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CONSENTING PROCESSES FOR OFFSHORE WIND: COMPARATIVE PERSPECTIVES AND THE CASES OF DENMARK AND BRAZIL

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This report has been prepared under the Strategic Sector Cooperation program implemented by the Danish Energy Agency (DEA) and funded by the Danish Ministry of Foreign Affairs, in collaboration with the Brazilian Center for International Relations (CEBRI). The observations, suggestions, and comparative analyses presented herein regarding offshore wind consenting processes in Brazil and Denmark are offered in a constructive spirit to contribute to knowledge exchange between our countries. For information related to other countries referenced in this report, we have conducted research to the best extent possible. While aligned with international best practices, all content is purely indicative and does not constitute an official position, binding commitment, or legal obligation by the Kingdom of Denmark, its agencies, ministries, or representatives. The responsibility for regulatory frameworks and implementation decisions remains solely with the Brazilian authorities.

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CONTACTS

Center for Global Cooperation, Danish Energy Agency, ens@ens.dk

Rafaela Guedes, Brazilian Center for International Relations, rafaela.guedes@cebri.org.br

FOREWORD

Stine Leth Rasmussen
Deputy Director General
Danish Energy Agency (DEA)

As the world faces the pressing challenges of climate change, the need for innovative, sustainable energy solutions has never been more urgent. Offshore wind energy will play a significant role in the global energy transition alongside solar PV, onshore wind and hydropower. The development of offshore wind farms, however, is complex, requiring careful planning, meticulous regulation, and strong cooperation among governments, industry leaders, and communities alike.

This report provides an overview of consenting processes for offshore wind development, with a focus on Brazil and Denmark, as it has been developed in the context of the energy partnership between the two countries. The sharing of expertise and knowledge is paramount, and as countries continue to push toward a low-carbon future, it is vital that we look to one another for guidance, lessons learned, and shared solutions. The observations, suggestions, and reflections of this report are therefore presented in a constructive spirit and should be seen as a contribution to the cross-border dialogue between our countries. Brazil and Denmark, both significant players in the global energy landscape, serve as exemplary models of how international cooperation can help accelerate the transition to renewable energy. Denmark, a pioneer in offshore wind development, can provide lessons learned on governance frameworks with decades of both good and bad experiences. Brazil, with its vast coastline and large offshore wind potential, stands at the precipice of an energy revolution. Sharing the same vision of a just and inclusive green transition of our societies, the exchange of knowledge between these two countries is a testament to the power of global partnerships addressing climate change.

Offshore wind development is globally at a crossroads, with many challenges ahead, and The Danish Energy Agency hopes this analysis provides Brazilian stakeholders with valuable inputs for their own pathway and can be a piece in a complicated puzzle that is just starting in Brazil.

Rafaela Guedes
Senior Fellow
Brazilian Center for International Relations (CEBRI)

The transition to clean and renewable energy sources has become a global priority. As a result, countries are seeking solutions that can balance socio-economic development with market competitiveness. Still, building sustainable energy systems that are affordable and capable of driving inclusive growth and long-term prosperity remains a significant challenge — especially for developing countries, which often experience barriers such as energy poverty, limited infrastructure, financial constraints, and restrictive regulatory frameworks.

The development of offshore wind in Brazil holds the potential to become a strategic complement to hydropower, reinforcing the country's position as a global leader in clean energy. As technology advances and economies of scale are achieved, offshore wind is poised to become increasingly cost-competitive. With effective strategic planning—anchored in a robust regulatory framework, targeted investment incentives, and demand-stimulating policies—Brazil can unlock the full potential of offshore wind. Beyond strengthening energy security and accelerating decarbonization, this emerging sector can drive regional development, create high-quality jobs, and catalyze industrial growth across the value chain.

This report aims to encourage entrepreneurs, policymakers, investors, and other key stakeholders by providing analyses regarding the experiences of Denmark and Brazil in developing offshore wind energy, focusing on institutional settings and licensing processes, and the enabling conditions required for the successful development of these technologies in Brazil. From this perspective, it seeks to contribute to Brazil's diverse energy potential, aligning economic and social progress with a low-carbon economy, as Brazil's long-standing experience in offshore oil and gas production, combined with its large-scale onshore wind power generation, offers a solid foundation for the advancement of offshore wind energy. As part of this effort, CEBRI aims to offer a strategic perspective—grounded in lessons learned from Denmark—to help ensure that wind offshore projects are both economically viable and environmentally sound while contributing to a sustainable energy transition in Brazil.

AUTHORS BIOS

Danish Energy Agency

Bernardo Busel Niedmann
Chief Advisor

Bernardo Busel Niedmann is Chief Advisor to the Danish Energy Agency with expertise in renewable energy regulation across Colombia, Brazil, Ukraine, Ethiopia, Indonesia, Türkiye, South Korea, and Chile. Previously, he was a law firm partner in Chile specializing in energy law litigation and transactions for international clients. He lectures on energy law at universities in Denmark and abroad. Bernardo holds an Advanced Master in Energy Law from the Universities of Copenhagen, Groningen, Aberdeen, and Oslo and a LL.B. from Universidad Adolfo Ibáñez, Chile. He is a recipient of the International Bar Association Section on Energy, Environment, Natural Resources and Infrastructure Law (SEERIL) Scholarship.

Federico Jensen
Team Leader

Dr. Federico Jensen is the Team Leader for the Brazilian-Danish Energy Partnership Program (BRADEPP) and special advisor on offshore wind energy and port development at the Danish Energy Agency's center for global cooperation, where he has also worked with other countries such as Mexico, Colombia, and Brazil, to accelerate the deployment of wind energy infrastructure worldwide. Federico holds a Ph.D. in international political economy from Copenhagen Business School.

Konstantinos Athanasiou
Advisor

Konstantinos Athanasiou is Advisor and Project Lead at the Danish Energy Agency, specializing in long-term energy systems modelling and planning. He possesses extensive experience on energy systems modelling and scenario analyses, with emphasis on power systems. Konstantinos holds an MSc in Sustainable Energy and Energy Systems Analysis from the Technical University of Denmark and an MEng in Environmental Engineering from the Democritus University of Thrace.

Brazilian Center for International Relations (CEBRI)

Rafaela Guedes
Senior Fellow

Rafaela Guedes is an independent consultant, Senior Fellow at the Brazilian Center for International Relations (CEBRI), International Advisor at APCO and member of a panel of experts on Energy Transition at the Institute for Climate and Society. She has 19 years of professional experience in the Energy Industry and for the last 8 years has been dedicated to energy transition strategies, strategic planning, sustainability and, most recently, business development. As senior fellow at CEBRI, she leads an Energy Transition Program in partnership with multilateral development banks, private and public sector.

Fabiane da Cunha Dantas
Researcher

Fabiane da Cunha Dantas is a Logistics Technologist and Lawyer with expertise in Maritime, Administrative, Tax, and Constitutional Law. She holds a Master's degree in Intellectual Property and Innovation from the Instituto Federal Fluminense (IFF) and is currently pursuing a PhD in the Energy Planning Program at COPPE-UFRJ. Her research focuses on regulation, innovation, and sustainable development, with a particular emphasis on offshore wind energy.

Bruna Targino
Researcher

Bruna Targino is an International Relations specialist and PhD candidate in Energy Planning at COPPE/UFRJ. She works as a researcher with a focus on just transition, industrial decarbonization, low-carbon technologies, and the role of critical minerals in enabling sustainable energy systems. Her professional experience spans climate policy and sustainable industry, contributing to the development of technical analyses and strategic recommendations that support decision-making in Brazil's energy landscape.

Guilherme Dantas
Senior Researcher

Guilherme Dantas is a founding partner of Essenz Solutions and a Senior Researcher at CEBRI. He is a consultant in the infrastructure sector with an emphasis on energy, sanitation, and biomass. He holds a PhD in Energy Planning from COPPE/UFRJ, a Master's degree in Energy and Environmental Economics and Policy from the Technical University of Lisbon, and a Bachelor's degree in Economics from UFRJ. Over the past 20 years, he has provided consulting services to several energy companies in Brazil. He is also the author of books and articles published in international journals.

EXECUTIVE SUMMARY

This working paper provides a comparative description of regulatory frameworks and licensing processes for offshore wind development, contrasting markets. The paper examines different approaches to offshore wind governance, offering insights for jurisdictions seeking to develop this renewable energy resource, giving inspiration for an informed debate.

Offshore wind has emerged as a cornerstone in the global energy transition with significant installed capacity worldwide. Despite technological advancements and cost reductions, permitting and consenting processes continue to present significant bottlenecks for accelerating deployment in jurisdictions around the world.

The global landscape of offshore wind consenting is often categorized into three predominant models. The centralized model establishes a national body to coordinate the entire consenting process. This approach typically features pre-designated development zones and "one-stop-shop" services that streamline decision-making and reduce administrative burden for developers. In contrast, the decentralized model involves multiple regulatory authorities overseeing specific aspects of the process. While this approach provides developers with greater control over project development, it also places higher responsibility and risk on them. The hybrid approach combines centralized supervision for initial planning phases with decentralized implementation at later stages of development.

Mature markets have pioneered offshore wind development, establishing the first utility-scale projects and refining their regulatory systems over time, incorporating learnings from decades of experience. These systems often feature a centralized "one entry, one exit" framework where a single governmental agency serves as the point of contact throughout a project's lifecycle. Such systems are typically integrated with maritime spatial planning, with portions of the sea under national jurisdiction dedicated to renewable energy development. It is important to note, however, that although Maritime Spatial Planning (MSP) and one-stop-shop approaches are now considered the gold standard in offshore wind regulation, these were not present in the initial regulatory frameworks of most mature markets. Rather, they represent an evolution of governance systems in response to challenges and inefficiencies identified over time, as the sector matured and project volumes increased.

Emerging markets, despite having limited or no installed offshore wind capacity at present, often possess significant potential for development. These markets are typically in the process of establishing regulatory frameworks through legislation after periods of stakeholder consultations. Newer markets frequently implement multiple allocation methods: government-led auctions for maritime areas alongside mechanisms that allow for developer-initiated site selection. Many are currently developing phased approaches to Maritime Spatial Planning. Environmental licensing in these contexts often follows a structured multi-step process: preliminary assessment of environmental feasibility, authorization for construction, and permission for operations. Multiple governmental institutions are typically involved in assessing potential conflicts with existing marine uses.

Markets at different stages of development are exploring various offtake mechanisms for offshore wind energy. These include hydrogen production and export considerations through comprehensive national strategies. Other potential mechanisms include grid integration, electrification of industrial facilities, powering data centers and supporting industrial decarbonization via producing low-carbon fuels in industrial hubs.

Several considerations emerge from this working paper. Clear and transparent institutional frameworks help reduce risk for early-stage project developers, while streamlined consenting procedures enhance investor confidence. Maritime Spatial Planning plays an important role in enabling efficient site allocation and conflict resolution, and predictable offtake mechanisms ensure project viability. Throughout the development process, stakeholder engagement supports social acceptance and mitigates potential conflicts.

This paper offers a comparative perspective that may contribute in stakeholder discussions as they shape their approach to offshore wind development, while recognizing that each jurisdiction must develop frameworks suited to their unique geographical, political, and economic contexts.

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ABBREVIATIONS

CfD	Contracts-for-difference
DCO	Development Consent Order
DIP	Declaration of Prior Interference
DSO	Distribution System Operator
EA	Environmental Assessment
EC	European Commission
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPA	Environmental Protection Administration
ESIA	Environmental and Social Impact Assessment
FiT	Feed-in Tariff
FLH	Full Load Hours
GJ	Gigajoule
GO	Guarantee of Origin
GW	Gigawatt
HRA	Habitats Regulations Assessment
IDP	Industrial Development Bureau
IRA	Inflation Reduction Act
LCoE	Levelized Cost of Energy
MSDI	Marine Spatial Data Infrastructure
MSP	Marine Spatial Planning
MW	Megawatt
NEPA	National Environmental Policy Act
NSIP	Nationally Significant Infrastructure Project
OSS	One Stop Shop
OSW	Offshore Wind
OWF	Offshore Wind Farm
PPA	Power Purchase Agreement
PtX	Power-to-X (energy conversion technologies)
RED	Renewable Energy Directive
REZ	Renewable Energy Zones
SAF	Sustainable Aviation Fuels
SAP	Site Assessment Plan
SEA	Strategic Environmental Assessment
SMP	Sectoral Marine Plan
TRL	Technology Readiness Level
TSO	Transmission System Operator
TW	Terawatt

1 Introduction

Massive build-out of renewable energy is an enabler of a low carbon global future and a global green transition. As such, over 150 governments during COP 28 in Dubai stated the commitment to triple renewable energy capacity by 2030. Materializing this commitment would require a total of 11,000 GW of renewable energy capacity installed globally by 2030 (International Energy Agency (IEA), 2024). Nonetheless, several key barriers exist to accelerate the deployment of renewables globally, with one of them being slow or inefficient licensing processes, as identified in several fora (IEA, 2024; Global Wind Energy Council (GWEC) & Global Solar Council (GSC), 2022; European Commission, n.d.a). More mature markets, such as those in the European Union, are working to simplify and expedite licensing processes (European Commission, n.d.a), which could potentially accelerate the expansion of offshore wind energy and offtake products, including green[1] hydrogen.

The licensing processes for global renewable energy projects, and in particular for offshore wind and renewable hydrogen, are complex and vary significantly across countries. Unclear national and regional regulations may create barriers to project development. The debate in most jurisdictions centers around how much state involvement, coordination of processes and new regulations are necessary for these large renewable energy projects to move forward. Non-harmonized institutional settings, potentially requiring different types of licenses and permits that contradict with one another, can lead to long licensing times and thus larger risks for projects. Green hydrogen production as an offtake mechanism of renewable energy (in this case offshore wind) can add extra layers of complexity to the licensing process, as very detailed assessments of environmental, safety, and infrastructure aspects are required.

The objective of this working paper is to provide an overview of the current status of selected mature and emerging markets and to analyze the experiences of Denmark and Brazil in developing offshore wind energy, focusing on the institutional settings and licensing processes, and relevant implications. Denmark, with its established institutional framework and infrastructure as well as global leadership in

[1] Green refers to hydrogen produced via electrolysis of H_2O using electricity from renewable energy. Based on the hydrogen production process and feedstock used, different hydrogen types have been classified, e.g. grey and blue hydrogen from steam reforming of natural gas or black and brown hydrogen via coal gasification.

offshore wind energy, provides important lessons learned on best practices and the challenges faced along the way. At the same time, developments related to renewable hydrogen are also relevant in Denmark, particularly as an offtake mechanism of its vast offshore wind resources and large capacity expansion plans. On the other hand, Brazil, with its remarkable potential and long-lasting experience in the offshore oil and gas sector, is in an early stage of organizing regulation and institutions for the development of offshore wind and various offtake candidates are being considered.

The description of the two countries seeks to understand how this energy technology can be efficiently implemented from an institutional perspective and can be adapted to the Brazilian context to accelerate the development of offshore wind energy in the country. Without attempting to be prescriptive[2], this working paper intends to provide inspiration to interested Brazilian stakeholders and public authorities regarding consenting processes for offshore wind and the relevance of securing demand as a means of speeding up project developments. In doing so, an argument is raised that clear and transparent institutional design and licensing process is a minimal precondition to de-risk project development for private actors, particularly at early stages of sector development in a new market, such as Brazil.

Brazil has significant offshore wind potential, mainly in the Northeast and Southeast regions, with ambitious scenarios suggesting an installed capacity of up to 96 GW by 2050 (Ministério de Minas e Energia (MME), Empresa de Pesquisa Energética (EPE) & World Bank, 2024). At the time of drafting this working paper, Brazil has just passed its offshore wind law, after many years of negotiations in parliament[3]. With the general regulatory setting now established, Brazilian public authorities must develop the institutional framework and consenting process to facilitate project approvals and bring them to fruition. As ninety-six offshore wind projects are listed at the Brazilian Institute of the Environment (IBAMA) awaiting further environmental licensing (IBAMA, 2024), this working paper is timely in providing further inspiration on the discussions of the institutional setting with a comparative perspective.

The report addresses the global development of offshore wind infrastructure, the importance of consenting processes, and institutional environments in certain countries. The document is organized as follows:

- Chapter 2 provides a general overview of the consenting processes and institutional settings for offshore wind energy development.
- Chapter 3 presents licensing trends in mature and emerging markets for offshore wind development, capturing the regulatory landscape of selected regions and countries.
- Chapter 4 describes offshore wind consenting processes in Denmark and Brazil.
- Chapter 5 discusses offtake mechanisms and specifically the development of hydrogen in Denmark as one potential offtake mechanism and the perspectives for Brazil.
- Finally, chapter 6 offers a short summary of this working paper with the lessons learned from different institutional settings and consenting processes on offshore wind energy.

[2] Please see the disclaimer on the first page.
[3] See:
https://valor.globo.com/politica/noticia/2024/12/12/senado-aprova-projeto-de-lei-das-eolicas-offshore-texto-segue-para-sancao.ghtml
or
https://abeeolica.org.br/aprovacao-do-projeto-de-lei-576-2021-eolicas-offshore-no-brasil/

2 Global models and institutional settings

Offshore wind energy deployment is considered to be a cornerstone in meeting global energy transition goals and achieving climate targets (International Renewable Energy Agency (IRENA), 2023). By 2023, roughly 1 TW of wind energy capacity has been installed worldwide, with 73 GW of offshore wind, which is more than double the operational capacity when compared to 2020 levels (IRENA, 2024a). Even though it is one of the fastest-growing renewable energy technologies, the expansion of offshore wind is often hindered by various challenges such as stressed supply chains, escalating costs, cumulative environmental impacts as well as lengthy and complex consenting processes (Det Norske Veritas (DNV), 2023; Ernst & Young (EY), 2023).

This chapter focuses on various consenting process schemes and their common and individual characteristics and components. Despite all the elements that can affect the final investment decision and the actual construction of large-scale renewable energy, there is a general understanding that permitting/consenting affects the viability of projects[4]. A potential indication of intricacies associated with building-out wind projects could be the fact that today, in the EU, roughly 88 GW of onshore and offshore wind is under permitting, which is four times higher than the current under-construction capacity (Global Wind Energy Council (GWEC), 2024)[5].

2.1. Consenting in offshore wind energy

From conception stage until full commissioning, offshore wind projects can typically take up to nine or ten years, with the majority of the time spent on permitting and consenting processes, however, once licenses are obtained, it usually takes roughly two years, depending on the size, to fully construct an offshore wind project (GWEC, 2024). Developers must secure all relevant consents for their project before the relevant authorizations are awarded and the construction phase can begin, while in the meantime,

[4] See for example: https://www.weforum.org/stories/2024/09/wind-energy-permitting-processes-europe/

[5] Of course, many other factors such as supply chain issues, macro-economic conditions and general processes in project development affect the ratio between projects under permitting and projects in construction. But it is generally seen as a useful metric to assess the agility of consenting processes.

technological and macro-economic conditions might change. Therefore, streamlined and agile consenting processes are crucial for the viability and realization of such projects.

Consenting is an overarching term entailing all aspects of ensuring that the project meets environmental, safety, navigational, and grid connection standards while also complying with local, national, and occasionally international regulations. This process requires different licenses, permits and approvals to be completed. Licenses by definition typically grant long-term permissions for accessing specific areas, e.g., seabed lease or marine licenses. Permits and approvals more often focus on particular aspects or stages of the project and validate or approve that a particular activity complies with certain regulations or standards, e.g., construction permit and environmental impact assessment (EIA) approval.[6]

Consenting processes and the relevant permits and approvals necessary to establish an offshore wind project vary between regions but also countries within a given region in most cases, but usually encompass: Permission/title to occupy the site (in relevant cases, after determining the quality of the resource and compatibility with other uses of the marine space, through the so-called marine spatial planning process), environmental and social consents, construction, operations, and grid connection authorizations.

2.1.1. Global models

Some institutions have identified three main permitting models identified globally: *centralized, decentralized* and *hybrid* model which is a combination of the two (IRENA and GWEC, 2023). Each model represents a different approach to organizing regulatory oversight, with varying degrees of flexibility, stakeholder involvement, and administrative complexity. Some of the key entities involved across all three models are national energy agencies, marine and environmental authorities, local governments, Transmission Systems Operators (TSOs) and the project developers. We believe this is a useful classification to have a dialogue, but the reality of most national permitting models is more nuanced.

In a *centralized consenting model*, a national body monitors the permission process, which speeds up decision-making and reduces the administrative requirements for developers. This approach is used by countries like Denmark, the Netherlands and Germany and enables the government to define predetermined offshore wind zones and conduct initial site assessments, environmental impact studies (at a strategic level or a proper EIA, depending on the jurisdiction and the tender at hand) and stakeholder consultations, while usually serving as a single point of contact for developers[7]. This concept is commonly referred to as One Stop Shop (OSS) or single-window and manages the end-to-end process, including granting licenses at different project development stages. In this setup, there is a general focus on maintaining consistency in the decisions that need to be taken in the different phases of the permitting process. Overall, this model secures holistic oversight for site-planning, and assessments to licensing anchored in one authority, which, from a market perspective, may benefit transparency of the collected process and a balanced regard to the collected stakeholder-input.

[6] These terms are generally used interchangeably and are author-dependent. This report uses the terminology as described above.
[7] In the Danish model, although information of the pre-investigation results is provided to developers to reduce risk, they are still responsible for the accuracy of the information used in project development phase. See: https://ens.dk/en/energy-sources/ongoing-offshore-wind-tenders/preliminary-investigations-ongoing-offshore-wind-farm

The *decentralized model*, as seen in the UK (IRENA and GWEC, 2023), involves multiple regulatory authorities in the consenting process, with each having a specific competence or function over parts of the project, while providing the developers more control over the required actions to establish a project. Consequently, the developer is bearing a higher risk as they are the ones responsible for site selections and assessments, stakeholder consultations and acquiring different permits. This approach is considered to offer great flexibility to both the government and the developer and could potentially enable a fast-paced legislative environment, however, it could also lead to delayed and uncertain permitting processes due to inadequate addressing of stakeholder concerns and/or unclear procedural steps resulting in overlaps when high development activity is underway. Overall, the consenting timing would highly depend on the developer's capacity and agility to coordinate the different permits.

The *hybrid model* combines centralized supervision with decentralized input, aiming to disaggregate responsibilities, while incorporating local concerns and expertise (IRENA and GWEC, 2023). The USA is an example of countries using this approach, where the government is responsible for the early development phase and may handle initial site assessments and grant preliminary permits, while developers should take upon detailed planning, environmental studies, additional permits etc. (U.S. Department of Energy, 2022). This model combines a top-down strategic approach with local inputs and considerations. However, an up-to-speed and well-integrated regulatory framework is needed to facilitate such a set-up (IRENA and GWEC, 2023).

2.2. Key consenting processes

All three aforementioned models involve some *key components* that are closely related to the overall permitting time:

- Marine spatial planning (MSP),
- Zonal planning for grid corridors and substation connection,
- Environmental and social impact assessment (ESIA) [8] and
- Stakeholder engagement.

The centralized approach may for example use a single process to secure the seabed lease (or other instruments such as usage authorization, temporary permit, concession etc.) and the PPA (Power Purchase Agreement), where the central authority conducts surveys to assess the feasibility of sites and complete an ESIA to gain project development consent. Both the centralized and the decentralized framework conduct marine zoning decisions, through for example the usage of MSP conducted by the government, to identify large areas but the developer is the one who then decides sitting, conducts site surveys and the ESIA, to acquire consent.

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[8] ESIA (Environmental and Social Impact Assessment) is a catch-all term for the different processes involved in categorizing all the impacts that an infrastructure project has on society and the environment. The term is more thoroughly described in the next section, however, there are different types of environmental assessments used by developers and regulators. For example, the Danish model uses Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) (see Chapter 4 for detailed explanation).
For more information on impact assessments, see: [https://www.iaia.org/best- practice.php](https://www.iaia.org/best-practice.php)

2.2.1. Marine spatial planning

Marine spatial planning is a very important process that guides the place and time that human activities should take place in maritime areas in order to minimize sectoral conflicts, such as commercial fisheries, shipping, oil and gas and offshore wind development, as well as to manage the sustainable use of marine resources and national security. (European Union, 2014; European Commission, 2022). Its goal is to organize the framework around maritime activity and complement the sectoral planning and environmental licensing and not to replace it.

This exercise involves allocating dedicated areas for the above listed activities in a way that balances environmental, economic and social objectives. In this regard, the aim of marine spatial planning is to balance conflict resolution with pre-designated zones, environmental protection with conservation zones to avoid or minimize negative impact upon habitats and biodiversity and efficient use of marine space via optimal placement of offshore wind farms that reduces costs and enhances performance of the wind turbines.

Typically, the responsibility of developing and maintaining marine spatial planning lies with government authorities who manage marine resources, national ministries or specialized agencies such as the Marine Management Organization (MMO) in the UK (Offshore Wind Industry Council (OWIC), 2024). Industrial stakeholders, environmental entities and local communities are all involved in the marine spatial planning process to ensure their interests are taken into consideration[9].

2.2.2. Environmental assessments

Environmental Assessment is any process that aims to estimate and evaluate positive and negative effects of a project on the receiving environment, including actionable proposals for minimizing, mitigating or compensating adverse impact. Although there are a number of different forms of environmental assessments, in the context of offshore wind, the most widely used are the Environmental Impact Assessment and the Strategic Impact Assessment (O'Hagan, 2024). Some countries also require a Sustainability and/or a Social Impact Assessment for exploring the combined economic, environmental and social impacts, incorporating in this way all three pillars of sustainable development, however, in the EU they are not yet a legal requirement (O'Hagan, 2024). In the context of this working paper, the overarching term ESIA is adopted to integrate all dimensions of effects linked to offshore wind projects (also see footnote 7).

As aforementioned, *Environmental and Social Impact Assessment (ESIA)* is a detailed evaluation process that aims to assess and quantify the potential environmental and social impacts of a given project before development is commenced. It entails various aspects that a future offshore wind project might have impact on, e.g., effects on marine life, water quality, noise pollution and the impact on local communities and industries. It is considered to be an integral first step towards the realization of wind projects as it provides regulators, developers and stakeholders with critical information when planning the project design, location and mitigation measures. Identifying potential environmental and socio-economic impacts at an early stage allows room for developing strategies to avoid, minimize or

[9] A comparative analysis of MSP processes can be found in: Kirkfeldt, T. S. (2021). *Marine spatial planning: Facilitating sustainability in an ocean of ambiguity*. Aalborg Universitetsforlag (https://doi.org/10.54337/aau429763432). The DEA, through its global cooperation programs has worked in the interlink between MSP and offshore wind, particularly in India, see for example: https://coe-osw.org/maritime-spatial-planning-for-offshore-wind-farms-in-tamil-nadu/.

compensate for any negative effects, thus ensuring public support and further legislative approvals (European Commission, 2022).

Many countries outside the EU have established ESIA as part of the permitting process to enable compliance with national laws and international agreements and decrease legal or other risks for the project developers. In national systems, ESIAs are mainly conducted by the developers or qualified consultants hired by them and reviewed by relevant authorities such as environmental agencies.

Coordinating these roles can improve the effectiveness of the consenting process in resolving potential environmental, social and economic concerns. Therefore, engaging stakeholders throughout project development and execution phases is another crucial component to an efficient consenting mechanism, as well as the overall viability of an offshore wind farm, and should be integrated in the ESIA process (IRENA and GWEC, 2023). An overview of how this is done in Denmark is provided in *Chapter 4.1*.

2.2.2. Stakeholder engagement

Stakeholder consultation can be public, including neighboring residents and community groups, with statutory consultees, where there is a requirement by law to consult a specific body, or non-statutory, where, despite not being defined by legislation, there are policy-related grounds for involving consultees who are bound to have an interest in a forthcoming development (Offshore Wind Industry Council (OWIC), n.d, Module 5). A non-exhaustive list of local stakeholder groups can be: Residential including coastal and port communities, resident cooperatives in the project's vicinity, community advocates such as large employers, public representatives and local media, various economic groups e.g. shipping companies, commercial fisherman and telecommunications companies, as well as relevant local authorities like the local government, marine management services, indigenous People and their representatives, and other groups like environmental, nature and conservation groups (Crowe, 2024)[10].

Stakeholder engagement commonly takes place during preliminary investigations (pre-application) or at various stages of the project, depending on each country's adopted model or regulatory context (IRENA and GWEC, 2023). In addition to stakeholder engagement, a broader debate exists in regard to addressing *social acceptance*, as renewable energy projects are increasingly confronted by resistance from local communities.

Taking Denmark as an example, although the Renewable Energy Act includes compensatory measures for onshore and near-shore facilities, in the case of offshore wind projects – despite having little to insignificant visible or audible impact from shore – they might still require large onshore infrastructure which needs to be taken into consideration. To address this, regulatory measures[11] could be designed to strengthen the relationship between offshore project developers and affected onshore communities, as well as land owners, aiming to enhance local acceptance (Olsen, 2021).

[10] In some countries, mandatory consultation processes may be required in compliance with the requirements set in The Indigenous and Tribal Peoples Convention of the International Labour Organization, also known as ILO Convention 169. Both Brazil and Denmark are parties to this instrument. A detailed legal assessment must be conducted on whether the consultation needs to take place according to the convention requirements and the domestic legislation.

[11] In Denmark, Taksationsmynigheden handles claims on loss of value due to offshore wind projects. An example on the Vesterhav Syd OWF can be found here: https://www.taksationsmyndigheden.dk/afgoerelser/midtjylland/ringkoebing-skjern-kommune/vesterhav-syd-ii

2.3. Chapter conclusion

The *centralized approach* with an established entity eligible to handle the project's consenting coordination offers developers easy access and monitoring of the permitting statuses and likely a more transparent procedure with a greater certainty of an overall balanced output. However, this approach requires governments having sufficient time and technical assessment capabilities to successfully handle the highly complex duties that the centralized framework is associated with, as well as a single institution or a designated group with the legal competences to orchestrate the process. Decentralized models provide greater flexibility and autonomy, which is potentially also associated with higher risk for the project developer.

Marine spatial planning is a key element to keep the process well-organized and minimize marine conflicts, amid maximizing co-existence and project de-risking. Although until recently government planning for offshore wind projects did not involve marine spatial planning, this tool has proved to be very relevant as more and more projects get developed and the co-existence between different national and public interests on the marine space becomes crucial. Another essential element is the *environmental and social impact assessment* procedure which can identify or anticipate severe future negative effects in advance, so that they can be efficiently addressed and resolved before development commences. Early identification of negative effects can prevent delays, but most importantly minimizing offshore and at-shore environmental and social impacts.

Lastly, *effective and timely engagement of local communities* and observing their rights are fundamental in achieving sustainability and social acceptance while protecting cultural assets and traditional ways of life. It is therefore crucial to engage impacted communities in a participatory and inclusive manner throughout the project lifecycle.

3 Selected mature and emerging markets

This chapter provides an overview of *regulatory and consenting processes* across both *mature and emerging key offshore wind markets*. Mature markets like Europe have been focusing on decreasing lead times and making the process more efficient, as also indicated through the 2023 Flagship Technical Support Project on accelerating permitting for renewable energy[12], yet environmental regulations and cross-border synergies remain significant hurdles. Emerging markets, e.g. Southeast Asia face different barriers, such as regulatory fragmentation, insufficient institutional capacity and grid infrastructure limitations (World Bank, 2021). This chapter attempts to succinctly *describe general consenting processes* as a means of inspiration to Brazilian stakeholders.

Today, the main offshore wind markets are considered to be in Europe and China. Key emerging markets with installed capacity are the US, Taiwan, Japan, Republic of Korea and Vietnam. Finally, new markets where regulation is being developed and there are positive prospects for offshore wind include: Colombia, the Philippines, Portugal and Brazil. Denmark has been a global pioneer of offshore wind technology, having installed both the first pilot and the first utility-scale offshore wind farm ever recorded (see *Chapter 4.1* for more information). Currently in Europe, the UK, Germany and Netherlands are the frontrunners in terms of installed capacity, followed by Denmark and Belgium, while France is becoming a leader in the floating offshore wind segment (World Forum Offshore Wind, 2024).

Figure 1 illustrates the global annual *capacity additions* (left chart) and total *cumulative capacity* installed (right chart) in 2023. Total offshore wind installations amount to roughly 75 GW with 11 GW established last year. China stands as the world leader and is responsible for approximately 50% of the global installed capacity with the United Kingdom and Germany following, and almost 60% of 2023's installations, tailed by the Netherlands and UK (GWEC, 2024).

[12] See: https://reform-support.ec.europa.eu/accelerating-permitting-renewable-energy_en

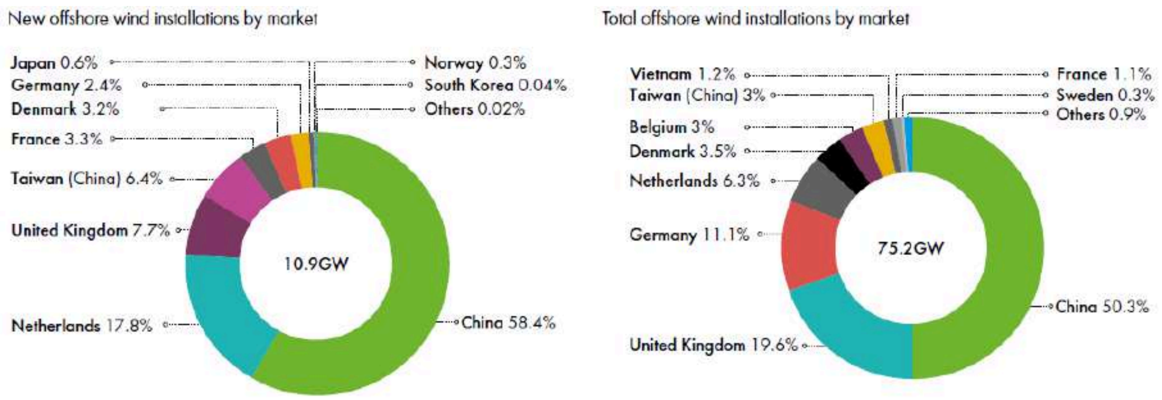

Figure 1. Offshore wind new and cumulative capacity in 2023 (GWEC, 2024).

In regard to *ongoing projects*, large volumes of capacity have already initiated construction by the end of 2023 and even more are in the planning phase. China is once again paving the way with 6.3 GW under construction, the UK and Taiwan come next with roughly 4 GW and 2.5 GW respectively, while Germany, USA and France follow right after, with their ongoing installations descending from 1.6 GW to 550 MW (World Forum Offshore Wind, 2024). In Denmark, construction approvals for the 1 GW Thor wind farm were recently granted by the Danish Energy Agency, with construction starting in 2025[13]. The next sections discuss how consenting processes are designed in selected markets.

3.1. Consenting processes for offshore wind in Europe

Europe has been at the forefront of offshore wind development, driven by ambitious climate targets and a strong policy framework at both the national and EU levels. One of the key enablers of Europe's offshore wind success has been its progressive approach to regulatory frameworks and consenting processes. The various regulatory frameworks in European countries generally include clear licensing processes, strong government support, and market incentives (Vasconcelos et al., 2022). Important features include integrated maritime spatial planning and licenses, market incentives like Feed-in Tariffs (FiTs), premiums and Contracts-for-difference (CfD), One-Stop-Shop systems and early-stage stakeholder engagement (deCastro et al., 2019). However, permitting has been labelled as the number one bottleneck for wind projects in Europe, significantly impacting the build-out rates across the continent (Wind Europe, 2024a).

At EU level, the European Commission (EC) has published multiple key directives that provide the framework for RE development, environmental protection and maritime spatial planning, which are crucial for establishing offshore wind projects. The Renewable Energy Directive (RED), the MSP Directive, the EIA and SEA Directives, as well as the Birds and Habitats Directives are some major examples that have shaped the legislative environment for offshore wind developers (European Commission, n.d.b).

This section focuses on the approaches followed by the UK, Germany and the Netherlands, while also broadly categorizing the markets in Belgium, France, Portugal and Spain.

[13] https://ens.dk/presse/thor-danmarks-stoerste-havvindmoellepark-faar-etableringstilladelse

3.1.1. The UK

The United Kingdom has the largest installed offshore wind capacity in Europe, driven by a phased approach that is initiated with open-door applications, where developers choose sites, followed by later rounds that involve strategic government-led tenders (Vasconcelos et al., 2022). The whole process is therefore led by the developer who prepares an application for various permits, once granted a lease agreement by the Crown Estate as the organizer of the bidding in the various leasing rounds (Paterson, 2024)[14].

However, depending on the jurisdiction and the size of the wind farm, the application process to obtain development consent varies. Overall, the Energy Act 2013, the Planning Act 2008 and Marine and Coastal Access Act 2009, along with other related acts passed by the devolved administrations[15], pave the way of marine management and licensing in the UK (OWIC, n.d., Module 4). The Crown Estate owns and manages the seabed out to the 12 nautical miles territorial limit in England, Wales and Northern Ireland, whereas the seabed around Scotland is managed by the Crown Estate Scotland. Additionally, the Crown Estate possesses the rights to issue leases between the territorial waters and within the Renewable Energy Zones (REZs) (UK Government, 2023).

The framework applying to England and Wales is quite similar where the developer seeks to obtain seabed right and Habitats Regulations Assessment (HRA) approval, secure key consents, grid connection license, win a CfD auction and finally enter into commercial and financial agreements. A Development Consent Order (DCO) from the Secretary of State (or the Welsh Ministers for projects in Wales) based on recommendations from the planning inspectorate (PINS) is required for any offshore wind power project in England, that has a capacity greater than 100 MW and is categorized as a Nationally Significant Infrastructure Project (NSIP) under the Planning Act[16]. Also, based on section 36 of the Electricity Act, there is an authorization requirement for projects having a capacity of less than 100 MW, with the Marine Management Organization (MMO) being responsible for granting approval in English waterways (OWIC, n.d., Module 5).

Scotland has its own parallel system with an established One-Stop-Shop, called MS-LOT, for project consent and a well-defined sectoral marine planning approach. The Sectoral Marine Plan (SMP) is the output of an integrated process that combines the uses of Strategic Environmental Assessment, Habitats Regulations Assessment, socio-economic impact assessment, as well as statutory consultation analysis. Developers are at minimum required to obtain marine licensing and the section 36 consent, which are usually submitted together with an EIA and/or HRA (Scottish Government, 2022).

3.1.2. Germany

Germany has established a government-driven system with high political ambitions targeting a large expansion of offshore wind projects as an overriding public interest, as defined in the recently adopted German Offshore Wind Energy Act (WindSeeG)[17]. Most of Germany's existing and envisioned offshore

[14] Most recently, the Crown State has received new powers, of particular interest is the power to borrow from financial capital markets, as a way to support the investment in projects, see: https://www.thecrownestate.co.uk/news/New-powers-granted-to-modernise-The-Crown-Estate-for-benefit-of-the-UK
[15] Each UK Government department has a team who specializes in devolution and each of the devolved administrations has a team who oversees engagement with other administrations. For more information, see here.
[16] https://www.legislation.gov.uk/ukpga/2008/29/contents
[17] https://www.gesetze-im-internet.de/windseeg/WindSeeG.pdf (in German, last amended in March 2023)

wind farms are located in the EEZ (North and Baltic Seas), at depths from 40 meters, to minimize environmental and landscape impact (adelphi & German Offshore Wind Energy Foundation, 2022). The Federal Maritime and Hydrographic Agency (BSH) is the one handling permits in the EEZ, while applications within the 12 nautical mile zone are screened by the authorities of the respective coastal federal state (Bundesverband WindEnergie (BWE, n.d.). This distinction also applies to the maritime spatial plans which are binding and therefore, OWF development is only permitted within the designated development areas. Germany's spatial planning in the EEZ is carried out by BSH, whereas the planning within the territorial waters is performed by the corresponding coastal federal state authorities.

The adopted centralized process of planning and tendering for OFW projects is characterized by publicly financed grid connection and pre-selected offshore wind areas to minimize project risk. BSH designates offshore wind sites in the Site Development Plan (FEP), which practically defines specific locations following the MSP, including a structure plan of the grid connections, and issues final permitting for construction to successful bidders (adelphi & German Offshore Wind Energy Foundation, 2022). TSOs plan and build the offshore grid connections after the auction is completed, and the Federal Network Agency (BNetzA) is responsible for awarding suitable offshore wind areas to bidders through government-led auctions (site tendering) (adelphi & German Offshore Wind Energy Foundation, 2022).

3.1.3. Netherlands

The Netherlands has developed a centralized consenting process for offshore wind projects (similarly to Denmark, which will be discussed in Chapter 4), adopting a centralized framework to manage coordination among state agencies and relevant stakeholders. This centralized permitting process is managed by the Ministry of Climate Policy and Green Growth via the Netherlands Enterprise Agency (RVO)[18], where the government pre-selects designated offshore wind zones.

This approach allows the Dutch government to conduct site assessments, such as EIAs and seabed surveys, before auctioning the sites to developers (Salvador et.al, 2018). The focus is on simplifying and speeding up the permitting process, ensuring that offshore wind projects are developed in alignment with environmental and spatial planning regulations. The Netherlands tends to front-load much of the regulatory work, requiring extensive site assessments by the government before auctioning projects to developers[19].

3.1.4. Other European Markets

Other mentionable cases for offshore wind development in Europe are *Belgium* and less mature markets like *France, Portugal* and *Spain*. *Belgium* is one of the leading European offshore wind players and aims to double its operational capacity by 2030. Constructing and operating offshore wind farms (OWFs) requires concession from the Belgian Federal Minister of Energy, along with an EIA performed by an independent institution, however, this regulatory setup is currently being amended, with a new competitive bidding framework being considered.

France has been advancing with existing, ongoing and planned projects, aiming at 5.2-6.2 GW of offshore wind by 2028, focusing on floating OWF (Peter et al., 2024). Recently, the French government also

[18] https://offshorewind.rvo.nl/

[19] See: https://www.rvo.nl/sites/default/files/2021/10/Dutch%20Offshore%20Wind%20Guide%202022.pdf and https://www.windandwaterworks.nl/cases/offshore-wind-farm-site-assessment-selection

announced the winners of the South Brittany floating offshore wind tender which is expected to be the largest floating OFW farm in the world (Wind Europe, 2024c). Emphasis is also largely put on decreasing the duration of auctions, as well as simplifying and shortening planning and permitting procedures as previous practices were deemed unsuccessful due to insufficient preliminary studies, complexity on permits and legal challenges on authorizations (Wind Europe, 2024c).

Portugal and *Spain* both have extensive experience on onshore wind, being the most dominant electricity source in the Spanish case (Del Guayo & Adán, 2024), but haven't yet harvested their offshore potential. The main focus in Portugal is on floating wind technology as the country's deep coastal waters make traditional fixed-bottom turbines less viable. Even though the initial phase for a first offshore wind auction took place at the end of 2023, the permitting process for floating wind projects remains slow (Wind Europe, 2024b). Spain has announced a target of installing 3 GW of offshore wind by 2030 (Wind Europe, 2024a), Spain has recently reformed its regulatory framework, to create a specific framework for offshore wind, given the creation of the Spanish marine spatial plan and the advancements of floating wind technology, which left the general renewable energy regulation from 2007 obsolete to deal with such projects[20].

Box 1. Consenting policy innovation: The North Sea Hub

In 2016, a joint political declaration established the North Seas Energy Cooperation (NSEC)[21] targeting cost-effective deployment of offshore renewable energy and particularly wind and promoting interconnections between the countries involved. Members of NSEC are Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway and the European Commission and an MoU between NSEC and the UK was also signed at the end of 2022, establishing a cooperation framework between the two parties.

On April, 2023, the Oostende Declaration[22] was signed on the basis of realizing a common vision of the North Seas as a green power plant of Europe by Ministers from NSEC members and the UK. The aim of the Declaration is to deliver cross-border projects and anchor the renewable offshore industry in Europe. In the same context, the North Sea Wind Power Hub (NSWPH) Programme[23] was established in 2017 with an ambitious new approach of integrating renewable energy that aims to link together the energy systems of North-West Europe in one coordinated network.

Denmark and Germany took a first step in developing such integrated grid planning: The Combined Grid Solution project connects the two countries via two offshore windfarms, the German 'Baltic 2' and the Danish 'Kriegers Flak'. Being the first project in the world to combine grid connections to offshore wind farms with a two-country interconnector, it is an example of innovation in the context of cross-country collaboration. The Combined Grid Solution became operational in late 2020 and allows electricity to be traded in both directions. The two wind farms are less than 30 kilometers apart and are linked by means of two sea cables that form the interconnector. The transmission capacity is 400 MW in each direction.

The consenting processes for the North Sea Energy Hub are framed within the European Union's legislative framework. Several key directives shape the approach that Member States have adopted in regard to permitting and licensing of offshore renewable infrastructure, ensuring that projects are both efficient and compliant with environmental and socio-economic considerations. While the Espoo Convention explicitly addresses cross-border environmental impacts, within the EU context, its main principles are fully transposed through the EIA and SEA Directives, among others. These directives require Member States to notify and consult neighboring countries if a project may have significant cross-border impacts and share EIA documentation and allow for participation of affected foreign stakeholders.

[20] See: https://www.boe.es/buscar/doc.php?id=BOE-A-2024-19172 (in Spanish)
[21] https://energy.ec.europa.eu/topics/infrastructure/high-level-groups/north-seas-energy-cooperation_en
[22] https://www.kefm.dk/Media/638179241345565422/Declaration%20ENERGY_FINAL_21042023.pdf
[23] https://northseawindpowerhub.eu/

3.2. Consenting processes for offshore wind in Asia

Asia is, apart from Europe, the other proven market for offshore wind projects. China is the global leader in capacity and installation pace (GWEC, 2024) and is considered a well-proven market. The Asian landscape for offshore wind has been growing at a high pace also outside of China with both *South Korea* and *Japan* developing several projects. Good prospects also exist in *Vietnam* and *India*, with both countries in the process of setting up their regulatory and institutional frameworks for offshore wind these years. Other notable markets in the region include the *Philippines*, and further south in the *Oceania region*, developments on offshore wind are accelerating in *Australia*, with a major allocation of sea-bed to offshore wind developers recently.[24] This section will discuss consenting processes in China, Japan and South Korea.

3.2.1. China

As aforementioned, *China* is currently the global leader in the offshore wind market, home to approximately half of the world's existing capacity and also ranked first in new installations in 2023. From the demonstration phase, between 2007 and 2010, to today's auction-based system, the Chinese wind industry has seen remarkable growth over the years (World Bank, 2021). The country's unique market conditions, along with the high level of state engagement across all relevant processes of developing offshore wind, makes the Chinese case a special one (World Bank, 2021).

According to deCastro et al., 2019, the Chinese regulatory framework on offshore wind is mainly defined via legislation on a general renewable energy level, which is not well-structured and driven by policies instead of laws and with provincial governments driving much of the project development process (Li, 2022). This has provided the Chinese regulatory system with incredible speed in accelerating offshore wind power development, but has also created issues for developers not accustomed to navigating the Chinese market.

Some examples of the key authorities involved in the process are the National Energy Administration (NEA) which is administered by the National Development and Reform Commission (NDRC) and oversees all aspects of the energy sector and the State Oceanic Administration (SOA) which is responsible for site selection (deCastro et al., 2019). To improve the management of Offshore Wind projects, the NEA and SOA issued departmental regulation "Measures for the Administration of Offshore Wind Power Development and Construction"[25], which is currently the most relevant regulatory document for OW in China (Deng, 2024). With the 14th Five-Year Plan[26], published in 2022 by NDRC and others, and spanning between 2021 and 2025, the wind sector has shifted from policy to a market-driven, subsidy-free mechanism (Deng, 2024)[27].

[24] See: https://www.dcceew.gov.au/energy/renewable/offshore-wind
[25] See: https://zfxxgk.nea.gov.cn/auto87/201701/t20170104_2417.htm
[26] https://www.ndrc.gov.cn/xwdt/tzgg/202206/P020220602315650388122.pdf
[27] Most recently, China announced the new construction of a CfD scheme similar to that used in many projects in Europe, the implications of this are still unclear though, as it has not been applied in practice yet, see: https://www.windpowermonthly.com/article/1905734/china-drops-renewables-subsidy-mechanism-favour-cfd-style-system

3.2.2 Japan

Japan has a total installed capacity of roughly 150 MW, with a 2030 target of 10 GW and a 2040 target of up to 45 GW (GWEC, 2024). Japan currently acts mainly within its territorial waters, i.e. 12 nautical miles from shore, following the country's Offshore Wind Promotion Act that allows activity for designated sites only in that vicinity. However, Japan's EEZ is the 6th largest in the world, meaning there is a huge unlocked potential for further offshore wind development, which is also why an amendment bill is under review (GWEC, 2024). The main regulatory framework that sustains the development of offshore wind is the "Promoting Marine Renewable Energy Act (Hunsa-Udom, 2024).

In 2018, to resolve legal uncertainties identified by developers, the act on promotion of the use of sea areas to develop offshore renewable energy was published, aiming to identify Promotion Zones on an ongoing basis in a more centralized process (Li, 2022). This resulted in the selection of 10 interest areas, of which four of these areas were then selected as high interest (Hunsa-Udom, 2024). These Zones require various criteria and principles to be met so that they can become part of the government's designation plan. The first tender, administered by the Ministry of Economy, Trade and Industry occurred in 2020, had one successful bidder[28]. In terms of regulatory permits required to establish and operate an offshore wind project, they vary depending on the project area and so does the issuer of the permit, which showcases some complexity in the framework[29].

3.2.3. South Korea

The procedure used in *South Korea* for site allocation can be categorized as an open-door procedure for offshore wind development[30]. The procedure is based on the principle that a project developer initiates the establishment of the project and takes all responsibilities for the development procedures necessary to complete the project, related tasks and activities. This includes activities such as investments, conducting site selection, site verification, and applications for all approvals before initiating construction, and thus plan and handle the entire process. One key license is the Electric Utility business license which allows the developer to explore the possibility of creating a power generation project, this license is granted by MOTIE (Ministry of Trade Industry and Energy) (Hunsa-Udom, 2024). Developers are also responsible for managing complaints of local residents through prior discussion and consultation with the relevant government departments. The procedure is a first-come-first serve approach, in which the developer receives a four-year exclusivity period with their wind measurement campaign (permit to install measurement equipment) approval[31].

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[28] See: https://www.meti.go.jp/english/press/2021/0611_004.html

[29] Calls for simplifying the process have been made, and the government is considering a reform of the process see: https://www.renewable-ei.org/en/activities/reports/20240228.php more recently the One-Stop-Shop law in Korea has been approved, but further process is still unclear, see: https://www.rechargenews.com/policy/can-special-act-get-south-korean-offshore-wind-back-on-track-/2-1-1785786

[30] For an overview, see: https://www.eeas.europa.eu/sites/default/files/documents/2024/ROK03%20Final%20Public%20Executive%20Summary%20v2.0.pdf

[31] See (RVO, DEA, COWI and Pondera 2019, p.19), available at: https://www.rvo.nl/sites/default/files/2021/06/Accelerating%20Offshore%20Wind%20South%20Korea%20May%202021.pdf

Stakeholders highlight that Korean offshore wind developers continue to face lengthy permitting processes and challenges in gaining approval for offshore wind projects[32]. The increased interest in offshore wind development in Korea, combined with the characteristics of the Korean open-door procedure with initial favorable conditions for developers, has led to a high amount of lease permit applications. However, currently only a few projects have crossed the licensing process.

3.3. Consenting processes for offshore wind in the Americas

The Americas, although large regional leaders in the adoption of renewables and particularly onshore wind (in countries like Brazil, Mexico and USA), has been slow in the uptake of offshore wind. Notably *USA* is the only country in the region with installed offshore wind capacity and at least until 2024, a growing industry. Offshore wind has a huge potential in *Latin America*, with *Brazil* leading the way in terms of large theoretical potential (as will be discussed in *Chapter 4*) and with *Colombia* having the first offshore wind tender on-going in the region. This section will discuss the USA and Colombia, but other key geographies where projects are advancing include for example *Uruguay*[33] and *Chile*, where a new OSS system is being created to address delays in infrastructure projects (including energy projects)[34].

3.3.1. The USA

The USA, by the end of 2023, presented 42 MW of operational offshore wind capacity, with various techno-economic and political parameters resulting in many offshore projects being scrapped off in 2024 and 2025, with an uncertain future for offshore wind in the USA moving forward. However, more than 4 GW are currently under construction and much more capacity is in development or planning phase (GWEC, 2024). Besides the Inflation Reduction Act (IRA), the Bureau of Ocean Energy Management (BOEM) in collaboration with the Bureau of Safety and Environmental Enforcement, announced an effort to modernize offshore renewable energy regulations, aiming to enhance security and clarity for project developers (GWEC, 2024).

The licensing framework in the United States is a rather complex system with multiple authorities involved and legislation applied in both state and federal waters. The United States employs three distinct lease-permitting processes: competitive, non-competitive and unsolicited (Severance, 2024). The competitive and non-competitive processes operate generally in a tender format, where BOEM may publish a request for interest (RFI) in scheduling auctions for certain sites, in the case of the competitive process or BOEM may consider leasing areas it finds appropriate without competition (non-competitive process) (Severance, 2024). The leasing process is a bifurcated one, where the federal level is in charge of tendering seabed in auction designs negotiated to accommodate states' interests, and from there the leasing framework (EIA and consultation processes) is decided on a state-level.

The process is generally led by the developer, who prepares and submits an application and relevant documentation once a lease is granted, and then engages with a wide range of federal, state and local

[32] For an overview, see: https://www.eeas.europa.eu/sites/default/files/documents/2024/ROK03%20Final%20Public%20Executive%20Summary%20v2.0.pdf
[33] See: https://www.enerdata.net/publications/daily-energy-news/uruguay-authorizes-offshore-wind-block-tender-3-gw-produce-green-h2.html
[34] See: https://blog.investchile.gob.cl/smart-permitting-system-bill

authorities to complete following surveys and consultation activities. BOEM is responsible for reviewing, commenting and deciding upon the Site Assessment Plan (SAP) and Construction and Operation Plan (OCP) based on the Outer Continental Land Shelf Act (OCSLA) and other environmental and natural resource laws, e.g. the National Environmental Policy Act (NEPA), as well as preparing the Environmental Impact Statement (EIS) via stakeholder consultation (Severance, 2024). The Federal government is tasked with providing relevant permits and takes the final decision regarding outer continental shelf leases, based on recommendations from BOEM, while state and local agencies review the power export system within their jurisdiction (World Bank, 2021) among other responsibilities.

3.3.2. Colombia

Colombia is quickly becoming an offshore wind pioneer in Latin America, rapidly moving in developing an offshore wind regulation and moving towards tendering, with currently the first offshore wind tender in Latin America in process[35]. Colombia has strived to build a centralized tender system for developing offshore wind, with the Ministry of Mines and Energy (MinEnergía), the National Hydrocarbons Agency (ANH) and the Maritime Directorate (DIMAR) as the main institutions in charge of offshore wind. The main administrator of the tender process is ANH, but the final authorization for the Maritime Concession will be given by DIMAR. The tender has two phases, first a temporary occupation of sea space permit, for developers to do initial exploration in prospective sites to determine its viability and a second phase where final licensing needs to be awarded.

Although Colombia is inspired by the centralized system, the licensing procedure remains scattered, with licenses and permits needed to be obtained at different institutions (Anchustegui & Piedrahíta, 2024). Some key authorities that need to be involved include the ANLA (environmental licensing), AUNAP (fisheries), ICANH (archeology and cultural heritage) among others. Furthermore, social consultation processes in Colombia and engagement with indigenous communities has proved difficult in the past, constraining the development of land based renewable energy projects and transmission lines (Anchustegui & Piedrahíta, 2024). Offshore wind is seen as an opportunity to provide green electricity to growing Caribbean cities disconnected from the national interconnected system, but risks still exist.

3.4. Chapter Conclusion

This chapter has explored *offshore wind regulation, policy strategy* and *licensing* procedures in key offshore wind markets, both *established and emerging*. It has done so in an attempt to provide Brazilian stakeholders with inspiration on multiple ways that licensing procedures are organized across the world, and some of the pitfalls thereof.

There is no single way of organizing the development of offshore wind that is unerring and this chapter demonstrates that all geographies have encountered issues in developing agile licensing procedures, and that offshore wind developers continue to push for even further simplification of processes and shorter lead times. The next chapter dives into the two key jurisdictions that this report concerns: Denmark and Brazil and their offshore wind experience.

[35] See: https://www.anh.gov.co/es/hidrocarburos/oportunidades-disponibles/ronda-colombia-e%C3%B3lica-costa-afuera/

4

Case studies on different consenting schemes: Denmark and Brazil

Building on the framework established in the preceding chapter through an overview of various consenting models, the present chapter focuses on the two principal *case studies*: *Denmark and Brazil*. First, a comprehensive summary of the *consenting processes governing offshore wind energy development in Denmark* is provided to serve as inspiration for the Brazilian case. A *description of the current regulatory landscape for offshore wind in Brazil* follows along with a discussion on the country's emerging trends around this technology.

4.1. Consenting processes for offshore wind energy in Denmark

Denmark is considered a pioneer in offshore wind development and possesses extensive experience in this sector that spans over three decades. The world's first offshore wind farm, named Vindeby[36], was established in Denmark in 1991, with a nominal capacity of roughly 5 MW, and using turbines designed for onshore settings. Also, the first utility-scale wind farm, Horns Rev 1[37], standing at 160 MW, was installed at the North Sea in 2002, following the Danish State's ambitions at the time, showcasing the potential of harvesting offshore wind at scale to the world. The main drivers for Danish authorities to explore the potential of moving wind turbines offshore, has been land scarcity, a wish for further diversification in the energy-mix, the abundance of shallow waters across the Danish coastline, as well as, ample wind resources, i.e. higher wind speeds and more stable conditions (Danish Energy Agency (DEA), 2017) besides the strength of the Danish technology advancements, supply chain and ancillary infrastructure.

[36] https://orsted.com/en/what-we-do/renewable-energy-solutions/offshore-wind/offshore-wind-pioneers
[37] https://stateofgreen.com/en/news/horns-rev-1-wind-turbine-reaches-the-100gwh-mark/

4.1.1. Legal framework

The Danish offshore wind industry has enjoyed considerable success, in part due to the country's long-term political commitment and the evolution of its regulatory framework. Despite the fact that technological development is continuous globally, offshore wind is inherently associated with risk, indicating the importance of well-designed planning procedures and risk allocation when formulating or updating the regulatory landscape (DEA, 2017). *One special aspect* of the development of renewable energy in Denmark is the role of politicians and consensus. Denmark has used politically binding decisions – through the approval of laws and binding energy agreements (*Energiaftaler*) – to determine the energy policy and support the regulations that allow the targets to materialize. Danish legal scholars have stated that these agreements have proven to be pivotal in the long-term continuity of the Danish energy policy[38]. The continuity is grounded in the fact that the political decisions, when made, are entered into by a wide majority of the parties and members of the Danish Parliament, making the decisions robust to changes in government.

The main *provisions that regulate offshore wind infrastructure* are stated in the Promotion of Renewable Energy Act (Consolidated Act 1791 of 2021 and subsequent amendments). The regulation is changing frequently to adapt to new technologies and to the incorporation/ transposition of EU law into Danish domestic regulation[39].

The Danish institutional setting from offshore wind is seen as a one entry and one exit system, in which the authorities and more specifically the Danish Energy Agency (DEA) initiates, coordinates and organizes the planning according to the established procedure, and accompanying the project throughout the operational life, all the way to the phase of decommissioning, aiming to reduce uncertainties and delays while encouraging environmental sustainability and stakeholder engagement. This process is not defined by law, but is an administrative procedure. The so-called One-Stop-Shop (OSS) is a part of the Ministry of Climate, Energy and Utilities and acts as a single point of contact for the developers throughout the procurement process and with regards to the main licenses needed for the project and a coordinator for relevant stakeholders (DEA, 2022).

[38] In this regard, see Anita Rønne, *Energy Law in Denmark*: Energy Law in Europe, 2016, Oxford University Press, p.445 and Birgitte Egelund Olsen and Bent Ole Gram Mortensen. *Offshore wind licensing in Denmark*: Offshore Wind Licensing, Edward Elgar, 2024, p.85.
[39] Idem

Figure 2. DEA's coordination of licenses' preparation with relevant authorities (DEA, 2019).

The OSS system applies to both historically established methods of developing offshore wind projects in Denmark. These two procedures, namely government tender and open-door (this procedure is currently suspended), are described in detail in the next section (Olsen & Mortensen, 2024).

4.1.2. Consenting procedures in the context of site allocation

Offshore wind projects can be historically linked with two different procedures in Denmark, a government call for tenders and an open-door procedure. Government tenders have been the main instrument for establishing offshore wind with the last open-door established project being erected more than a decade ago.

GOVERNMENT CALL FOR TENDERS

The Danish Energy Agency announces an offshore wind tender as a consequence of a political agreement, with a reference to a capacity target and a pre-determined geographical location that is consistent with the Marine Spatial Plan, and a planned nearby point of connection to the collective electricity grid. These tenders need to be conducted in accordance with EU procurement law, without local content requirements[40].

Historically, the first phase for the site selection is a rough screening, with the DEA performing an economic ranking of potential sites considering wind conditions, sea depth and distance to shore. The second phase considers a fine screening with a more granular economic evaluation to screen any red flag situations. In 2019, after the initial developments of the Danish marine spatial plan (Havplan), the agency starts the process with a fine screening, considering wind conditions, sea depth and distance to shore. Finally, the DEA coordinates[41] and oversees the site investigations and a Strategic Environmental Assessment (SEA).

[40] Birgitte Egelund Olsen and Bent Ole Gram Mortensen. *Offshore wind licensing in Denmark*: Offshore Wind Licensing, Edward Elgar, 2024, p.92

[41] The DEA also coordinates EIA of the onshore project as well as the license to establish the onshore project (Energinet, the Danish TSO performs both).

Historically, the agency has implemented a price (only) criterion to award the winner, with the strategy of giving the least state support with different types of mechanisms such as double-sided CfDs or premiums. Under the RE Act[42], the producer owner may be subject to a penalty for defective performance in case of failing to construct and/or connect the offshore wind farm to the grid in accordance with the tender specifications under a strict liability regime.

OPEN-DOOR PROCEDURE

Under the open-door procedure, developers have the right to apply for beginning an offshore wind farm project in any location that the Danish state has designated for offshore wind but not designated for state tenders, as described in Section 22 (5) of the RE Act. The developer submits an unsolicited application to the Danish Energy Agency to inquire for a license for conducting preliminary investigations and is required to possess the necessary technical and financial capacity to perform the project's feasibility study (Olsen & Mortensen, 2024). DEA first ensures that no public interests collide with the specific location in a consultation round with other relevant authorities, and then proceeds with the application processing. Permits under this regime are granted on a 'first come, first served' basis following the updated legal framework (Section 23 (4) of the RE Act). Since 1999, when the scheme was first introduced, six small offshore wind farms have only been established under this procedure (Olsen & Mortensen, 2024).

At the beginning of 2023, the open-door scheme was suspended until further notice, as concerns were raised regarding a potential violation of EU state aid rules. More specifically, with the conclusion of the Thor offshore wind farm tender at the end of 2021, a negative winning bid for subsidies, i.e. a concession payment to the state, was achieved for the first time in Denmark. Since the open-door process doesn't require concession fees, having both systems active could constitute state aid towards the open-door applicants, i.e. favorable conditions. The future of this procedure is uncertain at the moment.

4.1.3. Licenses and Permits

Establishing OWFs in Denmark requires three licenses and one authorization. Further, the project owner must perform an EIA if the project is expected to have an environmental impact to the surroundings, which has been the case for all Danish offshore wind projects so far. The procedure is described thoroughly in Executive Order no. 68 of January 26th 2012 and supported with DEA's elaborated guidelines that detail issues only related to the sea. The three aforementioned license applications are examined for approval by the DEA, in cooperation with other agencies, e.g., the Danish Environmental Protection Agency (DEPA) which handles the environmental regulatory framework. The licenses are listed below (DEA, n.d.b):

1. License to carry out preliminary site investigations (pre-investigation)
2. License to establish offshore wind park (construction)
3. License to exploit wind power for a given number of years and authorization to generate electricity (electricity production)

More specifically, the pre-investigation license enables the project owner to carry out investigations related to the construction of the offshore wind farm within the limits of the license. It is typically valid for one year after which an EIA report is to be submitted to DEA for approval. Based on the EIA report,

[42] Section 31 (1), see here in Danish: https://www.retsinformation.dk/eli/lta/2021/1791

DEA decides whether a full impact assessment is required. The construction license grants the licensee the right to commence wind farm construction at a certain location, including terms on the design and appearance of the foundations, towers and wind turbines, as well as requirements for the overall construction process. Finally, the electricity production license gives the owner the right to exploit wind and produce electricity, given that the construction license is secured. It generally spans for 25-30 years from the date of grid connection, with a potential extension if an application is submitted.

For all offshore projects, relevant environmental organizations and individuals who are significantly affected, can appeal and have a hearing at the Energy Board of Appeal within four weeks of the project's approval. Similarly, onshore infrastructure appeals are handled by the Environmental Board of Appeal (Olsen, 2021). However, due to rigorous strategic planning in selecting offshore sites ahead of the EIA process, projects are rarely appealed (DEA, 2017).

4.1.4. Marine spatial planning

As described in Chapter 2, it is very important that the construction of offshore wind farms is not viewed in isolation, but in the context of the broader natural and anthropogenic landscape surrounding the project (DEA, 2022). As marine spaces usually have competing interests by different stakeholders, planning systems like the Marine or Maritime Spatial Planning (MSP) are necessary to timely identify and address such issues and mitigate potential effects in the planning process, ultimately ensuring the selection of suitable locations that are in line with environmental standards and other maritime activities. Even though Danish offshore wind energy was largely developed without MSP, today it is considered to be the 'gold standard' and integrated into the Danish model.

MSP in Denmark lies within the Danish Maritime Agency's mandate which is responsible for the overall coordination of the process, with support from relevant authorities[43]. It includes two sets of data, one describing the current status of offshore activities, namely Maritime Spatial Data Infrastructure (MSDI) and another set that narrates the expected status on a specific time in the future. MSDI provides datasets, creates a knowledge network and gives access to an online platform with a visual interactive GIS map for easy navigation of the stakeholders in interest, resulting to the publicly available Maritime Spatial Plan[44] (DEA, 2022). The maintenance of MSDI and the spatial plan is a common effort of many different state agencies, including DEA, which is coordinated through continuous dialogues and therefore making the planning of offshore sites a dynamic process with constantly updated inputs, such as new sea cable installations and modified navigation routes.

The maritime plan illustrates four different types of zones, where only one is available for, among others, offshore wind permits, i.e. the Development Zones. Based on a draft amendment of the latest adopted version at the end of 2023 that was driven by political agreements, 30% of the Danish EEZ is dedicated for renewable energy projects (Danish Maritime Authority, n.d.). As illustrated below, these renewable energy areas in the maritime plan include sites for energy islands (a future prospect) in the far North Sea and close to the island of Bornholm, as well as spaces for near-future tenders in the near-to-coast Danish North Sea and Danish inner waters.

[43] The maritime spatial plan is based on the provisions of the Maritime Spatial Planning Act. The law implements EU Directive 2014/89/EU establishing a framework for maritime spatial planning, which obliges EU countries to prepare a maritime spatial plan. See: https://havplan.dk/en/about

[44] https://havplan.dk/da/page/info

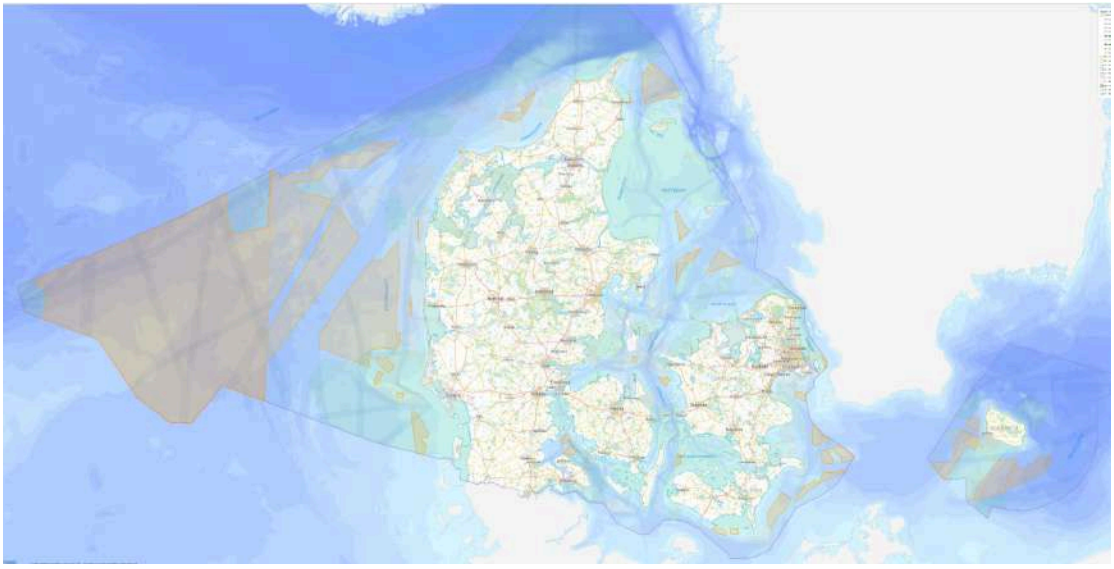

Figure 3. Danish Renewable Energy Zones as allocated in the Danish Marine Spatial Plan (Havplan, n.d.)

Since MSP designated areas are usually larger than the spatial requirements by the developer, once a new area is added in the maritime plan, the DEA is required to prepare a fine screening which is a more detailed mapping that specifies certain site locations. These locations are then evaluated in terms of various conditions and compared on a Levelized Cost of Energy (LCoE) basis, so that the most suitable ones are exploited first. The fine screening process steps upon existing knowledge and doesn't necessitate any further site investigations (DEA, 2022).

4.1.5. Environmental assessments

The environmental assessments for offshore wind farms in Denmark adhere to a standardized international framework, as laid down in the EU directives on Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA).[45] Before the OWF tender deadline, DEA in collaboration with the TSO, conducts a SEA and preliminary investigations. EIA is completed by the winning bidder once the tender is awarded to secure the final construction license (DEA, n.d.a).

Strategic Environmental Assessments rely on available knowledge and data at the time of assessment without an obligation for further data collection. The SEAs evaluate multiple scenarios, considering different numbers of turbines and sizes, capacities, and construction methods. Beyond ensuring compliance with Danish environmental assessment regulations for offshore wind tenders, SEAs serve to identify potential environmental challenges early in the process. These findings inform project developers, guiding future project design and set the basis for further assessments in the IEA (DEA, n.d.a).

In addition to the SEA, Energinet, the Danish TSO, as mandated by the DEA, carries out a range of site pre-investigations prior to the tender deadline, including wind resources, geophysical and geotechnical analyses of the seabed, as well as MetOcean data collection and environmental assessments are separately conducted. In practice, this data collection process aims to reduce project risk, and minimize the need for additional surveys and further investigations in the project development phase and during

[45] SEA: Directive 2001/42/EC and EIA: Directive 2011/92/EU as amended by Directive 2014/52/EU

the EIA[46] (Olsen & Mortensen, 2024). They mainly contain data on bird and bat surveys, marine mammals, seabed flora and fauna, safety of navigation, radio links and radar, fish and fisheries, marine archaeology, underwater noise. Before the submission of tenders, all data and reports compiled by the TSO are made publicly available to bidders in the tender processes (DEA, n.d.a).

The winning bidder then owes to undertake an Environmental Impact Assessment in accordance with European and Danish legislation as aforementioned, which include the wind farm, the offshore substation and export cables forward to the landfall. Also, Energinet in collaboration with the relevant municipalities is responsible for undertaking an EIA of the project on land, i.e. from the landfall to the onshore substations, the onshore substations, as well as onwards to the 400-kV transmission grid. The overview of the whole EIA process and its respective responsibilities among relevant authorities and the concession winner are illustrated in Figure 4.

Lastly, the developer is required to consult the local fishermen and discuss potential mitigation measures or financial compensation to the estimated loss of income. Based on documented data, these estimations are initiated during the Environmental Impact Assessment and finalized once the layout is confirmed. The DEA also urges that the negotiations be commenced as early as possible in the process (DEA, n.d.a).

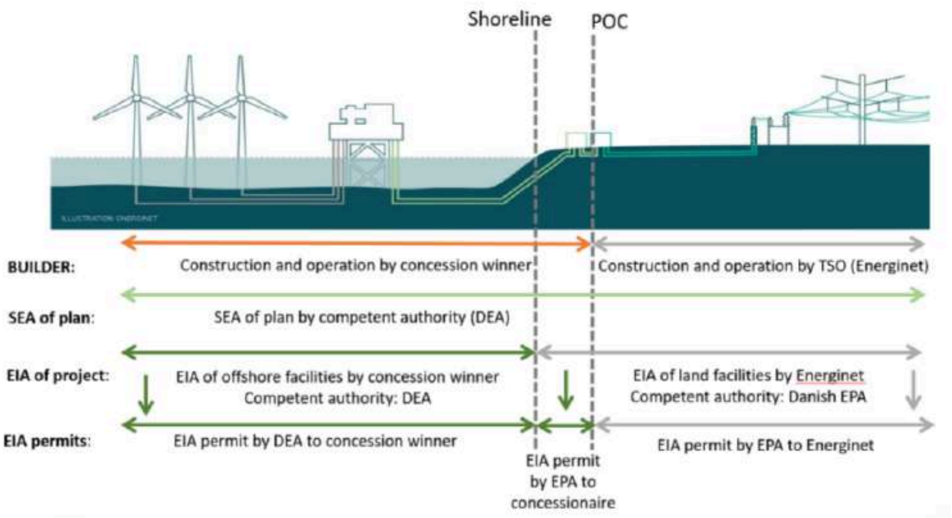

Figure 4. Overview of responsibilities in the Environmental Assessment process of Thor Offshore Wind Farm (Energinet)[47].

4.1.6. Current status and strategy for future development

The national climate ambitions, as proposed by the new government that came into power in December 2022, aim for a carbon-neutral energy system by 2045 and a 110% greenhouse gas emissions reduction goal for 2050 compared to 1990 levels. At present, these targets have not been included in the Climate Act. The current targets are a 70% GHG decrease by 2030 and carbon-neutrality by 2050 (Klimaloven § 1). However, the Climate Act prescribes that it must be revised in 2025 with a new goal for 2035. In such an

[46] The developer must conduct their own preliminary studies of the specific turbine positions. However, there should be no need for further collection of environmental data.

[47] This is only shown as an example, responsibilities may vary in different offshore wind projects in Denmark.

amendment, the goal for climate-neutrality and a new 110% GHG decrease target could be added. Depending on the level of ambition, for especially the 2035-goal, extended political action might be needed in regard to the planning of additional renewable energy in Denmark.

Denmark has a long history of politically binding decision-making that is directly applied in energy policy plans for the next seven to ten years. The Energy Agreement[48] of 2012 set the basis for roughly 1 GW of commissioned offshore wind energy capacity by the end of 2020 via two tendering processes. The next energy agreement concluded in June 2018 established a target of at least another 2.4 GW of offshore wind by 2030 which would double today's national capacity which is shown in Figure 5. The Parliament, based on this agreement, agreed to initiate three new tenders, while additional areas have been reserved for the establishment of up to 10 GW (Olsen & Mortensen, 2024). The Danish government, in response to Russia's invasion of Ukraine, published in April 2022 a strategy ('Danmark kan mere II'), which aims to de-link Denmark's dependence on Russian gas by building-out more offshore wind capacity (Olsen & Mortensen, 2024).

Figure 5. Installed capacity of onshore and offshore wind energy (left axis) and wind power's share of domestic electricity supply (right axis) between 2000 and 2023 (Danish Energy Agency).

The latest government tender published in April 2024 tendered out at least 3 GW of offshore wind energy in the North Sea for developing three separate OWFs and 3 GW in the Danish inner waters. These projects were part of political agreements materialized in the Financial Act of 2022 (2 GW) and Climate Agreement of June 2022 (4 GW). This excludes the Energy Island Bornholm (3 GW) that could further increase the ambition to minimum 9 GW[49].

The projects tendered in April 2024 resulted in the absence of any bids. The Danish Energy Agency on behalf of the Minister of Climate, Energy and Utilities conducted a market dialogue[50] with a wide range of active developers and subcontractors to uncover the barriers faced by relevant companies and potentially adjust parts of the current tendering framework. The dialogue results indicated that the

[48] Energy agreements are formal parliamentary majority decisions voted by represented political parties in the Danish Parliament.
[49] For more information and the results of preliminary investigations on the specific sites, see here: https://ens.dk/en/energy-sources/offshore-wind-farms-tendered-towards-2030
[50] Full summary report of the market dialogue can be found here in Danish: https://ens.dk/media/6454/download

business case was not viable for the developers due to a combination of sharply increasing costs (CAPEX, OPEX and financing costs) and the prospect of low and uncertain earnings opportunities in the Danish electricity market (DK1) due to expected low electricity prices, lack of sales opportunities and market uncertainties related to the electricity and hydrogen markets. Developers suggested adjustments focused on financial support, timeline flexibility and different penalties to reduce procurement costs, a pipeline for government call for tenders for offshore wind farms in Denmark, and improved general conditions to ensure future participation.

4.2. Consenting processes for offshore wind energy in Brazil

Brazil, although lacking any installed capacity, possesses a remarkable potential for offshore wind development and targets 16 GW by 2050 based on its National Energy Plan 2050 published by the Energy Research Company (EPE)[51]. The growing interest in offshore wind energy and the expanding maritime economy have made the need for effective planning increasingly evident. This emphasizes the current efforts to implement a comprehensive system, ensuring the orderly use of maritime space and preventing conflicts with other activities, such as navigation and environmental preservation (ABEEólica, 2023). As a result, Brazil is developing its regulatory framework, indicating that the momentum for offshore wind energy seems to be improving.

4.2.1. Legal Framework

Brazil approved the legal framework that regulates the potential of offshore wind energy through Law no 15,097 of January 12, 2025, which came into force on the same day of publication. The law provides in Article 3, VI, that the maritime regions under the Union's jurisdiction for aspects of consent for offshore energy generation projects include: i) the territorial zone, ii) the continental zone, and iii) the exclusive economic zone, as defined by the United Nations Convention on the Law of the Sea (UNCLOS).

The classification of these territories is relevant due to the centralization of the institutions that are part of the Federal Union, which helps to mitigate the complexity of sea governance, in accordance with Article 10, Decree nº 10,946/2022[52]. The Decree proposes the decentralization of the Declarations of Prior Interference (DIPs) which report potential interferences that offshore wind farms may cause within their operational areas. Additionally, it establishes nine operational bodies involved in maritime governance. For greater coordination on the issuance of these declarations, the aforementioned 2022 Decree established the definition of a federal institution to centralize the requirements and procedures. This establishment was reinforced in Article 6 of the Law approved in 2025.

The development of any offshore wind project will require evaluation from these nine institutions for the issuance of a Declaration of Prior Interference, as an opportunity to identify at an early stage, any kind of critical interference in the project (BRASIL, 2022). Federal institutions involved in these operations include:

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[51] However, this is only in a scenario where offshore wind costs are reduced significantly, relative to other renewables with potential in Brazil, Page 105 of the PEN 2050. More information can be found at: https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/Plano-Nacional-de-Energia-2050

[52] This decree assigns responsibility for issuing DIP (Declarations of Prior Interference, or *Declarações de Interferência Prévia*, in Portuguese), while Article 3, Item VI, of Law No. 15,097, of January 10, 2025, centralizes this responsibility in the executive branch of the Federal Government, simplifying in this way the DIP process. Although this may appear as a conflict between the rules, laws prevail over decrees and conflicts may be resolved by a subsequent decree.

i) Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), responsible for reporting on the ongoing environmental licensing processes for the exploration of the area.

ii) Brazilian National Petroleum, Natural Gas and Biofuels Agency (ANP), responsible for assessing the potential interference of the project in areas designated for natural gas and oil exploration.

iii) Brazilian Navy, responsible for assessing compliance with maritime regulations concerning navigation safety, ensuring the protection of water traffic management and national defense, and preventing water pollution.

iv) Brazilian Air Force, ensuring the safety and regularity of air operations.

v) Chico Mendes Institute for Biodiversity Conservation, which reports whether the area is located within or near a biodiversity conservation unit.

vi) Ministry of Infrastructure, which analyzes the compatibility of the projects with the port and waterway transportation sector planning.

vii) Ministry of Agriculture, Livestock and Supply, responsible for analyzing interferences in areas granted for aquaculture or in fishing routes.

viii) Ministry of Tourism, which assesses potential conflicts with tourist areas and the landscape impact in those regions.

ix) Brazilian National Telecommunications Agency (Anatel), responsible for assessing potential conflicts with areas of communication networks and systems.

The Federal Union has the authority to tender and authorize the use of maritime areas, which provides greater legal security for developers (BRASIL, 1988; BRASIL, 2010; BRASIL, 2025).

Two processes, also called offers, have been established regarding the consenting process for developing offshore wind projects in Brazil. The planned offer occurs when the Union, through an auction, provides certain maritime areas for the development of offshore wind farms. Interested parties must meet the requirements outlined in the public notice. The access to the area (leasing) is granted to the winners in the form of a concession, which provides the right to its exploitation given that the requirements of the concession are approved. On the other hand, the permanent offer allows the entrepreneur to select an area for developing the offshore wind farm and to submit its evaluation to the Union, which will evaluate it according to Brazil's interests. The law determines that if there are other interested parties, a public call will be opened to declare the winner. The form of this concession is authorization. Figure 6 illustrates the steps that must be followed in these two established offers.

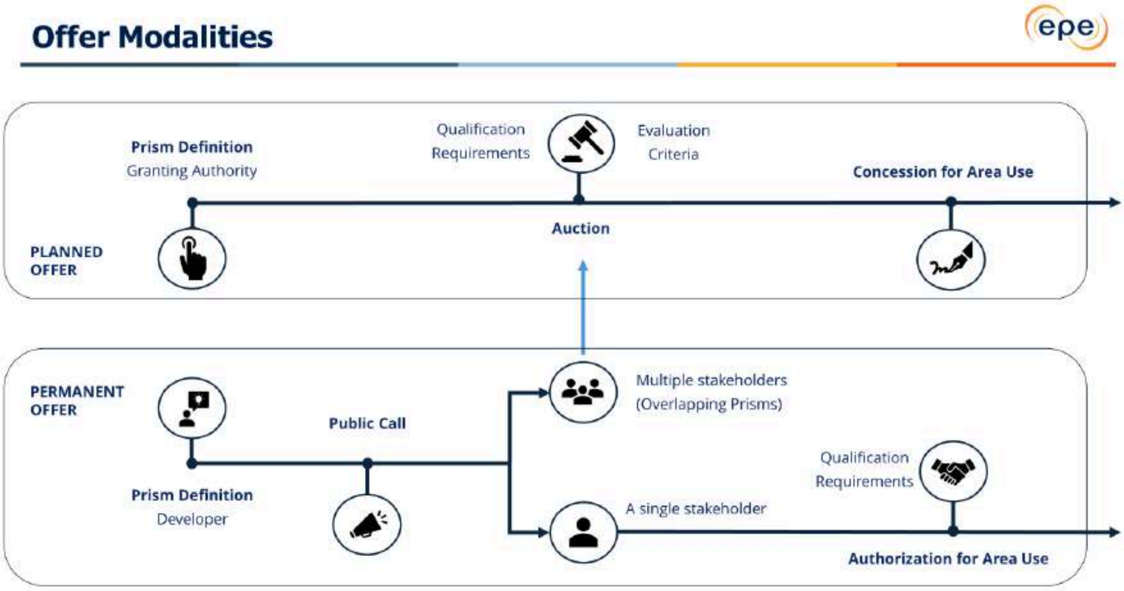

Figure 6. Offer modalities in Brazil (EPE, 2025).

The law establishes how the consenting process should be conducted, indicating the guidelines and the required Union competencies, along with the criteria and requirements for the seabed auction. That includes the parameters for bid definitions and payments that will be requested for the winner in the different phases of the development project.

It's important to clarify that the concession or authorization refer to the legal instruments granting the developer the right to access the offshore area. This is distinct from environmental licensing, which may be conducted by IBAMA, as determined by Article 11 of the Law, and separate from the right to generate energy, which must be evaluated by ANEEL in accordance with Article 10 and relevant regulations.

The Brazilian Ministry of Mines and Energy is currently in the process of establishing a working group that will discuss the subsequent regulations of the Law – specifically an updated decree, that will help to further regulate offshore wind projects in the country. This will include the prior locational definition of prisms based on suggestions from interested parties or their own planned delimitation, as well as the process for submitting DIP applications for each suggested prospectus including associated fees and deadlines.

Box 2. Brazilian Box regulatory considerations moving forward Box

Carbon Credit
The law on Article 6, §6, specifically addresses the right to commercialize carbon credits from offshore wind generation areas. These credits, in accordance with current regulations, can be traded enhancing the attractiveness of these projects by generating additional cash flow in addition to contributing to decarbonization goals (BRASIL, 2025).

Interconnection with the Grid
Regarding transmission, the Law does not address how the transmission of generated energy will be implemented. However, it provides the option of integrating generated energy into the National Interconnected System (SIN), in accordance with Article 7§1, and Article 9§5. Infralegal norms will fulfill this role, based on the needs of the network. This type of norms refers to regulatory instruments that are subordinate to the law, such as Decrees and Resolutions.

4.2.2. Maritime Spatial Planning

According to Law no 15.097/2025, Article 6, §7 the consenting of areas for offshore wind projects must be aligned with the guidelines of Maritime Spatial Planning (PEM in Portuguese) for the maritime areas which, in the Brazilian case, will be carried out region by region. PEM aims to establish effective governance of maritime space and is currently being implemented (BRASIL, 2025). The concrete initiatives for MSP in Brazil emerged in 2022, through a public call from the National Development Bank for Economic and Social Development (BNDES) with the Secretariat of the Interministerial Commission for the Resources of the Sea (SECIRM) (Medeiros et al., 2024).

PEM has been divided into several regional exercises. The South PEM began in February 2024, and has a deadline of 36 months for completion. A PEM is also expected to be implemented in the Northeast, Southeast and North regions of Brazil (BNDES, 2024). Although Article 6 is clear in the necessity to follow the guidelines of PEM or its equivalent in a planned or permanent offer, and given that the completion of the PEM for EEZ is envisioned to occur first in 5 to 10 years, the federal government could address this issue by for example implementing a regional division methodology that can enhance the speed of the PEM process or establish an equivalent methodology to maritime areas planning for offshore wind farms in synergy with MSP.

PEM is a crucial tool to help the sectorial planning to identify relevant areas for both planned and permanent supply, helping to avoid conflicts of areas and uses, such as those related to preservation or alternative industrial uses (i.e. areas of preservation, tourism, fishing, maritime routes, and other activities).

4.2.3. Environmental Assessments

The compatibility of offshore wind projects with environmental guidelines and technical requirements is essential for evaluating their sustainability, ensuring good practices to preserve natural ecosystems. Therefore, the Brazilian government has established licensing procedures for offshore wind farm projects that aim to minimize the impacts of the installation and operation of offshore wind complexes. These instruments include studies during the evaluation phase, when developers must report technical details, such as the Environmental Impact Assessment (EIA) and the Environmental Impact Report (RIMA), which are essential for identifying the environmental and social impacts of the projects (IBAMA, 2020).

In addition, Law 15.097/2025 requires that during the evaluation phase, developers evaluate the externalities of projects, as well as their compatibility and integration with other local activities, including maritime, river, lake and aeronautical safety. Once EIA and RIMA are submitted, a Preliminary License (LP) needs to be requested to IBAMA, which approves the environmental feasibility of the project, considering the location, size and potential impacts. After obtaining the LP, the project can request the Installation License (LI), authorizing the construction of the infrastructure required. It also includes mitigation and monitoring measures crucial to address the environmental and social impacts identified. The final step is the Operating License (LO) request, which allows the offshore wind complex to begin its operations, continuously monitored by IBAMA, analyzing aspects such as marine fauna, water quality, and interaction with navigation and other economic activities (IBAMA, 2020).

4.3. Chapter Conclusion

In this chapter, we have presented the consenting process for offshore wind farms in Denmark, including license types, tendering and considerations regarding environmental impact assessments at sea and on land. We have also discussed the integration of Danish offshore wind development in marine spatial planning processes. Although Denmark is an established offshore wind market, its tender and planning processes continue to evolve as the market matures and changes. An important lesson learned from the Danish experience is this need for continuous monitoring and revisions in the development of these infrastructures.

Also, key developments in the Brazilian landscape were described, as well as the initial regulatory framework and consenting process structure. Brazil is in its early days of creating a regulatory framework and many challenges are currently being faced and addressed by the government, nevertheless there is great potential for this technology to flourish in the country, especially if flexible guidelines are adopted that incorporate lessons learned from mature markets and improved over time as the domestic market evolves.

The next chapter will discuss offtake mechanisms for offshore wind, the interrelation between offshore wind and hydrogen in the Danish market and the future prospects for offshore wind demand in Brazil.

5

Discussion on offtake mechanisms for offshore wind

Electricity demand *is growing rapidly* in all different sectors of the energy system as *electrification* is a very efficient and highly applicable process in transportation, buildings, district heating, low- and medium-temperature industries and others. Thereby, the need for additional electricity generation is also increasing, while VRE technologies are becoming more and more cost-competitive.

Offtake agreements with existing but also emerging electricity consumers, such as electrolyzers for hydrogen production, heat pumps, EVs and data centers can improve the viability of VRE projects even further, while also ensuring that end-users can adopt sustainable practices in sight of the energy transition.

The present chapter focuses on potential offtake mechanisms for offshore wind energy projects in Denmark and Brazil. More specifically, it describes the *Danish framework and strategic objectives for renewable hydrogen development* and presents *Brazil's considerations on low carbon fuels and beyond*, within the broader context of *offshore wind deployment* in both nations. Considerations regarding these future developments are country specific, but the following chapters showcase strategies that could be relevant for policy-design in several countries.

5.1. Hydrogen and offshore wind energy

Hydrogen can be produced from many different energy sources (natural gas, electricity, biomass, etc.) through a wide variety of technologies e.g., electrolysis, steam methane reforming, thermal gasification and others (IEA, 2023). From hydrogen, a range of fuels can be produced, such as ammonia (by adding nitrogen) and carbon-based fuels such as methanol, methane etc. (by adding carbon). Hydrogen and hydrogen-based fuels are projected to be associated with uses in multiple sectors where *electrification is not possible*, such as *shipping, aviation* and *heavy industry*.

Renewable or low-carbon hydrogen and its derivatives remain so far *more expensive* than fossil-based hydrogen and conventional fossil fuels, due to various implications such as high capital and operational costs, inadequate infrastructure and limited access to low-cost electricity. Economies of scale, regulatory incentives, fiscal support and most importantly connections to cost-effective electricity generators could decrease and even eliminate the cost differences in the future.

From a *system integration perspective*, hydrogen can offer a flexible electricity demand which is important for systems with high VRE. Offshore wind energy is characterized by higher full-load hours (FLHs) compared to onshore wind and solar PV, while having higher marginal costs, presenting in this way a better opportunity to power flexible electrolyzers. Therefore, offshore wind energy could amplify low-cost hydrogen production without disrupting the remaining power sector operation, while also decreasing offshore wind power curtailment. Additionally, if electrolyzers are placed before the mainland's power grid entry points, it can reduce the need for grid reinforcements from TSOs, which is otherwise common for large offshore wind projects.

Revenue streams from hydrogen and derivative fuels could in the future also improve the cost competitiveness of offshore wind projects. *Coupling offshore wind and hydrogen production* could be especially relevant in systems where onshore renewable resources are constrained and/or transmission upgrades are slow, scarce or not economically viable, as electrolyzers can consume excess electricity (electricity that due to cost or technical constraints is not fed into the power grid) or operate during times of low electricity prices.

However, the attractiveness of deploying offshore wind linked with hydrogen production depends on various *techno-economic* but also *local and geographical* parameters (GWEC, 2024). Establishing an international market through international collaboration and the formation of bilateral agreements, could generate new economic opportunities for the *production and export of green hydrogen*. Large investments, along with strategic partnerships between governments and the private sector can push the creation of a favorable environment for the development of hydrogen *offtake agreements* and enable *international hydrogen trade* (IRENA, 2023).

5.2. Danish framework and strategic objectives for developing hydrogen and its derivatives

In Denmark, renewable hydrogen[53] is considered as a possible factor in fulfilling the national and European goals of climate neutrality by 2050, as stated in the 2020 Danish Climate Act and EU's long-term strategy[54]. Domestically, hydrogen's contribution is expected to be limited since international aviation and shipping are not accounted for in the climate goal, however the potential for hydrogen exports is high. Therefore, the parliament has agreed on ambitious targets for hydrogen production at scale which are expressed through the *Power-to-X strategy* and the *political agreement* on the development and promotion of hydrogen and green fuels in March 2022.

As renewable energy continues to grow its share in the Danish energy mix, with offshore wind leading the race, the possibilities for renewable hydrogen production have started being integrated in the

[53] In Europe, the European Commission defines that grid-connected hydrogen, hydrogen-based fuels, or other energy carriers can be considered as renewable fuels of non-biological origin (RFNBO), only if they meet two main types of criteria: Additionality and temporal and geographical correlation. These types are described in the Delegated Act 2023/1184 of 10 February 2023. For more information on renewable hydrogen see here: https://energy.ec.europa.eu/topics/eus-energy-system/hydrogen/renewable-hydrogen_en

[54] https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en#:~:text=The%20EU%20aims%20to%20be,to%20the%20European%20Climate%20Law%20.

process of assessing the feasibility of new renewable projects, and especially in the case of offshore wind. For that reason, the Danish authorities have agreed to allow for *overplanting* of offshore wind turbines in the coming *OSW tenders*, in order to ensure flexible designs that foster hydrogen production and cost-efficiency. Also, among other attempts to support a prosperous hydrogen market which are thoroughly discussed below, a framework is being developed that allows for *smart regulation* and *differentiated grid tariffs*, so that flexibility services are accounted for, incentivizing in this way larger integration of hydrogen production in the national grid.

Therefore, future offshore wind projects are not seen in isolation from establishing a competitive and well-regulated hydrogen market and vice-versa. *Hydrogen offtake agreements* can improve the viability of business cases for the tendered projects from the concession winners' viewpoint. Danish production of hydrogen and green fuels can benefit local growth and contribute to the broader European security of supply, while reaping the benefit of ample offshore wind resources and offshore wind expansion can support large volumes of flexibly-produced renewable hydrogen.

5.2.1. Power-to-X strategy

At the end of December 2021, the government published a national *Power-to-X strategy* [55] through the Ministry of Climate, Energy and Utilities, taking a major step into establishing a first set of framework conditions for PtX projects in Denmark and building upon the 2020 Climate Act. The strategy is strongly based on DEA's analyses and running dialogues with the PtX industry, resulting to four key objectives for the national promotion of Power-to-X activities (also illustrated in *Figure 7)*:

1. Power-to-X must contribute to reducing GHG emissions as set out in the Danish Climate Act[56].
2. The regulatory framework and infrastructure must be in place for Denmark to realize its full potential and for the Power-to-X industry to operate on market terms in the long run.
3. Energy system integration must be improved to maximize the benefits of a highly interactive system.
4. The realization of the export potential of Power-to-X products and technologies.

Some of the *main components* of this strategy is the aim to build-out 4-6 GW of electrolysis capacity by 2030, a tender-based government investment of DKK 1.25 billion (EUR 167.5 million)[57] to support the production of hydrogen, and finally fund allocation of roughly DKK 4 billion (EUR 536.2 million) towards research and technology innovation, and hydrogen value chain projects, through different initiatives and programs.

Following the strategy, a *PtX taskforce* has been established by the Ministry of Climate, Energy and Utilities, anchored in the Danish Energy Agency, with the objective to identify and address regulatory barriers and to strengthen the framework conditions within production, transport and use of hydrogen and PtX products in Denmark. More specifically, the taskforce contributes to the coordination between state and municipal authorities that work with PtX projects, focusing on approval and permit procedures, as well as ensuring continuous dialogue across the PtX sector, to tackle barriers that could set the capacity build-out target at risk.

[55] https://ens.dk/en/supply-and-consumption/power-x
[56] https://www.en.kefm.dk/Media/1/B/Climate%20Act_Denmark%20-%20WEBTILG%C3%86NGELIG-A.pdf (English translation)
[57] All amounts refer to 2022 price level

Figure 7. Objectives for overcoming Power-to-X barriers (Government's Strategy for Power-to-X).

5.2.2. The first Power-to-X tender

The abovementioned first ever Danish PtX tender for operational support was opened in April 2023 and closed five months later, attracting great interest from developers, who combined, applied for *more than three times the allocated budget* of DKK 1.25 billion (EUR 167.7 million). Five different projects have been *awarded the state aid* with a total electrolysis capacity of roughly 209 MW and all winning bids were lower than 70 DKK/GJ (9.4 EUR/GJ) (DEA, 2023), following the budget-regulating cap that was applied.

Each project bid with different support needs and different electrolysis capacities, with the lowest awarded subsidy price being at 40 DKK (5.35 EUR) per GJ of green hydrogen produced. The support is provided as a *fixed subsidy price* over a period of 10 years. The state aid only supports *green hydrogen*, and the *maximum number of fundable FLHs* per year for the electrolysis facility cannot exceed the threshold of 5,500. The plant can operate beyond the threshold, but without aid to the additional production. Also, if a project requires *grid connection*, a screening report from Energinet (Danish TSO) should be made. After contract finalization, the project owners have four years to complete construction and initiate operation to avoid penalties, however, production is expected to start sooner in most cases (DEA, 2023).

5.2.3. Regulatory framework for establishing Power-to-X projects on land

In order to enable, speed-up and streamline applications for establishing *onshore PtX plants* in Denmark, the Danish Energy Agency has created a *step-by-step guide*[58] with all relevant information. The whole process from initiation to commissioning is thoroughly described and for each step, if the information provided in the regulatory pilot is not sufficient, there are clear directions on how to obtain extra guidance.

[58] The guide can be found here: https://veprojekter.dk/sites/default/files/2023-12/Establishing%20Power-to-X%20plants%20-%20a%20regulatory%20guide_finalversion.pdf

The guide describes an overview of the *permits*, *approvals* and other *regulatory steps* required to develop and commission PtX projects and is relevant for the following *onshore infrastructure*: Electrolysis plants, synthesis plants, gas stations, storage of hydrogen and oxygen (excluding underground storage), storage of methanol, ammonia and other fuels, and finally pipelines for transporting PtX products.

Before applying, the project owner must, to the fullest extent possible, ensure a sufficient documentation basis for the authorities to initiate the case handling. Also entering into early discussions about the content of the application with the relevant authorities might be beneficial for the applicants and *decrease lead time*. Once the application process is *initiated*, a *valid planning framework* (zoning plan) is usually necessary to be developed in coordination with the relevant municipality. If required, an environmental assessment follows, calling project owners to submit an environmental impact report to secure an environmental permit and other approvals, e.g. groundwater or surface water extraction. Most PtX projects are subject to *environmental permit requirements* under Section 33 of the Law on Environmental Protection[59]. Subsequently, risk management, emergency preparedness, and fire safety measures are necessary to be addressed before the building and construction phase can commence which typically also involves a *building permit*.

Upon completion of construction, the project must undergo various *registration*s with the Danish Safety Technology Authority and apply for *grid connection*. Most PtX plants connect to the transmission grid operated by Energinet (Danish TSO for electricity, gas and hydrogen), though smaller plants may be connected to the distribution grid operated by local grid companies. Direct line connection, completely or partially outside the public grid, is also possible between a PtX facility and a source of electricity, usually wind or solar power plants. Such an option could be beneficial for the PtX facility owner because it will *reduce tariff payments*. Finally, before the plant can start operation, a *commissioning license* is required together with an energization, a temporary operation, and a final operation permit.

Box 3. Hydrogen Guarantees of Origin

Guarantees of Origin (GOs) according to the Renewable Energy Directive (RED II) are certificates that attest the renewable origin of energy, thereby allowing producers and consumers to prove that the energy produced or consumed is based on renewable energy. GOs are transferable and can be traded in the market. In Denmark, the same overall principles apply whether the energy source is electricity, gas or hydrogen, which are based on REDII as aforementioned and written into Danish law (Executive Order on Guarantees of Origin) (Energinet, n.d.b).

The development of hydrogen GOs is built on experience from electricity and gas certificates and shaped through cooperation between the Danish Energy Agency, Energinet and market participants through market dialogues. The GO scheme currently covers electrolysis-based hydrogen and aligns with Article 19 of RED and the future European hydrogen origin guarantee standard (Energinet, n.d.b). The Danish Energy Agency is responsible for issuing GOs for renewable hydrogen distributed outside grid infrastructure, e.g. for hydrogen-fueled trucks, while Energinet has been mandated as the issuing body for grid-based hydrogen distribution.

Hydrogen derivatives are not yet integrated in the certification scheme, however, the upcoming transposition of REDIII mandates the issuance of GOs for renewable fuels of non-biological origin (RFNBO) such as hydrogen. Once REDIII is implemented into national legislation, the relationship between GOs and RFNBO certifications – particularly for compliance and target accounting – will be clarified. Nevertheless, Energinet has already introduced e-methane GOs based on methanation of renewable hydrogen and CO2 captured from biomethane upgrading, signaling early progress toward certification of hydrogen-derived fuels.

[59] https://www.retsinformation.dk/eli/lta/2023/5

5.2.4. Site and network considerations

An important consideration when planning for hydrogen production facilities' deployment is the *location* as electrolysis could take place onshore, e.g. near the landing point/sector coupling zone, offshore on platforms or islands, but also directly in the wind turbines. The optimal solution depends on several factors such as the distance from the electricity production source, e.g. offshore wind turbines, the location of the offtaker or other downstream considerations, the cost of electrolysis plants including the offshore foundations and the value of power or hydrogen transmitted or transferred at shore (Energinet, 2022).

According to a *model-based analysis* by the Danish TSO, when producing hydrogen *exclusively from offshore wind*, for installed turbines relatively close to shore (less than 50km), onshore electrolysis is more cost-effective. In far-shore cases, the emerging concept of pure hydrogen wind turbines, i.e. turbines that only feed offshore electrolyzers, result in the lowest hydrogen production costs, however, the lack of interaction with the electricity market via the power grid could make this option less attractive for developers and it is not yet commercially available. In a hybrid offshore setup, where the wind farm is also connected to the grid, offshore hydrogen production is only appealing if foundation costs are kept low (Energinet, 2022).

Once hydrogen is produced, efficient means of *distribution* are necessary to ensure that it will reach the demand areas. As the sector is still at a nascent stage, trucks and ships could be viable transportation options, however, with the anticipated rapid scale-up of production in Denmark, transmission via pipelines could prove relevant and potentially more cost-efficient. As mentioned in the Power-to-X strategy, it is important that the two state-owned gas system operators, Energinet (TSO) and Evida (DSO), are able to own and operate *hydrogen networks*, where Energinet will be responsible for cross-border infrastructure and pipelines, as well as offshore facilities and Evida will connect national producers and consumers to the interconnected Danish hydrogen system.

As also outlined in the PtX strategy, market dialogues with neighboring countries, especially Germany, should be initiated to discuss the potential establishment of a hydrogen corridor. Following this ambition, Germany and Denmark *signed a joint declaration of intent* on March 2023[60], which underscored the significant value that hydrogen infrastructure could bring for PtX players, in terms of flexibility and access to larger-than-Danish markets like Germany (Energinet, n.d.a). The European Commission's *REPowerEU plan*[61] that targets 20 million tons of equal parts of domestic and imported hydrogen production also highlights this need of exploring *cross-border infrastructure* network planning.

5.2.5. Latest hydrogen developments

Most recently, a political agreement has been reached between the Danish government and a wide range of parliamentary parties to support the establishment of a *hydrogen pipeline* from Esbjerg, Denmark to

[60] https://www.kefm.dk/Media/638151855536501080/Joint%20Declaration%20Hydrogen%20DNK-DEU%20.pdf
[61] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en

the German border[62]. The agreement entails a state loan of DKK 7.4 billion (EUR 992 million) and operating support of up to DKK 8.3 billion (EUR 1.1 billion). The booking requirement is also being *reduced*, with producers now obliged to book at least 0.5 GW of hydrogen transport capacity in the pipeline on binding contracts, in order for the project to be realized.

Contracting parties aim to have the *pipeline operational by 2030* as relevant industries including the *German steel sector* have already expressed significant demand for hydrogen. Consequently, an ambitious timeline has been set by Energinet, which is supported by contractors' efforts to secure the necessary framework, starting with the adoption of a *planning act* and followed by a *construction act*. Energinet has already engaged in discussions with landowners and will actively involve local communities and other stakeholders throughout the process. According to the agreement, Energinet intends to submit a formal application to the Minister of Climate, Energy and Utilities in the spring of 2025, marking the next step toward establishing the *hydrogen infrastructure.*

Project-wise, in 2020, the *publicly announced* electrolysis capacity was just around 40 MW. This number has been growing rapidly ever since and the aforementioned 2023 PtX tender and agreement pushed it even further to currently being at gigawatt-scales. However, demand and relevant infrastructure development have not so far managed to keep up the pace and together with cost considerations in sight of remaining challenges, resulted in slowing down the overall built-up momentum, with some projects being halted or even cancelled.

Box 4. Indicative examples of Danish Power-to-X projects

Brande Hydrogen – Green hydrogen
The Brande Hydrogen pilot project combines a 3 MW wind turbine and a 400 KW alkaline electrolyzer delivered by a Danish manufacturer. The turbine operates independently, meaning that the electricity consumed by the electrolyzer bypasses the grid. In 2021, this project was granted test zone status, receiving exemptions to certain regulations that allowed for quick development. Everfuel has secured an offtake agreement to distribute the procured green hydrogen to their refueling stations, supplying green hydrogen to fuel-cell vehicles, including taxis in Copenhagen.

Kassø PtX – Green methanol
In Kassø, Southern Denmark, the world's first large-scale commercial green methanol plant has now been established and converts solar energy into e-methanol. The facility features three 17.5 MW electrolyzers that annually generate 6,000 tons of green hydrogen and 90,000 tons of purified water sourced from local boreholes and water suppliers. This hydrogen is combined with biogenic CO_2 to produce up to 42,000 tons of e-methanol each year. The facility has been granted certification for meeting the RFNBO criteria under EU's new sustainability framework for renewable fuels. Green methanol off-takers include the shipping company Maersk, the toy company LEGO and the pharmaceutical company Novo Nordisk.

REDDAP – Green ammonia
Renewable Dynamic Distributed Ammonia Plant (REDDAP) project aims to create the world's first dynamic green ammonia plant at a commercial scale of 10 MW in Lemvig, Western Jutland. Renewable energy from a connected 12 MW onshore wind farm and a 50 MW solar plant drives the Power-to-X plant, producing hydrogen which is then converted into ammonia. This dynamic approach makes its operational range of full-load hours very flexible, while surplus renewable energy is fed into the national grid. The plant is able to produce over 5,000 tons of green ammonia annually, preventing 8,200 tons of CO2 emissions and was officially inaugurated in August 2024.

[62] For more information see here (in Danish):
https://www.kefm.dk/Media/638745133989084465/One-pager%20brintr%C3%B8r%20til%20Tyskland.pdf

5.3. Offtake considerations for offshore wind in Brazil

Brazil boasts a predominantly renewable electricity matrix, largely driven by its hydroelectric power production. The country also holds significant potential in wind and solar energy and is a global leader in biofuels production, such as ethanol and biodiesel. This combination places Brazil in a strategic position in the global decarbonization scenario (EPE, 2024a).

However, despite these advantages, further efforts are required to meet its ambitious climate targets, in alignment with global initiatives focused on achieving net-zero emissions by 2050 (CEBRI et al, 2024). By strategically integrating *offshore wind energy into its national grid*, Brazil could not only enhance the resilience of its energy infrastructure but also position itself as a leading force in sustainable energy production in the coming decades.

For Brazil to advance in the development of offshore wind energy, it is crucial to establish reliable *offtake mechanisms* that will ensure the financial viability of the country's first offshore wind projects. These mechanisms aim to ensure a stable demand for the electricity generated, justifying investments in infrastructure, attracting investments, and mitigating the risks associated with the initial stages of project development of new markets.

5.3.1. Electricity demand growth and the role of offshore wind energy

Globally, the capacity for *renewable electricity* is expected to increase *twelvefold* compared to 2020, driven by the growing demand for *electrification*, particularly in the transportation sector, reaching an average of 1,066 GW of annual capacity between 2023 and 2050 (IRENA, 2023). *Modern biomass* and *hydrogen* are expected to play a significant role, contributing between 16% and 14% of energy consumption by 2050, with 94% of hydrogen coming from renewable sources. Notably, governments worldwide have been pressuring automakers to replace combustion engines with other decarbonization alternatives, and several automakers are announcing the *electrification of their vehicles*.

Additionally, companies such as Equinor, Shell, and BP are developing their own models. When analyzing the scenarios projected by these companies and by IRENA (IRENA, 2023), it is observed that there are variations in the results regarding the percentages of fuels and technological routes for *advanced renewable fuels*. However, they all converge towards *vehicle electrification* (Equinor, 2023; Shell, 2023; BP, 2024).

Considering this global trend of vehicle electrification, regarding the Brazilian demand[63], *offshore wind energy* could be integrated into the national grid, and with its high potential, it can be a *key source* to meet this potential growing demand. If supported by *public policies* for off-peak vehicle charging, it could also *enhance the resilience* of the National Integrated System (SIN), reducing the need for batteries to modulate the load (ABEEólica, 2023).

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[63] Brazil has several options for decarbonizing its transportation matrix, especially due to the availability of biofuels. However, the electrification of light vehicles has gained momentum worldwide in recent years, despite challenges such as the cost of vehicles and charging infrastructure expansion needs.

Brazil can allocate the significant potential of offshore wind energy to *different uses* beyond integrating it into the integrated network (SIN). The *electrification of oil and gas platforms*, contributing to the decarbonization of upstream operations and promoting sustainability in the sector could be one example. Another market to be explored is *data centers* whose consumption is expected to keep increasing in the future. The growing importance of data centers along with the need for sustainable solutions, represents an opportunity to meet their energy demand through offshore wind. Additionally, as *industries* shift from fossil fuels to electricity to reduce their carbon footprint, the integration of offshore wind energy could play a central role in supplying industries with clean electricity (CEBRI et al, 2024).

Projections of electricity demand are crucial for planning and investment in the wind sector. Brazil should set clear *long-term targets* for renewable energy, creating regular and transparent *auctions* that provide a stable timeline for developers. The Policy Paper 'Strategies for Offshore Wind Industry in Brazil (2024)' highlights *eight key strategies* for the development of the offshore wind sector in Brazil: a single window system to simply processes, legal certainty for investors, simplified environmental licensing, auction criteria beyond price, greater demand predictability, public policies that promote innovation and sustainability in offshore wind energy, and the engagement of multiple stakeholders (CEBRI et al, 2024).

To foster a favorable environment for offshore wind energy in Brazil, promoting sustainable development and ensuring investment certainty, through the implementation of a *multi-criteria tool in auctions*, can enhance the selection of the best projects. This approach ensures that multiple factors are considered, improving the overall quality and sustainability of the selected projects.

5.3.2. Potential applications of hydrogen in Brazil

Since offshore wind holds significant potential to generate large quantities of clean energy, it is considered a crucial source of power generation within the energy transition. This source of energy also *unlocks the potential* in Brazil to produce substantial volumes of *low-emission hydrogen* (as defined in Brazilian law) and *hydrogen-based products*, which is one of the possible substitutes for fossil fuels.

Broader *sectoral electrification* also creates new opportunities for Brazil in the production of low-emission hydrogen. The country could use its renewable capacity, including offshore wind, to produce *derivatives* such as ammonia, nitrogen fertilizers, oxygen, methanol, and sustainable aviation fuel (SAF) (ABEEólica, 2023). By utilizing offshore wind energy to produce these fuels, Brazil can further *strengthen its position* as a global leader in the renewable energy production and the promotion of low-carbon technologies (ABEEólica, 2023). With this set of resources and potential, Brazil is well placed to take advantage of global changes in the energy matrix, not only to meet its own electrification needs, but also to contribute significantly to the *global energy transition* (EPE, 2024b).

In Brazil, the *Northeast region* has been advancing in the *production of low-emission hydrogen*, particularly in the state of *Ceará*. One example is the *Port of Pecém*, which has a world-class port terminal, positioning it as a key player in the emerging hydrogen market. The port hosts the Ceará Export Processing Zone (ZPE), which has storage facilities, industrial areas and administrative support services. The ZPE has recently expanded with over 1,900 hectares dedicated to receiving new investments. This area will serve as the base for companies involved in the production of green hydrogen in Pecém[64].

[64] See: https://www.gov.br/secom/pt-br/assuntos/noticias/2024/10/governo-federal-aprova-instalacao-de-projeto-de-hidrogenio-v

Thus far, the Pecém complex has *six pre-contracts signed*, representing a total of around US$ 8 billion in investments by 2030[65]. These projects are expected to *boost the local economy*, creating both direct and indirect jobs in the region. Furthermore, the Port of Pecém and the Port of Rotterdam will be the closest *green hydrogen export-import route* between *South America* and *Europe*. In order to accommodate the companies that will produce green hydrogen in Pecém, the structure of the complex and the port will be modernized. To this end, a *utility corridor* will be created through which the ammonia, natural gas, hydrogen, water and electricity grid pipelines will circulate. Additionally, Pier 2 and the multiple utility terminal will be adapted to handle ammonia and other green hydrogen derivatives. These coordinated efforts indicate that Brazil is preparing itself to delve into the opportunities of this emerging market.

Other ports in Brazil are developing their own strategies to become production and export hotspots for low-emission hydrogen and derivatives, such as Açu, Suape, Rio Grande, and the ports at states Piauí and Rio Grande do Norte.

Efforts to support hydrogen development are further reinforced by Law nº 14,948 of August 2, 2024 (BRASIL, 2024a), which created the *legal framework for low-emission hydrogen in Brazil*, aiming to promote the energy transition. The law established a *national hydrogen policy* guided by principles that seek to insert hydrogen into the energy matrix, fostering decarbonization and promoting research and development, in order to support the domestic and international market.

As an incentive, the Brazilian government also created the *Special Incentive Regime for Hydrogen Production (Rehidro)*, providing *tax benefits* and *credits*, for a period of 5 years, to companies that invest in low-emission hydrogen. The law aims to encourage both *national* and *international* investments in *hydrogen production*, as well as to promote the domestic production of *nitrogen fertilizers from low-carbon hydrogen* to reduce external dependence and ensure food security in Brazil (BRASIL, 2024a). Also, in the Triennial Plan, three goals were established to be achieved by 2035, as illustrated in *Figure 8*.

Figure 8. Three pillars of Brazil's Triennial Hydrogen Strategy (Ministério de Minas e Energia, 2023).

erde-de-r-17-5-bilhoes-na-zpe-de-pecem-ce and https://www.gov.br/mdic/pt-br/assuntos/noticias/2024/outubro/aprovado-o-maior-projeto-de-producao-de-hidrogenio-verde-em-larga-escala-do-pais

[65] See: https://www.gov.br/portos-e-aeroportos/pt-br/assuntos/noticias/2024/05/complexo-do-pecem-destaca-se-com-projetos-de-hidrogenio-verde

5.4. Chapter Conclusion

Denmark and Brazil are at the starting point of the development of hydrogen and derivatives, however, government ambitions showcase determination towards supporting this emerging market in both countries. This chapter has provided an *overview of trends and developments* in the two cases and offered some examples of the projects being developed at the moment.

While in *Denmark* there is currently a relation between offshore wind development and hydrogen, that does not necessarily apply in the case of Brazil. *Brazil* has vast renewable energy on land that can provide the initial steps for a hydrogen market and its derivatives.

The primary goal in Brazil is to *decarbonize hard-to-abate sectors*, such as cement, steel etc., with considerations towards *export opportunities*. Denmark does not present extensive CO_2 emission reduction prospects via hydrogen domestically, which is why the priority is to export to other European countries, e.g. Germany. The remaining production in Denmark is expected to be used in the production of e-fuels for aviation and maritime transport.

6 Conclusions

This working paper aimed to share the latest insights on consenting processes for offshore wind globally, to inspire Brazilian stakeholders who are in the process of informed discussions for this new sector in Brazil.

Through a review of consenting processes in key markets globally, a detailed examination of Denmark's institutional settings, and an analysis of Brazil's evolving regulatory landscape, the paper highlights both the potential and the challenges that offshore wind regulation and development face globally. Furthermore, the paper emphasizes the dynamic nature of tendering and consenting processes worldwide. While being non-prescriptive in nature, the working paper highlights the importance of early planning and clear regulatory set-up as a way to motivate investments in the sector.

The paper underscores Brazil's significant resource capacity, while acknowledging the ongoing refinement of its regulatory framework. In upcoming months, we expect to see further work being done by Brazilian authorities to delineate further the regulatory settings that will accompany the recently passed law.

Finally, the discussion on offtake mechanisms reveals that both countries expect high electricity demand growth, of course on different scales but with similar patterns, that could enhance the need for offshore wind uptake, especially in the Danish case. Zooming into hydrogen as a potential demand driver and offtaker, regional priorities seem to slightly diverge: In Denmark, it's considered a possible supplement to new offshore wind projects and mainly an export opportunity, whereas in Brazil, although export considerations are on the table, the priority leans towards making hydrogen part of decarbonization strategies for hard-to-abate industries.

Ultimately, this working paper serves as a resource of insights and best practices to support Brazil in becoming a prominent offshore wind market. Since Brazil is prioritizing the just and inclusive energy transition, and given the geopolitical trends and its vast available resources for offshore wind, the country possesses the potential to become an offshore wind powerhouse in the future.

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