

# Offshore Wind in the Brazilian Power Market: Strategic and Policy Recommendations

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## 1. Context and objective of this report

### 1.1. The context of offshore wind in Brazil

Offshore Wind Energy (OSW) is recognized as a fundamental strategic component for diversifying the supply mix and maintaining the low carbon profile of Brazil's power sector in the long term, also contributing to decarbonize the hard-to-abate sectors. Brazil possesses robust technical OSW potential, estimated by the Energy Research Company (EPE), on its *Offshore Wind Roadmap (EPE, 2020a)*, at approximately 700 GW in locations with wind speeds above 7 m/s at 100 meters height and water depths of up to 50 meters, enabling the application of fixed-bottom foundation technology. This potential is mostly concentrated in three major clusters along the country's Exclusive Economic Zone and covering the Northeast, Southeast and South, as shown in **Figure 1**.



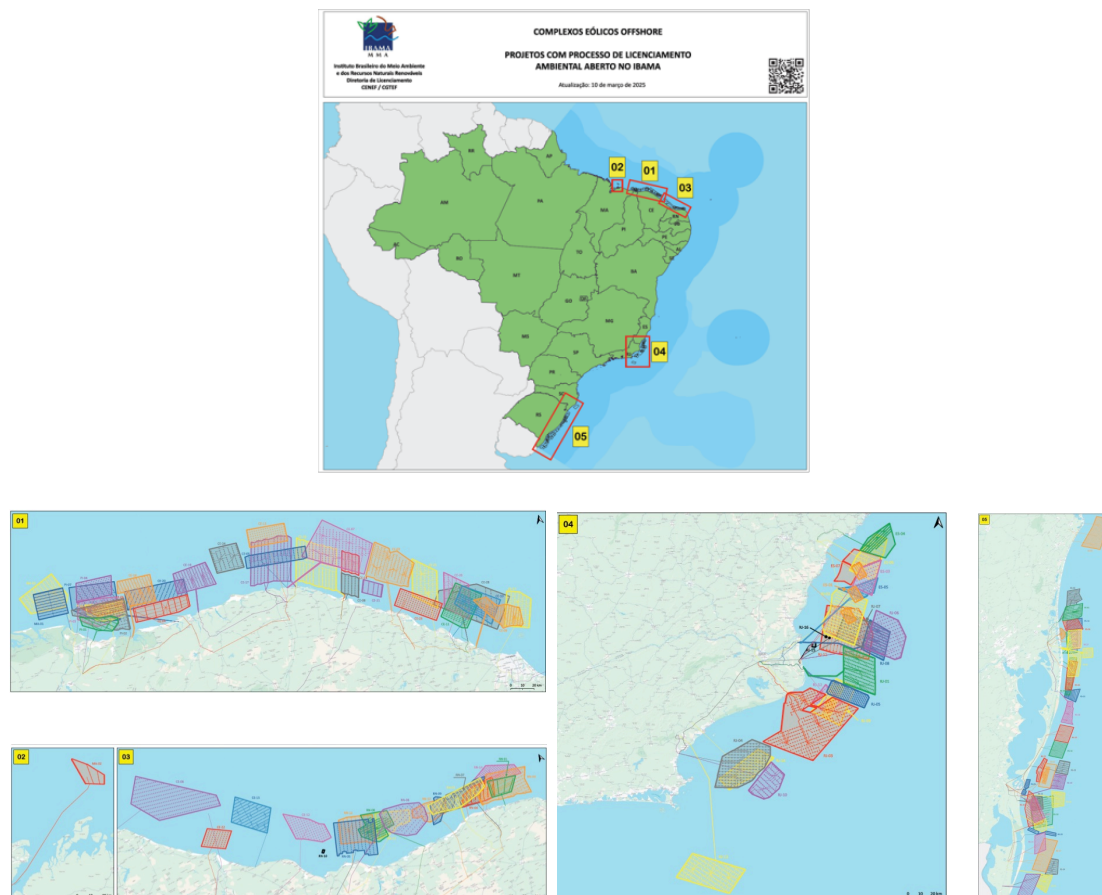
**Figure 1:** Brazil's offshore wind potential is divided into the Northeast, Southeast and South.

The significant technical potential of 700GW is formally included in the discussions of the National Energy Plan 2050 - PNE 2050 (*EPE, 2020b*) and in the Ten-Year Energy Expansion Plans - PDE (*EPE, 2020c*), confirming its role in the country's long-term energy strategy. These studies indicate that OSW is not competitive within the ten-year planning horizon under current cost benchmarks. However, under certain cost-reduction scenarios, OSW may become competitive in the 2050 horizon, highlighting its potential long-term role in Brazil's energy transition<sup>1</sup>. In addition to cost reductions, this outlook may be further influenced by evolving policy and market frameworks, including the introduction of carbon pricing for fossil-based generation, the valuation of complementary generation profiles (e.g., wind and water complementarity), and other climate-related requirements that could enhance the relative competitiveness of OSW.

The manifestation of interest from the private sector is overwhelming. The project pipeline under analysis by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) already registers

<sup>1</sup> The scenarios developed under PNE 2050, together with our own analysis presented later in this report, indicate an increasing share of wind power in the Brazilian energy matrix, and show that, with a 20% reduction in CAPEX relative to IEA (2019) values, offshore wind could become more competitive and eventually occupy part of the role currently held by onshore wind in the country's energy mix.

more than 100 proposed projects, totaling over 240 GW (**Figure 2**). The volume of proposed projects constitutes a "virtual pipeline", a situation that stems mostly from the absence of an organized process and methodology to grant seabed rights.



**Figure 2:** Projects under environment licensing at IBAMA (source: IBAMA).

According to the EPE roadmap for OSW, although Brazil has high-quality wind resources and significant potential for offshore wind, the country must address a combination of challenges. Brazil has several ports which present favorable characteristics for supporting offshore wind deployment, but most will require adaptations to meet the demands of this new industry. Port infrastructure remains a significant challenge due to the complexity of the facilities needed for installation, operation, and maintenance activities, as well as the requirement for large areas suitable for handling and storing components. Notably, major ports (such as Pecém, Açú, and Rio Grande) are aware of these challenges and have positioned themselves as potential hubs for the OSW industry (WB, 2024).

Additional challenges that must be addressed promptly include the lack of a mature local supply chain, the need for integration with the existing transmission infrastructure, limited net<sup>2</sup> electricity demand growth, and the absence of dedicated financing instruments for offshore wind. Altogether, these factors

<sup>2</sup> Given the projected strong growth of distributed solar generation, an increasing portion of electricity demand is expected to be supplied by these resources, thereby reducing the residual demand and the available market space for other technologies including offshore wind.

contribute to making the introduction of offshore wind generation in the country more challenging. Also, the development of the Brazilian Marine Spatial Planning (MSP), to organize the so-called country's "blue economy", is currently under preparation. Finally, the regulatory framework is still under development, which may constrain the pace of the industry's expansion.

The last few years have brought progress on the legislative and regulatory fronts. Following the publication of Decree 10.946/2022, the government issued two key ordinances—Portaria nº 52/2022 and Portaria Interministerial nº 03/2022—which assigned to the Ministry of Mines and Energy (MME) responsibilities such as calculating payments due to the Federal Government, defining maximum assignable areas, and creating the *PUG-Offshore* portal.

The **Unified Portal for Management of Offshore Areas**, known as **PUG-offshore** (*Portal Único de Gestão Offshore*) in Portuguese, is a single-stop digital platform for centralizing all requests for area assignment and authorization of offshore energy projects in Brazilian federal waters. Its primary goal is to provide transparency and prevent the overlap of maritime projects. It streamlines the crucial step of obtaining the Declaration of Prior Interference (DIP, or *Declaração de Interferência Prévia*, in Portuguese) from multiple government agencies.

EPE also published two Technical Notes with recommendations on these topics, although implementation of the PUG-Offshore has not advanced yet. Regulatory developments then slowed in early 2023, as the market awaited a new legal framework, but picked up on late 2024 and culminated in the approval of Law 15.097/2025.

Law 15.097/2025 established Brazil's regulatory framework for offshore wind and introduced two area-assignment mechanisms: planned offers, in which pre-defined prisms are auctioned under concession, and permanent offers, in which interested parties may request areas through an authorization process subject to public consultation and, if needed, competitive procedures. Although the law provided important guidance, it did not fully detail the operational rules for offshore area assignment, including how payments to the Federal Government should be calculated. In 2025, MME launched Public Consultation No. 191/2025 to gather feedback on EPE's proposed three-stage methodology for identifying viable regions, defining areas of interest, and prioritizing sectors for offering—an approach intended to support planning, inform future auctions, and contribute to a public database under the future PUG-Offshore Portal.

Despite these advances, several steps remain pending for consolidating the offshore wind regulatory framework in Brazil on the policy and regulatory sides. Outstanding items include methodologies for calculating payments due to the Union, defining maximum concession areas, and selecting areas for offer; creation of the PUG-Offshore Portal; procedures for submitting DIP requests; mandatory qualification requirements; rules for the permanent offer process; and detailed procedures for obtaining generation authorization. These elements are essential for providing legal certainty and enabling the structured development of the offshore wind sector in the country.

Moreover, the law does not provide detailed guidelines on how offshore wind will be integrated into the power market — such as energy contracting mechanisms, grid-connection rules, or potential incentives

— and still contain significant gaps that, ideally, should be addressed before the first seabed auction can take place.

## 1.2. Objective of this report

This report is a contribution of the *Instituto de Sistemas Complejos de Ingeniería* (ISCI), housed at the Universidad de Chile, together with well-known respected experts in the Brazilian power sector, to the current debate in Brazil. It proposes a set of policy and regulatory recommendations to harness the potential of offshore wind energy in Brazil. Building on the country’s evolving legal framework, lessons from national energy experiences, and emerging best practices, the report aims to provide actionable guidance to government institutions, regulators, and stakeholders. Its purpose is to support the creation of a coherent, predictable, and investment-ready environment capable of enabling offshore wind to contribute meaningfully to Brazil’s energy transition, industrial development, and long-term decarbonization goals.

The following chapters present a comprehensive examination of Brazil’s evolving offshore wind framework and some conditions that would be recommended for its successful development. Chapter 2 reviews the advances in the legal and regulatory landscape, beginning with the initial decree-based framework, the establishment of the 2025 Offshore Wind Legal Framework, and the subsequent regulatory agenda led by the MME and CNPE working groups. It also offers policy recommendations to guide the implementation of use-assignment mechanisms. Chapter 3 focuses on integrating offshore wind into Brazil’s power market, outlining the structure of the electricity sector, exploring relevant national experiences—such as onshore wind expansion, hydropower development, and shared biomass infrastructure—and deriving lessons for offshore wind. Chapter 4 focuses on the economic competitiveness of the technology and presents some scenarios for the Levelized Cost of Energy (LCOE) and policy recommendations on how to reduce it.

The report concludes in Chapter 5 with a consolidated set of policy recommendations to support a coherent, efficient, and investment-ready offshore wind framework in Brazil.

## 2. Legal and regulatory framework and policy recommendations

Over the past years, Brazil has undertaken a structured effort to establish a comprehensive legal and regulatory framework to ensure clear guidelines for the granting and use of federal marine areas for offshore wind power projects in the country. This process has sought to provide legal and regulatory certainties, transparent permitting pathways, and clear institutional roles for the use of federal waters.

In Brazil, the usual legislative sequence begins with a law, followed by a decree and subsequently resolutions and ordinances issued by the Ministry and Regulatory body. Yet, the approval of a law in the country is often slow and can take years. For this reason, Brazil's legal and regulatory foundation for offshore wind began to take shape in 2022, when the federal government issued the Decree No. 10.946/2022 (*MME, 2022a*), that introduced the first high-level guidelines and processes for the use of offshore areas, followed by ordinances No. 52/2022 (*MME, 2022b*) and MME/MMA Joint Ordinance No. 03/2022 (*MME, 2022c*), that established complementary rules and guidelines to the decree.

The evolution of this framework reflects a gradual shift from preliminary guidance to the consolidation of an Offshore Wind Legal Framework, culminating in Law nº 15.097/2025 (*MME, 2025a*) and triggering the need for an updated set of infralegal regulations.

### 2.1. The initial regulatory framework (Decree 10,946/2022)

The first significant step to structure the legal foundation for the offshore wind sector occurred with the publication of Decree No. 10,946/2022, in January 2022. This normative act primarily focused on providing high-level guidelines and processes for the assignment of physical spaces and the utilization of natural resources for electric power generation in waters under the country's domain.

The Decree issuance was crucial for introducing the necessary initial legal certainty. It established technical criteria, requirements, and the mandatory nature of studies for entrepreneurs. Most importantly, it defined the agencies responsible for analyzing, approving, and formalizing each stage of the projects, allocating the management of marine space assignments to the Ministry of Mines and Energy (MME) and maintaining the rigorous environmental licensing process under the responsibility of IBAMA.

Following the Decree, MME published Ordinance No. 52/2022, that provided supplementary rules and procedural steps for OSW project granting, and the MME/MMA Joint Ordinance No. 03/2022, that established guidelines for the creation, development, and use of a Unified Portal for Management of Offshore Areas (PUG Offshore), intended to centralize offshore permitting processes.

Although these instruments marked an important starting point, they soon proved insufficient to provide the regulatory and legal certainty required for large offshore wind investment.

Firstly, a dedicated Law was considered necessary because it could provide the stable, long-term legal certainty required for the large capital commitments characteristic of offshore wind projects. While decrees can be more easily altered by changes in government and in its priorities, laws carry greater permanence, legitimacy, and hierarchical strength.

Additionally, Decree No. 10,946 offered only high-level guidance on the use of federal marine areas without defining the detailed rules, procedures, and institutional responsibilities needed for project development. Many essential elements — such as the grant regime, contractual obligations, environmental licensing requirements, coexistence rules with other maritime uses, and grid-connection responsibilities — were left undefined or dependent on future regulations. Moreover, the Decree lacked a high-level policy background or guideline to support it, as is currently the case with the CNPE resolution mentioned in section 2.3.3.

As a result, investors and regulators lacked a complete, stable, and predictable framework to authorize projects, assess risks, and make long-term financial commitments, making higher-level legislation and further regulation necessary to close these gaps.

## 2.2. Establishment of the offshore wind legal framework (2025)

The consolidation of the offshore wind legal framework occurred with the sanction of Law No. 15,097, of January 10, 2025, resulting from Bill No. 576/2021<sup>3</sup>. This Law governs the utilization of offshore energy potential (not limited to wind energy) throughout Brazil's maritime extension, covering internal waters, territorial sea, Exclusive Economic Zone (EEZ), and continental shelf.

As mentioned, approving a law can take several years. Since 2017, a Bill (No. 484/2017) had been under discussion in Congress. Subsequently, two other bills (No. 11,247/2018 and 3,655/2021) with similar goals were proposed and eventually incorporated into Bill 576/2021, approved by the end of 2024 and published in 2025. In the meantime, the Ministry of Mines and Energy issued the Decree and ordinances mentioned above. This situation demonstrates the complexity and time required to approve a legal framework.

Some of the highlights of Law 15,097 are:

- It formalized the grant regime, establishing that the right to use Union assets will be conferred by the Executive Branch through authorization (*permanent offer*) or concession (*planned offer*), in accordance with its provision and Law 9,074/1995.
- For practical purposes, the Law defined the crucial concept of "prism": a vertical prism with depth coinciding with the subaqueous bed, with a georeferenced polygonal surface, which constitutes the Union asset subject to the grant for power generation. The prisms can be defined by the Executive Branch in the planned regime, or proposed by the developers (and approved by the Executive branch) under the permanent offer. In both cases, the prisms must ensure the harmonization of federal public policies and the prevention or mitigation of conflicts with other maritime uses.

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<sup>3</sup> Although the sanction of the Law was celebrated as a structural advancement, it quickly evolved into a regulatory crisis with the partial rejection of presidential vetoes. On June 17, 2025, the National Congress rejected eight vetoes, reincorporating a set of amendments unrelated to the main object of offshore wind. There are four other ones that still need to be appreciated by the Congress.

- The Law required that prospect submissions by interested parties be supported by a preliminary area study—including locational definition, assessment of energy potential, and a preliminary socioenvironmental impact evaluation.
- It also establishes that the granting of prisms by the Union shall observe the guidelines of Marine Spatial Planning (MSP) or an equivalent instrument. However, because the MSP is still under development, the Prior Interference Statement (Declaração de Interferência Prévia – DIP), to be issued by the competent authorities, is conceived as the primary instrument for assessing potential conflicts and compatibilities with other maritime activities.
- The Law establishes that, in the planned offer modality, the granting of a prism must be preceded by a bidding process in which the highest amount offered as government takes shall be considered as an evaluation criterion, together with other factors. As a result, this framework enables the incorporation of non-price criteria, in addition to economic ones, into the design of seabed auctions.
- Additionally, the Law defined qualification criteria for project proponents, set the parameters for national industry promotion, and established the principles governing government takes associated with the use of offshore areas.

As can be seen in **Figure 2**, many projects under environment licensing at IBAMA overlap (around 27% of them). Law 15,097 provides that overlaps in project proposals may be resolved through the redefinition or reallocation of areas among interested parties, or, when such solutions are not viable, through their submission to an auction.

### 2.3. The post-law regulatory agenda

With the enactment of Law 15,097, the challenge shifted to operational regulation. The legal framework delegated authority to the Executive Branch to regulate a set of provisions, which therefore requires the revision and updating of previously issued infralegal instruments (the 2022 Decree and Ordinances). Among the regulatory aspects that must be regulated, as expressly indicated in the Law, the following stand out:

- **Process for administrative procedures and institutional coordination** – clarifying the role of each institution (IBAMA, Navy, Air Force, MTur, MMA, ICMBio, etc.);
- **Process for approval of areas to be offered by MME and/or CNPE**, supported by EPE's studies using the area-selection methodology and in accordance with MSP;
- **Guidelines for evaluation criteria** for the planned-offer bidding process, in addition to the highest amount offered as government takes;
- **Definition of criteria for locational decisions**, including guidelines on maximum area limits, distance from shore and between projects, compatibilities, and restrictions;

- **Mandatory preliminary studies** required for submitting a request under the permanent-offer procedure;
- **Procedures and guidelines for integrating projects into the National Interconnected System** under both modalities (permanent and planned);
- **Compatibility of multiple uses within prisms**, defining technical and environmental parameters for the coexistence of activities, consistent with the results of the MSP when available.
- **Government takes: bonuses, fees, proportional participation.** Formulas for calculation, payment deadlines, and penalties for non-compliance. Distribution among institutions of the amounts allocated to the Federal Government.
- **Stages of the use-rights agreement:** assessment and execution.

Given the typical 8- to 10-year development timeline of an offshore wind project and the risk of losing investment to countries where the technology is more mature, most efforts so far have focused on organizing a process for granting seabed rights so that activity in the industry can begin.

### 2.3.1. The MME working group

In 2024 MME started an Offshore Wind Working Group (WG) to coordinate the technical initiatives and actions to establish the infralegal regulatory framework. This WG had four main guiding points for its actions:

**Regulatory framework**, which serves as a starting point for institutionalizing actions through decrees, ordinances, and resolutions, representing an important challenge to leverage activities in the sector. This includes efforts related to designing the necessary regulations to operationalize the procedures involved, in a manner consistent with the various cross-sectoral interests at stake;

- **Planning**, particularly with regard to identifying areas intended for OSW development. This process relies on building and applying the area leasing methodology aligned with the MSP framework, under construction. This axis also takes into account the aspects defined in the regulatory framework, ensuring regulatory consistency and alignment.
- **Integrated management of offshore areas**, with emphasis on implementing the Preliminary Interference Declaration (DIP) and the Unified Portal for Management of Offshore Areas (PUG-Offshore). In this regard, providing information associated with these actions can offer interested stakeholders a clearer understanding of the procedures, considering that regulatory and planning aspects are being developed simultaneously.
- **Technical and regulatory studies**, which help expand knowledge about the multiple uses of the sea in conjunction with offshore wind energy. This includes analyses on fishing activities, navigation, ports, stakeholder engagement, and energy commercialization models.

The WG has carried out structured actions across six strategic pillars, with focus on regulation, planning, and sectoral integration. Its main outcomes to date have been a few technical assistances sponsored by the World Bank and the International Bank for Reconstruction and Development (IBRD) to MME and EPE. Among other publications, the report *Scenarios for the Development of Offshore Wind Energy in Brazil (WB, 2024)* was released as part of this WG in collaboration with the World Bank. Also, EPE published two Technical Notes: the *Amount Due to the Federal Government for Area Assignment (EPE, 2024a)* and *Limitation of Area to Be Assigned (EPE, 2024b)*. Finally, the WG carried out a public webinar on area-selection methodologies and public consultation (Public Consultation nº 191/2025)

However, the apparent lack of engagement from other ministries and entities involved in the offshore wind development ecosystem became a significant issue. This raised concerns that future progress could be halted or significantly delayed due to the need for coordination and enforcement with entities and ministries other than MME.

Therefore, it became clear that a more formal group — established by a higher-level policy body and formally involving all organizations relevant to OSW development — was needed. This was the main motivation for the formal establishment of the working group under the National Energy Policy Council (CNPE) - which will be discussed later – alongside the regulation of the Offshore Wind Legal Framework, in compliance with the mandates set out in Law nº 15,097/2025.

### **2.3.2. Public consultation N° 191/2025 and the methodology for area assignment**

The Ministry of Mines and Energy (MME) and the Energy Research Office (EPE) have launched, on July 14<sup>th</sup>, 2025, public consultation (PC) N° 191/2025 to gather stakeholder input on the proposed *Methodology for Selecting Areas to Be Offered in Use-Concession Procedures* for offshore wind development in Brazil’s marine space. This consultation represents a decisive step toward operationalizing Law No. 15,097/2025 and establishing the technical, environmental, and spatial planning foundations needed for an orderly, transparent, and legally robust seabed-leasing process.

Brazil is still in the preparatory phase of regulating its offshore wind sector; thus, the consultation focuses not on defining specific areas but on discussing the criteria and analytical workflow that will guide future designation of “Sectors for Offer.” These sectors will delineate portions of marine space within which prisms (project-level polygons) may later be proposed according to the planned or permanent offers. The methodology is designed to integrate energy system needs, economic rationality, environmental protection, and compatibility with multiple marine uses, ensuring that offshore wind expansion occurs in harmony with broader Marine Spatial Planning principles and existing federal norms, including IBAMA’s EIA/RIMA requirements for offshore wind projects.

The proposed framework builds on national and international experience. Domestically, it incorporates lessons from marine spatial planning carried out by institutions such as the Ministry of the Environment and Climate Change (MMA), ICMBio and ANP, while also aligning with insights from the MME WG. Internationally, it draws on global benchmarks for offshore wind area planning, ensuring that Brazil’s methodology is coherent with best practices from leading jurisdictions.

Technically, the methodology is structured into three sequential stages that progressively narrow the universe of potential sites.

- Stage I identifies Viable Regions by excluding areas with hard legal or technological constraints.
- Stage II refines this to Areas of Interest by incorporating additional spatial filters—economic and technological constraints as well as zones classified as having extreme environmental or socio-economic sensitivity.
- Stage III then prioritizes which of these areas should be designated as Sectors for Offer, applying a multi-criteria classification that jointly evaluates energy-economic performance, environmental risk, and socio-economic interactions.

Across all stages, environmental and social sensitivity mapping plays a central role, providing spatial layers that highlight ecological hotspots, socio-productive activities, and other marine-use conflicts essential for responsible offshore wind siting.

Consistent with Brazil’s commitment to participatory governance, the methodology embeds formal mechanisms for stakeholder engagement. During Stage I, the Offshore Wind Working Group is consulted to validate legal and regulatory constraints. In Stages II and III, a broader engagement process is envisioned, including public meetings, technical workshops, and the publication of preliminary Sectors for Offer for online consultation. This ensures transparency, increases social legitimacy, and reduces the risk of future conflicts, permitting processes, or litigation associated with marine-space competition.

The methodology proposed by EPE is structured, progressive, and aligned with international best practices. Its three-stage sequence—exclusion, selection, and prioritization—adds robustness and transparency to the process, positioning Brazil closer to the approaches adopted in mature markets such as the United Kingdom, currently the world’s second-largest offshore wind market.

By integrating multiple evaluation dimensions, including environmental, socioeconomic, logistical, and technical criteria, combined with a structured mechanism for social participation, the methodology helps minimize future permitting and conflict risks. Moreover, its alignment with MSP and the coordinated engagement of MMA, IBAMA, ICMBio, the Brazilian Navy, ANP, and other authorities strengthens institutional coherence and demonstrates consistency with broader environmental and sectoral policies.

### 2.3.3. The CNPE working group (WG)

The establishment of the Offshore Wind Working Group (WG) under the National Energy Policy Council, on October 1, 2025, through CNPE Resolution nº 18/2025 (*MME, 2025b*), represents a significant institutional milestone in Brazil’s emerging offshore wind governance. The resolution formally creates a coordinated, high-level mechanism to steer the regulatory, infrastructural, environmental, and industrial-policy dimensions required to operationalize the new Offshore Wind Law (Law 15.097/2025). Its mandate embeds offshore wind within the broader national energy-transition and industrial-development agenda, signaling the strategic importance of the sector for Brazil, including its contribution to diversifying the Brazilian energy mix and increasing the share of renewable sources.

Law nº 15,097/2025 assigns to the CNPE the duty to establish the guidelines necessary for complying with §1 of Article 5 and Article 8, and to determine the adoption of the measures required for regulating the development of offshore wind. To meet this goal CNPE tasked the WG with the following:

- Proposing the infralegal regulations needed to implement Law No. 15.097/2025, including:
  - procedures for defining offshore “prisms,” either through government planning or suggestions from interested parties;
  - rules for submitting prism prospect studies, including preliminary locational, energy potential, and socioenvironmental assessments;
  - protocols for requesting DIPs, including applicable fees and deadlines;
  - sanctions and penalties for non-compliance with grant obligations;
  - technical, economic-financial, legal, and local-industry promotion requirements for qualification of developers in permanent or planned offers.
- Coordinating the technical studies required to support the development of the offshore wind sector in Brazil.

The governance structure is deliberately broad and interministerial. It brings together all institutions whose mandates intersect with offshore wind deployment: MME, Casa Civil, Finance, MDIC, Ports and Airports, Environment and Climate, Fisheries, Tourism, ANEEL, ANP, ANATEL, ANTAQ, EPE, IBAMA, ICMBio, the Navy and Air Force commands, ONS, BNDES, and others. This configuration acknowledges the cross-sectoral nature of offshore wind planning—spanning maritime spatial planning, environmental licensing, transmission integration, port readiness, industrial competitiveness, and national security considerations. Participation of the private sector, academia, and civil society is explicitly encouraged to ensure technical depth and stakeholder legitimacy during the process.

Operationally, the WG will meet regularly and may establish two specialized subgroups:

- Regulatory Agenda, focusing on drafting infralegal instruments required to regulate the Offshore Wind Law, and
- Infrastructure and Competitiveness Planning, tasked with analyses related to port, supply-chain, grid, and broader industrial-policy requirements.

Each subgroup may conduct in-depth studies on complex or multisectoral themes and will have deadlines and membership capped by resolution.

The WG must prepare all the regulatory instruments and interministerial policies and deliver a final report within a 360-day period (270 days, extendable for an additional 90 days). This period begins counting from

the date of publication of the ordinance appointing the Organs and Entities' representatives, which was done on the 5th of December 2025 (*MME, 2025c*). Intermediate deliverables include:

- a draft CNPE resolution required to complement the Offshore Wind Law;
- a draft presidential decree regulating the law;
- an integrated diagnostic and action plan to promote investment and accelerate sector development;
- and a proposed approval flow for the issuance of the DIP.

All meeting minutes, studies, and technical notes will be made public, enhancing transparency and predictability for investors.

The resolution provides Brazil with an institutional backbone for systematically developing its offshore wind regulatory regime. It consolidates ministerial coordination, establishes clear procedural responsibilities, and creates a structured pathway toward drafting the norms, planning tools, and industrial strategies that will shape Brazil's future offshore wind offerings and deployment.

Delays in the conclusion and publication of the WG outcomes currently constitute the *main threat* for OSW development, as until the DIP rules, the PUG-Offshore are operational, among other definitions, the MME cannot launch the first area auction tender. For this reason, the WG formalization was well received by the market as it is a concrete and impactful step towards a sustainable development of this technology. With all the institutions and entities engaged by the measures proposed by the CNPE Resolution, it is expected that the pathway towards a first seabed auction to develop OSW becomes clearly defined.

## 2.4. Policy recommendations

Below, we present our key policy recommendations. They are organized on the main topics addressed in this chapter.

### 2.4.1. Methodology for area assignment

EPE's proposal represents an institutional milestone for the development of offshore wind in Brazil. The methodology demonstrates strong structure, integration of criteria, and transparency, and it addresses a fundamental regulatory gap that has so far prevented the country from moving forward with its first offshore wind area auction. Our recommendations to improve the methodology are.

#### Criteria for exclusion and prioritization of areas

The proposal presents consistent criteria for the selection of areas; however, incorporating indicators of existing and planned onshore grid capacity for power flow already in Stages II and III would strengthen the approach. This integration should consider the effective of OSW integration into the electrical system and proximity to load centers. Such an enhancement supports investor decision-making and sectoral

planning, ensuring alignment between area-lease auctions and future SIN demand, consistent with offshore wind development timelines.

Such analyses become particularly feasible when assignment auctions are conducted in contexts where the granting authority identifies a demand need that could potentially be met by offshore wind projects within a timeframe compatible with their development and commission operation date - considering that these projects may still be subject to prior competition with other generation sources to meet that demand.

### Social participation

We acknowledge advancements in the methodology but recommend more robust mechanisms for social participation from the earliest stages. This would enhance legitimacy, transparency, and technical quality while reducing the likelihood of future challenges that could delay project implementation.

### Alignment with Marine Spatial Planning (MSP) and public policies

The methodology is well aligned with MSP and other sectoral public policies. As an improvement, we suggest harmonizing the process with transmission planning, coordinated between EPE and ONS, in line with the proposal made under the first item (*Criteria for exclusion and prioritization of areas*).

### Transparency and access to data

Transparency is essential to the legitimacy of the process. We recommend that:

- All georeferenced data used be made available on a public platform in an open, standardized format compatible with different systems;
- The criteria, weights, and parameters applied be documented in technical reports, accompanied by sensitivity analyses to assess the robustness of the results;
- An interactive portal be created to allow visualization and simulation of different combinations of criteria, weights, and parameters, strengthening trust and enabling independent analyses by civil society and academia.

### Differentiation across stages

We consider the methodological distinctions across stages adequate, both for permanent and planned offers. However, the process would be more robust with the inclusion of regional grid-connection capacity mapping, accompanied by lists of transmission reinforcements associated with each connection point. However, given the typical 8- to 10-year development timeline of an offshore wind project, the connection point might not yet exist; nevertheless, it can be included in the official transmission planning studies if required.

### **Coordination with the Prior Interference Declaration (DIP)**

The methodology already incorporates spatial restrictions and analyses of environmental and socioeconomic sensitivities. However, it is necessary to avoid overlap and redundancy between this methodology, the DIP, and environmental licensing to prevent unnecessarily long and costly project-implementation processes. For this reason, the engagement of the working group members must be effective during each stage of the methodology, facilitating the subsequent issuance of the DIP.

### **Integration with transmission planning**

We suggest that each prioritized area be linked to an indicative grid-connection plan, prepared jointly by EPE and ONS. Defining areas without clarity regarding power flow infrastructure may delay projects and increase costs.

### **LCOE calculation**

The inclusion of LCOE as a reference in Stage III is a positive development, however, greater clarity is required regarding the methodology, as the proposal appears to estimate only parameters influencing LCOE without calculating the indicator itself.

Enhancements include, for example, calculations be made available in a reproducible format, accompanied by international benchmarks and sensitivity analyses.

### **Coordination with energy-contracting mechanisms**

Area leasing could be coordinated with energy-contracting mechanisms to de-risk project development. The Brazilian experience with hydropower, that will be discussed in the next Chapter, demonstrates that coordination between project concession and long-term energy contracts is essential to make projects viable and to de-risk the seabed leasing. Without such integration, area leasing may not translate into actual project commissioning and investors might lack clarity on the cost recovery.

### **Institutional financing to enable the methodology**

Full implementation of the proposed methodology and the improvements identified in this consultation requires institutional and financial strengthening of EPE and other public entities involved. The complexity of integrated analyses—technical, socioenvironmental, and electrical-system related—combined with the need for broad social participation and transparency with open and reproducible data, demands expansion of multidisciplinary teams, as well as investments in digital infrastructure and primary data collection. We therefore recommend that the MME evaluate the allocation of additional resources and institutional support mechanisms for EPE to ensure the necessary capacity to implement the innovations required for offshore wind development.

#### **2.4.2. The forward-looking CNPE agenda and its working group (WP)**

It is essential to have absolute support by stakeholders to the CNPE WG Agenda and regulatory framework definition, aiming to the anticipation of the proposed schedule of deliverables. According to Law No.

15,097/2025 CNPE is responsible for establishing the guidelines necessary for complying with §1 of Article 5 and Article 8, and determining the mechanisms required to regulate the development of offshore wind. Our recommendations for this purpose are the following:

- Establishing that the granting of rights for the use of Federal Union assets for offshore energy development *must be aligned with the directives of the National Energy Policy* set forth in Law No. 9,478/1997.
- Determine that the locational definition of prisms be *supported by studies conducted by EPE, and that such studies must identify areas with the highest energy potential, consider the onshore grid capacity for power flow* and incorporate technical, logistical, and operational aspects into the selection process.
- CNPE should be authorized to designate priority areas considered strategic for offshore wind development, *based on the results of the Area Selection Methodology for Leasing, as executed by EPE*, to be offered in the planned modality.
- Guidelines for issuance of the Prior Interference Declaration (DIP) need to be defined, including a *mandatory coordination among competent authorities, the definition of the entity responsible for centralizing requests and procedures; and integration with environmental licensing* and other authorizations. Each DIP issuing authority must publish clear guidelines... Ideally, the request should be submitted in a single step through the PUG Offshore.
- CNPE should define which institution is in charge of developing the PUG Offshore. This Portal will be central for data management, DIP requests, and prism approvals. Its development may be time-consuming, and there is no clear mandate for it to date.
- Guidelines for the Unified Portal for Management of Offshore Areas (PUG Offshore) are key and CNPE should define the overarching guidelines for the creation and operation of the PUG Offshore, including principles of transparency, interoperability, and public access; the requirement to integrate environmental, maritime, and energy databases and the designation of the institution responsible for its implementation and maintenance.
- CNPE should be the main locus to discuss *industrial-promotion parameters* applicable to the offshore wind supply chain, including local-content guidelines; instruments for productive and technological development and mechanisms for coordination with federal neoinustrialization and energy-transition programs.
- CNPE should establish a *deadline for MME to present the full regulatory proposal for Law No. 15,097/2025*, including a date (ideally in the first half of 2026) to the complete workflow for *issuing the first DIP* and intermediate milestones consistent with the timeline set forth in CNPE Resolution No. 18/2025.

### **3. Integration to the power market and policy recommendations**

The Law does not provide detailed guidelines on the commercial integration of offshore wind to the power market. It does not present any mandates for energy contracting nor discusses business models for energy contracting and alternatives for grid integration. This Chapter will extract, from the already tested Brazilian experience of pathways to integrate new technologies in the country, lessons learned from a commercial and regulatory perspective. We have selected three experiences that are relevant for OSW: the integration of onshore wind in Brazil, the integration of hydropower in the country in the early 2000's and the coordinated grid-connection model that was developed to integrate bioenergy in 2008. We then conclude the chapter discussing international trend that could be worthy to explore: Contract for Difference (CfD).

#### **3.1. The onshore wind experience in Brazil**

The development of onshore wind in Brazil over the past two decades offers a comprehensive blueprint for how new renewable technologies can be integrated at scale into a hydro-dominated power system. The trajectory demonstrates how coordinated policy, stable contracting mechanisms, targeted incentives, and financial innovation can accelerate technology maturation, reduce risks, and enable sustained long-term investment. This experience is particularly relevant as Brazil moves toward structuring a viable offshore wind framework.

In addition to the detailed examples below, which represent the main incentive mechanisms for wind power generation in Brazil, it is important to mention that these plants also benefited from an exemption from the Research and Development (R&D) fee (mandatory for other sources) and simplified environmental licensing.

##### **3.1.1. Need for diversification in Brazil's power mix and the onshore wind start**

Brazil's electricity mix historically relied heavily on large hydropower plants, which by the early 2000s accounted for more than 80% of the country's installed capacity. This hydro-dominant configuration became a source of system vulnerability as the limits of expanding large dams approached and hydrological conditions grew more uncertain. The pivotal moment occurred in 2001, when a severe drought precipitated a national electricity supply crisis.

The crisis exposed the systemic risks of relying almost exclusively on hydropower and catalyzed a structural shift in Brazil's energy policy. Diversification became a national priority to enhance security of supply and reduce exposure to hydrological volatility. In the immediate aftermath, thermal plants — particularly natural gas units — were introduced as the first alternative. Subsequently, new renewable technologies such as onshore wind and later solar PV emerged as strategic complements to reduce long-term risk and strengthen security.

This context set the stage for dedicated public policies and mechanisms to support the introduction and scaling of these new renewables technologies within the National Interconnected System (Sistema Interligado Nacional - SIN), which at that time were still expensive compared to conventional ones.

### 3.1.2. PROINFA: Brazil’s first structured step toward large-scale onshore wind

The Incentive Program for Alternative Energy Sources (PROINFA), created in 2002, represented Brazil’s first comprehensive mechanism to bring new renewable technologies energy — particularly wind — into the national power system. Designed as a feed-in tariff scheme, PROINFA established 20-year power purchase agreements (PPA) with technology-specific tariffs (in R\$/MWh), for delivering a contracted amount of energy under the long-term contract, inflation indexation (IGP-M), and government-backed offtake through Eletrobras (later ENBPar).

The program targeted 3,300 MW of renewable capacity divided among small hydropower, biomass, and wind. By its completion, PROINFA delivered 131 projects totaling 2,975 MW, including 52 wind farms (1,282 MW). The scheme provided predictable revenue streams, guaranteed minimum payments for projects under financing, and socialized program costs among all consumers except low-income households.

PROINFA’s contribution went beyond installed capacity: it fostered the first investment environment for wind developers, enabled early learning-by-doing, attracted the industry and revealed the need for more competitive, efficiency-oriented mechanisms. As technology matured and the limitations of administratively set tariffs became apparent, the program was discontinued and transitioned into the auction-based model that would later drive Brazil’s exponential wind growth. PROINFA thus served as the bridge between initial market creation and the fully competitive procurement framework that followed, establishing the institutional, contractual, and financial foundations for large-scale onshore wind deployment in the country.

It is important to note that, even though discontinued, the program continues to be the subject of regulatory and political discussion, since PROINFA contracts start to expire in 2026, with complete phase-out scheduled for July 2031. Law No. 14,182/2021 authorized the possibility of extending these contracts for an additional 20 years, but conditioned the extension on ANEEL demonstrating a “tariff benefit for consumers”.

### 3.1.3. Evolution of Brazil’s onshore wind auctions

The most significant development of onshore wind in Brazil was shaped by a sequence of competitive, regulatory, and contractual adjustments that unfolded in distinct phases. Beginning in 2009, dedicated renewable auctions accelerated market entry: the first wind-only Reserve Energy Auction contracted 1.806 MW, and by 2010–2011 wind projects were already competing directly with biomass, small hydro, and later with hydropower and natural gas. This early phase delivered large contracted volumes, substantial discounts relative to price caps, and rapidly declining energy prices—supported by favorable macroeconomic conditions, lower post-2008 CAPEX, tax incentives, expanding equipment supply, and strong financing from BNDES and state tax exemptions. As the market for corporate PPA (known as free market<sup>4</sup>) gained relevance and the number of equipment suppliers increased, the sector matured quickly.

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<sup>4</sup> The “Free Energy Market” is a business environment where sellers and buyers can freely trade electricity with each other.

A second phase brought tighter regulatory requirements. The 2013 auctions shifted firm-energy methodology from P50 to P90<sup>5</sup>, strengthened local-content rules, and transferred transmission delay risk to generators, increasing costs and raising bid prices. The macroeconomic downturn of 2014–2015 further pressured project economics—reducing access to subsidized financing, increasing inflation and capital costs, and causing currency depreciation—yet wind maintained a strong presence in auctions, consolidating its role in Brazil’s power mix.

Between 2017 and 2021, contractual design evolved in ways that gradually increased operational and commercial risk for generators. Obligations that had been verified on a four-year basis became annual; contract types shifted from “availability”<sup>6</sup> to “quantity”<sup>7</sup>; and from 2019 onward, the energy delivery profile began to follow the system load profile placing greater market exposure on developers<sup>8</sup>.

The pandemic temporarily interrupted procurements, with auctions cancelled in 2020. When auctions resumed in 2021, contracting wind farms concentrated in the Northeast over a 15- to 20-year period; however, the resulting prices reflected higher investment costs, exchange-rate depreciation, and global supply-chain pressures.

A final relevant milestone occurred in 2022, when the A-4 auction removed the prior separation between wind and solar technologies. For the first time, the two competed for the same product, confirming their increasing cost competitiveness and technological convergence.

### 3.1.4. TUST/TUSD discount

A key element supporting the expansion of onshore wind in Brazil was the long-standing discount on transmission and distribution tariffs (TUST/TUSD), which granted renewable projects of up to 300 MW—including wind, solar, biomass, and qualified cogeneration—at least a 50% reduction in grid-use charges. This benefit applied across both the regulated and free markets. However, in the free market, the reduction in grid-use charges was applied to the consumer (oftaker of the PPA) as well, improving project economics and facilitating the large-scale renewable deployment of onshore wind through corporate PPAs (also known as “free market” PPAs), which will be discussed in the next section.

The cost of this incentive was socialized among all consumers. Along with the significant growth of onshore wind in the free market, there were also a significant growth of the subsidy. And as onshore wind became very competitive on its own, a process to terminate the subsidies for new projects started, since the pressure on electricity bills became high.

<sup>5</sup> P50 and P90 are, respectively, the certified annual energy production (in MWh) corresponding to the average production with a 50% and 90% probability of being exceeded.

<sup>6</sup> “availability contract”: In this type of contract, the allocation of risks and benefits associated with production variability (exposure in the short-term market) lies with the buyer.

<sup>7</sup> “quantity contract”: In this type of contract, the allocation of risks and benefits associated with production variability (exposure in the short-term market) lies with the seller.

<sup>8</sup> Seasonalization is the distribution of the total contracted volume across monthly intervals, and modulation is the distribution of the monthly volumes across hourly intervals. When the contract is adjusted to match the load profile, the generator assumes the risk of mismatch between generation and consumption and becomes responsible for any adjustments required in the short-term market to deliver generation according to the consumption profile.

This incentive framework then began to change with Law 14.120/2021, which determined the gradual elimination of TUST/TUSD<sup>9</sup> discounts at the end of each project’s concession period, even in cases of extension. Transitional provisions allowed developers who requested their permits within 12 months of the law’s approval and began operation within 48 months to retain the subsidy. For small hydropower plants, a differentiated transition was established, preserving a 50% discount for requests made within five years and a 25% discount for those submitted within ten years.

This shift marked a significant step in Brazil’s broader movement toward reducing cross-subsidies in the power sector, signaling that future renewable technologies—such as offshore wind—may need to rely on alternative mechanisms to ensure competitiveness rather than on legacy grid-tariff incentives.

### 3.1.5. Shift toward the free market and diversification of commercialization strategies

Historically, Brazil’s renewable generators relied predominantly on the regulated-market auctions, which offered long-term contracts, favorable financing conditions, and more predictable risk allocation. These auctions provided revenue stability compatible with project finance structures and, until 2018 for wind, allowed availability-based contracts that shifted price–quantity risk to consumers. They also ensured a ten-year stabilization of transmission tariffs (TUST), further reducing cost uncertainty. By contrast, participation in the free market was initially far less attractive: developers faced short-term contracts, annual TUST adjustments, and full exposure to price–quantity risk, making revenue streams more volatile and financing more challenging.

Over the past years, however, this landscape has changed substantially. A combination of structural, regulatory, and market drivers led many renewable generators — including wind energy producers — to redirect part or even all of their commercialization to the free market.

A key factor was the contraction of regulated-market demand from 2016 onward, driven by economic recessions, aggravated by Covid-19, the growing penetration of distributed generation and the accelerated consumer migration to the free market, due to rising regulated tariffs and the market liberalization. As distribution companies’ load forecasts shrank (due to the market migration), auction volumes decreased, limiting opportunities for new renewable contracting in the energy auctions.

The elimination of availability-based contracts for wind and solar also made auctioned contracts riskier, increasing developers’ exposure to variability in generation and market conditions. This reduced the relative advantage of the regulated market and encouraged a greater shift toward bilateral contracting.

The expansion of financing options tailored to free-market projects—such as infrastructure debentures, BNDES “Support Price” mechanisms, and similar lines from BNB—helped make the free contracting environment (ACL) contracting more viable. These instruments increased the bankability of merchant or partially merchant projects, enabling the free market to emerge as a significant commercialization pathway for onshore wind and shaping Brazil’s broader renewable procurement landscape.

<sup>9</sup> TUST – Transmission System Usage Tariff – aims to remunerate the transmission facilities classified as the Basic Grid and to recover part of the ONS operating costs not covered by member contributions.

TUSDg – Distribution System Usage Tariff for Generators – a tariff charged by distribution utilities to generators connected at voltage levels of 88 kV and 138 kV, corresponding to these generators’ “share” in the allocation of investment costs of the energy transport network.

However, possibly the most relevant aspect of the successful business models of onshore wind through corporate PPAs was the policy discussed above on the discount on TUST/TUSD that these generators granted to consumers who became their offtakers.

### 3.1.6. Fiscal and financial enablers as critical accelerators

A central driver of Brazil’s rapid expansion of onshore wind since 2009 was the introduction of comprehensive fiscal, tax, and financing incentives that significantly reduced project cost of capital and supported the emergence of a domestic renewable industry.

Federal measures included exemptions or reductions in taxes such as PIS/Cofins, IPI, import duties, and corporate income tax, as well as special regimes such as REIDI, which suspended PIS/Cofins on equipment and construction materials for qualified energy projects. Zero-rate PIS/Cofins on imported wind components, reduced import tariffs under the *ex-tarifário* mechanism, and IPI exemptions for renewable equipment further lowered costs, particularly in a period when Brazil had limited domestic manufacturing capacity. Additional incentives under Sudene and Sudam<sup>10</sup> regimes, offering up to 75% income tax (IRPJ) reduction for projects in priority regions, strengthened investment attractiveness in the Northeast, where most wind farms were developed.

Financing support played an equally crucial role. BNDES acted as the primary lender for wind projects, offering long-tenor credit at subsidized rates tied to the former Long-Term Interest Rate (known in Portuguese as *Taxa de Juros de Longo Prazo*, or “TJLP”), often covering 70–80% of investment needs. Financing was conditional on local-content requirements, which stimulated the establishment of manufacturing facilities for turbines and components. The Banco do Nordeste (BNB), using the Constitutional Northeast Fund for Financing, known in Portuguese as *Fundo Constitucional de Financiamento do Nordeste* (FNE resources), provided additional long-term subsidized credit, while specific programs such as *Fundo Clima* offered near-zero interest loans for renewable initiatives. Together, these mechanisms created a financing environment far more favorable than commercial markets, substantially lowering the effective cost of capital.

At the state level, ICMS exemptions were widely adopted to attract renewable investments. Through Confaz agreements—most notably Convênio ICMS 101/1997—states eliminated ICMS on internal and interstate sales of wind and solar equipment. Several states developed tailored programs, such as Ceará’s ProEólica, which combined tax relief with incentives to establish local manufacturing. Other key renewable states, including Rio Grande do Norte, Minas Gerais, and Rio Grande do Sul, offered similar ICMS reductions for equipment purchases or imports, reinforcing regional industrial development.

Collectively, these fiscal and financial instruments were decisive in enabling Brazil’s exponential growth in onshore wind and solar deployment and in driving sustained CAPEX reductions. Even after BNDES’s transition from TJLP to the more market-based TLP in 2018, public financing and tax incentives continued to play an important role in mitigating risk and improving bankability.

As Brazil advances toward offshore wind, it will be essential to draw on this history when designing mechanisms aimed at reducing investors’ risk perception and improving the bankability of projects.

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<sup>10</sup> Northeast and Amazon Development Offices, respectively.

### 3.2. A coordinating offshore grid-connection model: the biomass shared collectors

Designing an efficient and coordinated offshore grid-connection model is one of the central challenges for the development of offshore wind in Brazil. While the offshore context introduces new geographic and technological complexities, Brazil does have a valuable precedent: the 2008 shared-collector scheme (ICG) developed to integrate a large concentration of bioelectricity projects.

The parallels between the two situations—high project density, limited grid availability, large distances to the grid, complex permitting environments, and strong investor appetite—make the ICG experience an important reference point, especially considering the planned offer modality, established by Law No. 15.097/2025, or if there is the possibility of connecting offshore wind farms belonging to different owners.

#### 3.2.1. The context: a large-scale integration problem

During Brazil’s ethanol boom of 2007–2008, hundreds of biomass power plants were being planned across approximately 200,000 km<sup>2</sup> in Mato Grosso do Sul and Goiás—an area roughly half the size of California. Despite a dedicated auction offering 15-year supply contracts, most of these plants were effectively stranded: the region lacked a transmission network capable of integrating such dispersed capacity, and institutional conflicts created uncertainty about who should plan, build, and pay for the new infrastructure.

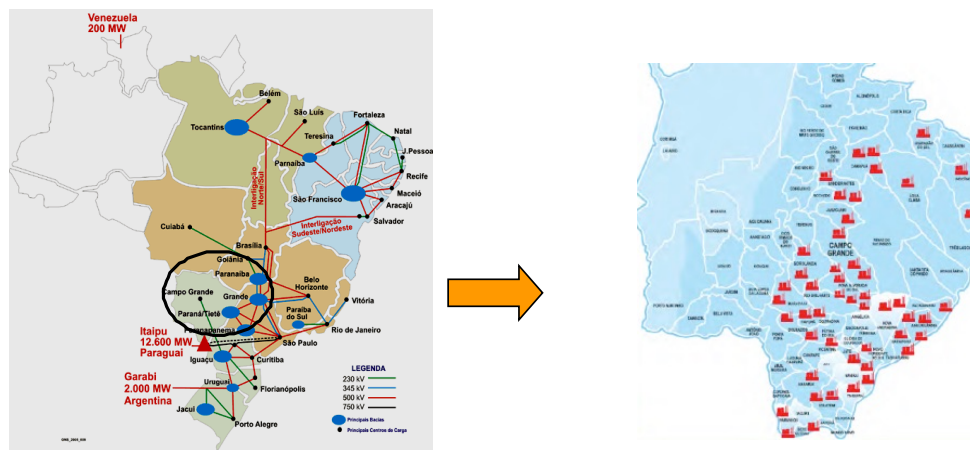


Figure 3: Bioelectricity plants located in the states of Mato Grosso do Sul and Goiás.

This scenario bears strong resemblance to today’s offshore wind landscape: numerous projects, large distances to the grid, complex multi-agency coordination, and the need for a cost-efficient, systemically planned integration solution.

### 3.2.2. The ICG concept: A structured, investor-led, regulator-approved solution

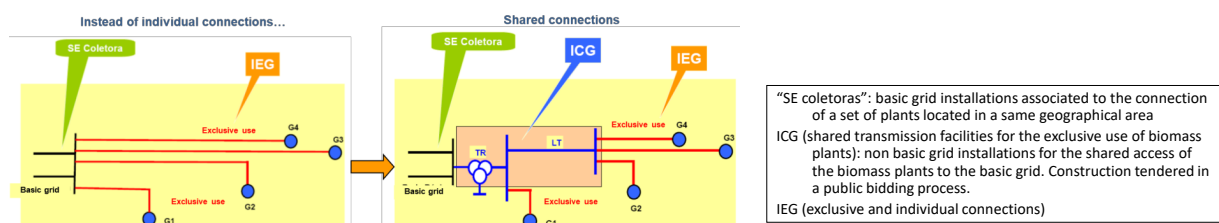
To unlock the biomass potential, generators proposed an innovative agreement to ANEEL and MME, known as the ICG scheme—Instalações Compartilhadas de Geração. Its architecture rested on three pillars:

- Centralized planning with exceptional governance: distribution companies temporarily waived their right to build integration assets. Instead, investors jointly hired a technical team to plan the entire connection network, in cooperation with EPE. The plan was then submitted to ANEEL for approval.
- Clear cost allocation: developers paid 100% of the integration network, in addition to the standard basic-grid access tariff (TUST).
- Grid construction via auction: once approved, the network—comprising both main grid ( $\geq 230$  kV) and dedicated collector infrastructure (138 kV)—was auctioned to transmission companies.

This approach created an unprecedented level of coordination among government, planners, and industry.

### 3.2.3. Technical design: Layered collector stations and least-cost network optimization

Given the geographical distribution of projects, the integration strategy required multiple layers of shared collector substations (SE coletoras) at different voltage levels.



**Figure 4:** layers of shared collector stations (ICG) at different voltage levels.

The planning process included:

- siting of collector substations,
- definition of voltage levels and transformer capacity,
- right-of-way selection, and
- choice of conductor characteristics,

all while minimizing total investment cost.

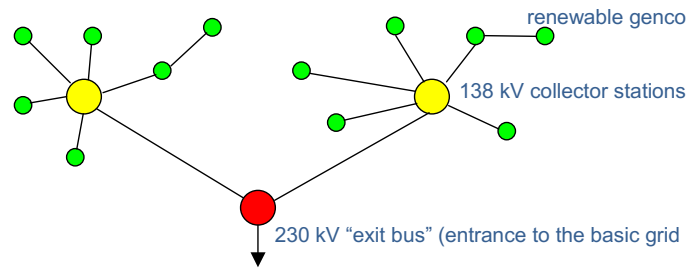


Figure 5: The planning of the ICG.

To solve this complex topological and locational problem, planners developed a dedicated optimization model that produced the least-cost integration network. This tool eliminated ad-hoc decision-making, mitigated conflicts among generators (since distance to shared collectors affected each plant’s cost allocation), and significantly simplified regulatory approval—ANEEL could authorize a single integrated scheme rather than dozens of disconnected requests.

The resulting infrastructure combined:

- Basic grid assets (230 kV) for system integration,
- ICG assets (138 kV) for shared access, and
- IEG (exclusive) connections for individual plants.

Payments were structured via TUST (basic grid), an ICG shared charge, and IEG exclusive costs.

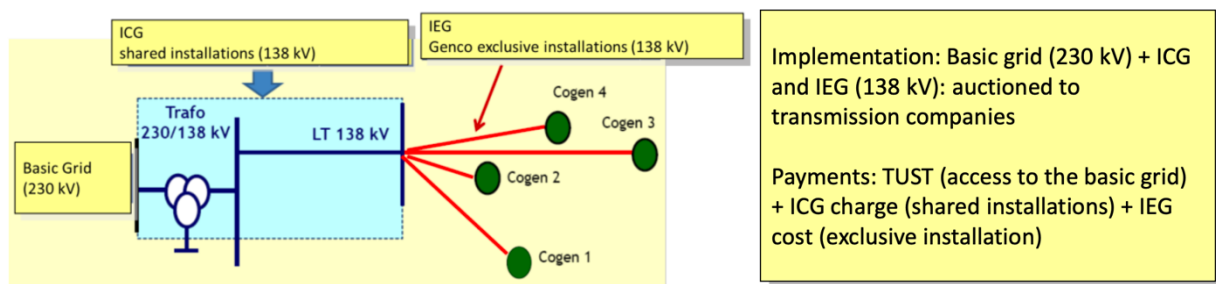


Figure 6: Summary of the solution approach.

### 3.2.4. Economic effects and systemic benefits

The shared-collector model generated significant economies of scale and avoided the duplication of corridors and substations. These savings translated into lower bidding prices for consumers in energy auctions, demonstrating that optimized, collective grid solutions can produce measurable societal benefits.

The approach also established a more orderly, predictable, and coordinated process.

### 3.2.5. Institutional and capacity challenges

Despite its conceptual strengths, the ICG approach exposes a key risk:

EPE's ability to plan such complex integration networks depends on having sufficient staff, tools, and methodological capabilities.

The 2008 experience revealed significant constraints, including limited modeling capacity and difficulty evaluating multiple design configurations. Those challenges would be even greater for offshore wind, given:

- larger spatial scales,
- underwater cable routing and landing points,
- marine spatial planning interfaces, and
- long-term uncertainty in project sequencing.

Moreover, the ICGs functioned similarly to a consortium, with shared costs among the connected generators. However, if one generator faced project delays or financial constraints, the ICG development encountered challenges and delays, affecting all the others. Thus, there were instances where the power plants were ready, but the connection facilities were not.

Thus, any attempt to adapt the ICG model to offshore wind would require capacity reinforcement within EPE, modern optimization tools, and clear governance structures to coordinate sector actors.

### 3.2.6. Why this matters for offshore wind

The offshore context presents challenges highly reminiscent of the 2008 biomass case:

- numerous projects competing for limited grid access;
- long distances between generation sites and load centers;
- need for coordinated maritime and onshore routing;
- multi-agency permitting and licensing; and
- risk of inefficient, piecemeal grid requests overwhelming the regulator.

EPE has already suggested in its roadmap that a wind farm collector system could be used to offshore wind, similarly to solutions widely used in Europe, where offshore substations and export corridors help lower costs and accelerate deployment.

Moreover, the ICG example **was explicitly mentioned** in the Decree No. 10,946/2022, extending it to any renewables, including offshore wind.

The 2008 shared-collector scheme then offers a valuable precedent for building Brazil’s offshore grid connection in Brazil: coordinated planning, cost-efficient infrastructure design, simplified regulatory approval, and equitable cost allocation among generators.

Although an offshore wind farm collector system is, according to international experience, typically designed to connect turbines belonging to a single offshore wind farm and owned by a single developer, the Brazilian context presents additional complexities. A significant share of offshore wind project proposals currently under environmental licensing at IBAMA—approximately 27%—exhibits partial or total spatial overlap. Moreover, in the absence of defined minimum distances between offshore wind farms or even a finalized methodology for selecting areas to be offered, there is limited clarity as to whether the connection of offshore wind farms owned by multiple project developers would be feasible.

In such cases, Brazil’s prior experience with shared collector infrastructure for biomass generation, which enabled the connection of multiple projects owned by different companies through centrally planned and optimized networks, offers a relevant reference. This precedent suggests that a shared offshore collector or transmission model could be a viable option for connecting multiple offshore wind farms developed by different entities, while reducing infrastructure duplication, environmental impacts, and integration risks.

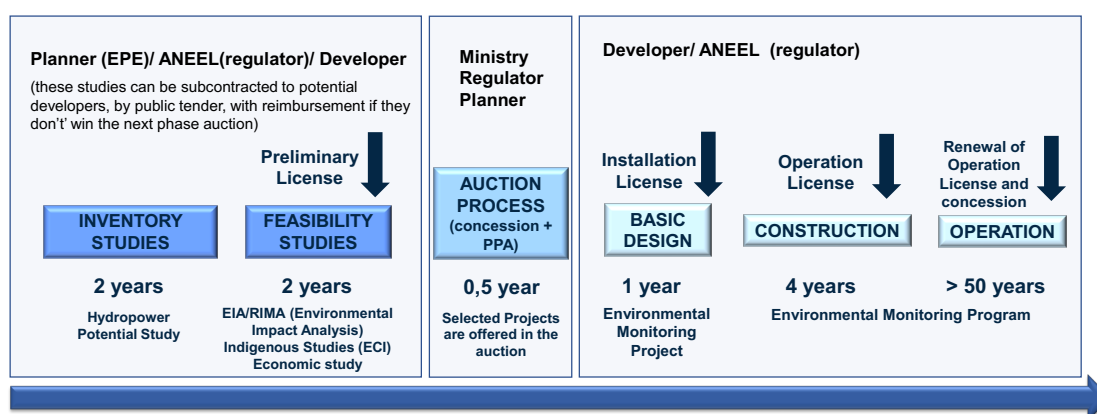
In addition, much of Brazil’s experience with shared collector infrastructure for biomass generation can be leveraged under the planned offer modality established by Law No. 15.097/2025. In this modality, the granting authority plays a more centralized role throughout the entire process, from area definition to the structuring of the offering, which creates favorable conditions for coordinated planning of connection infrastructure. This institutional arrangement allows the application of optimization approaches similar to those used in the biomass ICG scheme, particularly for defining shared substations, export corridors, and connection topologies.

Nevertheless, the applicability of shared infrastructure solutions should be assessed on a case-by-case basis, considering site-specific conditions, project clustering, transmission availability, market dynamics, and offer modality (permanent and planned) to determine which elements of the biomass experience are most suitable for adaptation to offshore wind development.

### 3.3. Hydropower development in Brazil

The development of hydropower in Brazil followed a highly structured, state-coordinated model that became the backbone of the country’s power-sector expansion for decades. This model combined central planning, competitive allocation of public resources (water), and a clear sequencing of studies, licensing procedures, and auctions for energy contracts sequencing the auctions to grant use of water. As offshore wind advances toward its own regulatory consolidation, the hydropower experience offers relevant institutional benchmarks—particularly to planned offer modality regarding how the State organizes the use of a public good, prepares areas for bidding, and allocates development rights along with energy contracts through competitive mechanisms.

As illustrated in the next Figure, hydropower projects begin with comprehensive basin-level planning. The first step consists of inventory studies, coordinated by EPE, which assess the technical potential of each hydrological basin and identify possible project sites. Once promising sites emerge, feasibility studies—including environmental impact assessments (EIA/RIMA), socioeconomic analyses such as Indigenous studies, and economic evaluations—are undertaken. Although EPE leads this process (usually subcontracting the studies), private companies can also request the right to carry out similar studies, as long as they follow the official guidelines<sup>11</sup>. In any case, the costs may be reimbursed when a selected site is auctioned. All studies must be approved by ANEEL, ensuring that only technically robust and environmentally vetted projects advance toward auction.



**Figure 7:** Development cycle of hydroelectric projects (planned process).

Once the candidate hydro projects are defined in the planning studies, they are integrated in an auction-based framework consisted of a two-phase auction process designed to separate the allocation of the concession to an investor from the procurement of energy:

- In Phase 1, investors compete for the concession that grants the right to use the hydro potential—a public good whose exploitation requires a concession under Brazilian law. The winning bidder is the one offering the lowest future energy-price commitment for an energy contract that supplies the regulated (“captive”) market, even though no energy contract is awarded at this stage.
- The winner of the concession of each hydro project then advances to Phase 2, which is an auction carried out in the same day of Phase 1’s auction where the investor competes with its project against other generation technologies for long-term contracts. The Phase 1 price becomes the project’s ceiling price in Phase 2, ensuring discipline in bidding and preventing price increases between phases. Only if the hydropower project secures a contract in this second auction does it retain the concession acquired earlier. For large and strategic projects there is a dedicated auction process, excluding phase 2.

<sup>11</sup> Defined at the oficial inventory manuals for Hydro basins, known in Portuguese as "Manual de Inventário Hidrelétrico de Bacias Hidrográficas" and "Instruções para Estudos de Viabilidade de Aproveitamentos".

Throughout this process, institutional roles remain well defined: MME sets auction guidelines, ANEEL conducts the auctions, and EPE calculates key parameters.

Beyond auctions, hydropower development involves sequential environmental licensing for installation, operation, and subsequent license renewals—all under ANEEL oversight and performed directly by the auction winner. The hydropower arrangement thus exemplifies a fully planned model, in which the State not only identifies project areas but also coordinates studies, sets development guidelines, and controls access to public resource.

One lesson learned over the year was the importance of having at least a preliminary environmental license before the auction, as in the past it was not mandatory and a few projects failed to obtain a license and be constructed.

A fundamental feature of the hydropower framework is its system of concession fees for the use of hydro potential. Two payments coexist. First, the “Public Good Royalty”, known as *Usó do Bem Público* (UBP) in Portuguese, calculated by EPE based on the project’s expected annual revenue and payable from commercial operation or the start of the energy contract. The UBP is fully retained by the federal government. Second, the CFURH (Hydropower Royalty), an operational cost shared between the Union, states, and municipalities. Together, these charges reaffirm the principle that exploitation of a public natural resource must occur through a competitive process and must generate financial compensation to the State.

### **3.3.1. Why this matters for offshore wind**

The hydropower development model demonstrates how a coherent sequence of planning, competitive allocation, and structured licensing can reduce uncertainty, align investor incentives, and protect the public interest. For offshore wind—another activity involving the use of a public asset, the marine space—this historical experience provides valuable insights to the planned offer modality on how to design concession systems, structure pre-auction studies and align institutional responsibilities.

Moreover, the hydropower experience de-risks hydropower concessions through a sequential auction-based process to grant hydro concessions and energy contracts. In the case of OSW, that still doesn’t have a clear offtaker for its energy production, a sequential process – energy auction after the competition for the use of seabed rights, would derisk the investments. The main challenge of this approach is that in the case of hydropower, the volumes procured, as declared by the distribution companies, were significant, and the cost of energy from hydropower was very competitive. Thus, the auction implied a liquid market where hydropower represented a competitive technology. Nowadays, the energy demand needed by distribution companies in the regulated auctions is non-existent and the economics of OSW is still challenging in the short run. Moreover, OSW projects are highly dependent on economies of scale, resulting in large installed capacities that are incompatible with the current perspective of future low energy demand from distribution companies due to the growth of distributed generation and consumer migration to the market. So, if this approach is strictly applied to OSW, then Brazil would be securing a volume for a technology ex ante, which may create competitive advantages, but with an oversupply risk. It is a policy choice and trade-off.

### 3.4. Other reference for offshore wind integration to the power market: CfDs

Contracts for Difference (CfDs) have been standing out internationally as a revenue-stabilization mechanism for reducing investors perceived commercial risk. The United Kingdom — now one of the largest offshore wind markets in the world — adopted the CfD model as a central public-policy instrument, enabling rapid expansion alongside a consistent decline in the energy price offered to consumer from OSW over time.

EPE has already made public that the application of this scheme as a commercial alternative to integrate OSW should not be ruled out and is being currently assessed. Among the challenges, however, is the need for a level playing field (or regulatory parity) between technologies, **avoiding an exclusive scheme** for OSW. CfD can be unidirectional (also known as One-way CfD) or bidirectional (also known Two-way CfD).

#### 3.4.1. One-way and two-way CfD

The unidirectional CfD is a financial mechanism in which the State (or a central counterparty) guarantees generators a minimum revenue level through a strike price, which acts as a remuneration floor. Its operation is straightforward:

- a strike price is defined, either through an auction or a regulatory methodology;
- when the reference market price falls below the strike price, the generator receives a compensatory payment equal to the difference;
- when the market price rises above the strike price, no payments are returned to the State.

With this structure, the generator remains exposed to market conditions but is protected against significant price drops that could undermine the project's economic viability. This partial protection reduces revenue volatility, mitigates downside risks, and facilitates financing for large-scale projects in the early stages of sectoral development — which is the current context for offshore wind in Brazil.

Because it preserves upside revenue in high-price scenarios, the unidirectional CfD is typically used in emerging markets that still require strong investment signals to attract developers, build cost history, and allow the nascent domestic supply chain to scale. At the same time, it maintains adequate economic incentives for efficient operation, since the generator continues to face market price fluctuations.

In a bidirectional CfD, the strike price serves as a stable target revenue:

- if the market price is below the strike price, the generator receives the difference;
- if the market price is above the strike price, the generator returns the excess revenue.

This model creates bilateral protection: it ensures predictable income for investors while limiting extraordinary gains during periods of high prices, thereby mitigating tariff and fiscal impacts. For this reason, two-way CfDs have become the international standard for large-scale renewable energy expansion and underpin the competitiveness of UK offshore wind auctions.

#### 3.4.2. United Kingdom case – Use of contracts for difference (CfDs) in offshore wind

The United Kingdom has established itself as a global reference in the use of CfDs as the main procurement mechanism for offshore wind, enabling the rapid expansion of the technology and a consistent trajectory

of cost reduction. After an initial development phase supported by the Renewables Obligation Certificates (ROCs) — which provided additional revenue per MWh but exposed projects to high volatility and the risk of windfall profits — the British government initiated, in 2014, the transition to bidirectional CfDs as a more efficient mechanism for revenue stabilization and consumer protection against excessive price spikes. As of 2017, all new offshore projects have been contracted exclusively through CfDs.

In the UK auction scheme, projects compete for a strike price, which establishes a stable remuneration level: when the market price falls below this value, the generator receives a compensatory payment; when it exceeds the strike price, the generator returns the surplus. This model significantly reduced investors' perceived risk, enabled long-term financing at lower capital costs, and created a competitive environment that allowed for a rapid decline in the levelized cost of energy (LCOE). As a result, the country reached 15.9 GW of offshore installed capacity in 2024 — representing 17% of its electricity mix — and set even more ambitious targets, such as reaching 125 GW by 2050.

### **3.4.3. Policy lessons to Brazil**

The adoption of CfDs is embedded in a structured process for developing offshore wind projects in the United Kingdom, consisting of five sequential stages: seabed leasing, project development and permitting, securing revenue through CfD auctions, construction, and operation. This institutional arrangement — combining centralized planning, regulatory predictability, and efficient competitive mechanisms — has made the UK the most advanced offshore wind market in Europe and provides valuable lessons for countries seeking to build a robust framework for offshore wind expansion, such as Brazil. In the Brazilian case, many parameters would have to be defined and responsibilities assigned (such as who handles the compensatory payment the generator receives when the reference market price falls below the strike price) and as it would be a new commercial instrument, the regulations would need to be adapted.

## **3.5. Policy recommendations**

### **3.5.1. Lessons from the onshore wind experience in Brazil**

The rapid expansion of onshore wind in Brazil over the past two decades offers valuable lessons for structuring a successful offshore wind (OSW) framework. Brazil's onshore trajectory shows that scale, cost reduction, and investor confidence result from a combination of clear policy, predictable regulation, transmission coordination, and access to long-term, low-cost financing. These elements — adapted to the higher technological complexity and risk profile of OSW — form the basis for policy recommendations tailored to the offshore environment. A set of lessons have already been discussed earlier in this report, including the lack of environment to create new specific subsidies for specific technologies.

A first major statement is that in every mature market, policy has preceded regulation. It is the suggested first step in the "Key Factors" report from the World Bank prepared to the Brazilian stakeholders in 2021.

Our key recommendation from the onshore experience in Brazil is the importance to design contracts that reflect offshore wind's risk profile: onshore contract structures evolved significantly — moving from availability-based to quantity-based schemes, with obligations increasingly aligned with load curves. This was effective only after the industry matured. For offshore, contract design must balance investor certainty with system needs, avoiding premature risk transfer. In the case of OSW, it is recommended to avoid placing full price–quantity and generation-profile risk on early offshore projects. Hybrid obligation

structures (tolerance bands, multi-year verification, or ramp-up periods) should be considered during initial years.

### **3.5.2. Lessons from the hydropower development in Brazil**

The hydropower development model demonstrated that the structured, State-led sequencing of studies, area preparation, and competitive allocation of public resources reduces uncertainty, improves environmental and social outcomes, and ensures that the use of public goods generates value for society. The application to offshore wind, under the planned offer modality, are direct:

- Brazil should adopt a State-coordinated pre-development process, in which EPE leads baseline studies (resource, environmental constraints, logistics, seabed, and grid integration) prior to offering areas, ensuring consistency, transparency, and reduced project-level risk.
- Competitive allocation of marine areas should follow a multi-stage process—similar to hydropower’s concession and energy-auction sequence—linking the right to develop an area to price discipline, project maturity, and alignment with system needs. It would in turn, solve the lack of a clear “route to the market” for OSW by securing it an energy contract.
- Institutional roles must be clearly defined, with MME setting guidelines, ANEEL overseeing concessions and regulatory milestones, and EPE performing technical planning and validation, besides all institutions whose mandates intersect with offshore wind deployment.
- Environmental licensing for offshore wind should replicate the structured sequencing seen in hydropower, integrating early-stage environmental and socioeconomic assessments to minimize conflicts and accelerate project maturation.
- To avoid speculative occupation of marine areas, concessions should be conditional on achieving clear development milestones—including survey completion, environmental licensing progress, grid-connection commitments, and financial close.
- As the existing guidelines for hydropower development, Brazil should implement transparent rules for study requirements, reimbursement and data sharing when private developers contribute to early-stage studies, ensuring a level playing field and preventing strategic withholding of information. It may also accelerate this stage of development of the project.

The hydropower experience de-risked the hydropower concessions through a sequential auction-based process to grant hydro concessions and energy contracts. However, in the case of OSW this is more difficult to apply in the short-term due to the lack of volumes needed by distribution companies (that could support an auction) and the current costs of OSW.

### **3.5.3. Lessons from the biomass shared collectors**

The 2008 Shared Collectors (ICG) experience provides a set of actionable lessons for structuring Brazil’s offshore wind transmission framework, especially considering the planned offer modality, established by Law No. 15.097/2025, or if there is the possibility of connecting offshore wind farms belonging to different owners. The following contributions highlight how this precedent can inform coordinated planning, shared infrastructure design, and regulatory governance for the emerging offshore sector.

- **Adopt a Coordinated, System-Level Approach for Offshore Grid Planning:** the ICG scheme demonstrated that dispersed generation projects benefit significantly from centralized and optimized coordination of connection infrastructure, rather than individual, uncoordinated requests. This avoids duplication, reduces environmental impact, and creates economies of scale. A dedicated optimization model—similar to the one used in 2008—should be developed to determine least-cost siting, routing, and voltage levels for offshore export systems.
- **Enable Shared Offshore Collector Substations and Transmission Assets:** the layered collector architecture used in 2008 offers a clear transferable concept: shared offshore substations should gather energy from multiple wind farms. Export corridors should then be designed as shared infrastructure connecting clusters of projects to the onshore grid. This lowers total investment cost, reduces seabed use, minimizes cable landings and provides faster regulatory approval due to fewer, larger integrated processes.
- **Use Auction Mechanisms to Build the Offshore Grid:** the ICG transmission network (basic grid plus ICG assets) was auctioned to transmission companies, creating competitive tariffs, transparency, and efficient allocation of construction risks. Brazil should evaluate offshore transmission auctions for shared assets, following the successful domestic precedent. Cost allocation rules for shared offshore substations, export cables and onshore reinforcements linked to offshore integration will need to be discussed.
- **Avoid Fragmented Build-Outs by Planning Offshore Wind and Transmission Together:** generation zones, transmission corridors, port logistics, and licensing must be integrated into a single strategic planning process, ideally coordinated through EPE and MME. This reduces risk of curtailment, delays, and misalignment between generation and grid availability.

Although offshore wind farm collector systems are, as per the international outlook, typically designed for single-project developments, the Brazilian context presents additional complexities, as approximately 27% of offshore wind project proposals under environmental licensing at IBAMA exhibit partial or total spatial overlap and there is no defined minimum distance between wind farms or finalized methodology for area selection. In this setting, Brazil's experience with shared collector infrastructure for biomass power generation provides a relevant reference, indicating that a shared offshore collector or transmission model could enable the connection of multiple offshore wind farms developed by different investors while reducing infrastructure duplication, environmental impacts, and integration risks.

Brazil's experience with shared collector infrastructure for biomass generation can be leveraged under the planned offer modality of Law No. 15.097/2025, where the granting authority's centralized role enables coordinated planning and optimized design of shared connection infrastructure, including substations and export corridors.

Nevertheless, the applicability of shared infrastructure solutions should be assessed on a case-by-case basis, considering site-specific conditions, project clustering, transmission availability, market dynamics, and offer modality (permanent and planned) to determine which elements of the biomass experience are most suitable for adaptation to offshore wind development.

#### **3.5.4. International lessons to Brazil**

The United Kingdom's experience with offshore wind demonstrates the importance of embedding revenue-stabilization mechanisms, such as Contracts for Difference (CfDs), within a structured and sequential project-development framework. In the UK, offshore wind deployment follows clearly defined stages—seabed leasing, project development and permitting, competitive CfD auctions to secure long-term revenues, construction, and operation. This integrated institutional arrangement, combining centralized planning, regulatory predictability, and competitive market mechanisms, has positioned the UK as the most mature offshore wind market in Europe. For Brazil, this experience highlights the value of aligning area allocation, permitting, and revenue support instruments within a coherent framework. Adapting CfD-type mechanisms to the Brazilian context would require the definition of key parameters and institutional responsibilities—such as the entity responsible for compensatory payments when market prices fall below the strike price and how to pass it to tariffs or state budget —and the adjustment of existing regulations to accommodate a new commercial instrument within the national power market.

## 4. Assessment of economic competitiveness

### 4.1. LCOE assessment

The economic competitiveness of OSW was estimated through the Levelized Cost of Energy (LCOE) of a typical “desk project” with economic parameters estimated from reference sources and utilizing a financial model that fully represents financing costs and taxation in Brazil. The LCOE calculates the expected cost to build, operate, and generate one unit of electricity over the lifetime of a power purchase agreement, factoring in capital, fuel, maintenance, and financing costs. It helps assess economic viability but doesn't capture all grid factors like intermittency.

The main assumptions we have utilized for the key parameters are as follows:

**Table 1** – Assumptions for OSW LCOE

Parameters	Value
Installed capacity	1.000 MW
Load factor	62% (Northeast region)
Capex <sup>1</sup>	13,000 – 19,000 BRL/kW (average: 16,000 BRL/kW)
O&M cost <sup>2</sup>	300 – 420 BRL/kW-year
Cost of debt	9% a.a. (real)
Leverage	80%
Debt amortization period <sup>3</sup>	16 years
Hurdle rate (IRR)	12% a.a. (real)
Transmission tariff	13 BRL/kW.month
PPA duration	25 years
Taxation	Tax regime: “lucro real” (in Portuguese) Taxes: PIS/COFINS (9%), CSSL (9%), IRPJ (25%)
<p>[1] Considers the average CAPEX (3.000 US\$/kW) from EPE’s Ten Year Expansion Plan (PDE 2035) at an exchange rate of 5,40 R\$/US\$. It corresponds to a greenfield project with a COD by 2031. CAPEX includes the cost of the exclusive connection.</p> <p>[2] 2,2% of CAPEX, according to EPE’s PDE 2035.</p> <p>[3] Grace period of 6 months after COD</p>	

The resulting LCOE for the above assumptions and the 3 scenarios of CAPEX are shown below:

**Table 2** – LCOE scenarios for OSW

CAPEX scenarios for COD by 2031 (BRL/KW)	13,000	16,000	19,000
LCOE (BRL/MWh)	624	742	860
LCOE (USD/MWh)	116	137	160
Exchange rate: 1 USD = 5,4 BRL			

Those figures are still above the all-in energy prices currently practiced in the country for other renewables, which hover around 250-300 BRL/MWh for wind and solar. The most recent energy auction,

carried out in August 2025, contracted 815,6 MW of small hydros at an average cost of BRL 392,84/MWh, a discount of 3,16% with respect to the auction price cap of BRL 411/MWh.

## 4.2. Sensitivities on LCOE assessment

We then utilized NREL’s Annual Technology Baseline Offshore Wind data<sup>12</sup> to estimate future scenarios for CAPEX reductions in Brazil, mirroring the year 2050 (COD). These scenarios are built based on assumptions on the maturity of the technology, the scale of global deployment and the level of innovation, among others. In the table below we present our CAPEX estimates and the corresponding LCOE:

**Table 3 – LCOE scenarios for OSW**

CAPEX scenarios for COD by 2050 (BRL/KW)	9,200	11,000	13,000
LCOE (BRL/MWh)	357	422	502
LCOE (USD/MWh)	66	78	93
Exchange rate: 1 USD = 5,4 BRL			

We then did the exercise of carrying out individual sensitivities on three main parameters with respect to the main assumptions shown in Table 1, keeping all the other assumptions unaltered: the hurdle rate, cost of debt and CAPEX. We calculated the resulting LCOE for the average of the estimated CAPEX of 16,000 BRL/kW in 2031 and of 11,000 BRL/kW in 2050 assuming a reduction of 1% in the hurdle rate, assuming all other parameters of Table 1 unaltered. We then repeated the exercise for a reduction of 1% in the cost of debt, assuming all other parameters of Table 1 unaltered and then a reduction of 10% in the CAPEX. The results are below:

**Table 3 – LCOE sensitivities on individual parameters**

Year (COD)	Base case	Sensitivities and LCOE in BRL/MWh		
		Hurdle Rate - 1p.p.	Cost of debt -1 p.p.	Capex - 10%
2031	<b>742 BRL/MWh</b> <b>(137 USD/MWh)</b>	712 BRL/MWh (132 USD/MWh)	710 BRL/MWh (131 USD/MWh)	671 BRL/MWh (124 USD/MWh)
2050	<b>422 BRL/MWh</b> <b>(78 USD/MWh)</b>	408 BRL/MWh (76 USD/MWh)	405 BRL/MWh (75 USD/MWh)	383 BRL/MWh (71 USD/MWh)
Exchange rate: 1 USD = 5,4 BRL				

For each 1 p.p. reduced in the hurdle rate the LCOE reduces 30 BRL/MWh for the assumptions for 2031 and 14 BRL/MWh for the assumptions for 2050. For each 1 p.p. reduced in the cost of debt the LCOE reduces 32 BRL/MWh for the assumptions for 2031 and 17 BRL/MWh for the assumptions for 2050. Finally, for each 10 p.p. reduced in the CAPEX LCOE reduces 71 BRL/MWh for the assumptions for 2031 and 29 BRL/MWh for the assumptions for 2050. If the CAPEX is reduced by 20 p.p., we could extrapolate

<sup>12</sup> available at [https://atb.nrel.gov/electricity/2024/offshore\\_wind](https://atb.nrel.gov/electricity/2024/offshore_wind)

the results above and conclude that the LCOE would reduce 142 BRL/MWh for the assumptions for 2031 and 58 BRL/MWh for the assumptions for 2050, thus producing LCOE of 600 BRL/MWh and 364 BRL/MWh, respectively.

We then carried out sensitivities on the hurdle rate, cost of debt and CAPEX all together, keeping all the other assumptions unaltered. The Table below shows the resulting LCOE if these parameters are reduced in 2 p.p., 3 p.p. and 10 p.p. at the same time. As we can see, these are the key parameters that need to be reduced in order to bring the OSW LCOE to the more affordable levels.

**Table 4 – LCOE sensitivities on parameters**

Year	Base case	Sensitivities		
		Hurdle Rate -2 p.p.	Cost of debt -3 p.p.	Capex - 10%
2031	<b>742 BRL/MWh</b> <b>(137 USD/MWh)</b>	539 BRL/MWh (99,8 USD/MWh)		
2050	<b>422 BRL/MWh</b> <b>(78 USD/MWh)</b>	317 BRL/MWh (58.7 USD/MWh)		
Exchange rate: 1 USD = 5,4 BRL				

We finally concluded the exercise with two other set of sensitivities. We have calculated the resulting LCOE for a simultaneous reduction in the CAPEX and hurdle rate for the base case of the 2031 reference CAPEX and for the 2031 reference CAPEX. Results are shown in the two tables below. As can be seen, the LCOE is highly sensitive on changes in these items.

**Table 5 – LCOE sensitivities table (2031 reference CAPEX of 16,000 BRL/kW)**

2031 CAPEX LCOE: 742 BRL/MWh		Sensitivity on Capex		
		-10%	-20%	-30%
Sensitivity on IRR	- 1p.p.	644 BRL/MWh	576 BRL/MWh	509 BRL/MWh
	- 2p.p.	618 BRL/MWh	553 BRL/MWh	488 BRL/MWh
	- 3p.p.	592 BRL/MWh	530 BRL/MWh	468 BRL/MWh

**Table 6 – LCOE sensitivities table (2050 reference CAPEX)**

2050 CAPEX LCOE: 422 BRL/MWh		Sensitivity on Capex		
		-10%	-20%	-30%
Sensitivity on IRR	- 1p.p.	371 BRL/MWh	333 BRL/MWh	296 BRL/MWh
	- 2p.p.	359 BRL/MWh	323 BRL/MWh	287 BRL/MWh
	- 3p.p.	347 BRL/MWh	312 BRL/MWh	277 BRL/MWh

### 4.3. The role of offshore wind in optimal power system expansion by 2040

This section evaluates the potential contribution of offshore wind to the long-term expansion of the Brazilian power system, encompassing generation, storage, and transmission investments. The analysis adopts a social cost–minimization framework to identify the least-cost investment pathway, taking the existing system configuration in 2025 as the initial condition. Within this setting, we assess whether offshore wind generation is selected as part of the optimal expansion portfolio.

The modelling framework relies on a representative network structure based on the geographical zones defined by the Brazilian system operator (ONS), whereby each node aggregates generation and demand from the underlying transmission buses. Planning is formulated as a brownfield expansion problem over the 2025–2040 horizon, solved in five-year increments. Investment decisions are endogenously determined for generation, storage, and transmission capacity.

Our primary objective is to examine whether offshore wind is cost-attractive within the Brazilian context. Although commercial deployment of offshore wind is unlikely to materialize before 8–10 years, we allow investment decisions in earlier periods to test whether the technology would be selected by the model under short-run economic conditions, abstracting from non-economic implementation constraints.

Two demand growth trajectories are considered: a low-growth scenario (2% annually) and a high-growth scenario (5% annually). Fuel price inputs are calibrated to current observed values and projected using IEA outlook assumptions. Baseline capital expenditure (CAPEX) assumptions for offshore wind are reported in Table 7.

**Table 7 – Offshore wind CAPEX assumptions in the base case.**

Year	2025	2030	2035	2040
OSW CAPEX (base case) [USD/kW]	3282	2832	2451	2260

Under the base-case assumptions reported in Table 7, offshore wind is not selected as part of the optimal investment portfolio. In the high-demand-growth scenario, however, the model indicates the deployment of approximately 7 GW of offshore wind capacity by 2040, with no investments occurring in earlier periods.

To identify the capital cost threshold required for offshore wind to become economically attractive, we conducted a CAPEX sensitivity analysis, progressively reducing investment costs and determining the approximate breakeven values at which OSW enters the optimal solution. The resulting breakeven CAPEX levels are summarized in Table 8.

**Table 8** – Approximate OSW CAPEX breakeven points for cost-effective integration.

Year	2030	2035	2040
Breakeven CAPEX, low demand growth [USD/kW]	< 1830	< 1450	1660
Breakeven CAPEX, high demand growth [USD/kW]	< 1830	1750	2260

For 2030, cost-effective integration of offshore wind is unlikely under either demand trajectory at the assumed baseline costs. By 2035, OSW remains unattractive in the low-growth case; in contrast, under high demand growth, a substantial cost reduction—on the order of 700 USD/kW relative to the base assumption—renders OSW cost-effective. By 2040, the high-growth scenario supports offshore wind deployment at the baseline CAPEX, whereas the low-growth scenario requires a cost reduction of approximately 600 USD/kW.

Overall, these results indicate that the competitiveness of offshore wind in Brazil is highly sensitive to both demand growth and capital cost trajectories. Under favorable demand conditions and CAPEX levels around 2,000 USD/kW, initial offshore wind deployment could emerge as part of the optimal expansion pathway by 2040.

These findings are consistent with studies conducted by EPE, which conclude that offshore wind is unlikely to be part of the optimal expansion plan over the next decade. Nevertheless, under specific long-term conditions—particularly sustained demand growth and continued cost reductions—offshore wind may become an economically attractive alternative from 2040 onwards. This underscores the importance of continuing to assess this technology, refine cost projections, and address regulatory and implementation barriers that could otherwise delay its potential contribution to the Brazilian power system.

#### 4.4. Policy recommendations

The Levelized Cost of Energy for offshore wind in Brazil, driven by high capital intensity and financial complexity, is the primary focus for policy and regulatory mechanisms on the economic competitiveness dimension. International experience suggests that LCOE can decline significantly in the long term, following the trajectory of onshore wind and solar photovoltaic energy. To achieve this, key parameters such as the Weighted Average Cost of Capital (WACC), Capital Expenditure (CapEx), and grid integration costs must be strategically addressed:

#### **4.4.1. Cost of capital and hurdle rates (Financial Risk Mitigation)**

The high hurdle rate, which reflects the perceived financial and regulatory risk of a pioneer market, is a significant component of LCOE. Our policy recommendation is to establish regulatory predictability and stability to improve investment signals, which is fundamental to lowering the cost of capital. This can be done by leveraging on state financial institutions, particularly the BNDES. The BNDES should take a leading role in initial financing, acting as a catalyst and anchor lender. This mitigates early project risk, attracting the necessary commercial and international financial institutions required for large-scale development. Credit reliability is enhanced by the participation of developers with experience in the sector.

#### **4.4.2. Capital expenditure (CAPEX)**

Reducing the upfront investment cost is crucial for LCOE reduction. Our policy recommendation is to utilize fiscal incentives and economies of scale. This can be done by maintaining or providing equivalence for fiscal incentives (tax exemptions) on the acquisition of imported machinery, equipment, and services. Fiscal benefits like the reduction of Corporate Income Tax (IRPJ) in regions such as SUDENE/SUDAM directly lower the net cost base of the project. Furthermore, policy must facilitate the path to large-scale deployments to fully realize cost reductions achieved through learning curves and economies of scale. Predictability, through the announcement of expected auctions, also plays a role in economies of scale, as developers gain visibility into future installed capacity.

#### **4.4.3. Operational costs (OpEx) and frid integration**

High penetration levels of offshore wind risk increasing system costs due to transmission losses, congestion, tariffs and the need for expensive grid upgrades. Our policy recommendation is to implement integrated transmission planning and incentivize local demand coupling. This can be done avoiding grid congestion and technical risk by implementing Integrated and Anticipated Transmission Planning. This involves ensuring transmission upgrades are planned ahead of generation capacity to minimize bottlenecks in the National Interconnected System (SIN). Additionally, OpEx can be optimized by locating generation close to demand centers. This proximity, coupled with the potential for direct energy consumption by large industrial users like Green Hydrogen (GH2) production facilities, helps manage the supply/demand balance and reduces transmission losses, lowering overall system costs and LCOE.

## 5. Conclusions and main policy recommendations

The enactment of Law 15,097 establishes a regulatory framework for the area grant regime and represents an important institutional milestone towards the first seabed auction, expected to be announced in 2026. This development is likely to stimulate substantive discussions regarding market design, risk allocation, and long-term integration strategies for offshore wind in Brazil.

From an economic perspective, however, offshore wind remains challenging under current conditions. In the base-case scenarios of the Ten-Year and Long-Term Expansion Plans prepared by EPE<sup>13</sup>, the technology does not emerge as cost-competitive in the short to medium term. This reflects prevailing capital cost levels, demand growth assumptions, and the availability of alternative generation options.

Nonetheless, under specific long-term conditions—particularly sustained demand growth and continued reductions in CAPEX—offshore wind could become an economically attractive component of the expansion portfolio from 2040 onwards. In this context, the recent regulatory progress should be viewed not as an indication of immediate large-scale deployment, but as a strategic step to preserve optionality. Continued analytical assessment, refinement of cost projections, and the gradual removal of regulatory and implementation barriers will be essential to enable offshore wind to contribute effectively to Brazil's long-term energy transition.

EPE has been contributing to regulatory development with the continuous release of Technical Notes and studies that analyze international experiences, compile norms and methodologies, and review criteria from other sectors (such as oil and gas), serving as a technical basis for formulating specific norms for the offshore sector. EPE has been working to identify technical barriers and challenges, covering aspects such as costs, grid connection, and legal/environmental issues. Finally, EPE has been studying the most relevant business models to introduce the technology in the country without unnecessarily burdening the electricity tariff of consumers and has been very vocal on the need to demonstrate the value of OSW for the country (or when this value will exist), given the other technological options available for system expansion.

The 5 key policy actions and recommendations to uphold the OSW agenda forward are:

- 1. Priority and support to the CNPE WG Agenda and regulatory framework definition, aiming to the anticipation of the proposed schedule of deliverables:** The immediate publication of rules for the Declaration of Prior Interference (DIP), establishment of the methodology for selecting areas to be offered in the use-concession procedures and the full operationalization of the Unified Portal for Management of Offshore Areas (PUG-Offshore) as well as other issues that require regulation, such as the definition of a methodology to calculate the amount owed to the Union for the use of public assets and the methodology to define the maximum area to be assigned under a single contract are the most critical actions to unlock the market. Overcoming the spatial impasse and defining how the competitiveness process will work is the key to enabling auctions in 2026.

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<sup>13</sup> EPE has already made public declarations that the Decennial Energy Expansion Plan (PDE) 2036 will not include any projections or signals for OSW, which is now expected to appear in the next National Energy Plan (PNE) targeting 2055, still to be published.

**2. Anticipation of Transmission Planning:** The MME, in coordination with the EPE, must accelerate the execution of Prospective Studies of Transmission Expansion, using prospective data and planning models. This measure aims to ensure that off-take infrastructure does not become the next technical bottleneck after resolving regulatory and area conflicts. Alignment between area allocation and transmission planning is fundamental for the long-term success of the sector. The experience of the ICG approach applied to biomass could be evaluated.

**3. Viability without Ratepayer (or electricity rate) Burden:** Given offshore wind's current cost premium, dedicated market mechanisms or incentives need to be structured to ensure initial OSW deployment and supply chain development without unduly burdening general electricity ratepayers or requiring substantial, ongoing fiscal subsidies, especially when compared to highly competitive renewable sources. This holds, for example, also to the alternative to use CfDs as a commercial mechanism to make offshore wind feasible. It is worth noting, however, that prior to the implementation of any such mechanisms, it is imperative to address the rapid and largely uncontrolled subsidy-driven expansion of distributed solar generation. Given its strong projected growth, an increasing share of electricity demand is expected to be met by these resources in the coming years, reducing residual demand for centralized generation and potentially limiting the market space available for the future entry of offshore wind in the country.

**4. Introduction of carbon pricing and valuation of climate attributes, aligned with Brazil's emerging carbon market:** The implementation of carbon pricing mechanisms for fossil-based generation would improve the relative competitiveness of offshore wind. As carbon costs become progressively embedded in the operation of thermal generation, offshore wind is expected to benefit from a structurally improved competitive position, especially in medium- and long-term horizons. In parallel, the incorporation of climate attributes — including emission intensity and contribution to decarbonization targets — into planning and energy procurement criteria would further strengthen the economic case for offshore wind, reducing reliance on direct subsidies and ensuring alignment between energy policy and Brazil's climate commitments.

**5. Maintaining and encouraging the continued contribution of stakeholders and civil society:** Within the scope of the Offshore Wind Working Group (GT Offshore), efforts should be directed towards advancing the delivery of the milestones established in the CNPE Resolution, in order to accelerate the consolidation of the offshore wind regulatory framework in the country. This progress should occur through the structured expansion of participation by society and relevant stakeholders, making use of the contributions already received and encouraging their continued engagement.

It is recommended to strengthen and institutionalize mechanisms for broader participation, ensuring that contributions from these actors are systematically incorporated into the regulatory process.

Expanding this qualified participation will allow for:

- greater technical robustness in regulatory proposals;
- alignment with the practical experience of developers, experts, and affected communities;

- increased transparency and social legitimacy;
- accelerated maturation of the instruments required to initiate the concession processes and the study phase.

**6. General guideline, possibly from CNPE, on what would (or should) be the role of Offshore Wind in Brazil:** the availability of abundant land and excellent-quality onshore winds in Brazil raises questions about the opportunity to invest in offshore wind generation, which still remains very costly. The arguments in favor emphasize the importance of diversifying the energy mix while maintaining the predominance of renewable sources. However, ultimately, it is necessary to wait until offshore wind becomes more competitive in order to economically justify investments in this source, without resorting to cross-subsidies that benefit a few while penalizing consumers.

The analysis of the motivations for investing in offshore wind power, with a focus on the global markets, indicates that there are 3 relevant drivers that justify energy policies and investment decisions:

1. Energy security, to reduce the uncertainties imposed by the oligopolistic fossil fuel market;
2. Energy transition, to ensure greater environmental and climate sustainability; and
3. Industrial and technological development.

Brazil, in turn, already has a predominantly renewable energy matrix, with prospects for maintaining this characteristic, given the abundance and competitiveness of renewable resources in the country. Therefore, in the Brazilian case, there is no clear short-term need for investments in offshore wind power aimed at reducing emissions and meeting climate agreements, as observed in other markets. As the National Interconnected System (SIN) accounts for only 3.6% of the country's GHG emissions (EPE, 2024), Brazil is well positioned with regard to emissions from electricity generation.

Nonetheless, under specific long-term conditions—particularly sustained demand growth and continued reductions in CAPEX—offshore wind could become an economically attractive component of the expansion portfolio. Additionally, it can be argued that offshore wind could contribute to job creation and greater diversification of the national electricity mix. Regarding the former, the literature does indeed point to very favorable figures, but a more detailed analysis is required to assess whether equivalent results could be achieved at lower costs, which was not the object of this assessment.

Recent history shows how diversification of the electricity mix is beneficial to the SIN, particularly in light of the drought crisis experienced in 2021. However, no national-level studies were found that quantify this attribute considering offshore wind generation. This remains a suggestion for future work, along with an analysis of the economic impact of introducing this technology in Brazil. This same discussion appears in articles such as the one presented by (Ponte et al, 2025), which provides a comprehensive analysis of the development of offshore wind in global markets and the case of Brazil.

Given the existing uncertainties, it is still too early to set a firm date for the first offshore wind farms. It is important, however, to support the government in finalizing the rules so that the area leasing auction

process can take place as soon as possible — with institutional and regulatory certainty — while simultaneously studying further the development of the market that will purchase energy from this source at no extra burden to the consumers, given the ongoing agenda of *subsidies termination* in Brazil.

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