THE OXFORD INSTITUTE FOR ENERGY STUDIES

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European Union Offshore Wind Strategy

Introduction

Europe is not just in a race to meet its medium- and long-term climate targets and to enable the energy transition. For geopolitical and energy security reasons, it is now also in a race to end its dependence on imports of Russian oil, refined products and gas imports as quickly as possible. As a result of the current war in Ukraine, the European Union (EU) is now working against the clock. The availability of alternative fossil fuel supplies, particularly natural gas, is insufficient. Meanwhile Europe's appetite for encouraging fossil fuel investment and committing to long-term fossil supply agreements is very limited given its climate targets. Bridging a short-term supply crunch is therefore one challenge, while the other is to develop stable alternatives that are more in line with the EU's long-term priorities.

While the Commission has signalled that an all-hands-on-deck approach is necessary to encourage a range of renewable and fossil-free energy supplies in the coming years, it is increasingly evident that the main large-scale sources of energy production on the continent in the coming 5–10 years will be from offshore wind. Other options with large-scale potential, such as nuclear, are still politically contested, while also widely regarded as having longer lead times. A large-scale uptake in offshore wind deployment in Europe is therefore one of the EU's top energy and climate priorities. Offshore wind, alongside a developed hydrogen economy, are viewed as the centrepieces in EU's strategy to reach its net-zero climate target by 2050, and the offshore wind industry is gaining more traction both from finance institutions and future offtakers.

Despite strong interest both from policymakers and market players, the growth in offshore wind projects has been relatively low and is definitely too slow for the EU Commission to reach the EU's offshore wind target of 300 GW by 2050.

This Energy Insight investigates the policy and regulatory challenges that the offshore wind industry is currently facing in their permitting processes, market integration steps, and project cost calculations. The first part of this paper analyses the EU's offshore wind strategy and related EU regulations are put in context of the volume target for offshore wind, as stated in the EU's strategy. The second part looks at the current cost environment for the offshore wind industry and ends with a discussion on how businesses can manage both the challenging regulatory and cost environments at an early stage by developing projects with more holistic business solutions.

Elin Akinci and Siddharth Iyer, ELS Analysis

1. EU offshore wind strategy

In November 2020, the European Commission presented an EU-wide strategy for offshore wind.[1] The strategy includes both the Commission's vision and targets for offshore wind in Europe, as well as non-binding guidance for European member states on how to reach their individual national goals and contribute to achieving the EU´s overarching targets for the uptake of offshore wind.

The strategy defines a non-binding volume target of 300 GW[2] by 2050, with a subtarget of 60 GW by 2030 for the whole of the EU. The Commission realizes that the current policy environment will have to be adjusted to offer better conditions for investment in offshore wind. The discussion on policy changes is chiefly centred on how to adjust the current legal framework within the Fit for 55 package to help stimulate the uptake in offshore wind investments. This will first be achieved by including offshore wind in all the relevant legal texts but also by prioritizing offshore wind projects in the EU's various financing programmes. The two main regulatory challenges for the offshore wind industry identified in the strategy are long national permitting processes and a lack of directed infrastructural investments. The latter would enable offshore wind to become an integrated part of the electricity system and market. These challenges are very much related to national legislations and bureaucracy. The Commission is therefore investigating how to adjust the relevant legal texts at EU level to put more pressure on member states to address these challenges. Following Russia's invasion of Ukraine, the focus has been further strengthened through the Commission's REPowerEU[3] document of March 2022.

It is very clear that the Commission realizes the regulatory challenges involved in reaching its ambitious target of 300 GW offshore wind by 2050. It concludes that with the current policy and legal framework, the EU will only reach 90 GW by 2050. Furthermore, the Commission estimates that around €800 billion in investment will be needed to reach the target, with two-thirds allocated to infrastructural investments and one-third to offshore wind production. Given the focus on infrastructure, both public and private investments are expected.

Figure 1: Energy targets

Source: ELS Analysis

[1] COM/2020/741
[2] The Commission suggests an increase to 450 GW in REPowerEU, a target that includes both solar and wind, but indicates a more ambitious renewable energy target overall.
[3] COM/2022/108

1.1 Policy framework and regulations

There are four main policy areas which are expected to play a significant role in future offshore wind deployment:

- national spatial plans;
- infrastructure developments;
- market rules and renewable energy targets;
- financing.

As mentioned above, the EU Commission is currently studying how to revise the relevant legal texts in these four areas to offer better conditions for the offshore wind industry. These EU-wide policy and legal changes will then have to be adopted and, to varying degrees, implemented into national laws.

1.1.1 National spatial plans

The member states' national spatial plans play a central role in the EU's overall offshore wind strategy. The requirement on member states to submit their national spatial plan to the Commission is legally binding as set out in Directive 2014/89/EU. The aim is to provide the Commission with information on how each member state plans for all maritime activities to coexist in their territorial waters. This will help the Commission to plan the EU-wide deployment of offshore wind and assess whether there will be enough maritime space available for developers to reach the target of 300 GW by 2050. The maritime areas outside the member states' territorial waters will be planned in consultation with the member states concerned and with the Commission as a facilitator. Sea areas outside territorial waters, in other words, the economic zone, are still somewhat unregulated and are expected to be the subject of future discussions. This is, first, because the potential for large-scale offshore wind production in the economic zone will become obvious and, second, because several national interests from member states will have to be considered in the permitting process. Member states were supposed to submit their plans to the Commission by 31 March 2021, but few managed to meet that deadline. Some of those who did, withdrew their plans as they wished to revise them. However, once all the plans have been submitted, they will form the basis for the strategic environmental analysis in the SEA (Strategic Environmental Assessment) Directive 2001/42/EC.

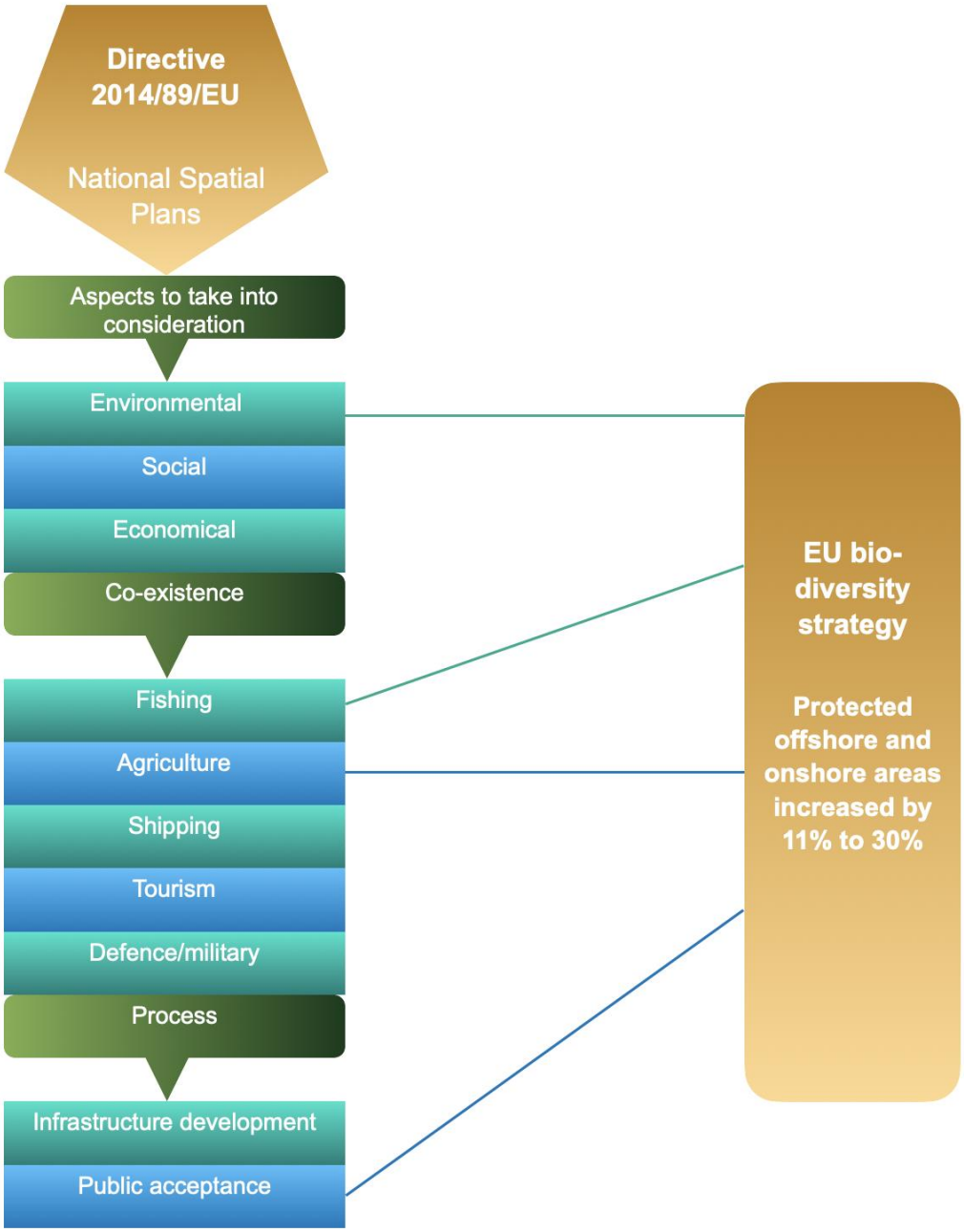
The national spatial plans must consider several aspects, such as the coexistence of all activities at sea and that new establishments take place safely through several processes involving everything from infrastructure planning to public acceptance. The plans will identify the member states' preconditions for the uptake of offshore wind in their respective territorial waters, but they will also identify each member states' strategic planning in terms of prioritizing between sometimes conflicting interests. The national spatial plans will play a key role in kick-starting offshore wind developments in territorial waters as they will identify which areas will be prioritized by the state and therefore also indicate which areas will receive government-backed infrastructural investment. The plans will also define a ceiling for how much offshore wind development there will be in territorial waters. The way in which the plans are structured will show many of the risks and issues that the offshore wind industry faces in terms of competition for space and access to infrastructure. It is therefore a major challenge for member states to integrate offshore wind in their plans. In national energy and climate plans, offshore wind is often given a prominent role and priority, but when these are to be coordinated with the national spatial plan, conflicts of interest arise.

At EU level, there is also conflict between different policy strategies and regulations. This becomes especially clear when the EU's strategy for offshore wind is set in relation to the objectives and vision of the EU's strategy for biodiversity, which contains concrete proposals and commitments to ensure that Europe's biodiversity begins to recover by 2030. This means, among other things, that Europe's protected areas on land and at sea will be increased from 11 per cent to 30 per cent. Of these 30 per cent, one-third will be defined as 'strict' protected areas. Previously this category only amounted to about 1 per cent of the EU's land and sea area.

Given that many maritime areas in Europe are already largely besieged with activities such as fishing, shipping, military, and are homes to a number of different animal species, coexistence remains a challenge for the expansion of offshore wind.

Another obstacle faced by the member states when developing their national spatial plans is that the areas where the conditions for offshore wind deployment are the best, are also the most crowded. These are often areas which the military has identified as strategically important from a defence perspective.

Figure 2: Maritime spatial planning and the EU biodiversity strategy



Source: ELS Analysis

1.1.2 Infrastructure developments

A challenge identified at EU level, but also in most member states, is the need to develop infrastructure that connects offshore production with the onshore grid and market. There are two main aspects that need to be addressed:

- offshore infrastructure development, in other words, offshore high-voltage direct current (HVDC) lines;
- onshore grid expansion.

In the EU Commission´s offshore wind strategy, government-backed infrastructure investments are identified as a crucial prerequisite to incentivize private investment in new production. The Commission has therefore, through several regulations, strengthened the requirements on member states to present medium- to long-term infrastructure development plans, both onshore and offshore. The requirements are quite detailed, and member states are obliged both to present a detailed plan of where and when the expansions will take place as well as how this will be achieved. The EU Electricity Regulation,[4] the EU Electricity Directive[5], and the Trans-European Networks for Energy[6] (TEN-E) regulation, require member states to plan and implement infrastructure strategies that offer good conditions for both off- and onshore renewable uptake and integration into the electricity system.

Energy islands and hubs

According to the Commission, the type of infrastructure required at sea needs to be built in a new way and must have a broader purpose than just serving one offshore wind project. Given that the Commission is planning for a very large expansion of offshore wind, different offshore wind farms should be connected through 'regional' infrastructure networks, so-called dual and/or meshed grid systems. Infrastructure investments should also have a broader purpose than just linking electricity production from offshore wind farms with the onshore grid, through 'hybrid projects' where the Commission sees great synergies with hydrogen and where the development and implementation of offshore wind and interconnection capacity is combined.

Member states are expected to identify 'go-to-areas' where offshore wind projects would be most suitable. These areas will most likely provide a base from where the national Transmission System Operators (TSOs) will build out cables and connect so-called energy islands. The concept of energy islands involves linking offshore wind sites and connecting them to shore but it can also involve more than one cable connecting the energy island to several markets.

The idea of energy islands has raised a discussion about introducing price areas at sea, which would require changes to the current electricity market design. For the above to be realized, strong regional cooperation and a robust regulatory framework are needed. The first step in this process would be for each member state to update its national energy and climate plans with a structure and plan for regional cooperation for offshore wind.

The future offshore grid configuration can be structured in different ways:

- offshore wind park(s) connected to onshore (see Figure 3);
- hybrid projects that connect offshore wind park(s) to interconnectors (see Figure 6);
- multiterminal offshore hubs connecting multiple platforms and member states, with or without offshore wind parks being connected (see Figure 7).

[4] Regulation (EU) 2019/943
[5] Directive (EU) 2019/944
[6] Regulation (EU) No 347/2013

Figure 1: Point-to-point IC

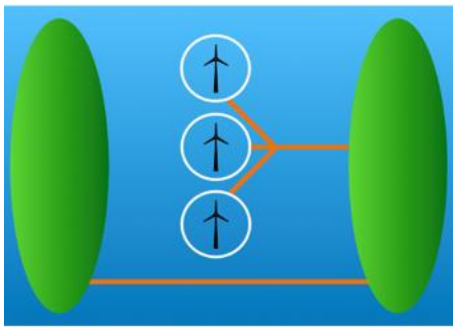


Figure 3: Radial offshore park-to-shore

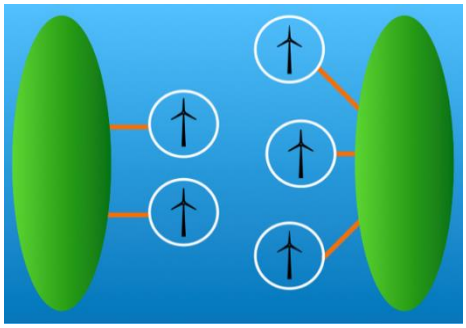


Figure 2: Radial hub-to-shore

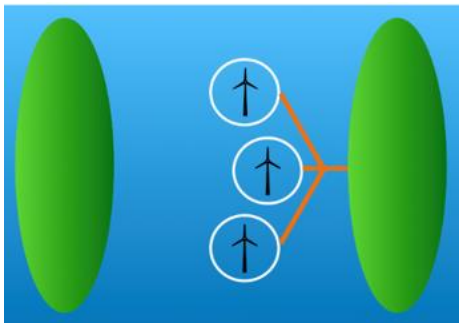


Figure 4: Hybrid project

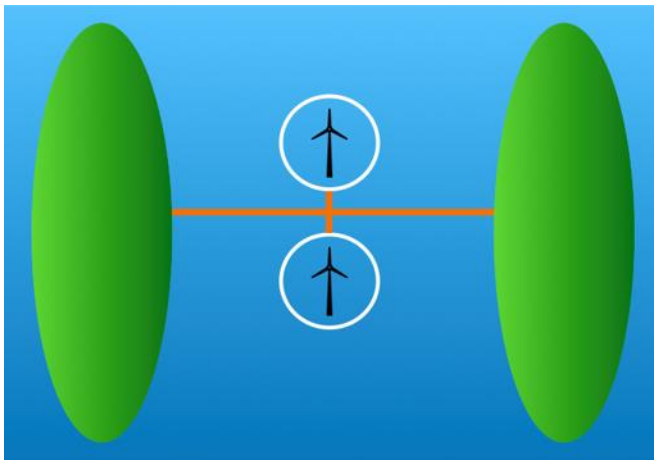
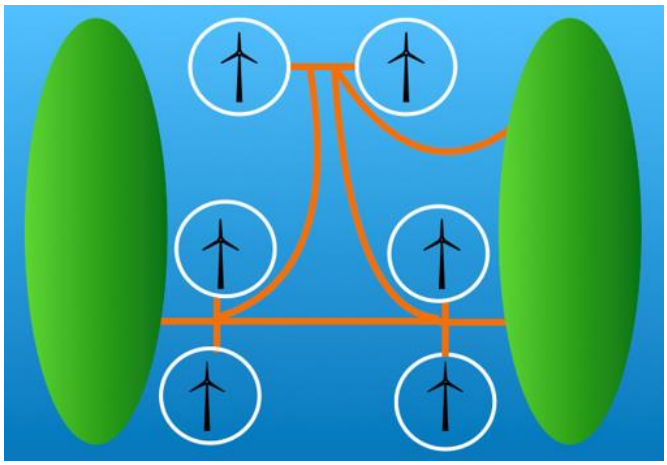


Figure 7: Multi-terminal offshore hubs



Source: ENTSO-E

An alternative to the idea of energy islands are radial offshore park-to-shore and radial hub-to-shore (see Figures 4 and 5) solutions. If government-funded offshore cable investments are what is going to lead the way in creating energy islands, in less mature markets the initial purely private funded projects will most likely be so-called radial offshore park-to-shore projects.

1.1.3 Market rules and renewable energy targets

According to EU institutions, current electricity market designs will have to be adjusted so that offshore electricity production will work under the same regime as onshore production. In short, this means that the EU's core principles on free and fair competition between all market players will also be applicable to offshore wind developers. In Directive (EU) 2019/944 and Regulation (EU) 2019/943 rules that regulate, for example, balancing responsibility, unbundling, and interpretability will also include offshore electricity production.

The Commission's proposal for amendments and revisions of the market rules therefore does not advocate prioritization for renewable production or exemptions to market rules for renewable energy producers, as has been the case in the past. The Commission is clear that market rules in their current form instead stimulate offshore wind growth. However, even though the offshore wind industry is expected to be fully included and to comply with general market rules, the Commission is proposing some amendments that aim to give some support to offshore wind in the existing legal texts. There are, in particular, amendments such as introducing offshore price areas and adjustments to state aid rules and to the Renewable Energy Directive that specifically target offshore wind.

The role of offshore price areas

Offshore price areas are very much related to the idea of energy islands to which more than one wholesale market is connected. The short-term goal of these price areas is to direct flows from offshore

electricity production to the markets with the highest demand. Given that electricity prices differ around Europe and among markets, the exposure to competition is expected to be significant. The long-term goal, however, is to create price signals that will result in investments in offshore hydrogen production and storage.

The idea of offshore price areas undoubtedly comes from an EU perspective that focuses on regional cooperation and cross-border trade. In other words, stability and security of supply are assessed from a European perspective. From a national perspective, however, this means reduced influence from national Transmission System Operators and that national balancing and security of supply interests become secondary. As the Commission advocates, in a perfectly functioning market, price signals seem best for directing flows to where demand is highest. However, experience in recent years proves most markets to be less functioning where free flows and full exposure to competition are limited.

Two separate market designs are being considered when discussing future offshore bid and dispatch structures:

The home market concept implies that the offshore wind farm bids and dispatches into its home market and is exposed to the electricity price in the home market. The home market concept often relates to radial connections of offshore wind farms.

The offshore bidding zone concept implies that the offshore wind farm bids and dispatches into a hub that forms a separate offshore bidding zone. Through market coupling, the offshore generation is matched with onshore demand. The offshore bidding zone concept often relates to hybrid projects where the offshore wind farms are connected to infrastructure that connects two or more bidding zones.

EU state aid rules

The Commission proposes to support significant changes to the EU guidelines on state aid for the growth and establishment of offshore wind. EU state aid guidelines define measures that national governments may take when distributing state aid. These measures are in line with internal market rules.

In December 2021, the Commission presented revised guidelines for state aid rules which opened up the possibility of state aid for offshore wind. The new guidelines make it possible for member states to hold competitive auctions for renewable energy projects. However, more importantly, the revised guidelines provide an opportunity to hold technology-specific auctions, which means that the state can direct investment and influence growth in a particular direction.

The guidelines further advocate so-called two-sided Contracts for Difference (CfD) as a useful tool for supporting the expansion of renewables.

EU principles lay down that prices should be the leading criteria for providing state aid for energy projects, but the Commission decided that up to 30 per cent of non-price-based criteria may be introduced in national auctions. The new guidelines will enter into force in the first quarter of 2022.

EU Renewable Energy Directive

The Commission's revision proposal for the Renewable Energy Directive follows the same principles as its offshore wind strategy, although with less detail on offshore wind. The objectives on the share of renewables in the EU's overall energy mix in this proposal are in line with the offshore wind target in the Commission's strategy. The proposal also sets a target increase of 1.1 per cent per year for renewables in the industrial sector.

However, more interestingly, the proposal fine-tunes the regulation on PPAs (Power Purchase Agreements) with additionality requirements and guarantees of origin. The changes put forward are beneficial for all renewable energy sources and the proposed regulatory framework for PPAs is expected to increase the use of PPAs, which serve as the main tool for renewable energy producers to manage price risk. Since price risk is one of the main uncertainty factors in investment decisions the new rules regarding PPAs should be seen as enabling more investment.

With the new proposal, member states can distribute guarantees of origin for all renewable electricity, regardless of whether the producer has been granted support in state auctions or not. This will lead to improved traceability.

1.1.4 Financing

Initial financial support is a key factor in scaling up and creating growth in new technologies, together with political signals and clear regulatory frameworks. The EU Commission has identified offshore wind and hydrogen as crucial for the EU to reach its climate targets for 2030 and 2050. The Commission has identified that €800 billion in investment will be needed to meet its offshore wind target for 2050 and a large chunk of that is expected to be private investments but EU funding is also available. EU funding can be provided both through loans and aid, and a large part of the overall EU budget and the recovery budget are earmarked for green investments.

There are a number of different institutions and functions within the EU that distribute financial support and loans relevant to offshore wind projects:

- InvestEU programme;
- European Investment Bank (EIB);
- NER 300;
- Next Generation EU, Recovery Resilience Facility;
- Connecting Europe Facility (CEF);
- Horizon Europe;
- Innovation Fund.

After a review of EU funds so distributed to energy projects, hydrogen projects stand out both with respect to the number of projects that have received allocated funds/loans but also the size of the funds paid out. This can, to some extent, be explained by the fact that there are several regulatory ambiguities and planning challenges regarding offshore wind which have contributed to fewer projects applying for funding and loans. If the planning framework is improved and the legislation made clearer, there is a good chance that more projects will apply and thus funds will be allocated.

Up until now, the EIB has been the dominant financial institution financing offshore wind projects. Since 2003, the EIB has allocated loans to offshore wind projects amounting to €9.4 billion, including to the UK.

In addition to the EIB, it is primarily innovation support that has been distributed to offshore wind/pilot projects through Horizon Europe, Invest Europe, NER 300 and the Innovation Fund. Hydrogen has dominated with regards to the funds that have been allocated. Of the €80 billion set aside for research and innovation from Horizon 2020, wind energy projects received €108 million, of which 72 per cent went specifically to offshore wind projects. Hydrogen projects, on the other hand, received a total of €460 million and the difference is even greater when it comes to funds distributed by the Innovation Fund.

1.2 Permitting processes

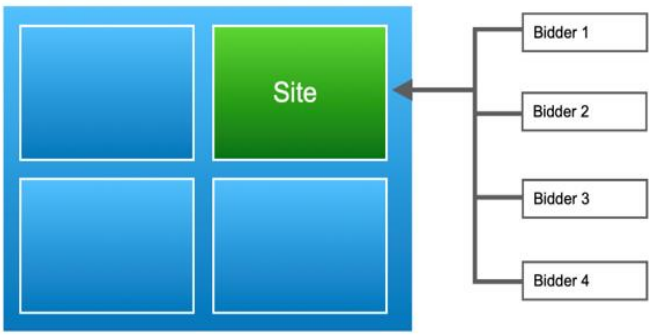
The issue of permitting processes is frequently discussed in the offshore wind industry, and national governments are often criticized for not offering more effective frameworks. The permitting process plays a central role in offshore project planning, and in countries where shorter and more effective processes are offered, the uptake in offshore wind deployment has been faster, less risky and more attractive for private investments and therefore lowered the public cost.

The EU Commission recognizes the problem with long, ineffective, and non-transparent permitting processes, and the fact that the processes vary a lot between different member states. Through legal

texts, such as the Renewable Energy Directive[7] and the REPowerEU,[8] the EU is offering both guidance and requirements to member states to shorten their permitting processes through a structure often referred to as the 'one-stop-shop' model. This model aims to form a central focus point for information between private developers and public authorities. It can also be the authority actively supporting or even conducting the permitting, which both eases and speeds up the permitting process.

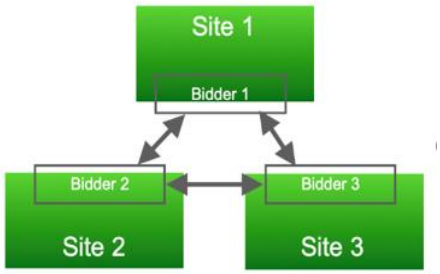
Even though the permitting processes vary in the member states, there are some general features for all offshore wind permitting processes. Even in countries that have the most effective processes, permitting processes take time since they involve many players and can therefore be very costly. In the permitting process, roles and responsibilities are divided between policymakers, government agencies, grid operators, and private developers. European member states divide roles and responsibilities differently and there are three main structures that are used: central, decentralized, and hybrid models.

Figure 8: Centralized model



Bidders compete for the site developed by the government

Figure 9: Decentralized model



Bidders compete with sites developed in-house

Source: EU Procedures for Offshore Wind

Centralized model

In the centralized model, the government finds suitable offshore areas for wind deployment, selects the sites and conducts preliminary site investigations. In the centralized model, the government carries both the project's financial and development risk. This model requires government and/or state agencies with technical expertise. A disadvantage of it is the lack of competition for cost reduction.

Decentralized model

In the decentralized model, the private project developer plays a key role in planning the site selection, investigation, permitting, and, in some cases, the grid development. In this model, the government is only working as the counterpart to the private project developer in the permitting process. This model opens the door to more competition and broader technical expertise while the private project developer bears all the project risk.

Hybrid model

The hybrid model is a combination of the central and decentralized model and often allocates initial responsibility to the government, while the private project developer takes over in the latter more costly stages when technical know-how is needed.

[7] Directive 2009/28/EC, Article 13
[8] COM/2022/108

The role of auctions

Auctions for offshore wind projects have come under scrutiny lately for several reasons. One is that many of the auctions that have been held have sparked a race to the bottom, ultimately placing the project at risk.

Auctions can be held at different times during the permitting process, depending on national circumstances and auction designs. The general view is that the earlier in the process an auction is held the better, as it lowers financial risks for project developers and leaves the more costly parts of the site investigation and technical planning until after the auction result. However, this view has been somewhat challenged and, in any case, some preparatory work needs to be done before acreage can be auctioned, or else the bidder will not be able to submit reasonable bids if the quality of the site has not been investigated. It is especially important for developers to conduct an economic analysis of the project so that if they win the auction they will be able to secure a permit.

A disadvantage with holding early auctions is that the commissioning period after the auction result is longer, meaning that it can be many years from the time the winner of the auction is announced to the final investment decision or project start. This creates a lot of uncertainty for the developer in terms of capital, turbine costs (access to the supply chain), and the development of a revenue stream, in other words, the electricity price. There is a growing fear that the level of uncertainty results in highly speculative auction bids, placing projects at risk, making auctions highly competitive, and encouraging a race to the bottom. As a result, in more mature markets, national governments are instead holding auctions when significant stages of the permitting process are already under way. However, one way of tackling the uncertainty related to early auctions could be to introduce a CfD structure, as in the UK model, in order to provide a predictable revenue line and give the financiers a time horizon for the risk exposure.

Non-price criteria in auction designs have been widely discussed recently, both within the industry and among policymakers. The EU Commission is pushing this issue and the idea of viewing offshore wind as a strategic asset should be reflected in these criteria. As explained above, the Commission included the possibility for governments to introduce non-price criteria in national auctions in the EU state aid rules. As the name suggests, all other criteria, such as qualitative criteria, aside from the price on a tender, bid, or proposal, which can be used, for example, to factor in sustainability or system integration.

Until now, most of the criteria considered have been in the context of environmental sustainability. However, ongoing discussions offer a new take and the use of non-price criteria in the context of creating more energy security, potentially factoring in criteria for stability and system integration.

Non-price criteria can bring complexity to the auction design leading to additional risks which need to be priced by the bidders. From an industry perspective, the non-price criteria are welcomed, but should have certain characteristics in order to minimize risks and complexity. For example, the criteria should:

- be clear;
- be objective;
- be comparable;
- be easy to track and measure;
- lead to a strengthened supply chain;
- not create additional administration.

A permitting process without auctions

A permitting process can also be structured without the auction element and, even though it is not general practice, models with sole permitting processes can be found, for instance in Sweden where a private developer hands in an application for an environmental permit to the government under the Swedish Environmental Code and a permit for water activities. The permitting process then includes an environmental impact assessment and a consultation with the relevant authorities, organizations, and

individuals. The process is slightly different if the site is located in territorial water or in the exclusive economic zone, and the developer who first hands in the application is prioritized in the permitting process. However, more than one developer can hand in an application for the same site and it is not certain that the developer who first handed in the application will ultimately be the one who granted the permit.

A model such as the Swedish one requires a highly competent and coordinated authority to handle the permitting processes to ensure that the permissions are based on cost-competitive, effective, and non-discriminatory factors. It also requires some sort of one-stop-shop to ensure that the permitting processes are not caught between different decision-making bodies and lead to delays. The latter is the case in Sweden and a framework is currently being reviewed by the national authorities and the government. The advantage with such a model is that non-price criteria that can prove to be a challenge to implement in auctions can be managed more easily if the government succeeds in introducing a coordinated body to handle the permitting processes.

2. Business opportunities in a high-cost environment

Even though the current policy and regulatory environment poses many challenges to the uptake in offshore wind, there is a clear policy direction and a push both from the EU and individual member states to reach the EU's offshore wind targets for 2030 and 2050. The EU Commission has identified offshore wind and hydrogen as priority areas and crucial elements in reaching the EU's overarching climate targets, and it is therefore proposing amendments and changes to relevant regulations to enable growth in offshore wind across the EU. Financing schemes have also been directed to offshore wind projects, both at national and EU levels, and infrastructural investments in particular are expected to be funded by the state. However, a large chunk of investments will have to come from the private sector.

There are three main factors challenging the uptake in offshore wind production:

- long and costly permitting processes;
- a lack of grid connections, both offshore and onshore;
- high initial production costs, or levelized cost of electricity (LCOE).

The first two points have been examined in the policy section of this paper. Even though they present high risks, and are not expected to be solved easily or quickly, they have been identified and measures to tackle them are being introduced.

Although the third point is strongly linked to policy-related challenges, it is something that the industry itself will have to tackle, in other words, reducing costs in order to make offshore wind cost-competitive. This part of the paper will briefly discuss how initial high production costs can be bridged to reach grid parity with the help of cooperation and policy opportunities.

2.1 LCOE scenarios

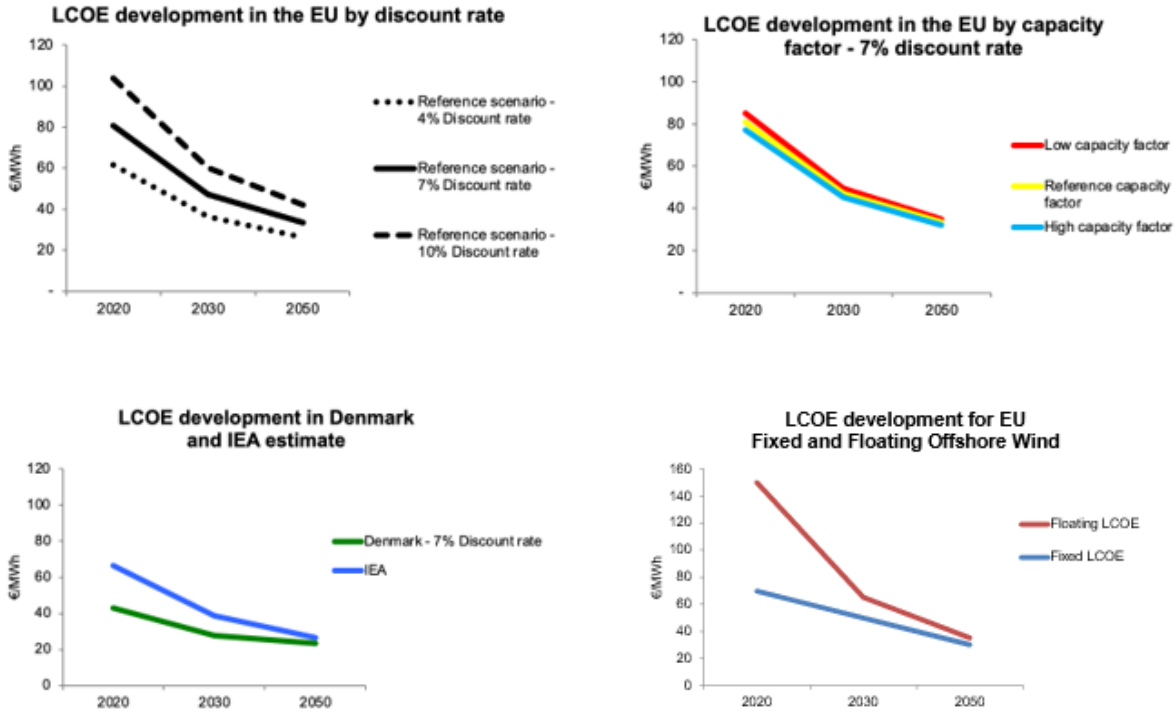
Figure 10 below shows the assumptions for European offshore wind LCOE development up until 2050. It is modelled with three different discount rates, since the discount rate has the single largest impact on how swift and sharp the cost decline will be.

With a discount rate of 4 per cent in 2030, the LCOE reaches €36/MWh compared with €60/MWh when using a discount rate of 10 per cent the same year. When we reach 2050, the curve for a 4 per cent discount rate has fallen to just above €26/MWh and for the 10 per cent discount rate to about €42/MWh.

Another key element in modelling the LCOE is the capacity factor. In the chart on the top left, the cost curves are modelled with a capacity factor of 0.50 in 2020, 0.55 in 2030 and 0.58 in 2050. The top-right chart is based on three different scenarios related to different capacity factor assumptions. For the bearish scenario, the capacity factor goes from 0.47 in 2020 to 0.55 in 2050. In the reference scenario, the capacity factor starts at 0.50 in 2020 and reaches 0.58 in 2050. For the bullish scenario a capacity factor at 0.53 in 2020 to 0.61 in 2050 is assumed.

In the bottom-left chart, the International Energy Agency (IEA) LCOE cost development curve is also included as a reference, together with selected Danish projects' LCOE curves. LCOE curves for fixed and floating offshore wind are shown in the bottom-right chart. The Danish LCOE cost curve is well below the rest of Europe due to a combination of factors. In Denmark, the policy environment is very favourable to offshore wind expansion, the country has one of the fastest and most effective permitting processes in Europe and the state carries the connection cost. These regulatory factors, together with very good wind conditions, make offshore wind production in Denmark very competitive.

Figure 10: LCOE cost curves



A common feature in all scenarios is that the cost curve sees a rather steep fall, which is very much driven by the assumption that offshore wind projects (both fixed and floating) are being built and the production is seeing rather rapid growth. Thus, the LCOE number will follow the above downward trajectory in line with volumes coming to the market.

2.2 LCOE and electricity prices

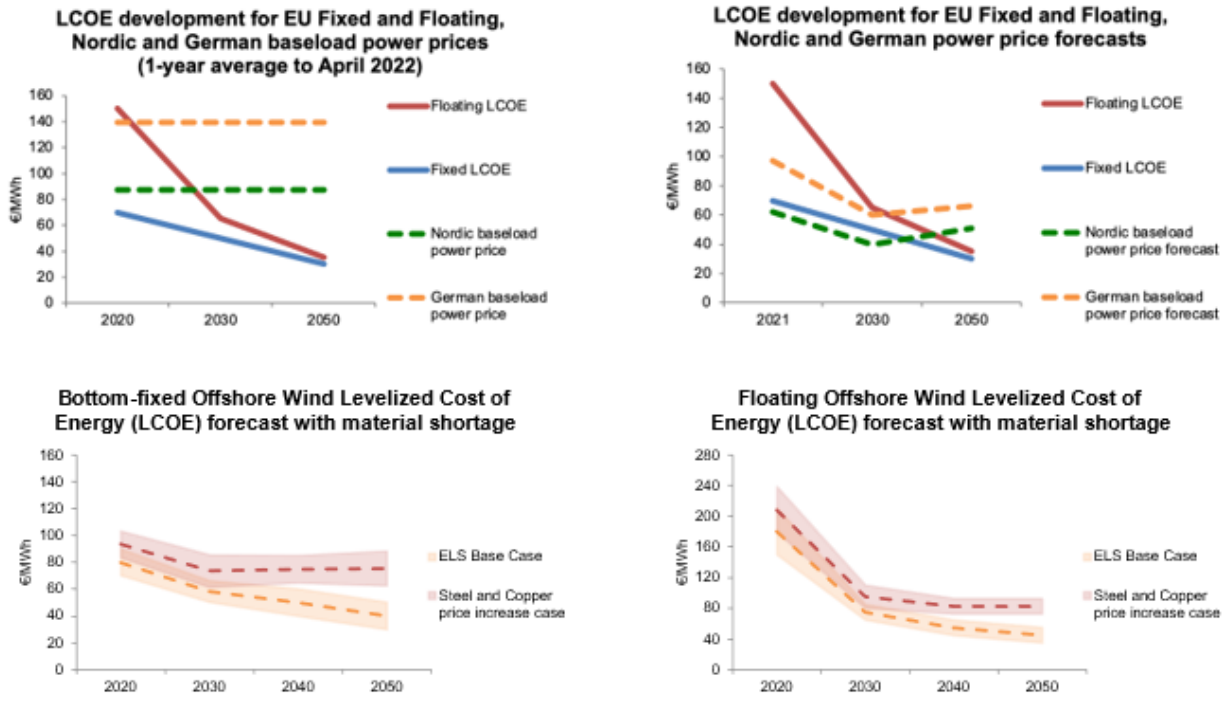
With current high electricity prices, even a high floating offshore wind LCOE make commercial sense and, if one believes prices will remain at these levels, this should trigger investment (see the charts in the top row of Figure 11 below comparing LCOE with electricity prices). There are, however, many uncertainties attached to that conclusion. First, long-term electricity price forecasts are highly uncertain and the market could, for a range of reasons, shift and challenge that idea. Second, the offshore wind industry is facing severe supply chain issues. This was already the case before Russia´s invasion of Ukraine, since many large offshore wind projects are due to come onstream roughly at the same, meaning high demand for steel and copper etc., but also due to constraints in access to yards to build the installations. With the Russia-Ukraine war, this risk has only been exacerbated. The bottom two charts in Figure 11 illustrate how supply chain constraints could influence the LCOE curve.

The EU's annual steel production has been decreasing and its consumption increasing. It became a net importer in 2019 and the difference is expected to grow. The amount of steel needed annually from 2022 to 2030 to expand both offshore and onshore wind, and achieve EU wind and renewable energy targets, will be about 4 per cent of Europe's total steel production (140 million tonnes), up from 1 per cent now. That is double the net steel import from Russia annually. Before the sanctions, Russia was

the second-largest source of EU steel imports. With Europe's production falling every year and more ambitious targets to 2050, the steel needed for wind farm buildout will rise to 10 per cent of European production.

Steel prices have doubled since early 2021 owing to supply shocks. Russia's invasion of Ukraine saw them shoot up 40 per cent in Europe; the US and China were less affected. Copper could be in an even tighter situation. While the offshore wind industry's demand for copper is about one-tenth of that of steel, copper production volumes are only one-hundredth of those of steel. European dependence on Russian copper has been growing over the past decade, especially since 2016 when Russian imports began exceeding those from Chile, the world's largest copper producer. Most of the EU's copper demand (2.35 million tonnes/year) is fulfilled by imports, with Russian imports accounting for more than 10 per cent of total demand. Copper is still exempt from sanctions, probably because of European industry's heavy dependence on Russian copper. Copper is a core component of cables for offshore wind farms. However, it can be substituted for aluminium, which is about one-third of the price per tonne and around 50 per cent lighter. The trade-off is lower durability. To expand offshore wind farms to the scale that is needed, especially considering the miniscule copper market and increased distance from the shore, aluminium cables will need to replace copper ones in several applications. Although the EU imports half of its aluminium requirements (12–14 million tonnes/year), and a large amount of those imports come from Russia, there is also a larger global market of aluminium to tap. That includes China, whose aluminium production is 10 times larger than any other country, but also India, the USA, Canada, and Australia.

Figure 11: LCOE compared with electricity prices. Impact of supply chain constraints on LCOE.



2.3 Holistic business opportunities

If one assumes that the industry will have to continue to view offshore wind as a technology that still cannot compete with the onshore market price, business opportunities will have to arise from more holistic approaches that include creative offtake agreements, connecting offshore wind with new technologies, markets, and grid cooperation.

It is becoming increasingly clear that, from a policy point of view, offshore wind projects that offer not only green energy to the system, but also more opportunities, serving the whole system and market, will be the projects that secure permits. Regardless of whether permitting processes are designed to include auctions or not, non-priced based criteria will most likely be included in the permitting processes.

This means that offshore wind projects that are placed strategically close to one or more markets with strong demand, especially if they comprise industries and sectors that are hard to decarbonize or markets which are constrained, will be prioritized both in the permitting process (but also in future auctions). Governments will also most likely pick them as prioritized areas and build connection points.

Receiving a permit does not just push down the LCOE cost, helping to bridge the cost gap between the LCOE and market price, EU regulation is rather clear on the fact that no direct subsidies can be directed to renewable energy production. However, there are many demand-side measures both at the EU and national levels which can help to make the cost gap more manageable through a broader offtake agreement.

Demand support related to hydrogen production, e-fuels, storage, and battery solutions could help bridge the gap in a broader offtake agreement between an offshore wind producer and an industry. For example, if the industry receives EU and/or government support to switch from its current fossil fuel to hydrogen, and receive its electricity from a renewable energy source, the industry might be willing to pay a premium that reflects the higher cost of electricity coming from offshore wind. If there is a battery solution in place as well, revenues from being active in the growing ancillary service market could also help in mapping out the whole cost estimate.

3. Conclusion

The EU policy for offshore wind sets out clear volume targets for offshore wind deployment throughout the European Union. The EU and many of its member states have also identified large-scale offshore wind deployment as a priority and a requirement to meet both EU, as well as national, climate, and renewable targets. However, the growth in offshore wind projects has been rather slow in many parts in Europe. This paper has investigated how the current policy and regulatory framework enables or challenges the uptake in offshore wind deployment and there are four main conclusions which can be drawn from this:

1. Clear and ambitious targets as well as strong policy-signals from the EU support a strong and fast uptake in offshore wind deployment.
2. There are few policy support mechanisms specifically directed to offshore wind projects and existing regulations for electricity markets will be amended to include other offshore wind.
3. The EU aims to harmonize national regulations and procedures, but there are still significant differences between member states.
4. Permitting processes and spatial planning are causing both delays and costs for projects.

There are major changes and improvements under way related both to EU and national legislation aiming to make permitting processes, spatial and infrastructure planning more efficient and transparent and, in turn, enable both private and public investment. However, this will take time, something the EU and its member states know they do not have on a strategic and security level. Nor does the offshore wind industry have time, with signs that the era of cheap credit might be coming to an end and metals prices moving higher, possibly for a prolonged period. Both those factors risk seriously impacting its cost calculations for projects that have already been proposed. For the EU and its member states it is increasingly clear that top-down political action is needed to implement the strategic urgency around energy security of supply, and to move permitting processes to lower decision-making levels in order to increase their efficiency and agility and make them purposeful for the EU's new strategic context.

Regulatory risks are causing delays and extra costs, but the offshore wind industry is also facing initial challenges when it comes to reducing project and production costs. The LCOE outlooks, especially for

floating technologies, show that reaching grid parity before 2030 is a challenge and the estimated cost reduction depends on significant growth in installed floating capacity. The question is whether the industry should wait for better regulatory conditions or if there are business opportunities to find elsewhere that will also be in line with future market designs and regulations.

An important issue that has been raised in this paper is the idea of qualitative criteria in permitting processes and auctions. The logic behind viewing offshore wind projects as a strategic asset could also, with the help of demand-side support measures and revenue streams from related markets such as the ancillary market, help bridge the cost gap that is currently viewed as the threshold for high-potential projects in the economic zone.

This Energy Insight therefore argues that the cost gap could be bridged through more holistic business strategies that build on strategic and long-term cooperation with offtakers on a path to decarbonization, innovative technologies, and constrained markets.