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The role of maritime spatial planning on the advance of blue energy in the European Union

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ABSTRACT

In recent years the European Union has firmly committed itself to energy from oceans as a means of decarbonising the European energy system. Despite a favourable political landscape, the development of offshore renewables still faces economic and technological barriers, which are coupled with the inherent difficulties of an increasingly industrialised marine environment, such as complex evolving regulation, lack of knowledge regarding the possible environmental impact of such an activity, as well as spatial conflicts with other traditional and emerging uses. Most of the coastal Member States have adopted Maritime Spatial Planning (MSP) as a fundamental tool for integrated and sustainable management of human activities in the marine environment. MSP is capable of definitively driving the use of offshore renewable facilities. Its proper application supports decision making, simplifies and accelerates the process of obtaining permits, improves compatibility of uses, integrates stakeholders in planning, prevents environmental deterioration of sensitive areas, enhances the availability of information and promotes cross-border co-operation. This paper aims to evaluate the influence of maritime spatial planning processes on the advance of blue energy within the framework of the European Union. The results show positive relationships between MSP and the development of offshore renewable energy in countries such as Germany, the Netherlands and the United Kingdom.

1. Introduction

Blue energy has gained special relevance in the European Union, representing one of the integral parts of the Integrated Maritime Policy. As indicated in the communication "Blue Growth" [1], marine energies offer the possibility of increasing efficiency in the exploitation of energy resources, minimising the demand from the energy sector in terms of land use as well as reducing greenhouse gas emissions (to around 65 million tons of CO_2 by 2020), a position strengthened in the Communication entitled "Blue Energy" [2].

In accordance with the National Renewable Energy Action Plans drawn up by Member States, the goal for 2020 is to have installed power of 41.97 GW of offshore wind energy and 2.25 GW of ocean energy systems[1] in maritime areas [3], however, forecasts from the industry are more conservative (24.60 GW installed power for marine wind and 850 MW for oceanic energy [4,5]) (Fig. 1).

To take advantage of this potential it will be necessary to move towards safe and reliable devices whose effective energy production allows marine renewables to compete in cost with other sources of energy and facilitate access to stable financial resources. In addition to technical barriers (characteristic of a technology that has not yet reached maturity) and economic barriers, the development of marine renewables depends on the establishment of an appropriate regulatory framework and on the capacity of the Member States to manage maritime space. Indeed, rapid deployment of renewable technologies is also a challenge for maritime governance, since the technology for exploitation of renewable resources has developed faster than the legal and political aspects [6].

These "non-technical" barriers (Table 1) have the potential effect of limiting the evolution of blue energy, endangering national and community objectives of decarbonisation of the energy system and exploitation of marine resources. Integrated and efficient management of maritime space is required to optimise the use of offshore renewable energies. This would make it compatible with other uses, minimise potential conflicts and guarantee the preservation of marine ecosystems. Additionally, improvement in the governance model will lead to

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[1] Including the energy of waves, tides and currents.

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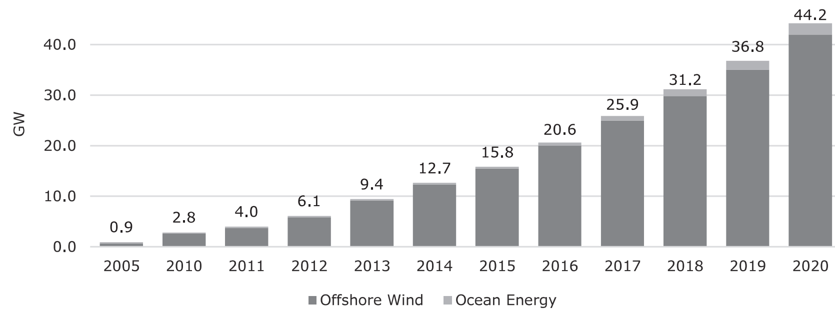

Fig. 1. Marine renewable energy capacity planned in EU member states according to the National Renewable Energy Action Plan Reports.
Source: authors' own elaboration based on [3].

Table 1
Main barriers to the development of marine renewables related to the management of maritime resources.
Source: authors' own elaboration based on literature review.

Barrier	Description
Elevated spatial requirements	The expected growth of the marine renewables industry requires a vast oceanic extension: an offshore wind turbine requires an area of approximately 1 km^2 (depending on its size) to which must be added the space occupied by the connection wiring to the terrestrial electricity network and other installations such as transformation centres, etc [7].
Institutions and management instruments not adapted	The experience of the Member States is, in general, limited with regard to management of marine resources. Beyond the necessary regulations, specific authorisation procedures and adapted government structures tend to be lacking [8].
Competition and multiple interests in marine space	Together with the greater demand for space in the oceans for energy uses, there are spatial requirements from emerging activities such as maritime tourism, aquaculture, blue biotechnology or the recovery of marine minerals - all of which are driven by the Integrated Maritime Policy of the European Union [1] – as well as conflicts with traditional uses such as fishing, navigation [9] or conservation of habitats.
Sectoral management model	As a general rule, the marine space is managed sector by sector, with a management authority for each activity with little consideration for the effects on other human uses or the oceanic ecosystem. This management model has consequences such as: temporal and spatial overlapping of human activities and their objectives, lack of coordination between the authorities responsible for each activity in the protection of the environment, difficulties in biological and ecological conservation of sensitive areas, insecurity for investors and developers of maritime projects and also a lack of connection between offshore activities, the use of resources and the coastal communities that depend on them [10–12].
Difficulty of land-sea coordination	Land and marine management systems often differ in terms of their legal and jurisdictional framework, resulting in serious complications for activities such as evacuation, transformation and the subsequent distribution to centres of onshore consumption for sea produced energy.
Environmental impact	Management of the environmental impact of renewable energy activity in the oceans is complex due to the lack of data on the environmental impact of offshore installations, the diversity of devices (especially in the case of ocean energy), and the variability of marine ecosystems [13].

greater transparency, agility and effectiveness for both authorisation and concession processes. In this context, maritime spatial planning (MSP) has emerged as an appropriate concept to fulfil these requirements [14].

According to Ehler and Douvere [15], MSP is the public process for analysing and assigning spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that are normally specified through a political process. This means detailed planning of different future uses of the sea in order to ensure effective and sustainable management of marine resources. The principal result is an integrated spatial management plan that establishes and defines priorities for the marine region.

MSP is therefore a key instrument, although not the only one, for confronting the transition from a traditional model of sector-by-sector administration to an ecosystem management approach to oceans [16]. This new paradigm of maritime governance proposes integrated management of human activities in order to achieve sustainable use of services while maintaining the integrity of the ecosystem [17]. The evolution of this field in the last decade has been rapid, prompted largely by growing concern for the cumulative effects of anthropological action to marine ecosystems, in particular the progressive use of offshore renewable energy [18].

2. Hypothesis, objectives, methodology and sources of information

This article aims to assess how MSP is able to accommodate the expansion of blue energy in Europe and contribute to the achievement of national objectives for the production of clean energy in the oceans. To facilitate this, the MSP processes of three of the most successful Member States in the implementation of marine energy in terms of installed offshore renewable power (GW) were studied: the United Kingdom, Germany and the Netherlands [4,19]. Other elements considered were the diversity of the approaches used to apply MSP and the various configurations of the identified marine spaces.

In each case, a set of six items were analysed (Table 2) with the aim of defining the elements of MSP that impact on the development of renewable energy use in the oceans. Two fundamental references were taken into account in the selection of the items: firstly, the key aspects that make up the "integrated management decalogue" as defined by Barragán [20] for coastal areas, which is a public policy analysis tool composed of ten key issues that have already been successfully applied in more than 14 Ibero-American countries at different management scales [21–23]. Secondly, the implementation methodology for applying MSP proposed by the Ehler and Douvere in the edited guide of UNESCO [24], considered a reference document for ecosystem management of marine areas.

This study includes a revision of the existing national and

Table 2
Description of the identified items for analysing the impact of MSP on marine renewable energy.
Source: authors' own elaboration based on [20,24].

Items	Description
Maritime and energy policy	The objectives and goals for the marine areas of the country were studied. Specifically, the energy policy was analysed (objectives for marine renewables, network connection and capacity), and their relationship and coherence with maritime policy.
Institutions	The organisation established to administer competences in energy matters and the management of the marine space was analysed by answering questions such as: Which institutions are responsible? How are they coordinated to achieve objectives? Which institution or organisation leads the marine management in the country? What role does the energy authority play and how do they relate to each other?
Strategic Instruments	Marine and energy plans were examined. Among other, questions asked were: Who is responsible for the development of these plans? What approach is used to manage the uses? Are areas defined for the use of energy? Are there mechanisms for cross-border cooperation?
Operative Instruments	Schemes for the selection of sites, concessions and licenses, tools for environmental prevention and mechanisms to support clean energy were detailed.
Information and knowledge	The management for generation, storage, dissemination and use of information was detailed. Are there monitoring and tracking tools? Is there transparency in the management process of marine areas? And in the marine energy sector? Do they share information; are companies involved in the generation of information?
Public participation	The mechanisms and scope of stakeholder participation were evaluated.

community norms, strategies and policies, as well as the most relevant sectoral regulation, scientific reports and public information prepared by marine management bodies, reports of European associations of the offshore renewable industry, articles from international scientific journals and analysis documents of various European projects on marine planning. The article develops a description of the three planning initiatives studied, as well as an analysis of the effects of MSP on marine renewable energy activity.

3. Results

The European Union has shown great interest in the application of MSP principles to the management of activities performed offshore, promoting its implementation through directives, policies and regulations related to environmental protection of the oceans, offshore renewable energy, fisheries and integrated maritime policy [25,26]. This interest is definitively embodied in Directive 2014/89/EU on the common framework for the management of maritime space. This text proposes the use of MSP as a tool for the spatial and temporal distribution of activities and uses at sea governed by an ecosystem approach, in line with the Marine Strategy Framework Directive, to promote the sustainable growth of maritime economies, the development of marine spaces and the sustainable use of marine resources, including offshore renewable energy [27]. It also recognises the ability of MSP to contribute to the accomplishment of renewable energy targets of the Union by creating a stable regulatory framework and reducing administrative costs and responsibilities.

According to the Directive, Member States should define management plans that determine the spatial and temporal distribution of activities and uses of their marine waters before 2021, although it should be mentioned that several countries have already begun to implement ocean management processes. In general, these are ad hoc processes, in many cases driven by national policies and objectives to develop offshore wind energy [11], with the aim of responding to the growing demand for space in the offshore industry and alleviate conflicts with other uses.

The analysis of maritime spatial planning processes in Germany, the Netherlands and the United Kingdom is included below, with special attention to the treatment given to offshore renewable energy (Table 3).

3.1. Germany

The target for 2020 is that the final gross energy consumption from renewable sources reaches 18% [28]. The "development corridors" defined in the 2014 Renewable Energy Act identify an increase in offshore wind capacity of 6.5 GW by 2020 and 15 GW in 2030 [29] for Germany. The German government's commitment to marine renewable energies became clear in 2002 with the approval of the Strategy on the Use of Offshore Wind Energy [30]. This document marks the beginning of the development of the sector and establishes the key elements that will define its evolution: the paper includes provisions with spatial implications, identifying potentially suitable areas for offshore wind installations (taking into account there is low level of conflict with existing uses). It also proposes differentiated management of the territorial sea and the exclusive economic zone and suggests institutional reforms as well as authorisation procedures.

The Federal Regional Planning Act (*Raumordnungsgesetz* - ROG) identifies the central Government as taking responsibility for the planning of the German Economic Exclusive Zone (EEZ), while the three coastal federal states take responsibility for the management of territorial waters. The Federal Maritime and Hydrographic Agency (BSH), an agency of the Federal Ministry of Transport and Digital Infrastructure (BMVI), developed the management plans for the EEZ of the North Sea and the Baltic Sea between 2005 and 2009. These plans aim to strengthen maritime traffic, making it safer, protect natural resources and promote and coordinate the development of offshore wind activity. Additionally, they foresee the designation of priority areas for offshore wind production where uses and projects that are incompatible with electricity generation are prohibited. The location of offshore installations in the rest of the German EEZ is also permitted, except for the areas of the Natura 2000 Network. Thus, only 28% of the EEZ is not available for offshore electricity generation. In any case, the construction and management of installations for the production of electricity should not impede the safety and efficiency of navigation [31,32]. For its part, the territorial sea is integrated into the coastal management plans of the Länder with access to the sea, which also includes provisions related with offshore wind generation.

In the EEZ concessions are regulated by the Marine Facilities Ordinance (*Seeanlagenverordnung* - SeeAnIV) and the BSH acts as the competent authority in the process that includes environmental impact assessment and several rounds of public participation [33]. In the territorial sea, spatial planning plans of each Länder and the Federal Pollution Control Act (*Bundesimmisionsschutzgesetz* - BImShC) determine the legal basis of approval procedures. This authorisation scheme has recently been modified with the approval in 2016 of the revision of the Renewable Energy Act (EEG 2017) and an Offshore Wind Act (WindSeeG). Both define a new model to be brought into force in 2026, which will see the governmental authorities responsible for investigating and preselecting appropriate areas for the installation of offshore wind power plants. Developers will vie for the development rights of the preselected sites at public auction. Information relating to possible sites, and the order in which they will be auctioned will be reflected in the Area Development Plans (*Flächenentwicklungsplan*), which will also collect information on the location of the converter platforms and substations, as well as the grid connections and cable routes (replacing the Spatial Offshore Grid Plan and the Offshore Grid Development Plan

Table 3
Summary of the main characteristics of MSP on the impact of uses of marine energy in Germany, the Netherlands and the United Kingdom.
Source: authors' own elaboration based on literature review.

Elements to analyse	Germany	The Netherlands	United Kingdom
Maritime and energy policy	Federal Regional Planning Act (2004) includes the EEZ. Maritime space planning aims to strengthen maritime traffic, protect natural resources and promote offshore wind activity. Target of 6.50 GW offshore wind by 2020 and 15 GW by 2030.	The National Water Plan includes the North Sea policy (2016–2020). It is committed to maritime development, with zones for new initiatives, and flexible management of the sea. Target of 4.45 GW offshore wind by 2023.	The MCAA defines the bases of maritime planning. The MPS constitutes the political framework for marine plans. These should contribute to the objectives of energy and climate change. Objective of 12.90 GW offshore wind and 1.30 GW of ocean energy by 2020.
Institutions	The central government is responsible for the planning of the EEZ, which it exercises through the BSH. Territorial waters are the responsibility of the coastal federal states. BSH also manages applications for offshore wind development in the EEZ.	The IDON coordinates the development of policies and decisions on maritime management. The processes for granting authorisation and subsidies for offshore wind are managed by the RVO.	The MMO has competencies in planning of English territorial waters and offshore marine areas of the United Kingdom, including licenses for energy generation projects < 100 MW. Above that threshold, the authority is the Planning Inspectorate. The Crown Estate holds the energy generation rights on the continental shelf.
Strategic instruments	The EEZ management plans define priority areas for offshore wind. The location of wind facilities in the rest of the EEZ is also permitted, except for the Natura 2000 network areas. The territorial sea is integrated into the coastal management plans of the Länder.	Planning defines areas of marine wind development and fundamental principles for the multiple and efficient use of space.	The marine plans provide a guide on the management of activities and resources, defining policies applicable to priority issues. In energy matters, policies are developed in accordance with the MPS: safe, sustainable and affordable energy supply for the economic and social welfare of the United Kingdom.
Operational instruments	The development rights for the areas pre-selected for wind power are granted to promoters at public auction. Area Development Plans collect information about the sites and the auction. These plans affect the EEZ, and may include territorial waters.	The Government specifies the location and conditions for offshore wind development in "site decisions". The exclusive right to build a wind farm is linked to obtaining a subsidy for renewable generation by public tender.	The Crown Estate assigns the zones for offshore energy development. So far, the allocation has taken place in three rounds following a criteria based approach.
Information and knowledge	Public SIG with geophysical data and the uses of the marine space. The MDI-DE collects data on coastal engineering, coastal protection and conservation of the marine environment. The Area Development Plans provide information on wind sites and the connection network.	The North Sea Atlas brings together maps about the marine ecosystem, uses and application policies. The RVO has public information on offshore wind areas (physical characteristics, wind resource, legal requirements, etc.).	The Marine Information System provides public information on marine planning in England. The Crown Estate has a database of renewable offshore projects (Marine Data Exchange). There are public-private initiatives such as MEDIN.
Public participation	Previous consultations and subsequent hearings to present drafts. Online portals to facilitate information and communication with managers. Consultations and public exposition of offshore projects during the authorisation period.	Participation of stakeholders and a period of public consultation for the draft of the National Water Plan. Consultations and public exposition of offshore projects during their authorisation period.	The Statement of Public Participation regulates participation in the preparation of the plans. Consultations and public exposition of offshore projects during the authorisation period.

[34]). These documents will affect the EEZ, although territorial waters could also be included under agreements with the corresponding federal states [35].

The introduction of auctions implies the progressive disappearance of the incentive system for electricity production introduced in the Renewable Energy Resources Act of 2000. This mechanism has been accompanied by other measures to encourage the expansion of offshore wind energy, including coordination of connections to the network through the operators of the transmission system, the construction of the Apha Ventus offshore test area, and the Offshore Wind Energy Credits Programme [33].

3.2. The Netherlands

The marine area of the Netherlands is one of the most intensively used in the world [36], partly due to maritime traffic generated by shipping routes that cross the North Sea. The management of this space has been closely linked to its development and economic profitability, a fact already evident in the first planning attempt, the National Spatial Planning Policy Document of 2005, and later in the Integrated Management Plan for the North Sea, 2015, which included an analysis of the uses of the sea and opportunity maps for new developments [37,38].

In 2009, a new Policy Document on the North Sea 2009–2015 was drawn up, this time with a more strategic approach, a greater future vision, centred on spatial development of the Dutch marine area, with production of renewable energy in large-scale already appearing as a priority use. In this sense, the document (part of the Water National Plan 2009–2015) defines the space for the installation of 6000 MW of offshore wind power by 2020 and creates preconditions for incremental growth of renewables from that date forward [39].

The most recent Policy Document on the North Sea 2016–2021 (again included as part of the National Water Plan) supports an approach based on maritime development, with zones for new initiatives and flexible management of the sea. The multiple use of space becomes a basic principle for the stewardship of the territory [40]. The document develops further the policy initiated in the previous period and reserves for marine wind development the areas of Borssele, IJmuiden Ver, the coast of Holland and the north of the Wadden Islands. To ensure multiple and efficient use of space, while avoiding possible territorial tensions between activities of national interest, it defines a set of fundamental principles for spatial management of offshore wind power generation (e.g. it establishes design criteria to allow for fast and safe navigation between wind farms, avoids the designation of wind power zones in areas of the Natura 2000 network or in priority zones for sand extraction, preserves the 12 nautical miles strip to avoid obstructions on the horizon, etc.). Additionally, definitive decisions on the location of wind farms should consider the preservation of fishing areas, and cultural and archaeological heritage. The maintenance areas for cables and pipes should be reduced to increase efficiency in the use of space.

The Interdepartmental Directors North Sea Consultative Body (IDON), founded in 1998, coordinate the development of policies and decisions on maritime management, ensuring that Ministries develop policies based on a single state vision, use and future development of the North Sea.

The Agreement on Energy for Sustainable Growth of 2013 established that 16% of the energy produced in the Netherlands be of renewable origin as a target for 2023. The participation of offshore wind is fundamental to achieve this objective. The Agreement foresees the expansion of offshore wind generation capacity to 4450 MW in 2023 through the progressive bidding for the installation and operation of offshore wind farms in a process initiated in 2015 that will take place annually until 2019 [41]. The new facilities will be distributed in previously designated areas found in the North Sea Policy Document: Borssele (1400 MW), the coasts of South Holland (1400 MW) and North Holland (700 MW). This measure will be accompanied by the construction of an offshore electrical network for direct connection to the national high-voltage grid and the development of a robust statutory framework that allows offshore installations to be operational in four years' time [42].

These elements constitute the basis for the subsequent drafting of the Offshore Wind Energy Act (*Wet Wind op Zee*, 2015) that defines the management system of the areas designated for offshore wind exploitation [42]. According to the Act, the use of wind is only allowed in the areas defined in the National Water Plan 2016–2021. Within these zones, the Government, through the Ministries of Economic Affairs, and Infrastructure and the Environment, will specify the location and the conditions under which it is possible to build and operate the wind farms through "site decisions" (*kavelbesluiten*). These decisions are subject to environmental impact assessment. The Government is also currently conducting a study on the characteristics of each site. The data is public, giving developers enough information to prepare their offers for the bidding process. Obtaining the exclusive right to build a wind farm in the designated area (the wind permit) carries a subsidy for the production of renewable energy. Selection is made through a bidding process under the SDE + subsidy programme, with the economically most advantageous tender selected [43,44]. It is also necessary to obtain a license where the developer applying has to demonstrate that it complies with the conditions established in the site decision, and that the construction and operation of the wind farm is economically and technically feasible. The Netherlands Enterprise Agency (RVO) takes both decisions simultaneously.

3.3. United Kingdom

The UK electricity market reform programme launched by the Energy Act of 2013 promotes investment in safe, decarbonised and accessible electricity generation for consumers [45,46]. The British Climate Change Act [47] includes a commitment to reduce greenhouse gas emissions by 34% by 2020 and 80% by 2050, taking 1990 as the reference year. In terms of energy, the aim is to increase the share of renewable sources by up to 15% in the supply by 2020. The abundance of wind and the physical characteristics of the British coasts give offshore wind energy a key role in achieving these objectives [48]. The United Kingdom is expected to have 12.9 GW of offshore wind and 1.3 GW of ocean energy by 2020 [49]; in both cases these are the most demanding forecasts of the European Union.

It should be noted that the policies to support marine renewables in the United Kingdom are largely a result of the objectives imposed by the European Union, but also a response to the problems of energy dependence arising from the depletion of the country's fossil energy resources [50]. The production of crude oil and gas in the North Sea deposits peaked in 2000, rendering the United Kingdom a net importer since 2005, leaving consumers exposed to increases in electricity and gas prices [51].

Although the UK initially lagged behind neighbouring countries, the various decisions taken by the British government to promote the generation of marine renewable energy have led it to a position of leadership in these types of technologies. Thus, in 2009 the Renewable Obligation, the main economic incentive mechanism for the production of renewable electricity, was modified to offer higher incentives for the most expensive technologies, including offshore wind [52]. Active from 2002 to 2017, it is considered one of the most appealing economic support systems for renewables.

Offshore energy has also been one of the main arguments for the change in the model of marine governance that took place with the approval in 2009 of the Marine and Coastal Access Act (MCAA) [53], a law that provides the legal basis for planning maritime activities at the national/regional level. The new law introduced a simplified licensing system for activities taking place in the ocean and required the British authorities to develop management plans for the marine space [54]. During the development of this law, the UK Marine Policy Statement 2011 (MPS) was adopted, which constitutes the general policy framework for the preparation of all marine plans in the United Kingdom and for all decisions affecting the marine area [55].

The plans include a series of indications for the management of activities and resources in the affected areas. In this sense, they provide a spatial guide on where authorisation for certain uses is most likely, taking into account the cumulative impact of different activities, as well as reducing the regulatory burden on users [56]. In England, drafting responsibility lies with the Marine Management Organisation[2] (MMO), an organisation created by the MCAA with competencies for planning the marine environment of English territorial waters and offshore marine areas (beyond 12 nautical miles) throughout the United Kingdom (for those subjects that have not been decentralised) [57]. This includes the management of licenses for energy generation projects of less than 100 MW. Above this threshold, projects are considered infrastructures of national importance and the Planning Inspectorate is the central licensing authority [58].

The Crown Estate is another key player in offshore energy management given its role as the virtual owner of the entire seabed up to the 12 nautical miles limit, including the rights to explore and use the natural resources of the British continental shelf (except oil, gas and coal). It is therefore necessary to obtain a license from this organisation before locating any offshore structure.

The Crown Estate grants exploitation rights for renewable energy in the form of lease agreements that give the developer a lease option over a certain area of the seabed [59]. So far, the allocation of these rights has taken place in three leasing rounds, in each of which improvements have been introduced to facilitate the concession. Thus, if in Round One (2001) a complex authorisation process took place in which the potential promoters were invited to identify the "preferred" locations to locate wind turbines, in Round Two (2003) the Government defined three large areas depending on its economic and technical potential with a competitive bidding mechanism for the allocation. In Round Three (2010), already subject to the new authorisation regime defined by the MCAA and the Planning Act, proposals for the development of complete areas were invited (not individual projects, forcing the formation of consortiums). In this third round, the Crown Estate had a greater involvement: it prepared the studies on the most favourable areas through a GIS, participated in the selection of sites, in obtaining permits and even co-invested in certain projects [60]. This round tripled installed offshore wind capacity in comparison to the previous ones (more than 30 GW).

4. Discussion

The development of marine spatial planning processes is greatly influenced by the physical characteristics of the space to be managed, the activities and prevailing uses, the regulatory and institutional framework of each state and the level of maturity of the offshore renewable industry. As has been seen, different contexts have given rise to a diversity of approaches to implement MSP [61]: in some cases, existing

[2] In decentralised administrations the responsibility has remained with the respective central governments.

legal instruments have been adapted, including the principles of MSP (in the case of Germany, where the management of the area is based on the 2004 amendment to the Federal Regional Planning Act), while in others, entirely new systems of governance have been developed (as in the United Kingdom with the MCAA). Some Member States have opted for integrated or strategic management plans (for example, the National Water Plan in the Netherlands, which incorporates the Dutch government's guidelines for maritime management, or the Belgian Maritime Spatial Plan, the latest version of which was approved in 2014) [62] This diversity is also reflected in the treatment that different maritime spatial planning instruments give to offshore renewables, resulting in a broad configuration of authorisation schemes, zoning systems, requirements for ensuring the environmental protection of marine ecosystems or mechanisms for the participation of agents from the sector. Despite the differences, it is possible to identify a series of positive effects of marine spatial planning in the development of marine renewable energies [63]:

- Political framework and investment climate. Spatial planning helps address the complexity of ocean management, improving the integration of objectives at different levels and giving specific priority to key sectoral policies such as renewable energies. Indeed, contributing to the sustainable development of the energy sector is one of the objectives of MSP according to Directive 2014/89, and one of the main drivers of marine spatial planning initiatives in Europe (including the cases analysed). This support favours the creation of a stable environment that reduces commercial risks and facilitates long-term investment decision making for public and private developers [64].
- Processes of authorisation and fragmentation of ocean governance. The complexity of the authorisation processes for offshore energy exploitation facilities and the lack of specific regulation constitute a barrier to the development of the marine renewable industry [65]. MSP simplifies and speeds up decision-making, licensing and authorisation procedures [66] improving quality, transparency and regulation. Simas et al. [65] compare the authorisation procedure for ocean energy in different Member States and conclude that integrated planning can help improve coordination and communication between the authorities involved in the authorisation procedure.
  Management of competencies within the marine environment takes place through existing bodies that are endowed with new responsibilities (IDON in the Netherlands or BSH in Germany) or with institutions such as the MMO in England, created specifically to facilitate coordination and avoid the adverse effects of fragmentation of maritime governance. In general, these bodies exercise specific competencies in planning and administer licensing systems for activities in the marine environment. However, for large infrastructure projects (including energy generation), these schemes are not valid, with management responsibilities handed to different authorities.
- Conflict reduction. MSP facilitates identifying optimal areas for the development of marine renewable energies, and the possible compatibility with other uses, including other offshore renewable energies, this increasing efficiency in the use of space. Azzellino et al. [18] demonstrated the usefulness of spatial planning techniques for the analysis of sites where offshore wind installations and use of wave energy were co-located. Faced with sectoral management, the application of models based on MSP allows for the detection and resolution of potential conflicts with other uses [67], while increasing the economic performance of the managed sectors and improving participation processes [68].
  The management of maritime space in the Dutch and German case is executed according to an area-based approach in which areas where energy use is permitted are defined according to their specific characteristics. In the United Kingdom the evaluation of projects is done according to the fulfilment of certain standards or criteria (criteria-based approach) mainly related to environmental and security issues. This approach seems more appropriate for the promotion of offshore wind energy since it does not restrict developers to certain pre-established areas or exclude them from others [69], although it could potentially be in conflict with other interests such as the conservation of marine environments.
- Participation. MSP provides the necessary mechanisms to promote stakeholder participation and involve them in the decision-making process. The literature deals extensively with the importance of social factors in offshore renewable projects and the need to reach the highest level of consensus among the different actors operating in the same maritime area [70–73]. The active participation of these agents is crucial to increase their level of acceptance, avoid NIMBY (Not In My Backyard) effects and reduce possible socio-political and socio-economic risks [74].
  The initiatives analysed foresee stakeholder participation processes generally associated with the assessment of strategic environmental plans and during the authorisation processes of the offshore installations. In the United Kingdom, the manner in which interested agents can intervene and influence the development of a plan is regulated beforehand in a public participation document (Statement of Public Participation).
- Availability of information. The collection of reliable and quality data is a fundamental element for proper spatial management and planning in the marine environment. MSP favours greater data availability and better management [75,76]. In the Netherlands, IDON manages a public information system (North Sea Atlas) that brings together maps with data on the marine ecosystem, uses and application policies. The British Crown Estate has a specific database for data related to offshore renewable projects (Marine Data Exchange) independent of the online tools that provide information on marine plans. This information is a valuable resource during the planning phase of offshore facilities, which may well result in significant cost reduction for developing projects [77].
- Reduction of environmental impact. The greater availability of environmental information on the oceans also makes it possible to identify areas of special environmental sensitivity or ecological importance. This allows for planning by selecting the appropriate protection measures to reduce the risk in advance of possible environmental impacts caused by the construction and operation of offshore energy exploitation systems and enables their prevention in the project phase [78]. As an example, German federal marine plans prohibit the installation of new wind farms in the areas of the Natura 2000 Network of the EEZ. According to the North Sea Policy Document, marine spatial planning in the Netherlands will avoid protected areas by designating wind energy areas. In the United Kingdom, as a general principle, any development of marine plans must avoid negative impacts on the environment considering mitigation measures and even changes in location. The British approach, in this sense, is the most flexible of the three cases analysed, by not excluding from the start, any area for renewable energy use.
- Cross-border cooperation. The planned deployment of offshore renewable generation facilities requires electrical networks that distribute the energy produced in the ocean to the on-land consumption centres. MSP facilitates the design and planning of these networks and incorporates a necessary cross-border dimension for the interconnection of offshore infrastructure in neighbouring countries [79,80]. The plans studied include the need to cooperate in matters that go beyond the limits of planned areas. This cooperation takes the form of international agreements or projects such as the North Sea Countries' Offshore Grid Initiative, an initiative involving agents from ten countries of the North Sea with the objective of supporting the exploitation of offshore wind resources by developing an offshore transmission network and the connection to land [81,82].

- Integration with land planning. The use of marine renewable energy depends to a large extent on the infrastructure located in the coastal zone (cables, transformation centres, auxiliary equipment such as jetties, docks, etc.). In turn, the repercussions of this activity extend in many cases to the terrestrial strip (e.g. the environmental and visual impact of the facilities or the effect on the local socio-economy). MSP seems an appropriate tool for the management of land-sea relations, integrating both planning systems [83].
  Directive 2014/89 calls for consideration of land-sea interactions in the development of maritime management plans. The manner in which this integration occurs varies depending on the territorial organisation and the approach taken to implement MSP. In Germany, the management of the territorial sea is the responsibility of the coastal Länder, who have chosen to extend their terrestrial planning to include the marine area. In the Netherlands the Policy Document on the North Sea considers land-sea connections of different uses (including electricity generation). For its part, in the United Kingdom the limits of the marine planning area extend to the level of the highest tide, while land planning extends to the lowest tide line so that the marine plans will overlap with land planning by forcing the coordination of the responsible authorities [55]. The MMO facilitates the integration of marine plans with land planning in the United Kingdom, focussing special attention to the participation of local authorities [84].

5. Conclusions

The policies for the promotion of marine renewable energy are one of the elements that have driven the development of marine spatial planning processes in Europe with the greatest force. Countries such as Germany, the United Kingdom and the Netherlands have sought a framework in MSP with which to respond to the demands for space in the offshore renewable industry and rationalise the proliferation of facilities for the use of energy on the high seas.

The manner in which these processes have been developed, and especially the final result, has been conditioned to a large extent by the particular characteristics of each region, giving rise to different approaches in planning of energy uses in the marine space. Each of these models can be effective in certain circumstances to encourage the deployment of offshore renewables, although it is difficult to quantify which one has more advantages. This is due, in part, to the fact that these are processes that have not passed their first planning cycles, and because objectives for offshore energy in national policies are established in the long term. In any case, and despite differences, MSP allows for the integration of different elements that constitute the regime of marine renewable energy management and defines a common framework for the development of these activities, which implies the authorities taking control and balancing the interests of economic development with protecting the natural environment. On the other hand, MSP helps to define, in a clear manner, the conditions under which activities can be carried out, avoids conflicts stemming from competitive uses and gives security to investors in the offshore energy industry. These are key elements to eliminate barriers to allow the sector to reach a state of maturity quickly and effectively, especially in the case of ocean energies.

All in all, analysis shows a positive relationship between MSP and the development of offshore renewable energy, MSP being a tool that will undoubtedly contribute to the achievement of blue energy objectives while respecting the principles of sustainability that govern European regulation for management of the marine environment.

However, from the experiences analysed in this article we can extract a set of challenges to which MSP will have to respond in the short-to-medium term. As has been demonstrated, the granting of licenses and permits for large-scale electric generation projects is outside the normal scope of the organisms responsible for marine management. It is necessary to leave behind sectoral approaches and move towards integrated models that facilitate the coordination of uses and coherence in the application of marine policies. Following examples such as Marine Scotland [85], improvements of coordination should be accompanied by the implementation of simpler authorisation schemes for marine renewables, managed by the maritime authority.

Another aspect to be taken into account by the next generation of marine management plans is a cross-border dimension in terms of electricity networks and facilities for offshore energy generation, especially in marine areas with high demand for space and confluence of borders such as the North Sea or the Baltic Sea. New plans should embody the requirements of Directive 2014/89 in the form of specific objectives to enhance cooperation and multi-level governance systems at an international level, incorporating the results and lessons learned from international projects and other joint initiatives that are currently being developed [86].

Finally, multiple use of space is emerging as an option to be considered by managers to optimise the use of space, reduce conflicts and take advantage of the environmental and economic synergies generated by the joint deployment of offshore renewable facilities and activities such as fishing, aquaculture and even the conservation of natural areas [87]. Although the concept has already been incorporated as a priority in plans such as those of the Dutch, the industrialisation of the oceans, and especially the progressive introduction of facilities for the production of ocean energy, will require, as a tool to support decision making, systematic incorporation of techniques for co-location of uses during spatial planning.

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Declaration of interest

None.

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