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Strengthening Ireland's offshore wind policy: A review of international practices in offshore wind governance

Amiya Pandit [a,b,*], Fulya Islek [c,d], Abdollah Malekjafarian [c], Md Salauddin [d], Michael O'Shea [a,b,e]

[a] Structural & Hydro-Environmental Dynamics Group, University College Cork, Cork, Ireland
[b] ERI, University College Cork, Cork, Ireland
[c] Structural Dynamics and Assessment Laboratory, School of Civil Engineering, University College Dublin, Dublin, Ireland
[d] Environmental Hydrodynamics and Coastal Resilience Laboratory, School of Civil Engineering, University College Dublin, Dublin, Ireland
[e] School of Civil, Structural and Environmental Engineering, University College Cork, Cork, Ireland

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ABSTRACT

Offshore wind energy (OWE) has significant potential to transform Ireland's energy market. Hence, Ireland has shifted its attention to expand offshore wind sector, particularly with the fixed offshore wind, which has demonstrated commercial readiness and can help achieve the climate goals. However, the technical design of offshore wind farm for decarbonizing the electricity system is typically governed by legal framework that covers the planning and permitting. Arguably, the planning permission remains the unique obstacle for offshore wind development (OWD). To support the OWD in Ireland, this review article aims to provide justifications for resolving these issues, particularly by streamlining the consenting process, while identifying the good practices among different nations. Therefore, PRISMA based methodology is incorporated in the article to select current state of policy and legal framework governing OWDs and it adopted 11 different countries as the case study. By unpacking the review, it is revealed that several policy amendments have been approved by the policy makers to promote the sustainable development of offshore wind projects. One conclusion of this study is that adoption of one-stop-shop procedure is a good practice to ease of legal barriers, as demonstrated in several case countries. Therefore, this study advises that restructuring planning permission can significantly reduce the complexity and promote innovation in OWD. Furthermore, based on the comparison made between different case-studies selected in this study, evidence supporting Project Design Envelope (allowance of design flexibility) approach has been noticed which is extremely important to support the future developments. This PDE approach has clear potential to shift the direction of Ireland's offshore wind industry.

1. Introduction

Renewable energy sources are widely acknowledged as a sustainable alternative to carbon-intensive traditional fossil fuels. Among these, wind power [1] plays a vital role in supporting the ambitious target of reducing greenhouse gas (GHG) emissions by at least 55% by 2030 under the Paris Climate Agreement [2]. Given the 2030 target and the need to mitigate the land-based conflicts with onshore wind in populated areas, particularly visual effects and noise, a shift towards installation of larger capacity modern wind turbines with rated power from 5 MW to 15 MW [3] rotor diameter 126 m to 240 m at sea over the past decades is noticed. However, these accelerated energy technology developments, such as the need for upgrading foundation type, cable connections and onshore grid, have introduced unknown challenges that bring additional barriers [4]. Subsequently, growing competition for the use of marine areas [5], [6], (mineral drilling, tourism, fishing, etc) across different sectors has intensified the risk of environmental impacts. This further complicates OWD while posing challenges to the long-term sustainable management of marine resources [7]. Therefore, reliable and accurate assessment of offshore wind potential in marine environment is essential as it provides convincing evidence for for fair allocation while supporting the effective management of maritime space.

To regulate OWD sites, the European Union (EU) has established an

* Corresponding author. Structural & Hydro-Environmental Dynamics Group, University College Cork, Cork, Ireland.
E-mail address: apandit@ucc.ie (A. Pandit).

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application for Maritime Spatial Planning (MSP) [8–10], which is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve economic, ecological and social objectives [1,11]. The typical MSP framework is shown in Figure (1). In fact, the MSP is a practical strategy to identify when, where and how different sectors are involved in marine activities and implement an ecosystem approach for conservation of marine resources [13,14].

In response to the need for effective management of the marine boundaries, over 60 MSP initiatives have been established worldwide [15], as per the EU directive (2014/89/EU) framework to harness the wind sector. From an economic and societal perspective, MSP has been accelerated by policymakers, democrats, and researchers, as it integrates various stakeholders [16], which involves the political process. Hence, MSP is promoted as a centralised rational system where other environmental regulations or policies can integrate to achieve the desired objectives while fixing intricate socio-economic-political issues. It is important to note that there is no universal framework for MSP especially due to differences among advisory bodies and government administrations [17].

Although the widespread adoption of MSP [18] frameworks for developing the OW (Offshore Wind) market creates difficulties from both a governance and methodological standpoint, implementing these processes presents numerous challenges. One explanation lies in the limited substantive influence of key implementation tools such as Environmental Impact Assessment (EIA), which in offshore wind consenting often functions as a procedural compliance mechanism rather than a determinative element shaping project outcomes [19]. Recent contributions to the offshore wind literature underscore the growing complexity of policy, spatial planning, and stakeholder engagement in the sector [20]. [21] advance spatial analysis methodologies that integrate metocean, geoscience, ecological, and anthropogenic constraints highlighting the critical role of robust MSP in balancing offshore wind expansion with marine ecosystem protection. Further, [22]. demonstrate the ecological trade-offs through modelled benchmarking scenarios, revealing shifts in keystone species and fisheries productivity. From a governance perspective [23], emphasise the value of public dialogue in South Korea's offshore wind rollout, reinforcing the need for inclusive and transparent planning frameworks. Meanwhile [24], provide a comparative analysis on innovation system evolution in Norway and the Netherlands, illustrating how contextual factors particularly legacy industries shape regulatory and market trajectories. Collectively, these studies reinforce the argument that effective offshore wind policy must be adaptive, spatially informed, and socially embedded, particularly as Ireland navigates its own transitional pathway.

In addition to the growing body of literature on offshore wind consenting and spatial planning, recent Irish [25] and international studies underscore the critical role of design flexibility in enabling adaptive,

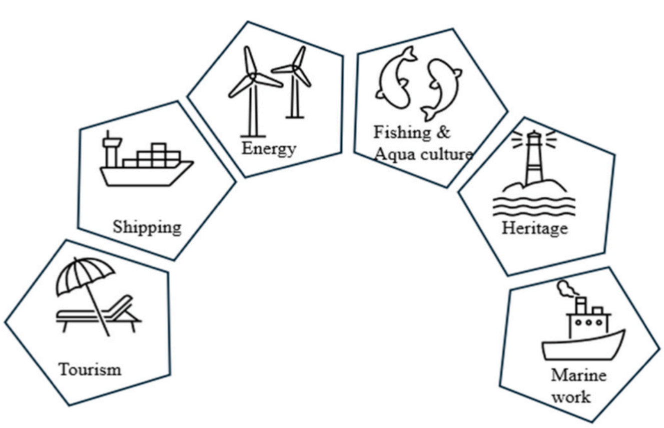

Fig. 1. MSP framework [12].

future-proofed development. The report [26] further reinforces this position, highlighting the legal and procedural uncertainties in Ireland's current framework and recommending statutory PDE guidance, variation mechanisms, and stakeholder engagement to unlock consenting efficiency. As Ireland moves toward its 5 GW by 2030 target, embedding design flexibility into policy through published PDE guidelines, variation pathways, and expanded Designated Maritime Area Planning (DMAP) [27] will be essential to ensure regulatory resilience and project viability.

Recent studies on OWD are increasingly focusing on the temporal, institutional, and governance aspects of large-scale energy transitions, as well as on improving the efficiency and adaptability of regulatory frameworks. Research on infrastructure planning and transition governance shows that the combination of policy tools a government uses in OWD planning can significantly impact the trajectory and risk profile of a project [28,29]. This combination refers to when spatial designation, environmental assessment, and market support mechanisms are incorporated into the development process. When these (spatial designation, environmental assessment and market support mechanisms) are developed asynchronously, uncertainty often creates a ripple effect across the various stages of development for developers, regulators, coastal communities and other users of the marine environment [30]. Importantly, governance scholarship highlights that OWD is not merely a technical or administrative process, but a fundamentally social and political one, shaped by how decision-making power, responsibility, and participation are distributed across actors [31,32]. Early design decisions in the regulatory process will typically create path dependencies, which will limit future adaptability and the ability of the governance systems to respond to new technology or societal changes [33]. From this larger perspective, OWD is not simply a technical challenge of deployment but is increasingly being viewed as an ongoing journey of societal change that must be governed in a manner that provides the ability to learn, coordinate and adjust over time. It follows, therefore, that there is a need for more comparative studies of the offshore wind policy and consenting architecture, particularly in contexts where regulatory policy portfolios have evolved through incremental policy layering and path-dependent adjustments rather than transformative reform [34].

Many jurisdictions have reassessed their approaches to governing their OWD, including Ireland, which has a unique position among the various nations that are studying this process. Having entered offshore wind market considerably later than many of its counterparts, Ireland faces challenge to grow its overall capacity while simultaneously establishing regulatory, permitting systems and spatial planning framework to accommodate future technological growth while also protecting the environment. To better understand how Ireland can accomplish this, the present study employs a comparative analysis of eleven different jurisdictions that are growing their offshore wind industry at different rates and have varying levels of regulatory centralisation and flexibility in their planning processes. This approach enables a comparison of the best attributes and limitations of each national framework in these jurisdictions, providing a detailed description of each. It also allows Ireland to learn from the other ten jurisdictions that have developed and continue to evolve their offshore wind industries. Even though the comparison will provide many insights for the future evolution of offshore wind governance in Ireland, these comparative insights are not intended to be directly applied to Ireland's circumstances; rather, they will be used to develop an evidence-based resource for Ireland that will assist in developing a resilient, flexible and sustainable offshore wind governance system.

A distinguished contribution of this study is to identify the unexplored research areas within offshore wind policy literature, thereby establishing foundation for the formulation of the research question.

1.1. Motivation

The aggressive ambitions for the OWDs face significant challenges when considering the associated environmental and social impacts. Discussion aimed at influencing the traditional legal framework that covers the planning and permission in connection with the innovations in the offshore wind technology becomes critical. The consenting process for the OWD is still regarded as one of the greatest non-technical barriers to their progress.

At the same time, the opacity of different policy frameworks related to offshore wind operations developed by each country varies depending on multiple variables (metrics) such as energy demand, institutional capacity, technology adoption, etc. Nevertheless, it is noteworthy that China continues to lead the world in new annual installations. Against this backdrop, this study seeks to address the main research question.

RQ1: How can Ireland's planning and permitting framework be shaped, drawing on international best practices to accelerate the OWDs?'

This led to secondary questions.

RQ1a: What are the key legal factors that hinder the offshore wind development projects across different stages of planning permission?
RQ1b: What are the research trends and opportunities that could support the adoption of Project Design Envelope approach to advance Ireland's OWDs?

1.2. Contribution

The significance of establishing effective policy and regulatory frameworks in new and emerging markets extends well beyond the OW industry itself. A central contribution of this article, therefore, lies in identifying critical interaction between planning systems and social-political systems, which has considerable research value and has direct implications for accelerating the delivery of OWD. In doing so, this study provides insight and lessons that have not previously been highlighted in existing studies. Several studies focus on comparing policy dimensions in a small group of countries, limiting their scope. A broader and more comprehensive analysis is therefore essential to uncover cross-national patterns. To address the gap, the main contribution of this article can be summarized as follows:

Identification of research gap: The review critically examines the existing policy frameworks across case study countries (UK, Denmark, Germany, France, the Netherlands, Belgium, Sweden, the USA, China, Japan and Ireland). Through comparison, the study identifies both positive and negative regulatory approach. By doing so, the article evaluates their effectiveness in advancing OWDs and offers recommendations to bridge the identified gaps.

2. Research methodology

2.1. Literature analysis process

In this study, desk-based research is conducted to gather the data from different jurisdictions. Special attention is given to reviewing the policies adopted by the governments of different countries over the last 17 years, related to OWD. However, the documents inaccessible through the internet due to privacy concerns from the official websites of government institutions and agencies are excluded from this study. The data available only in English is included in this article, despite several countries/regions are selected. A systematic review is conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement to answer the research question. The electronic publication databases Web of Science (WOS) core collection and SCOPUS have been selected as the source of information. Additionally, there are publications that are not articles but relevant to this study. These sources such as official reports or guidelines are obtained through additional searches through government and private organization websites. Therefore, the search string is restricted to slightly narrower content coverage.

All searched results are screened based on the titles, keywords and abstracts. During the identification of records, irrelevant articles to this investigation are excluded. Additional exclusion criteria are introduced to prevent duplication. Mendeley reference manager is employed to remove the duplicate records from the database. Grey literatures are excluded from the database. Separate records are created for the papers passing through the full screening. The interconnection between different keywords, relevant to the study is shown in Fig. 2

The PRISMA flow diagram for determining study collection is shown in Figure (3).

The methodology adopted here is a case study approach exploring historical research cases with the aim of scrutinising the policy frameworks for OWD. Each case study includes a brief description of environmental licences requested, licensing entities, permitting procedures and who formulates the policies. The three-phase research included in this study is shown in Figure (4).

Although the opinions vary across geographical locations, the authors utilised the data to analyse and deepen their understanding of the co-relation between different government agencies and their role in shaping the future energy landscape.

2.2. Selection of indicators

Quantitative comparison of consenting process from a variety of jurisdiction requires a defined evaluation strategy. Hence, in this study an evaluation matrix is developed for explicitly identify the co-relation between selected indicators (Spatial planning, regulatory efficiency, design flexibility, etc). This strategy includes a simple scoring system (1-5 scale) to comprehensively assess the quality within the matrix. The scoring system is the following 1 = poor, 2 = fair, 3 = moderate, 4 = good and 5 = excellent. In this scenario, the scores are also colour-coded: red, dark orange, orange, yellow and green.

3. Current constraints

Based on a range of existing studies, there is a pertinent need to explain the limitations that significantly affect the delivery of OWE [35]. Although acceptance of existing policy has often been the most used concept to accelerate these large projects, it cannot be denied that the interdependencies among legislation, supply-chain continue to minimise or balance serious threats to the environment, while maintaining national sovereignty. The debate over establishing international rules and regulations to reduce the uncertainty on ORE development not only encourages a flexible, robust policy framework but also requires coordination between funding bodies through situational conditions.

Rather than describing an exhaustive list of constraints which influence the growth of OWE, only two major constraints are focused on in this article.

3.1. Government interventions

As the offshore wind industry is upscaling to tackle climate change, this transition faces significant constraints. The coordination failure between the central government policy and industry growth strategies led to market failures, compromising the ORE development. In recent years, with the push for sustainable development, the government intend to intervene because other marine activities, such as fishing, mineral extraction, have contributed significant disruptions to the marine environment, and some overlap is inevitable when ocean water is used to harness renewable energy resources such as offshore wind. Hence, the commercialization of OWE development is regulated by the government due to its role in the national economy. Another key concern is the issue of legal permissions for ensuring the exact quantification of energy to be developed, as it brings general security concerns

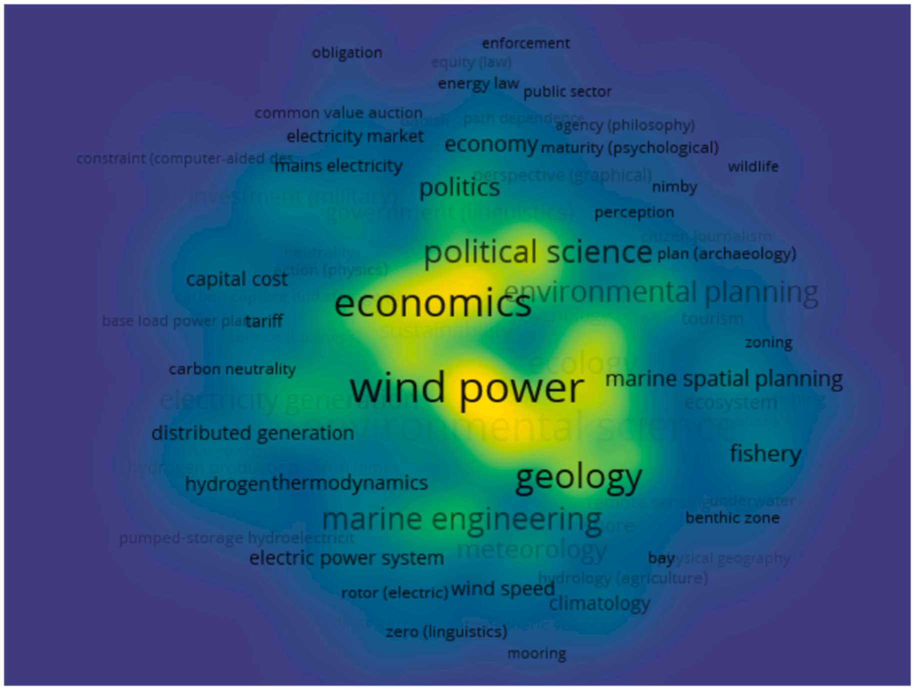

Fig. 2. Density visualization of different keywords used for the data screening.

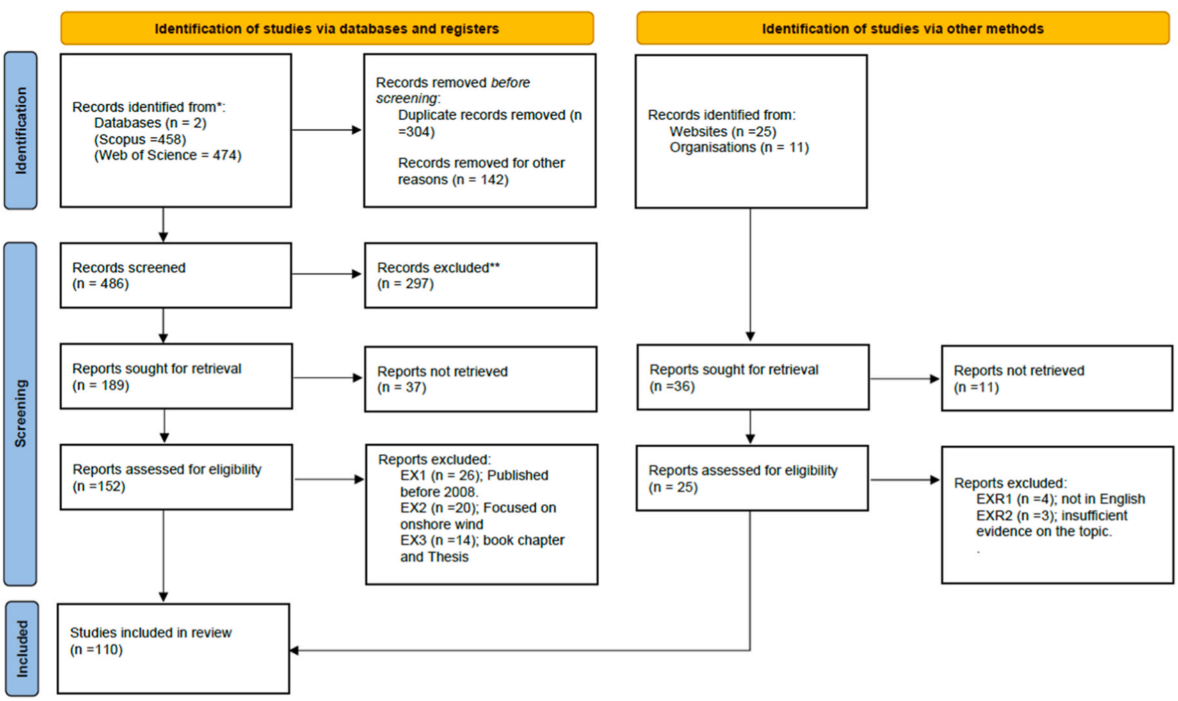

Fig. 3. PRISMA structure (http://www.prisma-statement.org/).

Fig. 4. Research phases.

for the storage and supply. Hence, it is imperative that both developed and developing nations, before reforming the policy framework to address potential disputes arising from the future growth of wind farms, closely keep track of the maturity of relevant technologies.

3.2. Economic challenges

Wind turbine technology is advancing towards multimegawatt scales, but the details of technological improvements for OWD are sparse in nature, such as lifting solutions for 15 + MW wind turbines [36–38]. These uncertainties affect the investors' confidence in projects at the very beginning. Subsequently, the absence of adequate information on uniformity and the global track record of the technologies poses a significant challenge to planning systems by limiting the opportunity for cost reduction. Although OWE has a lot of momentum, insufficient funding support still holds back production and purchasing (IEA) [39]. For instance, newly developed concrete-based foundation designs for fixed OWTs require substantial concrete production and heavy-load port infrastructure. It is evident that technologies and experiences are accumulated via demonstrated projects [40] but scaling up the different components of wind turbines (nacelle, tower, etc) substantially enhances the manufacturing complexity and material needs [41], while exacerbating challenges related to installation. The storage and transportation of these large components from different facilities to the shipyards requires trained personnel.

Therefore, a tentative model to reduce the uncertainty in the pricing mechanism of energy, which depends on water depth, shipyard conditions, is important while performing a comparison analysis across various regions. Moreover, predicting the tariff rate of electricity over a long term requires robust policies. So, to overcome the constraints it is necessary to understand current regulatory frameworks across the different countries, who urge to support the OWD.

4. Case selection

Offshore wind development is not evenly spread across the world, with Europe and Asia leading the industry. This is mainly because many countries in these regions have high population densities and limited land availability, which necessitated a strategic shift towards OWDs. Furthermore, relatively consistent strong wind speed available offshore provides significant advantage for site selection. But embracing the wind technology to enhance productivity requires the development and implementation of spectrum of strategic measures. The inherent complexity of national and international legal frameworks governing offshore wind development has driven countries to build substantial regulatory experience, progressively refining their consenting and permitting processes. While all the countries tend to address the climate issue, the policy frameworks in individual country are commonly integrated to different subsystems and influenced by political leaders. So, in this section, the authors examined the different policy frameworks, to identify the key issues that impacted the fixed OWDs in different countries. The selected case study countries have accumulated valuable lessons throughout their regulatory journeys in governing the OWDs. Most of the case study countries in this article is going through transitional phase, while gathering lessons from the group of mature markets. While USA

Is least studied. The information provided in this section recognises the rapidly evolving government level coordination as a guiding principle.

4.1. United Kingdom

The UK has installed a large capacity of offshore wind, and it is expected to reach 40 GW of offshore wind installed by 2030 [20]. Hence, the regulatory landscape for offshore wind in the UK has evolved, aiming to streamline and expedite the consent process. According to the Provisions of the Energy Act of 2004, the Crown Estate (TCE) [42,43] oversees the rights to generate electricity from wind, waves, and tides on the continental shelf in England, Wales, and Northern Ireland. Meanwhile, The Crown Estate Scotland (CES) manages the Scottish seabed, whose regulatory framework differs from the rest of the United Kingdom.

The main pieces of legislation for offshore renewable energy projects in the United Kingdom are the Planning Act 2008, the Electricity Act 1989, the Marine and Coastal Access Act 2009 and for Scotland only, the Marine Act 2010 (White & Case, 2019). Under the aforementioned Planning Act 2008, any OWD in England and Wales greater than 100 MW in capacity is classified as a Nationally Significant Infrastructure Project (NSIP) and is processed by the Planning Inspectorate (PINS). These developments require a Development Consent Order (DCO) from the Secretary of State (or the Welsh Ministers for developments in Wales) [44]. OWDs with a capacity of less than 100 MW must obtain consent under section 36 of the Electricity Act 2019, also known as an s36 Consent. The Marine Management Organization (MMO) [45] are the body responsible for issuing licenses for projects with less than 100 MW in English Waters, while in Wales, this power was transferred to Natural Resources Wales (NRW) in 2017. In Scotland, OWF projects exceeding 20 MW capacity are categorized as major developments. If approved by the Scottish Ministers, they will be issued a section 36 (s36) Consent [46]. Almost all seabed within UK territorial waters is owned by The Crown Estate or The Crown Estate Scotland [47], which are responsible for granting leases of the seabed or seabed rights to developers of OWF projects. The design envelope approach for developing OW in Scotland also falls under s36. This document considers the use of the 'Rochdale Envelope' (Project Design Envelope) approach. The precise dimensions of OWTs and their components are associated with a degree of uncertainty at the beginning of the project. Hence, the design envelope guidance is prepared on the basis of enquiries by applicants for discussions on what degree of flexibility would be seen as appropriate.

The United Kingdom's current leasing procedure involves the tendering of specific areas identified by The Crown Estate [48]. In the latest offshore wind leasing round, round 4. The UK incorporated a five-stage tender process, evaluating both bidders' capability and their proposed projects, before using option fees to determine the award. These five stages are 1. Pre-qualification questionnaire (PQQ): Assesses potential Bidders' financial capability, technical experience and legal compliance. 2. Invitation to Tender Stage 1 (ITT Stage 1): Assesses the financial and technical robustness of projects submitted by Pre-qualified Bidders. 3. Invitation to Tender Stage 2 (ITT Stage 2): A multi-cycle bidding process, using option fees bid by Eligible Bidders to determine award. 4. Plan-Level Habitats Regulations Assessment (HRA): assesses the possible impact of the awarded projects on relevant nature conservation sites of European importance. 5. Agreement for Lease (AFL): enter into a Wind Farm Agreement for Lease with successful Bidders depicted in Figure (5).

4.2. Denmark

Denmark is considered a pioneer in OWD and has played a significant role in advancing the technology and industry globally, since the installation of the world's first OWF in 1991. As of 2019, Wind energy accounted for 47% of the country's gross electrical consumption [49]. The country has ambitious targets of being completely independent of coal, oil and gas by the year 2050. Denmark has implemented a 'One Stop Shop' policy for OWE projects. The Danish Energy Agency (DEA) [50]is the authority responsible for all consenting and permitting for OWD in Denmark, acting as a central coordinating body and serving as the primary point of contact for developers seeking permits and approvals for OWDs, as shown in Figure (6). In the Danish permitting process, three licenses are required to develop Offshore wind. The first license allows the developer to conduct specific preliminary research and investigations of the proposed area where the OWD is to be constructed. The second licence, the license for the establishment of wind turbines, is granted only if the preliminary investigations from the

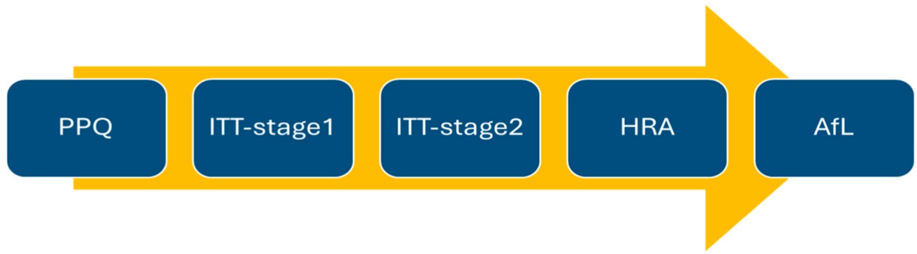

Fig. 5. Five-stage tendering procedure in the UK (Wales, England, Northern Ireland).

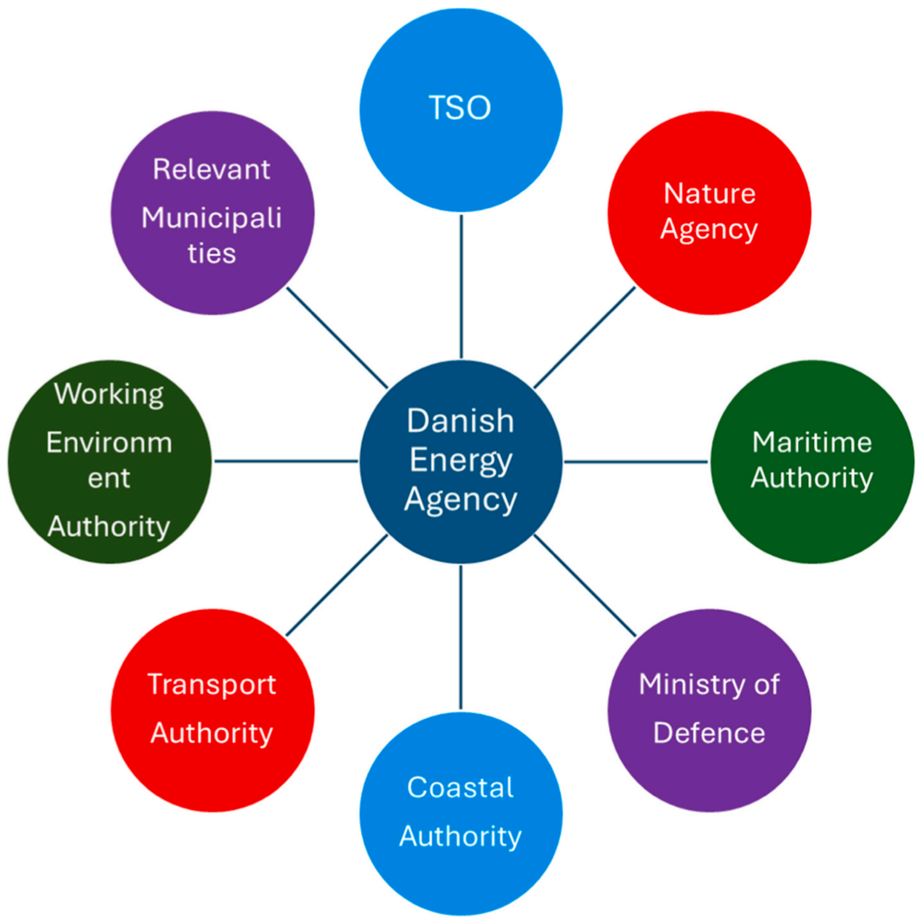

Fig. 6. One-stop shop for licensing process [51].

previous license are approved. And lastly, the license to exploit the OWD and generate electricity. The farm will only be able to produce electricity after the concession of this last license, which will only be issued if all the conditions of the process are fulfilled [52]. However, some other authorities have certain roles in the country's offshore energy regulatory process.

Danish Transmission System Operator (TSO) [53], Energinet, is an independent state-owned company that owns the Danish gas and energy transmission system. The Danish Maritime Authority (DMA) [54], responsible for regulating the transport of vessels from the coast to the

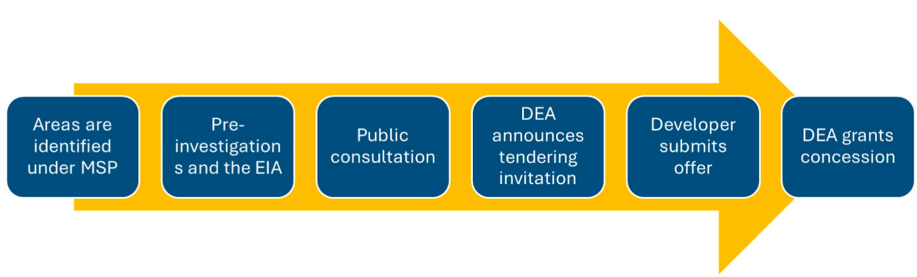

Fig. 7. Offshore wind tendering procedure in Denmark.

farm, and the Danish Nature Agency (DNA) [55], responsible for nature conservation.

There are two different procedures for obtaining consent for OWDs in Denmark, tendering and an open-door policy. The most employed procedure is the tendering process (Fig. 7), where areas are identified through the country's marine spatial planning, by an Offshore Wind Committee, consisting of the aforementioned DEA, DNA, DMA and TSO. The DEA announces a tender for an OWP of a specific size within a geographical area and invites applicants to submit bids. In Denmark's tender process, the Transmission System Operator (TSO) conducts the environmental impact assessment (EIA), geophysical and geological studies of the areas identified, and publishes the results prior to the tender opening. These previous studies aim to reduce the time of the approval process as well as provide security for the developer's investment.

In Denmark's open-door procedure [56], the developer submits a request for a license to carry out preliminary investigations in the specific area the developer wishes to develop. The DEA then conducts a hearing along with other governmental bodies to assess whether the application is appropriate, as well as any conflicts with other major public interests that could block the implementation of the project. In the event of a positive decision, Denmark's Energy Agency determines what the EIA for the site should include. Once the DEA has received the EIA together with a final application to establish the OWF, it goes on public consultation. If the DEA does not receive any objections, it grants a license to construct the OWF. Finally, the project developer must apply for a license to exploit wind power and an authorization to produce electricity, similarly to the tendering process in case of wind farms of more than 25 MW. The scheme was originally instated in 1999 and allowed for developers to initiate a development process in all waters that were not already reserved for the government's tendering of wind farms. In June 2021, a political agreement was made to limit the open-door scheme to coastal waters, within 15 km from the shoreline.

The revised legislation went into force on 1 July 2022. During the time preceding this, 44 new projects were submitted in waters outside of the 15 km limit. Many of these were large (eight were over 1 GW), which was not within the intention of the open-door scheme. Finally, Denmark's open-door scheme was permanently discontinued in late 2023 to streamline the process.

Denmark has long used a project design envelope approach for offshore renewable energy developments, to avail of the improved technology in the industry as well as the numerous other benefits it offers. As a result, environmental assessments are based on a development description that takes into account the worst-case scenario for each potential environmental impact. The Anholt OWF, completed in 2009 b y Ramboll for Energinet, faced criticisms from residents living close to nearshore OWFs (less than 8 km from shore). This is an example of the parameters for design flexibility being too wide, causing issues with projects, and the criticism caused a change in approach from the DEA.

4.3. Germany

As of 2024, Germany has an installed offshore wind capacity of over 8 GW, with plans to expand to 20 GW by 2030 [40,57] GW by 2035 [58], and 70 GW by 2045 [59,60] to align with its net-zero emissions goal [61]. Germany is indeed a global leader in the offshore wind market. The legal framework is established by the German Renewable Energy Sources Act (EEG) and the Federal Regional Planning Act (ROG). But in 2021 Offshore Wind Energy Act (Windenergie-auf-See-Gesetz WindSeeG), 7, a new maritime spatial plan for the German EEZ has come into force, replacing the first plans for the North Sea and Baltic Sea dating back to 2009.

In Germany, a “state-led” model is also applied in the development of OWE, but since 2024, the primary focus has shifted to the Exclusive Economic Zone.

OWFs in the German Exclusive Economic Zone (EEZ), between 12 and 200 nautical miles in the North and Baltic Seas, are regulated by the Federal Maritime and Hydrographic Agency (BSH) [62] in order to avoid possible conflicts arising from nature conservation and environmental protection. The BSH, apart from the Maritime Spatial Plan (MSP), also comprises the preparation of the sectoral site development plan for offshore wind. The BSH [63] has also been responsible for the testing, approval and monitoring of wind turbines and structures, as BSH is a branch of the Federal Ministry for Economic Affairs and Energy (BMWi).

Germany has implemented the “Emergency Regulation-Council Regulation (EU) 2022/2057” into national law mainly in the field of on- and OWE. Based on the MSP, a site development plan is initiated. Germany follows two tracks for the development and tendering of the sites. The current legal framework indicates a 50/50 split in-between the two tracks. The tendering procedure in the German EEZ is illustrated in Figure (8). The BSH designates sites in the side development plan for tendering, and the TSOs supply the sites with grid connections. The BNetzA tenders the sites, and the BSH handles final permitting. As a last step, the awarded bidder is informed to develop wind farms on those pre-selected sites. This centralised process aims at minimising the project risk for the developer through thorough planning, pre-investigations and guaranteed timely grid connection. Similarly, two new auction strategies are designed. For the centrally pre-investigated sites, the evaluation is done in one step, whereas for not centrally pre-investigated sites, the first step includes the developers to place bids for a market premium/subsidy. If several zero bids are submitted, the tender will be sent to the second step, where the developers place concession payment bids in a dynamic bidding procedure. At the time of preparation of this article, the authors found that a wide range PDE is not accommodated by BSH.

4.4. France

In recent years, France has established ambitious targets for renewable energy, aiming to generate 40% of its electricity from renewable sources by 2030 [27]. So far, France's renewable efforts have been mainly concentrated on onshore wind power, with the country having close to 2000 onshore wind farms installed, for a total capacity of just under 19 GW, equating to 8% of France's national electricity production. In contrast, the offshore wind industry in France is underdeveloped, having been given less focus until recent years, as France has begun to explore the offshore market. France has great offshore wind potential, with the second largest offshore wind resource in all of Europe, with a coastline over 3500 km long along 3 maritime fronts, the Atlantic. However, France has been lagging behind its European neighbours with only two operational OWFs as of 2024, these being Saint Nazaire and Saint-Brieuc OWFs with a combined total capacity of 975 MW. In recent years, France has shown determination to bridge these gaps through the implementation of a legislative and regulatory framework that greatly favours the development of OWE, making the French market a highly compelling one with immense potential for investment opportunities (Norton Rose Fulbright, 2024).

The *Conseil National de la Mer et des Littoraux* (CNML) implements the *Stratégie de la Mer et des Littoraux* (SNML). The SNML is a dynamic document that defines maritime areas suitable for offshore projects, such as FOW projects. The current legal framework in France is seen to be highly conducive to the progression of OWPs [29]. The first phase in the legislative process is the selection of a suitable area for the wind farm. This task is undertaken under the responsibility of the State and involves identifying suitable locations for building OWFs in relation to the competitive bidding procedures, all the while considering environmental constraints and concurrent marine activities. Through successive reforms, the State has made great efforts to involve all stakeholders in the country's planning process; by more effectively involving investors as well as ensuring the public is informed and participates in the

Fig. 8. Offshore wind tendering procedure in Germany.

selection process, in efforts to reduce the risk of litigation. The ESSOC Act, published in 2018, marked significant progress in the planning stage, through the implementation of a State-led public participation phase at the same time as when the areas for future projects are selected, preceding any competitive bidding procedure, ensuring the public is consulted on all decisions as to where proposed facilities are potentially located.

During this selection process, the creation of strategic seaboard documents is also utilised, whose objective is to enable various sea-based activities to be conducted concomitantly, while at the same time protecting the environment and maintaining it in sound ecological condition. These documents provide an overview of the marine environment and its ecosystem, the various activities undertaken at sea and their coexistence, as well as the country's strategic environmental and socio-economic objectives, identifying areas in which offshore renewable energy developments can be located and providing an action plan for offshore renewable energy in France [30]. France's National Regulatory Agency CRE (Commission de R'egulation de l'Energie) is an independent entity that evaluates and approves tender specifications prepared by the Directorate General for Energy and Climate (DGEC). In France, the regulation and legislation of energy policy, including OWE projects, is carried out by the Ministry for the Ecological Transition (MTECT) within the framework Energy Code (Code de l'énergie). In recent years, France has introduced a new competitive dialogue process to develop tender proposals between the administration and preselected bidders before issuing the tender specification (Norton Rose Fulbright, 2024). Originally, a simple tender procedure (see Fig. 9) is used to award projects by choosing the most economically attractive bid.

Since March 2017, a single environmental authorization is required for OWFs. This change has merged a dozen different authorisations governed by the environmental code, the forestry code and the energy code into one license in the EEZ. This unified environmental authorization procedure aims to streamline and shorten the processes and timelines for project initiators. However, in French waters, an environmental permit, along with the Convention d'Utilisation du Domaine Public Maritime (CUDPM), is required. It also seeks to offer a clearer insight into a project's environmental aspects, provide enhanced legal certainty as well as foster a deeper comprehension of the various regulations. For OWFs, a license to occupy the public domain is also required alongside this environmental authorization, which is needed to lease the seabed from the state. The French government has decided to promote a double-sided Contract for Difference (CfD) scheme. The Contract for Difference is a contract between the electricity generator and a "Low Carbon Contracts Company (LCCC)", which is a government-owned entity. Under a double-sided CfD, the project developer is obligated to remunerate the state for the negative difference between the strike price and the produced electricity's market price.

4.5. Netherlands

Up to 2019, only a few OWFs were actually in operation in the Dutch Economic Zone of the North Sea [64]. Project developers [65]are responsible for site selection and investigation, as well as having to go through the permitting process for projects, with no guarantee that the projects would be approved. With an open-door approach [66,67], it is a first-come-first-served process, or a call for competition is launched when a developer indicates its ambition to construct an ORE at a certain location. As a result, project developers faced high costs and risks before they could even apply for a subsidy. Indeed, out of 80 initial applications, just four OWFs with a combined capacity of less than 1 GW were actually built in the Dutch Economic Zone of the North Sea by that time. In September 2022, the Dutch Government presented its long-term target for offshore wind capacity by 2050. The Government set a target for 70 GW of OWE by 2050, based on the assumption that 50 GW could be installed by 2040.

As part of the Energy Agreement, the Government introduced a more proactive and supportive regulatory framework for OWD. Figure (10) shows the new, more centralised framework [68,69] tackles the disadvantages of the previous approach, in which wind farm developers were left responsible for site selection and investigation, permitting process and grid connection. It is more proactive by nature, providing favourable market conditions for OWP developers, such as legal planning of zones for long-term OWD.

The Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland: RVO. nl) [35] under the Ministry of Economic Affairs and Climate Policy acts as a one-stop shop for the Dutch offshore wind programme. It provides pre-investigated site survey data and environmental impact information (EII), ensures clear consenting and timely

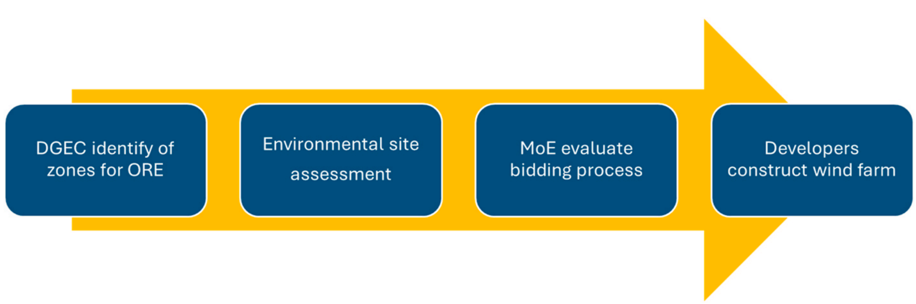

Fig. 9. Offshore wind tendering procedure in France.

Fig. 10. Offshore wind tendering procedure in the Netherlands.

permitting in one process and includes level playing field tenders. The Ministry of Infrastructure and Water Management (Min I&W) allocates areas for future wind farms together with the Ministry of Climate Policy and Green Growth. Rijkswaterstaat (RWS), an agency of the Ministry of Infrastructure and Water Management, is responsible for the Environmental Impact Assessment and the consenting process. High-quality site data is provided by the Netherlands Enterprise Agency to prospective developers of designated wind farm sites. Transmission system operator, TenneT, is responsible for all grid connection infrastructure. Meantime, Rijkswaterstaat grants consents for wind farm sites and monitors environmental impact. This approach provides greater certainty for developers, increases investor confidence, and has been proven to foster innovation and drive down overall costs for OWPs.

As per the Dutch offshore wind innovation guide, revised in 2025. In the Netherlands, all permits are combined into one, the Windvergunning. This license to produce OWE replaces the 'Water Licence' (Watervergunning) [56], which is usually required for operations that take place in the water or at sea. At the same time, the Wind Licence gives the selected project developer the right to construct and operate a wind farm within the designated area, which makes the Wind Licence a construction licence and an operation licence. The environmental impact assessment (EIA) takes place before it is clear which party is going to construct the wind farm and what the project design is going to be. A 'bandwidth approach' is used in the Dutch OWF EIA. With this approach, different alternatives concerning for example, the minimum capacity per turbine and the total number of turbines, are investigated within a certain range, i.e. environmental impact is measured for 50 large turbines and for 100 smaller turbines. The project developer of the wind farm is allowed to plan and construct the wind farm within the bandwidth indicated in the EIA.

4.6. Belgium

With nine operational OWFs, Belgium is amongst Europe's leading offshore wind markets and is the 4th largest OWE producer globally [70]. As Belgium has a federal system, some competencies are divided between the regions, while other competencies remain at the federal level. The competence concerning energy is a shared competence between the three regions, Flanders, Wallonia and Brussels. Each region has jurisdiction over its own energy policy [71].

On that basis, offshore activities are regulated by the federal state; more specifically, for OWDs, the legal framework is established under the federal Electricity Act. The Belgian OW that have been developed are located near the border with the Netherlands, ranging from the Thornton Bank to the Bligh Bank.

According to the Electricity Act and the Royal Decree of 20 December 2000, three permits and licenses are required to develop an offshore wind activity. Overview of offshore wind tendering process is given in Figure (11). More specifically, (i) a domain concession, (ii) a marine protection permit, and (iii) a cable permit is required. Moreover, within three months after the last concession, permit, or license has been granted, the Federal Minister of Energy needs to authorise the development of the OWFs. On 4 April 2019, the Belgian Parliament adopted a new law that introduces a competitive tender procedure to award domain concessions for new OWFs, where reduced subsidies are granted to offshore wind, replacing the previous procedure.

According to the Electricity Act [72], an offshore wind power developer needs to acquire a domain concession from the federal Minister of Energy. This can only be obtained after getting advice from the CREG (the Belgian Federal Commission for Electricity and Gas Regulation) on the construction and operation of the power plant in the designated marine areas. A domain concession grants a developer the right to occupy a piece in the zone designated for wind development and renders that area inaccessible to the public. Following, the concerned ministries and the CREG will, within a certain timeframe, evaluate the application and give their advice, which can contain proposals for imposing technical conditions. An OWD in Belgium needs an environmental permit, also known as a marine protection permit, that grants the holder the right to construct the installation and a license to operate. A procedure can start via a public hearing. Depending on the impact, the public inquiry can cross borders and will be held within 45 days. The application will need to provide certain mandatory information, such as the identity of the applicant as well as the financial resources for the project. An environmental impact study needs to be submitted to the MUMM [73] of the Operational Directorate Natural Environment. The MUMM then carries out an EIA and can conduct further studies, all to assess the acceptability of the impacts of the project.

Federal public service (FPS) economy co-ordinate the pre-tendering MSP for the selected zone, including the EIA with the Belgian federal Government. The Elia [74](TSO) prepares the grid connection infrastructure. Elia was previously involved in the operation and maintenance of the 'Offshore Switchyard', part of the Modular Offshore Grid (MOG) in the Belgian North Sea. In response to the exceptional market circumstances experienced in 2022 (both in terms of volatile electricity

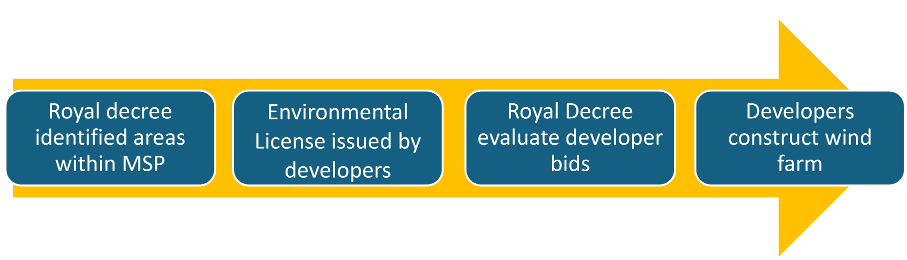

Fig. 11. Offshore wind tendering procedure in Belgium.

prices and lower-than-anticipated wind production), the one-sided contract for difference (CfD) support mechanism for these four existing wind farms has been replaced by a two-sided system. The Belgian Federal Government has taken a clear stance in favour of a two-sided contract for difference (CfD) as its chosen support model for the Princess Elisabeth Zone in four wind farms (Rentel, Norther, SeaMade and Northwester 2). The one-sided contract for difference (CfD) support mechanism is replaced by a two-sided CfD, where the Belgian federal government pays the developer the difference between the market price and the strike price.

4.7. Sweden

In Sweden, the offshore industry has 138 OWF projects in various stages of planning and development phase; 14 projects already approved; 0 projects under construction; 5 projects in the operational phase, 10 OWFs in the Swedish economic zone are waiting for government decision, and the Swedish government rejected 13 OWPs in the Baltic Sea, citing defence concern [75].

Sweden uses open open-door system, also termed as 'Box Model', allowing companies to submit proposals, but this brings conflict of interest among the developers when bidding for the same sites. In Sweden, it is possible to construct a wind park without specifying the exact location of the wind turbines during the permitting procedure, but only later, during the construction phase. The tendering process is outlined in Figure (12). The system is called the 'Box Model', and it allows the developer to have more flexibility in the placement of the turbines and the technology used [76].

Within the Swedish territorial sea [77,78], the legal procedure for establishing a wind farm is similar to the process on land. The time to develop an OWF can vary from 7 to 10 years or even more, and the life expectancy of a project is between 25 and 30 years. The Swedish government announced that the Swedish Energy Agency will be in charge of Creating Sweden's first offshore marine plan to identify suitable areas for the offshore wind industry [79,80]. The Swedish Agency for Marine and Water Management (HaV) is responsible for the marine spatial planning (MSP) process, which is the pre-Tender preparation. Further Environmental Impact Assessments (EIAs) and Strategic Environmental Assessments (SEAs) are conducted to evaluate potential impacts and set guidelines.

In Sweden, there is no one-stop shop to get a permit, authorization or concession for an OWD. Depending on the Territorial Sea or EEZ (EEZ Act 1992:1140), one or more permits may be needed, such as a permit to use public waters, a permit for exploration, a building license, or a concession for an electrical cable. Developers can apply to OWFs anywhere in the Swedish Sea. However, when it comes to the Territorial Sea, all projects need to have the approval of the municipalities (decentralised approach).

This could be different in the EEZ, as the government can assign priority areas for OWPs and the energy sector. For projects in the Exclusive Economic Zone (EEZ) or areas of national interest, the Swedish government directly oversees or influences the process. The development of offshore wind in Sweden is governed by a combination of national laws and EU directives. At present, Sweden has not introduced auction based tender procedure.

4.8. USA

The USA's offshore wind market is expected to experience tremendous growth over the next decade, with the NREL (National Renewable Energy Laboratory) estimating the United States's OWE pipeline to have over 52,000 MW of capacity, as of May 2023 [81]. This is the sum of all installed projects, projects under construction, projects approved for future construction, projects undergoing various state and federal permitting processes, as well as projects in the early planning stage [82]. The majority of projects advancing through these different stages are situated in the Northeastern and mid-Atlantic regions of the United States [83]. However, recent regulatory developments in the Pacific and Gulf of Mexico indicate a growing trend towards broader geographical diversification and enhanced economic feasibility for OWE throughout the nation. The USA has set a goal of deploying 30 GW of offshore wind capacity by 2030, an ambitious target considering offshore wind in the United States is still in its infancy, with a regulatory framework that has yet to be tested by large-scale OWDs.

In the United States, the Bureau of Ocean Energy Management (BOEM) [84]and the Bureau of Safety and Environmental Enforcement (BSEE) [85] are the primary regulators responsible for renewable energy projects. BSEE is responsible for the development, oversight and enforcement of safety and environmental standards for the offshore energy operations. BOEM is the main federal agency responsible for managing energy development on the outer continental shelf (OCS). Licencing processes differ depending on if the development is located in state or federal waters. State oceanic waters cover the first three nautical miles measured outwards from the coast, with the exception to Texas and Florida, where it is set at 9 nautical miles. Federal oceanic waters extend from the outer boundary of the state oceanic waters to the outer limit of the exclusive economic zone, which is up to 200 nautical miles from the coast. It is expected that developments in federal waters will likely be the norm for the offshore wind industry in America to ensure an adequate distance from coastal communities as they develop these large-scale projects. However, the federal government must still coordinate with states, especially where grid interconnection is involved.

The licensing framework in the United States is a complex system involving multiple authorities [86] and agencies, in which a large amount of legislation is applied in both federal and state waters. The overall tendering process is summarized in Figure (13). The decentralised framework poses uncertainty to the development of offshore wind. Developers interested in developing an OWF project in federal waters must obtain a lease for the occupation of the outer continental shelf issued by the BOEM. These leases are issued via an auction process, awarded to the highest bidder. Federal permitting in the United States involves several major steps after a lease area is acquired. First, BOEM reviews and approves the site assessment plan (SAP) that enables the developer to begin collecting data on the lease area. The developer will then submit a Construction & Operations Plan (COP).

4.9. China

China's renewable energy installation capacity has reached 1213 GW at the end of 2022, with year-on-year growth of 2.5%. As of October 2024, China marked a 19.8% increase in wind power capacity [87–89].

Fig. 12. Offshore wind tendering procedure in Sweden.

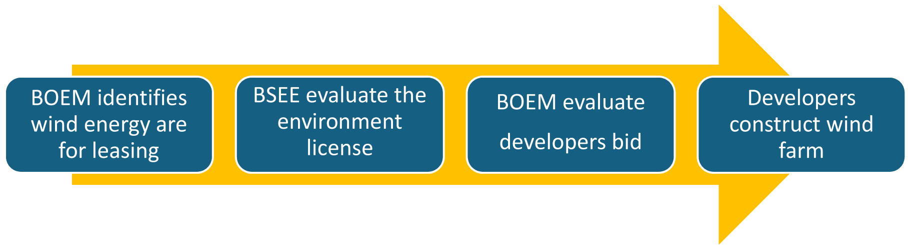

Fig. 13. Offshore wind tendering procedure in USA.

Besides, China officially issued the 14th Five-Year Plan for Renewable Energy Development (14th Five-Year Plan) on 1 June 2022, applicable from 2021 to 2025, which set the following targets: (i) 50% increase in renewable energy generation (from 2.21 trillion kWh in 2020 to 3.3 trillion kWh by 2025), (ii) 50% of China's incremental electricity and energy consumption shall come from renewables over the 14th Five-Year Plan period; and (iii) 33% of total electricity consumptions shall come from renewable energy sources by 2025. The regulatory framework for OWD projects in China is particularly challenging because it is comprised of a complex set of rules at the national and local levels (sometimes inconsistent with each other). The Energy Law of the People's Republic of China published guidelines to streamline the overall framework governing the entire energy sector, including offshore renewable energy, while adopting a hybrid consenting model. However, China followed a decentralised consenting model until 2016. One of the main authorities involved in China for the development of offshore wind is the National Energy Administration (NEA: A bureau administered by the NDRC), which oversees the energy sector. At the central level, the NEA is responsible for issuing a nationwide offshore wind power development plan (Offshore Wind Power Plan), while its branches at the provincial level (Local NEA) are entitled to formulate their own local Offshore Wind Power Plans [90]. The NEA's responsibilities also include the administration of the planning, development and construction of offshore wind power projects, the selection of offshore wind power projects and their developers through competitive procedures, and the issuance of the Project Approval (as defined below) and business licence for electricity generation. A business license is a certificate of incorporation of a company. It is a document required for all businesses involved, including the Contractor, to be able to engage in any offshore project within China. The State Oceanic Administration (an administrative agency incorporated into the Ministry of Natural Resources (MNR) in 2018) (SOA) and its local branches (Local SOA) are responsible for approving the sea areas where projects are carried out, providing the Certificate of Use of Sea Areas which certifies the right to use the areas, approving the installation of the submarine cables, and approving land use and construction [90]. The Ministry of Ecology and Environment (MEE) and its local branches are responsible for reviewing and approving oceanic project environmental impact assessments. The NDRC is responsible for determining the feed-in tariff for offshore wind power projects. The MOF is responsible for controlling and distributing subsidies and funds for offshore wind power projects (as central subsidies are being phased out, local subsidies may be granted by local authorities). The Ministry of Science and Technology (MOST) is responsible for promoting research and technology in offshore wind power projects. The Ministry of Housing and Urban-Rural Development (MOHURD) is responsible for issuing the construction-related approvals and permits for construction activities on land. The State Administration for Market Regulation (SAMR) is responsible for issuing national technical standards. In particular, the SAMR and the Standardisation Administration of China published the National Standard GB/T 51, 308-2019 Design of OWF that is applicable to offshore wind power projects.

As illustrated in Figure (14) offshore wind power projects and their developers are selected by the Local NEAs through a competitive procedure (Competitive Allocation Scheme), pursuant to the administrative guidance for competitive allocation of wind power projects. The competitive allocation scheme applies to all centralised onshore and offshore wind power projects. Each local NEA adopts its own rules, issued pursuant to the competitive allocation guidance. Some provinces have specific competitive rules for offshore projects, while other provinces have issued a single set of rules covering both onshore and offshore projects. However, the competitive allocation guidance divides projects into two categories such as pre-defined and non-predefined developers.

4.10. Japan

In 2018, Japan enacted the Act on Promotion of Use of Marine Areas for Development of Marine Renewable Energy Generation Facilities (the Offshore Wind Act) to enable business operators to operate OWPs in those areas outside these port areas but within Japan's territorial waters [91]. Because the basis for granting the right to use territorial sea areas was drawn from the Port and Harbour Act (PHA), together with local government ordinances on the management of national property (LGO). Essentially, pursuant to the Offshore Wind Act, the Ministry of Economy, Trade and Industry (METI) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) are empowered to designate certain prescribed general sea areas as “Promotion Areas”.

Another important development came in July 2020 [92], with the establishment of the Public-Private Sector Council. Its goal is to (i) strengthen the offshore wind industry's competitiveness by promoting the introduction and expansion of offshore wind power generation through the Renewable Energy Sea Areas Use Law, (ii) strengthen the

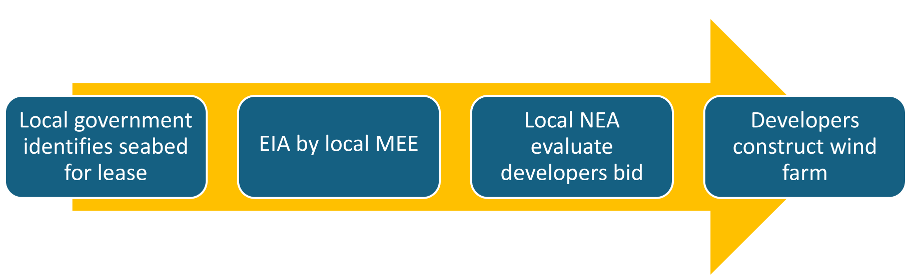

Fig. 14. Offshore wind tendering procedure in China.

competitiveness of related industries, and (iii) develop domestic industrial clusters and infrastructure in a manner that unites the public and private sectors. The council's Offshore Wind Industry Vision of 15 December 2020 (first edition) ("First Industry Vision") states that the government's targets for the introduction of new projects are: "for the next ten years, to continue designating areas for projects producing approximately 1 GW annually. Japan aims to achieve 10 GW of installed offshore wind capacity by 2030 and 30 to 45 GW by 2040. Japan's EEZ is the sixth largest in the world and has great potential. Business operators intending to submit a bid for a Promotion Zone should initiate a consultation process with the fishery trade associations that are members of the Council to determine whether an offshore wind facility could cause any adverse impacts on the fishery activities on the relevant site. If any adverse impacts are identified through the consultation process, the government will not designate the site as a Promotion Zone [93,94].

Four ministries, the Ministry of Environment (ME), the Ministry of Agriculture, Forestry and Fisheries (MAFF), METI and MLTI are involved in regulatory reforms of the offshore wind in Japan.

But the inability of ME to update the survey maps for different sites gradually gives rise to the New Energy and Industrial Technology Development Organization (NADO), an institution affiliated with METI, to integrate all national maps relevant for offshore wind selection. The different stages of tendering process in Japan for offshore wind development are shown in Figure (15).

METI and MLTI collect various available information which may evidence conformity to the criteria for Promotion zone, such as the Promotion Zone must be at an appropriate distance from secured sailing routes, grid connection between the offshore renewable energy facilities, hydrographic conditions, and suitable base ports for offshore wind power. Moreover, too big and uneconomical Promotion zones are avoided, and references are determined with European market figures. In November 2020, a special task force called the Full Check Taskforce on Renewable Energy Regulations was established under the leadership of the Minister of State for Regulatory Reform. The primary objective of the reform is to integrate the licensing system for offshore electricity generation facilities and the EIA. Further, METI and MLTI form a council and assess, designating the zone. It takes approximately ten months to collect all the relevant information and complete the procedures set out in these steps. However, before construction activities, the successful developers must complete the EIA.

Depending on the area where the facility will be developed, permissions from the local governor and/or other governmental authorities will be necessary.

4.11. Ireland

Ireland's ambitious 2030 renewable energy targets have put a great emphasis on OWE to power the nation [95]. As a result, Ireland has made wholesale changes to the country's marine energy regulatory framework [96]. Until recent years, Ireland's offshore wind consenting process was fragmented and underdeveloped, requiring developers to obtain different consents, including a foreshore site investigation license, planning permission from the relevant local authority, numerous marine consents, as well as consent from the Commission for Energy Regulation for OWDs. This process was confusing and very time-consuming. However, in recent years, Ireland has begun to enhance and streamline their legal and administrative framework to support offshore renewable energy developments and make use of its advantageous location. The Maritime Area Planning (MAP) Bill, which passed through the Oireachtas in December 2021, established a new planning regime for the maritime area in Ireland. Its purpose was to fix the lack of cohesion in Ireland's marine planning consent regimes. To accomplish this goal, the Bill aims to establish a new legal framework for Ireland's maritime zone, merging existing foreshore, planning, and environmental procedures into a unified and simplified consent process [97]. The Bill represents a key element of great progress in marine management reform, including Ireland's National Marine Planning Framework (NMPF), introduced in July 2021.

Under the MAP Act, the Irish Government introduced the creation of a new agency dedicated to the licensing of projects and developments within Ireland's Offshore Renewable Energy sector. Established as the Maritime Area Regulatory Authority (MARA), it commenced operations on July 17, 2023, demonstrating the government's commitment to streamlining the regulatory framework for offshore renewable energy projects, while promoting sustainable development. MARA's responsibilities include evaluating applications for Maritime Area Consents (MACs), which are prerequisites for developers of offshore wind and other maritime projects to submit planning applications. In essence, a MAC serves as an entry point into the Irish planning system. Without it, an applicant cannot obtain planning permission. A MAC authorises occupation of the maritime area, while the corresponding planning permission is overseen by A Bord Pleanála and local coastal authorities.

However, evaluating MAC applications for the maritime area represents just one facet of MARA's responsibilities. The agency is also tasked with issuing marine licenses for designated activities, ensuring compliance and enforcement of MACs, licenses and offshore development consents. Conducting investigations and prosecutions, managing the existing Foreshore consent portfolio, as well as promoting cooperation among maritime area regulators. MARA is anticipated to play a crucial role in advancing Ireland's ambitions in the Offshore Renewable Energy sector. Moreover, the agency will facilitate the delivery of other strategically significant projects such as cabling and telecommunications initiatives, port development, and more. By doing so, MARA will assist the State in capitalizing on the substantial benefits of transitioning to a low-carbon economy, enhancing energy security, and unlocking new avenues for economic growth.

The Maritime Area Planning (MAP) Act 2021 provides for forward marine spatial planning through the establishment of DMAPs, which can be used to develop multi-activity area plans or to promote the use of specific activities. Regarding ORE, DMAPs will identify and designate specific marine areas within which these developments are permitted to take place. This approach is consistent with the National Marine Planning Framework (NMPF), which ensures that developments in Ireland's marine areas, including OWPs, are carried out sustainably and strategically.

To achieve the 5 GW target of fixed OWD by 2030, as well as a further 2 GW of floating offshore wind, Ireland has created a programme consisting of 3 separate phases to establish the building blocks for a

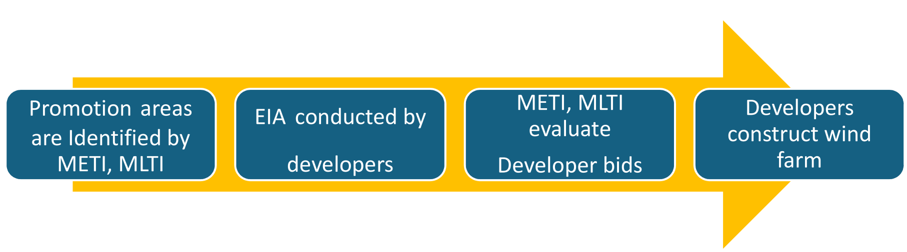

Fig. 15. Offshore wind tendering procedure in Japan.

long-term sustainable offshore renewable energy industry in the country. The first phase aims to secure the development of the largest possible proportion of the government's 5 GW of OWE target, to the onshore grid by 2030, while also establishing Ireland's new legislative, regulatory and policy framework for offshore renewable developments. This involved the establishment of the MAP Act, the new National Marine Planning Framework, as well as the creation of MARA and new Maritime Area Consents (MACs) as outlined earlier. Phase 1 also included Ireland's very first Offshore Renewable Energy Support Scheme auction (ORESS 1). Six 'Phase one' projects were awarded MACs and were allowed to participate in the auction, with four of the six projects that bid in ORESS 1 awarded long-term contracts based on the strike price they submitted, these being Codling Wind Park, Dublin Array, North Irish Sea Array and Sceirde Rocks. The unsuccessful projects will be afforded a time-limited opportunity to secure an alternative route to market via a Corporate Power Purchase Agreement (CPPA) before the expiration of Grid Connection Assessments (GCAs) provided by EirGrid. The current timeline for unsuccessful projects to negotiate an alternative pathway to access the Irish market is three months from the initiation of the planning consent process with A Bord Pleanála, as set by the Commission for Regulation of Utilities (CRU). Should no agreement be reached within this period, the developer will be obligated to relinquish their Grid Connection Assessment. Ireland's tendering process is elaborated in Figure (16).

Phase 2 of Ireland's offshore wind plan aims to procure the remainder of the 5 GW target, with the volume and location of these new OWFs depending on the availability of Ireland's onshore grid capacity. One of the key differences in Phase 2 is the introduction of a new plan-led approach. In this approach, the State is responsible for designating areas for renewable energy development through the creation of DMAPs, as well as having greater general control over Ireland's OWD. As of this moment, there is currently one proposed DMAP for an area off the south coast with an aim to acquire between 700 and 900 MW of offshore wind capacity in this area during Phase 2. Ireland's competitive auction (ORESS 2.1) process will once again be utilised, but instead participants will be competing for a pre-established benchmark volume of offshore wind capacity to be developed. All Phase Two projects will similarly require a Maritime Area Consent (MAC) to be eligible to apply for planning permission. However, in Phase 2, MACs will be obtained after ORESS auctions. At the moment, ORESS 2.1 is expected to take place in early 2025. Under this plan-led approach, the Government will play an increasingly involved role during project development, including through the oversight and commissioning of marine surveys as well as environmental assessments, while guiding project design envelopes.

5. Comparative policy analysis

Building upon the systematic approach established in Section 4, this comparison applies a standardised protocol across all the case studies to ensure consistency in evaluation. The scoring system adopted in this study is based purely upon the functional assessment of legal frameworks across different states. The clear reason for selecting this technique is that the high ambitions of OWD are significantly influenced by certain parameters. Accordingly, the underlying factors are compared and ranked to identify, whether the progress toward wind energy legal strategies has been positive or negative. It should also be noted that there is no statistical data used in the evaluation, rather it is mere qualitative comparison.

Each indicator is assessed on a 5-point scale enabling direct comparison between jurisdictions as discussed in sub section 2.2. A structured synthesis of these scores is detailed in Figure (17) below, providing a robust framework for interpreting the data across multiple dimensions. The structured matrix is used to illustrate how the five indicators affect the OWDs depending upon the values assigned.

Despite the growing demand for ORE development, particularly offshore wind turbines, the permitting duration remains onerously long and highly uncertain. This uncertainty is largely driven by iterative feedback loops between project scoping and construction planning, where evolving assessments of metocean conditions, geotechnical constraints, turbine capacity, and foundation type repeatedly influence project design. As a result, anticipated permitting durations vary substantially by project scale and national regulatory frameworks, especially across coastal states. Both Germany and the Netherlands have the shortest permitting duration of 4-5 years, where France has the lengthiest. The shortest permitting duration is scored 5. In Ireland, the consenting process for 900 MW offshore wind farm in SC-DMAP is set forth. In parallel, several other projects on the east coast are under the consenting process, which is surprisingly lengthy. Both Japan and Ireland scored 1, in this analysis and reflected in the heatmap. Following, Germany and the Netherlands, UK has the shortest permission duration which is 5-6 years among the assessed countries. In contrast, most other nations report permitting durations ranging from 8 to 12 years and are scored accordingly.

MSP has been revised based on the raised awareness on protecting marine resources [98–101]while facilitating the economic growth of individual states. While discussing MSP to achieve sustainability, a significant criticism has been noticed featuring 'hard' and 'soft' [102] sustainability. This dichotomy is grounded in the degree of substitutability permitted between environmental capital and economic growth, with hard sustainability rejecting such substitution and soft sustainability allowing it to varying extents. Here, France has oriented its MSP to take up future challenges while identifying 13 promising zones, scored 5, in the table. Similarly, Belgium, UK and Ireland have focused on achieving balance between marine space, scored 4. Germany, scored 3 in the analysis, although it has higher potential for offshore renewable energy production, the MSP in North Sea and Baltic Sea has become more complex [103] since 2021, due to revision of German EEZ. Also, German MSP is influenced by regional coastal protection. In the Netherlands, a lower number of zones are identified within MSP when compared to France, UK, Belgium, Ireland and Germany, so scored 2 in this analysis. The Dutch ministry has not specified port-related activities as a distinct sector within MSP which outline strategic challenges to the already identified areas certainly affecting the activities (oil and gas, Defense, sand extraction etc). This lack of explicit sectoral recognition becomes bottleneck for ORE development [104]. The remaining jurisdictions considered, score 1. These nations have prioritised the area for offshore renewable energy, but the MSP required to enable adoption. These countries can strengthen their MSP framework by ensuring

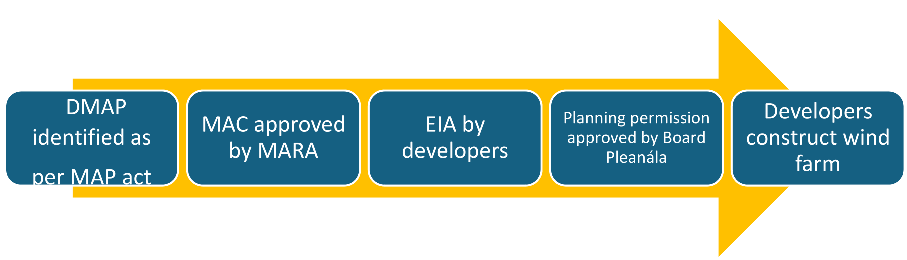

Fig. 16. Offshore wind tendering procedure in Ireland.

Countries	Denmark	Germany	Netherlands	France	Belgium	Ireland	Sweden	UK	USA	Japan	China
Permitting duration	3	5	5	2	2	1	3	4	2	1	1
MSP	1	3	2	5	4	4	1	4	1	1	1
Licensing process	5	5	5	4	3	4	2	4	3	2	3
Technology adoption	4	5	1	1	1	1	1	1	3	2	2
Policy coherence	5	3	3	4	4	3	2	4	2	2	2

Fig. 17. Overview of comparative analysis.

essential alignment, while identifying best practice across different nations.

The comparative efficiency of each jurisdiction is also analysed so that the licensing process for OWD is analysed. The comparative analysis highlights clear differences among juridictions, providing strong justifications for the adoption of best practice, an essential step toward achieving the sectors ambitious and time-sensitive objectives. The three states, Germany, Denmark and the Netherland have adopted a centralised regulatory model supported by a dedicated one-stop-shop authority directed towards streamlined legal frameworks. This approach has demonstrably reduced administrative complexity, improved coordination among permitting bodies, and enhanced overall process efficiency. Hence, these are assigned the highest score in this assessment. Neither China nor Japan currently operates a one-stop-shop permitting organization, which constrains regulatory efficiency in comparison with leading European jurisdictions except Sweden. In a direct comparison between China and Japan, China has implemented a decentralised hybrid model, whereby provincial governments retain significant regulatory authority to accelerate offshore wind deployment. Although China lacks a formal one-stop-shop [105] organization, this hybrid decentralisation has proven relatively effective, particularly because offshore wind resources are predominantly concentrated in the eastern and south-eastern regions.

Another critical dimension of comparison concerns the rate of technology adoption in offshore wind development. Germany emerges as a clear leader, driven by the rapid deployment of advanced turbine technologies, including larger rotor diameters, longer blades, and increased hub heights. This technological leadership is reflected in the volume of offshore wind–related patents granted, which serves as a widely used proxy for innovation capacity and technological maturity (IRENA [106]).

Alongside Germany, Denmark is at the forefront. In this scenario, USA, Japan and China, have been actively participating in adopting new technology to support decarbonisation. This trend demonstrates unexplored potential for PDE approach in these countries. This PDE mechanisms not only accommodate technological evolution but also mitigate environmental and regulatory risks, as evidenced by the cancellation of Docking Shoal [107] due to cumulative impact assessments based on overly cautious envelopes.

Policy coherence can be defined as the extent to which different horizontal or vertical policies mutually support each other while minimising the conflict [108], [109]. Strategic plan has been prepared to evaluate the policy coherence because describing it for some countries are difficult. To make the comparison, overlap between feed in tariff, EIA and stake holder engagement process is identified. It is quite debatable but understanding the overlap dynamics contributes to the study in the context of offshore wind development. Denmark demonstrates the highest degree of policy coherence in this assessment. Its capability based CfD scheme is systematically aligned, and each ORE development is supported by EIA. Concurrently, Denmark has identified suitable stakeholders' engagement procedure by clarifying expectations, because stakeholders centred system is essential to identify concerns [110]. France, Germany and UK are placed second in this assessment, primarily due to limitations in the effectiveness and consistency of stake holder engagement process, which needs to be further improved. Most countries have identified CfD scheme, notable exceptions include USA and Germany. However, both France and UK employ 2 sided CfD offering greater stability to the developers. To the best of the authors' knowledge, this study represents the first systematic cross-country comparison of policy coherence specifically focused on offshore renewable energy development.

6. Discussions

This study demonstrates that Ireland's OWE governance transition is not merely an administrative reform, but a structural realignment toward international best practice in plan-led marine energy development. By situating Ireland alongside mature OWE markets, the analysis shows that fragmented, developer-led consenting systems previously characteristic of Ireland are consistently associated with longer timelines, higher development risk, and reduced regulatory predictability. Ireland's shift toward a plan-led framework under the MAP Act, therefore, represents a necessary correction rather than an experimental departure.

A central insight from the comparative analysis is the importance of early spatial designation combined with coordinated permitting authority. Jurisdictions such as Denmark and the Netherlands illustrate how state-led site identification, pre-investigation, and consolidated consent pathways reduce uncertainty at critical early stages of project development. Ireland's introduction of DMAPs and the establishment of MARA align closely with this model. However, international experience also suggests that the effectiveness of plan-led systems depends less on formal centralisation and more on how responsibilities are operationalised across planning, environmental assessment, and grid connection processes.

Design flexibility emerges as a critical but underdeveloped component of Ireland's evolving framework. The comparison highlights that jurisdictions explicitly embedding PDE or bandwidth-based approaches within environmental assessment processes are better equipped to accommodate rapid technological change over long project timelines. Given Ireland's ambition to deploy both fixed and floating offshore wind at scale, the absence of clear statutory guidance on PDE use and post-consent variation mechanisms poses a risk of regulatory lock-in. Without such flexibility, Ireland's consenting system may inadvertently constrain innovation and increase the likelihood of delays or re-consenting as turbine technologies continue to evolve.

The results also provide evidence of a governance conflict that is especially important for Ireland as a late-entry market: balancing regulatory certainty with adaptability. Centralised systems tend to expedite permitting; however, at times, excessive rigidity can undermine the development of sustainable long-term resilience. Conversely, decentralised systems offer flexibility but often lack coherence and predictability. Ireland's challenge lies in navigating this trade-off by using DMAPs and MARA not simply as control instruments, but as coordination mechanisms that enable learning, iteration, and adjustment over time.

Figure (18) illustrates a comparative overview of offshore wind energy tendering processes across the case study countries. The figure reveals a consistent policy trajectory away from open-door frameworks toward competitive auction systems. The open door policy framework is non-competitive. It is important to note that, significant strategic shifts have been observed in the process, reflecting broader efforts to streamline consenting framework. Ireland's positioning as a latecomer thus shapes the governance challenge identified in this study.

While delayed entry increases exposure to regulatory and technological uncertainty, it also allows Ireland to draw selectively on institutional arrangements that have evolved through trial, error, and reform in more mature offshore wind markets.

According to comparative data, the extent to which Ireland can successfully convert this advantage to timely and resilient deployment is largely based on how well the emerging plan-led framework coordinates, incorporates flexibility, and includes learning throughout the entire project lifecycle.

7. Conclusions

This paper demonstrates that Ireland's OWD ambitions are being reshaped by a period of significant regulatory transformation, bringing the national framework broadly into line with international best practice. Comparative analysis indicates that plan-led spatial planning, centralised coordination, and early state involvement in site preparation are key enablers of timely OWD. While Ireland's recent reforms provide a strong institutional foundation, their ultimate effectiveness will depend less on legislative intent than on how these mechanisms are implemented in practice.

To support the delivery of Ireland's, OW targets, three policy priorities emerge. The first is the embedding of clear and legally robust guidance on the use of PDEs within the DMAP-led planning and consenting processes. The second priority is the establishment of transparent and proportionate post-consent variation pathways that enable technological evolution without requiring the re-opening of entire consent procedures. The third priority is the definition of clear minimum requirements for sustained coordination between MARA (one-stop-shop), planning authorities, and grid operators, to ensure regulatory consistency across the full project lifecycle.

Ireland is well-positioned to capitalise on its late entry into OW within Europe and take advantage of lessons learned in more developed OW markets. Moving forward, Ireland can reduce development risks, build investor confidence, and contribute to a resilient transition to large-scale OWD by aligning the speed of regulation with the flexibility of institutions. Future research should investigate the effectiveness of Ireland's developing Governance Framework in practice, as DMAPs and later project phases are implemented.

The present study acknowledges that the comparative assessment of policy and legal frameworks is based on qualitative interpolation of available information across the selected jurisdictions. No statistical data is employed in the evaluation process; rather, the findings are derived from a systematic and structured qualitative analysis. It may be recognised that the interpretation of the qualitative analysis may be subjective, particularly in the absence of quantitative indicators across the selected jurisdictions.

Credit author statement

Amiya Pandit: Investigation, Visualization, Formal Analysis, Methodology, Conceptualization, Resources, Writing-Original Draft,

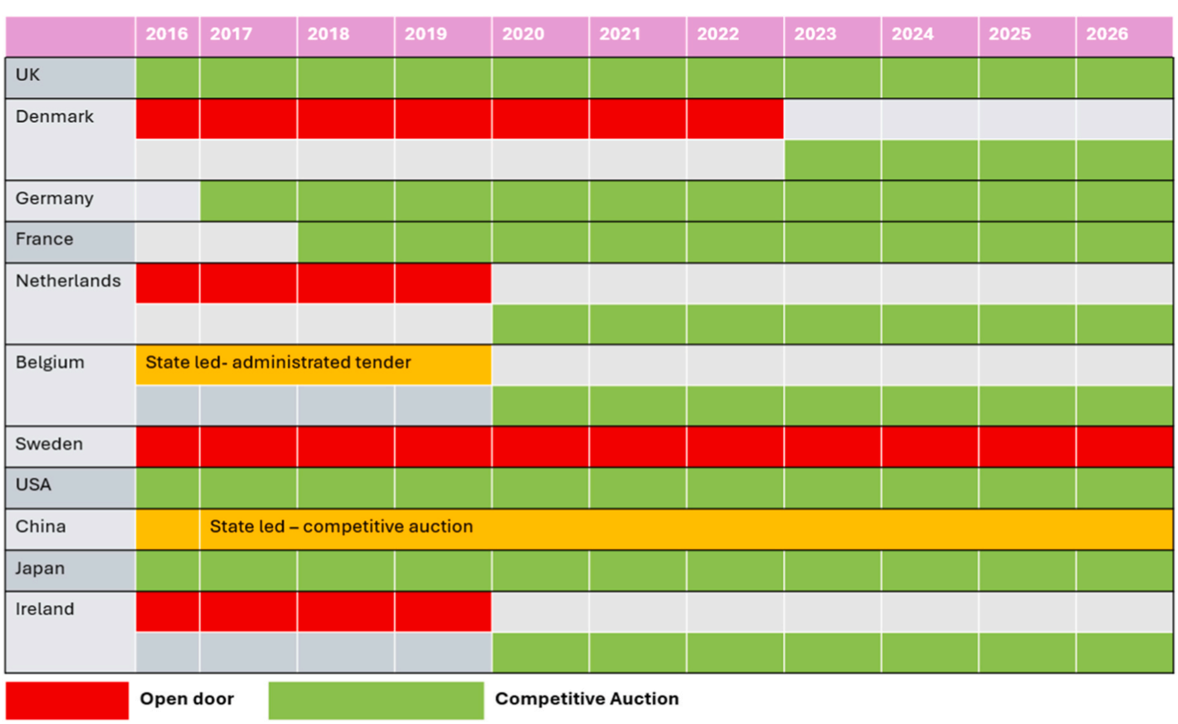

Figure (18). Comparison of offshore wind development tendering process.

Fulya Islek: Investigation, Methodology, Writing-Original Draft, **Abdollah Malekjafarian:** Writing-review & Editing. **Md Salauddin:** Writing-review & Editing. **Michael O'Shea:** Investigation, Supervision, Funding Acquisition, Project administration, Writing-review & Editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Amiya Pandit reports financial support was provided by Foras na Mara. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

No data was used for the research described in the article.

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