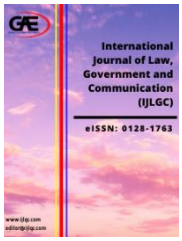
International Journal of Law, Government and Communication
EISSN : 0128-1763
Volume 9 Issue 38 (December 2024) PP. 132-153
DOI 10.35631/IJLGC.938010



INTERNATIONAL JOURNAL OF LAW, GOVERNMENT AND COMMUNICATION (IJLGC)
www.ijlgc.com

ASSESSING THE LEGAL FRAMEWORK FOR FLOATING SOLAR PHOTOVOLTAICS IN MALAYSIA: OPPORTUNITIES AND CHALLENGES IN WATER LAW AND ENVIRONMENTAL REGULATION

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Article Info:

Article history:
Received date: 03.10.2024
Revised date: 24.10.2024
Accepted date: 12.11.2024
Published date: 13.12.2024

To cite this document:

Abd Rani, M. N (2024). Assessing the Legal Framework for Floating Solar Photovoltaics in Malaysia: Opportunities and Challenges in Water Law and Environmental Regulation. *International Journal of Law, Government and Communication, 9* (38), 132-153.

DOI: 10.35631/IJLGC.938010

Abstract:

This study critically examines the legal framework governing Floating Solar Photovoltaics (FPVs) in Malaysia, identifying key opportunities and challenges within the current water law and environmental regulations. As FPVs emerge as a promising solution to the nation's land scarcity issues and renewable energy goals, their integration into Malaysia's legal and regulatory landscape remains underdeveloped. Through a doctrinal legal analysis, this research assesses existing statutes, including the Federal Constitution, Environmental Quality Act 1974, and state water enactments, alongside renewable energy policies such as the Renewable Energy Act 2011. The study highlights regulatory gaps, particularly the absence of comprehensive guidelines on water usage rights and environmental impact assessments for FPVs. Additionally, it explores the jurisdictional complexities arising from the shared governance of water resources between federal and state authorities. A case study of the Netherlands' regulatory approach to FPVs provides valuable insights for potential reforms in Malaysia. The findings emphasize the need for a coherent and supportive legal framework that addresses water rights, environmental protections, and jurisdictional coordination, fostering sustainable FPV development in Malaysia's renewable energy landscape.

Keywords:

Legal Framework, Floating Solar, Malaysia, Water Law, Environment

Introduction

Malaysia's journey into renewable energy began as a gradual but determined shift, reflecting the country's growing awareness of environmental sustainability and economic resilience. It was in the early 2000s when this momentum truly took shape, as the government sought ways

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EISSN : 0128-1763
Volume 9 Issue 38 (December 2024) PP. 132-153
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to reduce greenhouse gas emissions, diversify its energy mix, and build a foundation for sustainable growth. This marked an important moment in 2000, with the introduction of the Fifth Fuel Policy (Maulud & Saidi, 2012). For the first time, renewable energy was officially recognized as an essential part of Malaysia's energy strategy, standing alongside the established giants of oil, coal, natural gas, and hydro. This policy laid the groundwork for Malaysia's Renewable Energy Policy and Action Plan (2010), aiming to increase the share of renewable energy in the national energy mix (Kaman et al., 2019).

Despite these advancements, Malaysia's renewable energy sector has faced challenges such as limited land availability, regulatory ambiguities, and insufficient policy coordination (Jaafar et al, 2003; Lau et al., 2022). These issues have necessitated exploring alternative renewable energy technologies, such as Floating Solar Photovoltaics (FPVs). FPVs present an innovative solution by utilizing water surfaces, such as reservoirs, lakes, and even hydro dams, to generate electricity while addressing land scarcity issues (Ahmed et al, 2023). Moreover, FPVs can potentially reduce water evaporation rates and enhance solar panel efficiency (Ranjbaran et al., 2019), making them an attractive option for Malaysia's renewable energy landscape.

However, integrating FPVs into Malaysia's energy mix poses significant legal and regulatory challenges. The existing water law, environmental regulations, and renewable energy policies have not evolved in tandem with this emerging technology, leading to uncertainties regarding water rights, environmental protection, and jurisdictional conflicts between state and federal authorities. These regulatory gaps hinder FPV development and risk undermining Malaysia's broader renewable energy targets.

Research Problem

The central research problem of this study is that Malaysia's current legal and regulatory framework does not adequately support the deployment of FPVs. Key legal uncertainties include the absence of clear guidelines on water usage rights, lack of comprehensive Environmental Impact Assessment (EIA) requirements for FPV projects, and the absence of dedicated policies or incentives that cater specifically to FPV installations. These issues raise concerns about the environmental sustainability, regulatory feasibility, and potential conflicts that may arise from the use of water bodies for renewable energy generation.

Research Questions

To address the research problem, this study aims to answer the following questions:

1. Does Malaysia's water law framework adequately accommodate the use of water bodies for FPV installations, and what legal gaps exist in this context?
2. To what extent do Malaysia's environmental regulations, particularly the Environmental Quality Act 1974, address the potential ecological impacts of FPVs, and how can these regulations be improved?
3. How does Malaysia's current renewable energy policy framework facilitate or hinder the development of FPVs, and what policy adjustments are necessary to support this emerging technology?

Objective of the Study

The primary objective of this study is to critically assess the existing legal framework governing FPVs in Malaysia, identifying regulatory gaps, challenges, and opportunities for policy enhancement. By examining international best practices, the study seeks to provide

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concrete recommendations to establish a more coherent and supportive legal framework for FPV development, contributing to Malaysia's renewable energy transition.

Methodology

The research adopts a qualitative doctrinal legal analysis to assess the legal framework governing Floating Solar Photovoltaic (FPV) systems in Malaysia. This method is suitable for examining existing legal texts, statutes, regulations, and policies related to FPVs, allowing for a thorough understanding of the current legal landscape. The study also incorporates a case study approach, focusing on the Netherlands to explore how their legal framework addresses FPV systems, providing insights into possible improvements for Malaysia's context.

Data collection relies on both primary and secondary sources. The primary sources include statutes, regulations, and policies such as the Federal Constitution, Environmental Quality Act 1974, Renewable Energy Act 2011, and state water enactments. It also examines relevant guidelines like PLANMalaysia's "*Garis Panduan Perancangan Pembangunan Ladang Solar*." Secondary sources encompass academic journal articles, government reports from agencies like the Sustainable Energy Development Authority and the Ministry of Energy and Natural Resources, as well as international guidelines and publications on FPV development. These secondary sources offer context and broader perspectives on the challenges and opportunities of FPV integration.

The methodology employs a legal gap analysis framework, focusing on identifying inconsistencies, ambiguities, and deficiencies in Malaysia's current legal and regulatory framework for FPVs. This analysis reviews the extent to which existing laws, including water laws and renewable energy policies, address FPV projects. It also identifies areas where specific regulations or guidelines for FPV installations are either missing or inadequate. Additionally, the analysis examines jurisdictional conflicts, analysing overlaps between federal and state authorities and how these affect the development of FPV projects.

The study includes a case study of the Netherlands to understand how their legal framework accommodates FPV systems. This case study provides a practical perspective on how an established legal system has addressed FPV technology and offers potential lessons for Malaysia's regulatory environment. By examining the Dutch experience, the study seeks to identify practices that could inform Malaysia's approach without direct comparison but through observing the functioning of their legal structures.

In addition to legal analysis, the study incorporates a policy analysis to evaluate the effectiveness of Malaysia's renewable energy policies, such as the Feed-in Tariff (FiT) scheme, in promoting FPV projects. This involves assessing how existing policies align with FPV technology and identifying potential areas for policy enhancement.

To ensure the robustness and reliability of the findings, the research employs triangulation by cross-referencing data from various sources such as legal texts, academic literature, and government reports. This method ensures the accuracy and consistency of the analysis, enhancing the validity of the study's conclusions.

The study acknowledges certain limitations, particularly the evolving nature of FPV technology and the legal frameworks governing renewable energy in Malaysia. As the

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regulatory environment for FPVs is still developing, the analysis may not capture future changes that could impact the legal and regulatory landscape.

This methodology provides a comprehensive and structured approach to understanding the legal framework for FPVs in Malaysia, integrating doctrinal analysis, case study insights from the Netherlands, and policy evaluation. It offers a solid foundation for identifying the challenges and opportunities in regulating FPVs, contributing to more informed policy recommendations for Malaysia's renewable energy sector.

Floating Solar Photovoltaics: An Overview

Floating Solar Photovoltaics (FPVs) represent a transformative approach to harnessing solar energy, particularly in regions where land availability is limited or where land use conflicts arise. This section synthesizes recent studies and analyses on FPVs, focusing on their efficiency, environmental impacts, technological advancements, and socio-economic implications. The concept of FPVs involves the installation of solar panels on floating platforms on water bodies, such as lakes, reservoirs, and oceans. This innovative approach has gained traction since the first floating photovoltaic power station was constructed, with significant advancements noted since 2007 (Agrawal, 2024). FPVs offer several advantages over traditional land-based solar installations, including reduced land use conflicts and enhanced energy generation efficiency due to the cooling effects of water (Huang, 2023; Woolway, 2024). The ability to deploy solar technology on water bodies not only maximizes the use of available resources but also mitigates the ecological footprint associated with land-based solar farms (Silva & Branco, 2018).

Research indicates that FPVs can achieve energy gains of 15% to 25% compared to ground-mounted solar systems due to their ability to maintain optimal operating temperatures (Paul, 2023). The cooling effect of water significantly enhances the performance of solar panels, leading to higher energy conversion efficiencies. For instance, Agrawal (2024) conducted experimental studies that demonstrated the superior performance of FPVs under various environmental conditions, confirming their viability as a sustainable energy solution. Moreover, the integration of advanced technologies, such as tracking systems, further enhances the efficiency of FPVs. These systems allow for the dynamic adjustment of solar panels to optimize sunlight exposure throughout the day, which is more easily implemented in floating systems than in traditional land-based setups (Paul, 2023). This adaptability not only increases energy output but also reduces operational costs associated with maintenance and installation (Kumar et al., 2023).

The environmental implications of FPVs are multifaceted. On one hand, FPVs can significantly reduce water evaporation from reservoirs, which is particularly beneficial in arid regions (Ravichandran & Panneerselvam, 2021). This reduction in evaporation can lead to improved water conservation and enhanced water quality by limiting algal blooms, which are often exacerbated by sunlight exposure (Gamarra & Ronk, 2019). Furthermore, FPVs can contribute to carbon emission reductions by displacing fossil fuel-based energy generation, aligning with global sustainability goals (Sen et al., 2021).

On the other hand, the installation of FPVs must be carefully managed to mitigate potential ecological disruptions. Studies have shown that while FPVs can improve local ecosystems by providing shaded areas that inhibit harmful algal growth, they may also alter aquatic habitats

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and affect local biodiversity (Andini et al., 2022). Therefore, comprehensive environmental assessments are essential prior to the deployment of FPVs to ensure that their benefits outweigh any potential negative impacts.

Recent advancements in FPV technology have focused on enhancing the structural integrity and efficiency of floating platforms. Innovations include the development of hybrid systems that combine FPVs with other renewable energy sources, such as wind or hydroelectric power, to create more resilient energy systems (Solomin et al., 2021). These hybrid systems can optimize energy generation by leveraging multiple sources, thus enhancing overall efficiency and reliability (Shayan & Hojati, 2021). Moreover, the integration of smart technologies, such as IoT and AI, into FPV systems is paving the way for improved monitoring and management of energy production (Jamil et al., 2020). These technologies enable real-time data collection and analysis, facilitating predictive maintenance and operational optimization, which are crucial for maximizing the performance of FPVs (Kumar et al., 2023).

The economic viability of FPVs is a critical factor in their adoption. Studies have shown that FPVs can be a cost-effective alternative to traditional solar installations, particularly in regions with high land costs or limited available land (Goswami et al., 2019). The techno-economic analysis conducted by Abiyasa (2024) highlights the financial benefits of FPVs, demonstrating that the initial investment can be offset by long-term savings in land use and maintenance costs.

Additionally, FPVs systems offer enhanced energy security and resilience in regions prone to natural disasters by being less susceptible to damage compared to terrestrial solar installations (Huang, 2023). FPVs, installed on bodies of water, are more adaptable to harsh weather conditions such as flooding or storm surges, which commonly threaten land-based solar farms in coastal regions (Haas et al., 2019). Additionally, FPVs benefit from cooling effects of water, which improves efficiency even in extreme weather, making them reliable during critical times of energy demand (Hooper et al., 2020). This unique resilience helps secure uninterrupted energy supply in vulnerable regions.

Despite the numerous advantages of FPVs, several challenges remain. The installation and maintenance of FPVs can present unique occupational safety and health (OSH) issues, particularly for workers involved in these projects (Sen et al., 2021). Addressing these challenges is essential to ensure the safe and sustainable deployment of FPVs. Furthermore, regulatory frameworks and policies must evolve to support the integration of FPVs into existing energy systems and to facilitate their widespread adoption (Rai et al., 2020). Future research should focus on optimizing the design and materials used in FPVs to enhance their durability and efficiency. Additionally, exploring the potential for FPVs in offshore applications could unlock new opportunities for renewable energy generation (Huang, 2023; Silalahi & Blakers, 2023). As the global demand for clean energy continues to rise, FPVs represent a promising avenue for sustainable development.

Water Quality and Environmental Concerns

The installation of FPV systems presents a dual opportunity for renewable energy generation and environmental management, particularly concerning water quality. However, the ecological implications of such installations warrant thorough examination. Floating solar panels, by their very nature, alter the dynamics of the water bodies they occupy, which can lead to both beneficial and detrimental effects on water quality and local ecosystems.

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One of the main environmental concerns associated with FPV systems is their impact on aquatic ecosystems. The shading provided by the solar panels can significantly reduce light penetration into the water, which is crucial for photosynthesis among aquatic plants and microalgae. This reduction in light can lead to a decline in primary production, potentially disrupting the entire food web within the aquatic environment (Andini et al., 2022; Lima et al., 2021). For instance, the excessive coverage of floating solar panels can diminish the growth of pelagic primary producers, which may have cascading effects on higher trophic levels (Andini et al., 2022). Conversely, FPV systems can also mitigate issues such as excessive algae growth by limiting sunlight availability, thus potentially improving water quality in certain contexts (Gamarra & Ronk, 2019; Cüce et al., 2022).

Moreover, FPV installations can contribute to water conservation by reducing evaporation rates from reservoirs and lakes. This is particularly significant in regions facing water scarcity, where every drop counts. Studies indicate that FPV systems can lower evaporation by up to 90%, thereby conserving valuable water resources (Nugroho, 2024; Nebey et al., 2020). Additionally, the cooling effect of water on solar panels can enhance their efficiency, leading to higher energy output compared to land-based systems (Rai et al., 2020; Spencer et al., 2018). This dual benefit of energy generation and water conservation positions FPV as a promising technology in the context of climate change and sustainable development.

However, the introduction of FPV systems is not without challenges. The materials used in the construction of floating solar panels can leach chemicals into the water, potentially affecting water quality. Research indicates that certain polymers used in FPV systems may release harmful substances, which could pose risks to aquatic life and human health (Mathijssen et al., 2020). Furthermore, the physical presence of these installations can alter local hydrodynamics, potentially leading to changes in sedimentation patterns and water temperature, which can further impact aquatic ecosystems (Lima et al., 2021; Yang et al., 2022).

Overview of Malaysia's Renewable Energy Development

Historically, Malaysia's energy landscape has been characterized by a heavy reliance on fossil fuels, particularly natural gas and coal, which have dominated electricity generation for decades. This dependence has raised concerns regarding energy security, environmental sustainability, and the long-term viability of fossil fuel resources. In response to these challenges, the Malaysian government has initiated a strategic shift towards renewable energy (RE) through various policy interventions aimed at diversifying the energy mix and promoting sustainable development.

The transition towards renewable energy in Malaysia can be traced back to the introduction of the Small Renewable Energy Programme (SREP) in 2001. This program allowed Independent Power Producers (IPPs) to sell electricity generated from renewable sources to the national grid, marking a significant step in the country's energy policy (Aziz, 2024). However, despite these initial efforts, progress was slow due to several factors, including insufficient incentives for renewable energy adoption, regulatory barriers, and a lack of public awareness regarding the benefits of renewable energy technologies (Ilham et al., 2022).

A pivotal moment in Malaysia's renewable energy journey occurred with the introduction of the Renewable Energy Act in 2011, which established a more structured framework for renewable energy development. This legislation led to the formation of the Sustainable Energy

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Development Authority (SEDA), tasked with promoting and facilitating the growth of renewable energy in the country (Azlina et al., 2018). The implementation of Feed-in Tariff (FiT) schemes under this act significantly spurred growth in the solar photovoltaic (PV) sector, enabling a greater number of stakeholders to participate in the renewable energy market (Mansur et al., 2018).

Despite these advancements, challenges remain. Limited land availability and the rising costs of land acquisition have posed constraints on the expansion of solar PV installations (Li, 2023). These challenges have underscored the need for innovative solutions, such as floating photovoltaic systems (FPVs), which leverage Malaysia's abundant water bodies to generate solar energy without competing for valuable land resources (Ghosn, 2024).

In recent years, the Malaysian government has set ambitious targets for renewable energy integration into the national energy mix. The National Renewable Energy Policy (NREP) and the Malaysia Renewable Energy Roadmap (MyRER) aim to increase the renewable energy share to 31% by 2025 and 40% by 2035 (Salleh et al., 2020). Achieving these targets will require overcoming significant regulatory and legal barriers, particularly in the context of emerging technologies like FPVs and other innovative renewable energy solutions (Flórez & Ghazali, 2020).

The government's commitment to renewable energy is further reflected in its efforts to enhance public awareness and engagement. Initiatives aimed at educating the public about the benefits of renewable energy and the importance of energy conservation are essential for fostering a supportive environment for renewable energy projects (Sahid et. al., 2019). Additionally, the establishment of partnerships with private sector stakeholders and international organizations can facilitate technology transfer and capacity building, which are critical for advancing Malaysia's renewable energy agenda (Yusoff et al., 2023).

Significance of PFVs in Malaysia's Energy Transition

The significance of Floating Photovoltaics (FPVs) in Malaysia's energy transition is underscored by the country's strategic geographical advantages, technological advancements, and policy frameworks aimed at enhancing renewable energy adoption. As Malaysia grapples with the dual challenges of meeting rising energy demands and mitigating environmental impacts, FPVs emerge as a viable solution that aligns with national goals for sustainable energy development.

Malaysia's energy landscape is characterized by a growing reliance on fossil fuels, which has led to significant greenhouse gas emissions. The government has recognized the need for a transition towards renewable energy sources, setting ambitious targets such as achieving a 20% renewable energy mix by 2025 and a 23% target for the ASEAN region (Ilham et al., 2022; Ghosn, 2024). FPVs, which utilize water bodies for solar energy generation, present a unique opportunity to harness solar power without the land use conflicts associated with traditional solar farms. This is particularly relevant in Malaysia, where urbanization and land scarcity pose significant challenges to conventional solar installations (Lim, 2024).

The potential of FPVs in Malaysia is bolstered by the country's favourable climatic conditions, characterized by high solar irradiance levels averaging between 4000-5000 Wh/m² annually (Zaini, 2023). This abundant solar resource, combined with Malaysia's extensive network of

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lakes, reservoirs, and coastal areas, creates an ideal environment for the deployment of FPV systems. Recent studies indicate that FPVs can significantly reduce water evaporation and enhance the efficiency of solar panels by keeping them cooler, thereby improving energy output (Zhou, 2024). Furthermore, FPVs can mitigate the impacts of climate change by reducing reliance on fossil fuels and lowering carbon emissions, aligning with global sustainability goals (Essak & Ghosh, 2022).

Technologically, FPVs have seen rapid advancements, with various designs and configurations being explored to optimize performance and integration with existing energy systems. Research has highlighted the importance of integrating energy storage solutions with FPVs to address challenges related to intermittency and grid stability (Zhou, 2024). The development of smart monitoring systems, such as those utilizing LoRa networks, further enhances the operational efficiency of FPVs by enabling real-time data collection and management (Fernandez et al., 2020). These innovations not only improve the viability of FPVs but also contribute to the overall resilience of Malaysia's energy infrastructure.

Government policies play a crucial role in facilitating the adoption of FPVs. The Malaysian government has introduced several incentives and regulatory frameworks aimed at promoting renewable energy investments, including feed-in tariffs and tax exemptions for renewable energy projects (Zainuddin et al., 2021). These initiatives are essential for attracting private sector investments and fostering public-private partnerships that can drive the deployment of FPV systems across the country. Collaborative efforts between government, industry stakeholders, and local communities are vital for overcoming barriers to implementation, such as financial constraints and public acceptance (Ghosn, 2024).

The socio-economic benefits of FPVs are also noteworthy. By generating clean energy, FPVs can contribute to job creation in the renewable energy sector, stimulate local economies, and enhance energy security (Ghosn, 2024). Additionally, the integration of FPVs into urban planning can improve energy access in densely populated areas, addressing the energy needs of underserved communities while promoting sustainable development (Rababah, 2023). The potential for FPVs to serve as dual-use infrastructure—providing both energy and recreational opportunities—further enhances their appeal in urban settings.

Despite the promising outlook for FPVs in Malaysia, several challenges remain. Issues related to the environmental impact of FPV installations, such as effects on aquatic ecosystems and water quality, require careful consideration and management (Andini et al., 2022). Moreover, the high initial capital costs associated with FPV systems can deter investment, necessitating innovative financing models and risk-sharing mechanisms to encourage broader adoption (Ghosn, 2024). Addressing these challenges will be critical to realizing the full potential of FPVs as a cornerstone of Malaysia's energy transition.

National Energy Transition Roadmap

The National Energy Transition Roadmap (NETR) outlines Malaysia's commitment to accelerating its transition toward renewable energy, with a target of achieving a 70% renewable energy (RE) capacity mix by 2050 (Ministry of Economy, 2023). As part of this transition, the NETR identifies FPVs as a significant contributor to the nation’s renewable energy landscape, leveraging Malaysia’s abundant water resources for energy generation.

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The NETR aims to address the energy trilemma of security, affordability, and sustainability, and FPVs offer a sustainable solution that aligns with this objective (Ministry of Economy, 2023). Additionally, the roadmap sets a goal to reduce greenhouse gas (GHG) emissions in the energy sector by 32% by 2050, and FPVs are considered an important element in achieving this target by providing a clean energy alternative.

From an economic perspective, the NETR projects that investments in renewable energy, including FPVs, could increase Malaysia's GDP value from RM25 billion in 2023 to RM220 billion by 2050, generating around 310,000 jobs (Ministry of Economy, 2023). The roadmap also emphasizes the role of policies such as the Renewable Energy Act 2011 and the Feed-in Tariff (FiT) scheme in supporting renewable energy projects, and suggests that FPVs should be integrated within this regulatory framework. Overall, the NETR positions FPVs as a key flagship project within Malaysia's broader energy transition strategy, highlighting the government's commitment to promoting this technology as part of its renewable energy goals (Ministry of Economy, 2023).

Legal and Regulatory Landscape in Malaysia

Federalism and Water Law

The governance of water resources in Malaysia is characterized by a complex interplay between federal and state jurisdictions, as outlined in Schedule 9 of the Federal Constitution (FC). Schedule 9 places water under the Concurrent List, meaning it is a shared responsibility between the federal and state governments. However, this division is not straightforward, leading to a decentralized system where water resources are primarily managed at the state level, while water supply and services fall under federal regulation.

The FC grants state the autonomy to manage water resources within their territories. This means each state possesses legislative and administrative power over the use, management, and allocation of water resources. Consequently, states enact their own water laws, creating a diverse range of state-specific water enactments that govern matters such as water rights, licensing, and water resource protection. These enactments serve as the primary legal instruments for regulating water bodies, reservoirs, and rivers within each state.

The decentralized nature of water governance creates legal and administrative complexities, particularly when projects span multiple jurisdictions. For instance, an FPV project situated on a river that flows through multiple states may encounter different regulatory requirements, leading to potential jurisdictional conflicts. This situation is further complicated by the fact that states have differing levels of legal sophistication and resources to manage such projects. This fragmentation undermines the potential for cohesive regulation and management of water resources at the national level. For instance, the ongoing water dispute between the states of Kedah and Penang over Sungai Muda demonstrates how state jurisdiction can lead to conflicts over water rights and usage. In the context of FPV projects, similar disputes could arise if one state decides to develop FPV infrastructure on shared water resources, potentially affecting the rights and interests of neighbouring states, especially if downstream users perceive changes in water quality or flow due to the upstream FPV installation. Such impacts could exacerbate tensions and raise questions about equitable water usage rights between states.

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Besides, given that the development and use of water bodies fall under state jurisdiction, one would expect state enactments to provide clear guidance on FPV projects. However, most state water laws and regulations do not explicitly address FPVs, renewable energy projects, or the commercial use of water surfaces for such purposes. This legal vacuum creates uncertainties regarding whether FPVs can be legally developed and, if so, under what conditions. For example, state water enactments typically focus on regulating water abstraction, pollution control, and resource management, but they lack provisions on leasing or licensing water surfaces for energy generation projects like FPVs. This absence raises significant questions about the authority of state agencies to grant permits for FPVs and the legal rights of developers to operate such projects. Additionally, it leaves unresolved issues related to environmental compliance, fees, or taxes for using water surfaces, making it challenging for investors to assess legal risks or obligations when pursuing FPV development.

Critical Analysis of the Legal Gaps in State Enactments

Most state water enactments primarily address water abstraction, discharge, and pollution control, with minimal or no provisions for non-consumptive uses such as floating solar energy generation. This lack of specificity raises important questions about the legal basis for granting rights or licenses to FPV developers. For instance, there is ambiguity about whether a developer can obtain a lease or permit to install FPVs on a reservoir and who holds the ultimate authority to grant such rights. In the absence of clear FPV-specific provisions, state authorities are left to interpret existing laws, which may lead to conflicts with other water uses like irrigation, fishing, recreation, and conservation. For example, if an FPV project is proposed on a reservoir designated for drinking water, the compatibility and permissibility of such a project remain unclear. This ambiguity can lead to legal challenges, delays in project approvals, and potential disputes between FPV developers and other water users. Such uncertainty might also deter investors due to the lack of a transparent legal pathway for FPV development.

Conflicts Arising from the Overlap of Jurisdictions

The dual jurisdiction over water resources and energy regulation inevitably creates conflicts between federal and state authorities. While states have the authority to manage water bodies, energy regulation, including renewable energy policies, falls under federal purview. This overlap becomes problematic in the context of FPVs, as the projects lie at the intersection of water resource management and renewable energy generation.

Consider a scenario where the federal government, through agencies like the Sustainable Energy Development Authority (SEDA), seeks to promote FPVs as part of Malaysia's renewable energy targets. However, if a state government imposes stringent regulations or refuses to grant access to water bodies for FPV installations, the federal government's initiatives could be effectively blocked. On the other hands, state government might keen to develop the FPV project, but might receive objection from Department of Environment and Department of Town and Country Planning (PLANMalaysia) due to environmental issues. This conflict highlights the need for a coordinated approach to water and energy governance. Without clear legal mechanisms for resolving such conflicts, FPV projects face the risk of regulatory gridlock, where federal and state interests are at odds. This uncertainty can hinder the advancement of FPVs and impede Malaysia's broader renewable energy goals.

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Environmental Regulations

The Environmental Quality Act 1974 (EQA) stands as the cornerstone of Malaysia's environmental protection legislation, offering a comprehensive framework for managing pollution and advancing sustainable development. A pivotal element of the EQA is its mandate for Environmental Impact Assessments (EIAs) for activities likely to have significant environmental effects, as outlined in the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015. This order delineates various categories of projects requiring EIAs, including energy developments. However, the current legislation does not explicitly classify FPV installations as activities requiring mandatory EIAs. This omission has resulted in a regulatory gap that overlooks the distinct environmental challenges posed by FPV projects.

The absence of explicit reference to FPVs within the EQA leads to uncertainty regarding whether these projects fall under EIA requirements. This ambiguity paves the way for inconsistent application of environmental regulations, allowing some FPV projects to voluntarily undergo EIAs, while others proceed without comprehensive environmental scrutiny. Such inconsistency weakens the EQA's core objective of ensuring thorough environmental protection. Unlike traditional energy projects, FPVs can significantly impact aquatic ecosystems. For instance, large-scale FPV installations can alter water temperatures due to the shading effect, potentially disrupting the habitats of temperature-sensitive aquatic species. Additionally, reduced sunlight penetration beneath FPV panels can impede photosynthesis in aquatic plants, ultimately affecting the entire aquatic food chain. Furthermore, the installation and maintenance of FPVs may introduce pollutants such as lubricants, chemicals, or construction debris into the water. Despite these potential impacts, the current EQA framework lacks specific provisions to assess these risks, resulting in an inadequate evaluation of how FPVs might affect aquatic biodiversity, water quality, and overall ecosystem health.

Moreover, the existing EIA process is not tailored to address the unique considerations of FPV projects, meaning critical aspects may be overlooked during environmental assessments. For example, there is no stipulated requirement for evaluating the cumulative impacts of multiple FPV installations on the same water body, a factor that could become significant as more projects are developed in close proximity. Likewise, current EIA guidelines do not mandate detailed studies on how FPVs may influence fish spawning areas, migratory patterns, or the habitats of endangered species, potentially leading to environmental harm that the regulatory process fails to anticipate or mitigate.

Although FPVs are not explicitly covered in the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015, one could argue that large-scale FPV projects fit within the broader category of 'infrastructure development.' Section 34A of the EQA stipulates that EIAs are required for activities with potentially significant environmental impacts. However, the absence of clear guidelines specific to FPVs within this regulatory framework results in uncertainty about how compliance should be achieved. Similarly, Section 24 of the EQA prohibits pollution of inland waters, raising concerns about the legal consequences if FPV installations were to cause chemical leaching or alter water temperatures. Therefore, the current legislative framework necessitates either judicial interpretation or legislative amendment to clarify the environmental responsibilities of FPV operators.

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Given these gaps, it is imperative to reform and expand the EIA guidelines to explicitly include FPV projects as a prescribed activity under the EQA. Doing so would ensure that all FPV installations undergo a rigorous assessment process, accounting for their potential effects on water quality, aquatic ecosystems, and overall environmental sustainability. These expanded guidelines should mandate detailed evaluations of how FPVs may alter water quality and temperature dynamics, alongside ongoing environmental monitoring and the implementation of prompt mitigation measures to address any negative impacts. In conclusion, while the EQA offers a foundational framework for environmental protection, its failure to address the specific challenges associated with FPVs constitutes a significant regulatory gap. Revising the EQA to incorporate FPVs within mandatory EIA requirements would enhance environmental safeguards and ensure that Malaysia's renewable energy projects align with the country's broader sustainability goals.

Renewable Energy Law and Policy

The Renewable Energy Act 2011 serves as a main piece of legislation that establishes the regulatory framework and provides financial incentives to promote renewable energy sources in Malaysia, including solar, wind, hydro, and biomass energy. However, while Floating Solar Photovoltaic (FPV) systems fall under the broader category of solar energy, the Act does not explicitly address water-based solar technologies. This lack of specificity introduces legal ambiguities and uncertainties regarding how FPVs should be treated under the existing regulatory framework, especially concerning the application of incentives, tariffs, and regulatory standards.

The core mechanism of the Renewable Energy Act 2011 is the Feed-in Tariff (FiT) system, designed to encourage investment in renewable energy projects by guaranteeing fixed payments to producers for a specified period. This mechanism provides financial certainty to land-based solar installations and other renewable energy projects. However, the Act's failure to explicitly include FPVs within its provisions means there is uncertainty about whether FPV projects qualify for the FiT scheme or other incentive programs. As a result, investors and developers may be reluctant to engage in FPV projects due to concerns about the financial viability and regulatory compliance of these installations.

The absence of clear legal provisions for FPVs creates a significant challenge for developers in securing financing and investment, as financial institutions often require a well-defined and predictable regulatory framework. This lack of clarity may deter potential investors from supporting FPV projects, thereby limiting the expansion of this innovative technology in Malaysia's renewable energy sector. Moreover, without explicit guidance from the Act, FPV developers face the risk of inconsistent interpretations or applications of the FiT scheme by regulatory authorities, potentially resulting in uneven or inadequate access to financial incentives.

Additionally, while the Renewable Energy Act 2011 authorizes the Sustainable Energy Development Authority (SEDA) to set technical and operational standards for renewable energy installations, the absence of specific guidelines for FPVs means that developers lack clear regulatory guidance on the requirements for integrating FPV systems with the national grid or adhering to technical standards. This gap can lead to uncertainties in the regulatory approval process, causing delays and additional costs for FPV developers.

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Furthermore, the Act's provision that FiT approvals do not exempt renewable energy projects from compliance with other applicable laws, such as water and environmental regulations, implies that FPV projects would need to navigate multiple layers of regulatory requirements. However, the lack of coordination between the Renewable Energy Act and other regulatory frameworks, such as water laws and environmental protection regulations, adds to the complexity faced by FPV developers, making it more challenging to implement FPV projects efficiently.

SEDA, which is responsible for implementing and overseeing Malaysia's renewable energy policies, plays a critical role in the administration of incentives and the regulatory framework for renewable energy projects. However, SEDA has not yet developed specific guidelines or regulatory standards tailored to FPV systems, further contributing to the uncertainty surrounding the legal and regulatory treatment of FPVs. This gap in policy development is particularly problematic because FPVs present unique technical and environmental considerations compared to land-based solar installations, such as their impact on water quality, aquatic ecosystems, and the technical requirements for floating structures. Without clear guidelines from SEDA, developers may struggle to navigate the regulatory process, resulting in delays, increased costs, or even the abandonment of potential FPV projects.

The lack of explicit legal provisions and policy guidelines for FPVs not only creates uncertainty for developers but also poses a challenge to Malaysia's broader renewable energy goals. The National Renewable Energy Policy and Action Plan and Malaysia's commitment to international climate change agreements, such as the Paris Agreement, highlight the country's ambition to increase the share of renewable energy in its energy mix. Given that FPVs have the potential to contribute significantly to this target by utilizing water bodies for solar energy production, the absence of a clear legal and regulatory framework hampers the integration of FPVs into Malaysia’s renewable energy strategy.

To fully leverage the potential of FPVs, there is a need for a more comprehensive legal and policy framework that explicitly recognizes and supports FPV technology. This would include clarifying the eligibility of FPVs for existing incentives, adapting tariff structures to accommodate the unique characteristics of FPV projects, and developing specific guidelines that address technical, environmental, and safety considerations. Without such reforms, the current Renewable Energy Act 2011 remains inadequate for addressing the complexities of FPV projects, limiting their contribution to Malaysia’s renewable energy targets. Therefore, establishing a clear legal pathway for FPV integration is crucial for ensuring that these innovative technologies can play a central role in Malaysia's transition to a sustainable energy future.

PLANMalaysia’s Guidelines for Floating Solar Photovoltaic (FPV) Development

Department of Town and Country Planning, Malaysia Ministry of Housing and Local Government (PLANMalaysia) has developed a comprehensive guideline titled "*Garis Panduan Perancangan Pembangunan Ladang Solar*," which provides detailed guidance on the planning and implementation of FPV systems in Malaysia. This guideline serves as a technical reference for state authorities, local planning authorities, and stakeholders involved in FPV projects, ensuring that these projects are developed in a systematic, safe, and sustainable manner.

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According to the guideline, the installation of FPV systems is permissible on certain types of water bodies while prohibited in others. Specifically, the guideline permits FPV systems to be installed on abandoned mining ponds and lakes. These water bodies, often found in former mining areas, are considered suitable due to their stagnant water conditions and large surface area, making them ideal for solar installations. Another permissible location is wet retention ponds, which are often used for flood control or stormwater management. These artificial ponds can accommodate FPV systems without conflicting with their primary function. While the installation on hydroelectric reservoirs is not explicitly encouraged, the guideline allows FPV systems on these reservoirs, provided they receive approval from Tenaga Nasional Berhad (TNB) and relevant state authorities. The potential energy synergies between FPV systems and existing hydropower infrastructure make such installations beneficial.

Conversely, the guideline strictly prohibits FPV installations on certain water bodies. Reservoirs designated for drinking water supply are off-limits to avoid any risk of contamination or interference with water quality management. FPV installations are also not allowed on agricultural irrigation dams, as they may impact water distribution and quality, potentially affecting agricultural productivity. Recreational lakes are unsuitable for FPV development due to safety concerns and potential conflicts with recreational activities such as boating, swimming, or fishing. The guideline also prohibits installations in areas of scenic beauty, including locations recognized for their aesthetic, historical, or cultural significance, to preserve their natural beauty and heritage value. Additionally, environmentally sensitive areas (ESAs), classified under KSAS (*Kawasan Sensitif Alam Sekitar*) as highly sensitive environmental zones, are protected from FPV installations to safeguard biodiversity and ecological functions.

PLANMalaysia’s guideline emphasizes key considerations and requirements for FPV development. Developers are required to assess the potential impact of FPV installations on aquatic ecosystems, water quality, and local biodiversity. Although FPV projects do not always necessitate a full EIA under existing regulations, proponents must ensure that the project does not harm the water body’s ecological integrity. Furthermore, the guideline encourages the selection of sites within a 5 km radius of grid infrastructure to enhance economic efficiency by reducing transmission costs. It also emphasizes the importance of accessibility and safety in FPV design, requiring systems to include safe access points, floating walkways, and anchoring systems capable of withstanding variations in water levels and weather conditions.

Providing detailed criteria on suitable and unsuitable locations for FPV systems, PLANMalaysia's guideline plays a crucial role in balancing the promotion of renewable energy generation with the need to protect Malaysia’s valuable water resources. It ensures that FPV projects are both economically viable and environmentally responsible, contributing to the nation’s sustainable energy goals while safeguarding its ecological and scenic assets.

While PLANMalaysia’s guideline provides a comprehensive framework for Floating Solar Photovoltaic (FPV) development, it is crucial to recognize that these guidelines do not carry the force of law. They serve as a planning reference and do not override the legal authority of state governments, especially when it comes to water resources. Under the Malaysian Federal Constitution, water resources fall under state jurisdiction, granting the state government the authority to make decisions regarding the use and management of water bodies within their territory.

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In cases where a state government wishes to approve an FPV project that contradicts PLANMalaysia's guidelines, the state's authority over water resources prevails. For instance, even if PLANMalaysia identifies certain water bodies as unsuitable for FPV installation, a state government may still approve such projects if it deems them appropriate or in line with state policies. This is particularly relevant in situations where a state sees the economic or strategic benefits of developing FPV systems in areas deemed sensitive or restricted by the guidelines. Therefore, although the PLANMalaysia guidelines provide valuable technical and planning insights, they lack legal enforceability and cannot compel state governments to adhere strictly to their provisions. This situation underscores the complexity of water governance in Malaysia, where state sovereignty over water resources may sometimes lead to decisions that diverge from national planning guidelines. Consequently, while the guidelines aim to encourage sustainable and orderly FPV development, the ultimate decision-making power rests with the state authorities.

International Case Study: The Netherlands

The Netherlands is at the forefront of integrating FPV systems, supported by a robust legal and regulatory framework that addresses renewable energy goals while ensuring environmental sustainability. The country, with approximately 52,000 hectares of shallow inland water suitable for FPV deployment, has developed legal guidelines and best practices to facilitate the growth of this innovative technology (Rijkswaterstaat, 2019).

A significant contribution to this framework is the "Guide for the Licensing of Floating Solar Parks on Water," published by the Foundation for Applied Water Research (STOWA) in collaboration with the Dutch Ministry of Infrastructure and Water Management (STOWA, 2019). This guide serves as a comprehensive reference for developers and water authorities, offering insights into the permitting process, environmental considerations, and technical requirements for FPV systems. The guide emphasizes that FPV projects must obtain permits from water authorities, which involves evaluating the potential impacts on water quality, ecosystems, and other designated uses of water bodies.

The Netherlands' water management laws, particularly Dutch Water Act (Waterwet) plays a crucial role in regulating FPV installations, even though it does not specifically mention FPVs. The Water Act governs the use, management, and protection of water bodies and mandates that any structure on water body, this should include FPV projects, should not adversely affect water quality, flood protection, or other water uses, such as recreation, agriculture, or drinking water supply. This means FPV developers must conduct thorough Environmental Impact Assessments (EIAs) to ensure compliance with water regulations and obtain the necessary permits from water authorities (Waterwet, 2009). Specifically, under Chapter 6 of the Water Act, FPV developers must secure a water permit before installing floating solar systems. The law requires that FPV projects do not compromise water management objectives, ensuring the protection of water resources and ecological integrity. Additionally, the Act's emphasis on spatial planning under Chapter 4 means that FPV projects must align with national and regional water plans, ensuring compatibility with existing water usage, conservation, and flood control strategies.

The renewable energy policy landscape in the Netherlands also supports the expansion of solar energy, including FPVs. The Dutch Climate Agreement (Klimaatakkoord, 2019) sets ambitious targets for increasing the share of renewable energy to 45% by 2030, promoting solar

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technologies as a key component of this transition. This policy framework has led to various financial incentives and subsidies being made available for renewable energy projects, including FPVs, thus encouraging their development (Ministry of Economic Affairs and Climate Policy, 2019).

To complement the regulatory framework, best practice guidelines have been established, such as the "Floating PV Best Practice Guidelines" by SolarPower Europe (2023). These guidelines emphasize that FPV projects should adhere to sustainability principles, including compliance with the EU Green Deal's objectives, the Sustainable Finance Reporting Directive (SFRD), and the Corporate Sustainable Reporting Directive (CSRD) (SolarPower Europe, 2023). The guidelines encourage FPV developers to prioritize water conservation and land-use efficiency, aligning with the broader sustainability goals of the Netherlands and the European Union.

Case studies, such as the Bomhofsplas Floating PV Plant and the Sekdoorn projects, demonstrate how FPVs can successfully integrate into the Netherlands' water management and energy systems (SolarPower Europe, 2023). These projects illustrate the benefits of co-locating FPVs with other water uses, such as water treatment and recreation, while contributing to the country's renewable energy targets. Additionally, the integration of battery storage with FPV systems, as demonstrated in projects like BayWar's installation in the Netherlands, highlights innovative approaches that enhance energy efficiency and security, further showcasing the adaptability of FPV technology in the Dutch context (SolarPower Europe, 2023).

Challenges and Gaps in Malaysia's Legal Framework

The regulatory landscape governing FPVs in Malaysia is characterized by several challenges and gaps that hinder the full integration of this innovative technology into the country's renewable energy framework. One of the most significant issues is the lack of a clear and comprehensive legal framework that specifically addresses FPVs. The absence of explicit laws or regulations tailored to FPV systems creates legal uncertainties, especially concerning water rights, environmental protection, and jurisdictional authority. This legal ambiguity complicates the approval process for FPV projects, as developers face difficulties in understanding the regulatory requirements and potential compliance obligations.

The first major challenge is the overlap of jurisdictional authority between federal and state governments. Under the Malaysian Federal Constitution, water resources fall under state jurisdiction, while energy regulation is a federal responsibility. This dual jurisdiction creates a fragmented legal environment where state and federal interests may conflict, particularly in the context of FPV projects. For instance, while the Sustainable Energy Development Authority (SEDA) is tasked with promoting renewable energy at the federal level, state governments hold the ultimate authority over water bodies within their territories. This situation often leads to regulatory gridlock, where FPV projects may face delays or even rejection due to differing priorities or interpretations of regulations by state authorities.

Another challenge arises from the absence of specific provisions for FPVs in state water enactments. Most state laws governing water resources focus primarily on water abstraction, pollution control, and resource management, without addressing the use of water surfaces for renewable energy projects like FPVs. This creates a legal vacuum, making it unclear whether state authorities have the power to grant licenses or permits for FPV installations. Furthermore, the lack of guidelines on leasing or licensing water surfaces for energy generation adds another

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layer of complexity, as developers are left without a clear legal pathway to follow. This uncertainty not only discourages investment but also poses risks of potential legal disputes over water usage rights between FPV developers and other stakeholders, such as fishing communities or irrigation authorities.

The environmental regulatory framework presents additional challenges. The EQA 1974 is the principal legislation governing environmental protection in Malaysia, but it does not explicitly include FPVs as a category requiring EIAs. As a result, FPV projects often proceed without a thorough assessment of their potential environmental impacts, particularly on aquatic ecosystems. Given that FPVs can alter water temperature, light penetration, and local biodiversity, the absence of EIA requirements poses significant risks to the sustainability of water bodies. This gap highlights the need for an updated EQA framework that includes FPVs as a prescribed activity, ensuring that all FPV projects undergo rigorous environmental scrutiny before implementation.

PLANMalaysia's guidelines for FPV development, as outlined in "*Garis Panduan Perancangan Pembangunan Ladang Solar*," provide a valuable technical reference for stakeholders. However, these guidelines lack legal enforceability, meaning they serve as advisory rather than mandatory regulations. While the guidelines specify where FPV systems can and cannot be installed, such as prohibiting installations on drinking water reservoirs or recreational lakes, state governments retain the ultimate authority to approve FPV projects. This creates a potential conflict, as state authorities may permit FPV installations in areas deemed unsuitable by the guidelines if they prioritize economic or strategic benefits. Consequently, the guidelines' lack of legal power limits their effectiveness in ensuring that FPV projects adhere to sustainable and environmentally responsible practices.

The absence of specific policies or incentives for FPVs under Malaysia's Renewable Energy Act 2011 further exacerbates the regulatory gap. While the Act establishes incentives such as Feed-in Tariffs (FiT) for renewable energy projects, it does not explicitly include provisions for FPVs. This omission creates uncertainty about whether FPV projects qualify for such incentives, making it challenging for developers to secure financing or assess the financial viability of their projects. Additionally, SEDA has not yet developed regulatory standards tailored to FPV systems, leaving developers without clear guidance on technical, environmental, or safety requirements.

Policy Recommendations

To address the existing regulatory gaps and challenges in the legal framework governing Floating Solar Photovoltaics (FPVs) in Malaysia, the following policy recommendations are proposed. These suggestions aim to create a coherent, clear, and supportive regulatory environment that encourages the sustainable development of FPVs while ensuring environmental protection and efficient use of water resources.

Establish a Comprehensive Legal Framework for FPVs

The most pressing need is to establish a dedicated legal and regulatory framework that specifically addresses the development, installation, and operation of FPVs. This framework should outline the rights and obligations of FPV developers, including the processes for obtaining permits, leasing water surfaces, and securing access to the grid. A new regulation or amendment to existing laws, such as the Renewable Energy Act 2011, should be introduced to

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include FPV systems explicitly. This would provide clarity on the eligibility of FPV projects for financial incentives, such as Feed-in Tariffs (FiT), tax exemptions, and grants, thereby promoting investment in the sector.

Integrate FPVs into the Environmental Quality Act (EQA) 1974

The Environmental Quality Act (EQA) 1974 should be amended to include FPV projects as a Prescribed Activity under the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015. Making FPVs subject to mandatory Environmental Impact Assessments (EIAs) can ensure that the potential impacts on aquatic ecosystems, water quality, and biodiversity can be thoroughly assessed before project implementation. This amendment should also require FPV developers to conduct continuous environmental monitoring and implement mitigation measures to address any negative effects on the water bodies where FPVs are installed. Such regulatory oversight would ensure that FPV projects align with environmental sustainability goals.

Strengthen and Enforce PLANMalaysia's Guidelines on FPVs

PLANMalaysia's existing guidelines for FPV development should be elevated from an advisory status to a legally binding regulatory instrument. This could be achieved by integrating the guidelines into state planning laws, making adherence to them mandatory for FPV projects. This integration would provide a standardized framework for FPV development, ensuring that installations occur in suitable locations and in accordance with best practices for environmental protection. Additionally, the guidelines should be regularly updated to reflect technological advancements and emerging environmental considerations associated with FPVs.

Develop State-Level Regulations for FPV Licensing and Permitting

Since water resources are under state jurisdiction, each state should develop clear regulations for licensing and permitting FPV installations. These regulations should outline the criteria for granting access to water bodies, specify the terms of leasing or usage rights, and establish the roles and responsibilities of FPV developers in maintaining water quality and safety. States should consider implementing a standardized licensing framework that aligns with national policies to ensure consistency and predictability in the regulatory environment. This would reduce the risk of conflicting interpretations of laws and provide clearer pathways for project approvals.

Conclusion

Floating Solar Photovoltaics (FPVs) represent a critical advancement in Malaysia’s pursuit of renewable energy, particularly in addressing land scarcity while tapping into the vast potential of water resources. However, the current legal and regulatory framework remains inadequate to fully support the deployment and expansion of FPVs. This study has identified significant gaps in water law, environmental regulations, and renewable energy policies that must be addressed to ensure the sustainable growth of this technology. The overlapping jurisdictions between federal and state authorities over water resources and energy regulation further complicate the legal landscape, creating uncertainty for FPV developers. Drawing lessons from international best practices, particularly the Netherlands, it is clear that a more integrated and coherent legal framework is needed. This framework should clearly define water usage rights, mandate environmental impact assessments, and streamline jurisdictional coordination between federal and state governments. Without these critical reforms, Malaysia risks

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undermining the potential of FPVs to contribute meaningfully to its renewable energy targets. By addressing these legal and regulatory challenges, Malaysia can better align its renewable energy ambitions with sustainable environmental management, positioning itself as a leader in innovative solar energy solutions.

Acknowledgement
The author would like to extend sincere gratitude to the reviewers for their valuable insights and constructive feedback, which significantly contributed to the enhancement of this study. A special thanks is also extended to Global Academic Excellence (M) Sdn. Bhd. for accepting and supporting this article for publication.

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