions early. With this system, operational decision-making can be made more quickly and precisely, so that the risk of equipment damage and production disruptions can be minimized. In addition, the organizational management aspect also has an important role in managing offshore operational risks. Companies need to have a structured risk management system, including weather-based operational planning, adaptive logistics management, and effective communication systems between operational units. The application of international standards and safety regulations is also an important factor in ensuring that offshore operations are carried out in accordance with the principles of safety and protection of the marine environment (Jiao et al., 2024).

In terms of human resources, the formation of a work safety culture is the main factor in reducing the potential for work accidents in offshore operations. Workers who have competence and a good understanding of safety will be able to respond to emergency conditions more effectively. Safety training programs, emergency simulations, and increased awareness of marine environmental risks are important parts of supporting the effectiveness of operational risk management systems. Overall, operational risk management on offshore platforms must continue to be developed in line with changing global environmental conditions and technological developments in the offshore industry. The integration of modern technology, adaptive operational management systems, and the readiness of human resources is the main key in increasing the resilience of offshore operations. With a sustainable approach, the offshore industry is expected to be able to maintain the stability of energy production while protecting worker safety and the preservation of the marine environment. In addition, the operational challenges of offshore platforms in the future are expected to become more complex as energy exploration activities increase in deep-sea areas and areas with extreme environmental conditions. Deep-sea operations require more advanced technology and a more stringent risk management system due to the heavier levels of pressure, depth, and environmental conditions than shallow sea areas. Therefore, offshore companies need to continue to innovate technology and improve their operational management systems to face these challenges. The development of industrial digitalization also provides a great opportunity in increasing the effectiveness of offshore risk management. The implementation of the digital twin concept, big data analytics, and artificial intelligence systems allows companies to simulate operational conditions virtually before applying them to real conditions. With this technology, potential system failures can be predicted earlier so that companies can take preventive measures more effectively. This will help improve operational efficiency while reducing potential losses due to operational disruptions (Rasmussen & Ahsan, 2022).

In addition to technological and operational aspects, attention to the protection of the marine environment is also an important part of offshore risk management. Operational failures on offshore platforms have the potential to cause marine pollution that can damage ecosystems and disrupt marine life. Therefore, offshore companies need to implement an environmental management system that is integrated with an operational risk management system. The application of environmentally friendly technology and waste control systems is an important part of supporting the sustainability of the offshore industry. Ultimately, the success of offshore operational risk management is highly dependent on the company's ability to integrate various aspects, ranging from technology, organizational management, human resources, to environmental protection. A holistic and sustainable approach will help the offshore industry in dealing with increasingly complex marine environmental dynamics. With good risk management, offshore platform operations can run more safely, efficiently, and sustainably in the long run. In addition, it is important for the offshore industry to continue to increase collaboration with research institutions, academic institutions, and international organizations in developing more effective risk management technologies and methods. Joint research can lead to innovations in the design of platform structures that are more resistant to extreme weather conditions, the development of more corrosion-resistant materials, and more accurate monitoring systems. This collaboration also supports the development of operational standards that are more adaptive to changing global marine environmental conditions (Macrander et al., 2021).

In the future, the application of the concept of sustainability and industrial resilience will be the main focus in the operational management of offshore platforms. Companies are not only required to maintain the sustainability of energy production, but must also be able to adapt to environmental changes, technological developments, and international regulatory demands. By integrating sustainability principles into operational risk management, the offshore industry can increase competitiveness while contributing to maintaining the balance of marine ecosystems in the long term. From a sustainability perspective, risk management on offshore platforms is also closely related to the protection of the marine environment. Extreme weather has the potential to increase the risk of oil spills, chemical leaks, or sewage system damage. Therefore, environmental protection systems such as double barrier systems, automatic shutdown systems, and spill containment equipment must be designed to remain functional in extreme conditions. This shows that offshore risk management is not only oriented towards the safety of people and assets, but also on the protection of marine ecosystems. In addition, the discussion of the article also emphasizes the importance of an asset lifecycle risk management approach. Risks not only arise during operations, but also from the design, construction, installation, to decommissioning stages of the platform. Designs that take into account long-term extreme loads, the use of corrosion-resistant materials, and predictive maintenance strategies can significantly reduce the potential for failure in the event of inclement weather. This approach suggests that risk control should be carried out proactively from the initial planning stage of the project (Adumene & Ikue-John, 2022).

Finally, technological developments such as digital twins, artificial intelligence, and predictive maintenance provide great opportunities in increasing the effectiveness of offshore risk management. This technology allows simulation of extreme weather scenarios, prediction of equipment failures, as well as optimization of maintenance strategies based on actual data. The implementation of this technology helps operators make faster and more accurate decisions, so that potential losses due to operational disruptions can be minimized. As such, the future of operational risk management of offshore platforms will increasingly depend on the integration of intelligent technology and data-driven monitoring systems. The rapid advancement of digital technologies is transforming the way offshore operational risk is managed, particularly in environments exposed to extreme weather conditions. Technologies such as digital twins allow operators to create virtual replicas of offshore platforms that can simulate structural performance, environmental loading, and equipment behavior under various scenarios. By testing different operational strategies in a virtual environment, companies can identify potential weaknesses before they occur in real operations. This proactive approach significantly improves safety planning and reduces unexpected operational failures. Artificial intelligence (AI) is also playing a major role in improving offshore safety and operational efficiency. AI systems can analyze large volumes of environmental and operational data, including wave height, wind speed, equipment vibration, and temperature changes. Through machine learning algorithms, AI can detect abnormal patterns that may indicate early signs of system failure or hazardous environmental conditions. This allows operators to take preventive action before small issues develop into major operational risks.

Predictive maintenance is another important technological advancement supporting offshore risk management. Unlike traditional maintenance methods that rely on fixed schedules, predictive maintenance uses real time sensor data to determine the actual condition of equipment. This approach reduces unnecessary maintenance activities while ensuring that critical components are repaired or replaced before failure occurs. As a result, operational downtime is minimized, maintenance costs are reduced, and overall platform reliability is improved. Furthermore, the integration of these technologies supports more efficient decision-making processes. Real-time dashboards and automated alert systems enable offshore operators and onshore control centers to respond quickly to changing environmental and operational conditions. Faster decision-making is particularly important during extreme weather events, where delays in response can increase safety risks and financial losses. Data-driven decision support systems provide a more accurate basis for operational planning and emergency response. In the future, offshore operational risk management will increasingly depend on the integration of smart technologies, automation, and data-driven monitoring systems. As digital infrastructure becomes more advanced and accessible, offshore operators will be able to implement more sophisticated risk management strategies. This technological evolution will not only improve operational safety but also support sustainable offshore energy and resource development in an increasingly challenging marine environment (Anaba et al., 2025).

5. Conclusions

Operational risk management on offshore platforms is an important element in maintaining worker safety, production system reliability, and operational sustainability of the offshore industry. Dynamic marine environmental conditions and the potential for extreme weather events make offshore platform operations have a high level of risk compared to operations on land. Therefore, the implementation of a structured and integrated risk management system is the main need to support safe and efficient offshore operations. The application of modern technology such as real-time monitoring systems, environmental sensors, and weather prediction systems has made a significant contribution to improving the ability to detect potential operational disruptions early on. In addition, the implementation of strict occupational safety procedures and the improvement of human resource competence through occupational safety training also play an important role in reducing the potential for work accidents in offshore platform operations. Integration between technology, operational management, and workforce readiness is a key factor in offshore operational risk management. In addition to technical and operational aspects, attention to the protection of the marine environment is also an important part of offshore risk management. Good risk management can help prevent marine pollution due to operational failures and support the concept of sustainable marine industry development. By integrating aspects of occupational safety, environmental protection, and operational efficiency, the offshore industry can increase operational resilience in the long term. Overall, the implementation of adaptive and sustainable operational risk management is key in facing the challenges of changing marine environmental conditions and increasing intensity of extreme weather. Through the application of appropriate technology, an effective management system, and the development of competent human resources, the operations of offshore platforms are expected to run more safely, reliably, and sustainably in the future (Adeoye Taofik Aderamo et al., 2024).

References

Adeoye Taofik Aderamo, Henry Chukwuemeka Olisakwe, Yetunde Adenike Adebayo, & Andrew Emuobosa Esiri. (2024). AI-enabled predictive safeguards for offshore oil facilities: Enhancing safety and operational efficiency. Comprehensive Research and Reviews in Engineering and Technology, 2(1), 023–043. https://doi.org/10.57219/crret.2024.2.1.0060

Adumene, S., & Ikue-John, H. (2022). Offshore system safety and operational challenges in harsh Arctic operations. Journal of Safety Science and Resilience, 3(2), 153–168. https://doi.org/10.1016/j.jnlssr.2022.02.001

Anaba, D. C., Odochi Agho, M., Onukwulu, E. C., & Egbumokei, P. I. (2025). A Predictive Maintenance Framework for Offshore Industrial Equipment: Digital Transformation for Enhanced Reliability. Engineering and Technology Journal, 10(01), 3666–3676. https://doi.org/10.47191/etj/v10i01.24

Chen, W., & Huo, E. (2023). Opportunities and challenges of ocean thermal energy conversion technology. Frontiers in Energy Research, 11(May), 1–4. https://doi.org/10.3389/fenrg.2023.1207062

Jiao, P., Ye, X., Zhang, C., Li, W., & Wang, H. (2024). Vision-based real-time marine and offshore structural health monitoring system using underwater robots. Computer-Aided Civil and Infrastructure Engineering, 39(2), 281 299. https://doi.org/10.1111/mice.12993

Kubacka, M., Matczak, M., Kałas, M., Gajewski, L., & Burchacz, M. (2021). Weather risk management in marine survey campaigns for the offshore investment projects in the polish exclusive economic zone. Weather, Climate, and Society, 13(4), 899–911. https://doi.org/10.1175/WCAS-D-20-0168.1

Macrander, A. M., Brzuzy, L., Raghukumar, K., Preziosi, D., & Jones, C. (2021). Convergence of emerging technologies: Development of a risk-based paradigm for marine mammal monitoring for offshore wind energy operations. Integrated Environmental Assessment and Management, 18(4), 939–949. https://doi.org/10.1002/ieam.4532

Novico, F., Sudjono, E. H., Egon, A., Menier, D., Methew, M., & Pratama, M. B. (2021). Tidal current energy resources assessment in the patinti strait, indonesia. International Journal of Renewable Energy Development, 10(3), 517–525. https://doi.org/10.14710/ijred.2021.35003

Rahman, M. S., Khan, F., Shaikh, A., Ahmed, S., & Imtiaz, S. (2019). Development of risk model for marine logistics support to offshore oil and gas operations in remote and harsh environments. Ocean Engineering, 174, 125 134. https://doi.org/10.1016/j.oceaneng.2019.01.037

Rasmussen, H. B., & Ahsan, D. (2022). The safety programme as a tool of improvement for safety culture in the workplace: an exploratory follow-up study from the Danish offshore oil and gas sector. International Journal of Occupational Safety and Ergonomics, 28(4), 2173–2182. https://doi.org/10.1080/10803548.2021.1985303