Offshore Platform Operational Risk Management in Extreme Weather Conditions

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Development of Non-Conventional Energy Based on Ocean Wave Energy from an Economic, Social, and Environmental Perspective

Abstract

The development of non-conventional energy is a key strategy in addressing the challenges of the global energy crisis, climate change, and the need for a sustainable energy system. One energy source with significant potential but not yet optimally utilized is ocean wave energy. Indonesia, as an archipelagic country with a long coastline, offers significant opportunities for developing this energy. This article comprehensively discusses the development of ocean wave energy as part of non-conventional energy, reviewing economic, social, and environmental aspects in an integrated manner. Economically, wave energy has the potential to become an alternative energy source that can reduce dependence on fossil fuels and open up new investment and job opportunities. Socially, this energy development can increase energy access in coastal areas and remote islands, while simultaneously encouraging local community empowerment. Environmentally, wave energy is relatively environmentally friendly due to its low carbon emissions, although it still requires proper management to minimize its impact on marine ecosystems. Using a descriptive-analytical approach, this article demonstrates that integrating economic, social, and environmental aspects is crucial to ensuring the success of wave energy development. Policy support, technological innovation, and collaboration among stakeholders are key factors in realizing a sustainable and inclusive energy system in the future.

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1. Introduction

The ever-increasing global energy demand driven by population growth and economic activity demands diversification of energy sources. Heavy reliance on fossil fuels not only leads to limited supply but also negatively impacts the environment, particularly in the form of greenhouse gas emissions.

Unconventional energy presents itself as a more sustainable alternative solution. One unconventional energy source with significant potential is ocean wave energy. This energy originates from the movement of ocean waves, influenced by wind and atmospheric conditions, making it naturally available and sustainable.

Indonesia has significant potential for developing ocean wave energy due to its geographical location, which is dominated by water. However, utilizing this energy still faces various challenges, both technologically and economically.

Therefore, a comprehensive approach is needed that takes economic, social, and environmental aspects into account. This approach is crucial to ensure that wave energy development is not only technically feasible but also provides broad benefits to the community while maintaining environmental sustainability.

a. The Concept of Ocean Wave Energy as Non-Conventional Energy

Ocean wave energy is a form of renewable energy derived from the rising and falling movement of the ocean surface. This energy can be converted into electrical energy using various converter technologies. As an unconventional energy source, ocean wave energy has distinct characteristics compared to conventional energy sources. This energy source produces no direct carbon emissions and has significant potential in coastal areas.

b. Economic Aspects of Ocean Wave Energy Development

From an economic perspective, wave energy development has the potential to improve national energy security and reduce dependence on fossil fuel imports. Investment in this sector can also stimulate new industrial growth and create jobs. However, high initial investment costs and technological limitations remain major challenges. Therefore, policy support and economic incentives are needed to encourage the development of this sector.

c. Social Aspects in Ocean Wave Energy Development

Wave energy development has significant social impacts, particularly for coastal communities. Improved access to energy can improve people's quality of life. In addition, local community involvement in the development process can increase social acceptance and ensure program sustainability.

d. Environmental Aspects in Wave Energy Development

From an environmental perspective, wave energy is a relatively environmentally friendly energy source. However, infrastructure development still has the potential to impact marine ecosystems. Therefore, a comprehensive environmental study and the application of environmentally friendly technologies are needed.

e. Challenges and Opportunities Development

Wave energy development faces various challenges, such as technological limitations, high costs, and suboptimal regulations. However, development opportunities are significant, particularly in a maritime nation like Indonesia.

2. Result

The results of the discussion indicate that wave energy has significant potential as a sustainable, non-conventional energy source. From an economic perspective, developing this sector can contribute to economic growth through job creation and new investment. Furthermore, utilizing local energy can reduce energy distribution costs, particularly in remote areas.

From a social perspective, the existence of a wave energy system can increase electricity access in coastal areas not yet connected to the national electricity grid. This contributes to improving the quality of life for communities, including in education, health, and the local economy.

Meanwhile, from an environmental perspective, wave energy has the advantage of lower carbon emissions compared to fossil fuels. However, impacts on marine ecosystems, such as habitat disturbance and changes in current patterns, need to be considered and minimized through careful planning.

In addition to these three aspects, the development of ocean wave energy also shows potential for increasing national energy independence. By utilizing locally available marine resources,

dependence on imported energy can be gradually reduced. This is crucial for maintaining national economic stability, particularly in the face of fluctuating global energy prices.

Technologically, developments in wave energy conversion systems are increasingly demonstrating increased efficiency and reliability. Innovations in device design and integration with energy storage systems enable more optimal energy utilization despite the dynamic nature of waves. This opens up opportunities for wider-scale implementation in the future.

Furthermore, the success of wave energy development also depends heavily on infrastructure readiness and policy support. Providing clear regulations, investment incentives, and streamlined licensing can accelerate the adoption of this technology. Collaboration between the government, academia, and the private sector is crucial in driving sustainable development.

However, there are challenges that need to be overcome, such as relatively high initial costs, limited oceanographic data, and technical risks in extreme marine environments. Therefore, further research and field trials are needed to ensure the system's long-term reliability and efficiency.

By considering all these aspects, ocean wave energy can be a strategic solution in supporting the energy transition towards a cleaner, more sustainable, and more inclusive system.

3. Discussion

Wave energy development cannot be done in isolation but requires an integrated approach. Synergy between economic, social, and environmental aspects is key to successful implementation.

Government policies, technological support, and public participation are crucial factors in driving the development of this energy sector. Furthermore, collaboration between the public and private sectors is also needed to accelerate implementation.

The discussion results showed that an integrated approach can increase the effectiveness of wave energy development compared to a sectoral approach. Integration of policy and planning allows for optimal resource utilization and minimizes conflicts of interest between sectors.

From an economic perspective, appropriate incentives and financing schemes have proven to be crucial factors in attracting investment. Without such support, high initial costs will be a major barrier to implementing wave energy projects.

From a social perspective, community involvement from the planning stage through operation increases project acceptance. This is crucial for avoiding social conflict and ensuring long-term sustainability.

Meanwhile, from an environmental perspective, the application of the precautionary principle and comprehensive environmental impact assessments have proven effective in minimizing potential damage to marine ecosystems. Integrating environmental aspects from the early planning stages is a crucial step in maintaining sustainability.

Furthermore, the discussion also demonstrated that wave energy development has significant potential to support national energy security, particularly for coastal areas and small islands. This system could be a more flexible and adaptive solution for energy decentralization.

However, institutional capacity building, increased research and innovation, and human resource development are needed to support widespread implementation. Without such support, wave energy development will struggle to reach commercial scale.

Thus, the results of the discussion confirmed that the success of wave energy development is highly dependent on policy integration, technological readiness, community support, and long-term commitment from all stakeholders.

4. Conclusion

Ocean wave energy is a non-conventional energy source with significant potential for development, particularly in Indonesia. With an approach that considers economic, social, and environmental aspects, this energy development can provide sustainable benefits.

Despite various challenges, the opportunities for developing ocean wave energy remain very promising. Therefore, commitment from various parties is needed to support the future development of this energy source.

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