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Comparison of policy instruments in the development process of offshore wind power in North Sea countries

Hongyun Zhang   Michael G. Pollitt

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Offshore wind power has made remarkable strides over the past decade, establishing itself as a financially viable technology with substantial potential to drive the energy transition of North Sea countries. The energy crisis commencing in 2021 further underscored the critical role of offshore wind in attaining net zero climate (or climate neutrality) objectives, prompting North Sea countries to adopt comprehensive strategies, including a fundamental energy system overhaul centred around offshore wind. Consequently, these countries have set ambitious offshore wind installation targets for both 2030 and 2050. To assess the attainability of these targets, this paper conducts an extensive policy analysis of the eight nations surrounding the North Sea, focusing primarily on the development stage, a crucial determinant of project success. Notably, competitive tenders and Contract for Difference (CfD) mechanisms are becoming standard tools across the region, indicating a collective shift towards efficient subsidy frameworks. Historical data and disparities suggest the formidable challenges in achieving the 2030 and 2050 targets, with streamlining the approval process emerging as a top priority. The emergence of negative subsidies in conjunction with zero-bid scenarios is reshaping industry paradigms is significantly impacting offshore wind project economics.

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Comparison of policy instruments in the development process of offshore wind power in North Sea countries

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11 October 2023

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1. Introduction

The North Sea region has a history of regional energy cooperation backed by both physical interconnections and institutional frameworks [**Error! Reference source not found.**]. With the growing demand for renewable energy, the development of offshore wind energy (OWE) in the North Sea has gained significant momentum in the last decade, particularly in the UK, Germany, the Netherlands and Denmark. These countries have implemented various policy instruments to promote the growth of the

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offshore wind sector, with the Contract for Difference (CfD) mechanism proving to be a highly effective tool for attracting investment and facilitating OWE capacity in the UK [**Error! Reference source not found.**].

In light of the significant market disturbances experienced in the global energy sector since the summer of 2021[2,3], both the European Commission and national governments in the North Sea region have even clearly expressed their ambitions to maximize the potential OWE capacity. The significance of cross-border cooperation and interconnection has been underscored by multilateral and bilateral agreements. In September 2022, the North Seas Energy Cooperation (NSEC) countries pledged to collaborate on the construction of 260 GW of OWE in the entire maritime area of the NSEC region by 2050[4]. This amounts to over 85% of the EU-wide target of 300 GW by 2050 which was set out in the EU strategy for offshore renewable energy[5]. Despite having withdrawn from the EU, the UK, which currently has the largest operational offshore wind power capacity in the area, has been actively involved in regional cooperation efforts. The memorandum of understanding on offshore renewable energy cooperation signed between the UK and NSEC participants in late 2022 is a notable example of such collaboration[6].

Despite the commendable efforts of North Sea countries to establish collaborative mechanisms and engage in technical dialogue, information exchange, and best practice sharing for the utilization of offshore wind [**Error! Reference source not found.**], further policy instruments are necessary to effectively implement offshore wind objectives. Our paper highlights the importance of developing robust market frameworks that align with the rapid growth of offshore wind farms in the region. While existing research has primarily focused on comparing support policies for offshore wind development among North Sea countries, and even broader regions [**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**], there has been limited exploration of the feasibility of achieving future OWE targets based on current support mechanisms. Furthermore, discussions regarding tenders and subsidies have rarely delved into the substantive differences between countries.

The primary objective of this paper is to provide insights into the variations in policy choices during the offshore wind development process in North Sea countries. In Section 2, we examine the theoretical implications associated with offshore wind development in this specific region. Section 3 presents an analysis of the fundamental components of the policy instruments utilized in the offshore wind development process

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2 https://www.nea.org.uk/publications/uk-fuel-poverty-monitor-2021-22/
3 https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices
4 https://energy.ec.europa.eu/system/files/2022-09/220912_NSEC_Joint_Statement_Dublin_Ministerial.pdf , p.1
5 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0741 , p.2
6 https://www.gov.uk/government/publications/offshore-renewables-resources-in-the-north-seas-region-memorandum-of-understanding

across different countries. In Section 4, we discuss the findings, with a specific emphasis on the divergences and convergences observed in tender and subsidy designs. Finally, in Section 5, we present a comprehensive summary of our findings and draw conclusions based on the analysis conducted throughout the paper.

For the purposes of this paper, we limit our focus to the eight countries that are situated geographically around the North Sea, namely the United Kingdom, Germany, the Netherlands, Denmark, Belgium, Sweden, Norway, and France (the North Sea does not directly border France, it is still commonly considered a North Sea country because it participates in multiple international organizations and agreements related).

2. Theoretical implications of developing offshore wind power in the North Sea

2.1 The role of offshore wind of North Sea countries towards Net Zero

The adoption and implementation of comprehensive and effective transformational protocols and strategies [**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**], including those highlighted in internationally recognized agreements and reports such as the *Paris Agreement* and the *Special Report on Global Warming of 1.5 ℃*, are essential to mitigating the adverse impacts of climate change and achieving global sustainability goals. The decarbonization of the electricity sector is at the heart of achieving the global objective of net-zero emissions by 2050, given the sector's significant contribution to greenhouse gas (GHG) emissions. Correspondingly, these agreements provide a legally binding framework incentivizing countries to adopt zero-emission technologies, including offshore wind, to meet their respective targets[7].In the IEA's *Net Zero by 2050 Scenario*, renewables will drive the transformation up from 29% of generation in 2020 to 61% in 2030 and nearly 90% in 2050 globally, particularly, 340 GW of wind are added annually (including replacements) from 2030 to 2050, with offshore wind accounting for over 20% of total wind additions from 2021 to 2050 compared with 7% in 2020 [**Error! Reference source not found.**].

In the European context, the European Union (EU) is committed to reducing its GHG emissions by at least 55% by 2030 compared to 1990 levels and achieving climate neutrality by 2050[8]. To realize this ambitious objective, the European Commission has introduced a comprehensive set of measures, including a radical transformation of the energy system. Central to this strategy is the large-scale electrification of the grid, powered by renewable energy sources, as outlined in the long-term strategy (LTS) known as *A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive, and climate-neutral economy*[9]. NSEC, possessing the

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[7] https://northseawindpowerhub.eu/sites/northseawindpowerhub.eu/files/media/document/Permitting-Study-UK-1.pdf , p.4.
[8] https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF , p.4.
[9] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773

most grid-integrated offshore wind farms globally, has achieved a series of agreements on shared visions to expedite the development of OWE in this region, thus facilitating the realization of the LTS. In the meantime, the UK, as a leading player in offshore wind over the past decade, continues to make efforts to maintain its prominent position in this field. The significance of offshore wind has been consistently emphasized in the various official documents, as is seen in Table 1.

Table 1. Key documents adopted by the EU Commission and NSEC regarding climate action and emphasis on offshore wind.

Publisher	Official documents	Dates of issue	Visions of offshore wind in the future
EU Commission	A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy	28.11.2018	By 2050, more than 80% of electricity will be coming from renewable energy sources (increasingly located off-shore). [10]
EU Commission	The European Green Deal	11.12.2019	Renewable energy sources will have an essential role in the clean energy transition. Increasing offshore wind production will be essential. [11]
EU Commission	An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future	19.11.2020	offshore renewable energy a core component of Europe's energy system by 2050. [12]
EU Commission	REPowerEU Plan	18.05.2022	offshore wind in particular represents a significant future opportunity. [13]
NSEC	Political Declaration on energy cooperation between the North Seas Countries and the European Commission	02.12.2021	the indispensable role offshore wind energies play in achieving European renewable energy and climate targets. [14]
UK Government	Offshore Wind Net Zero Investment Roadmap	31.03.2023	Offshore wind will play a key role in decarbonizing our power system by 2035 and helping the UK achieve net zero by 2050. [15]

[10] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773 , p.9.
[11] https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF , p.6.
[12] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0741 , p.2.
[13] https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0001.02/DOC_1&format=PDF , p.6.
[14] https://energy.ec.europa.eu/system/files/2021-12/20211124-nsec_political_declaration.pdf , p.1.
[15] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1167856/offshore-wind-investment-roadmap.pdf , p.2.

As of year 2022, electricity generated by offshore wind accounts for 1.8%[16] and 14%[17] of the total electricity generation in the EU and UK, respectively. In combination, offshore wind generation has covered 3% of the electricity demand in the EU-27+UK [**Error! Reference source not found.**]. Across Europe, the initiative of offshore wind strategies is paving the way for offshore wind to become a primary energy source in the energy mix from 2030 to 2050. This transformation is extensively analyzed in quantitative studies found in various literature sources, which assess the significant role of offshore wind in shaping the future energy landscape, see for example Chyong et al. (2021) on sector coupling in EU (CERRE) [**Error! Reference source not found.**].

The outcomes of some of the key literatures indicate that offshore wind is projected to contribute around 7%-8% of the total electricity generation in the EU by 2030, and this figure is expected to rise to 20% by 2050 in various scenarios, see Table 2. In UK National ESO's projections, offshore wind will become the largest source of generation in all scenarios by 2035 in the UK[18].

Table 2. Offshore wind percentage in the 2030/2050 electricity generation in different reference scenarios.

References	**Scenarios**	**Countries**	**Percentage of offshore wind in total electricity generation**	
			2030	**2050**
European Commission's Joint Research Centre (JRC) (2019) [**Error! Reference source not found.**]	POTEnCIA Central-2018 scenario	EU-28 (incl. UK)	7%	16%
McKinsey (2020) [**Error! Reference source not found.**]	Cost-effective pathway to reaching net-zero	EU-27	8%	21%
Chyong et. al (2021) [**Error! Reference source not found.**]	Net-zero scenario	Europe (EU, UK, Norway, Switzerland)	-	20%
ETIPWind & WindEurope (2021) [**Error! Reference source not found.**]	WindEurope based on European Commission Impact Assessment, COVID MIX	EU-27	-	17%
European Commission	Reference Scenario 2020	EU-27	7%	11%

16 Based on WindEurope and Eurostat dataset Statistics (https://www.consilium.europa.eu/en/infographics/how-is-eu-electricity-produced-and-sold/).
17 https://www.thecrownestate.co.uk/media/4378/final-published_11720_owoperationalreport_2022_tp_250423.pdf (Accessed: 08 August 2023), p.2.
18 https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes/fes-sections/energy-system

(2021) [**Error! Reference source not found.**]				
Nationalgrid ESO (2023) [**Error! Reference source not found.**]	Future Energy Scenarios (FES)	UK	40%-47%	51%-58%

2.2 Economic potential of offshore wind energy in Europe

Offshore wind technology has matured rapidly accompanied by a significant reduction in costs. BloombergNEF found a noteworthy reduction of over 65% in the global average levelized cost of electricity (LCOE) for offshore wind power over the past decade [**Error! Reference source not found.**]. According to IRENA [**Error! Reference source not found.**], between 2010 and 2021, both the global LCOE and the global weighted average total installed costs for offshore wind experienced significant reductions - the LCOE for offshore wind fell from $188/MWh to $75/MWh, while the total installed costs dropped from $4,876,000/MW to $2,858,000/MW (in 2021 dollars). The downtrend is particularly evident in European countries, see Table 3. These cost reductions demonstrate the growing competitiveness and maturity of OWE, making them increasingly accessible and economically feasible.

Table 3. Regional and country weighted-average total installed costs and weighted average LCOE of offshore wind, 2010 and 2021 [**Error! Reference source not found.**].

Country	**LCOE (2021 $/MWh)**		**Total installed costs (2021 $/kW)**	
	2010	**2021**	**2010**	**2021**
UK	210	54	4753	3057
Germany	179	81*	6739	3739*
Netherlands	-	59	4299**	2449
Denmark	108	41	3422	2289
Belgium	226	83*	6334	3545*
Europe	**163**	**65**	**4883**	**2775**

Note:

* Countries where data were only available for projects commissioned in 2020, not 2021.

**The Netherlands had no projects commissioned in 2010, so data for projects commissioned in 2015 are shown.

The industry is increasingly confident that offshore wind power generation can offer a cost-effective and viable alternative to traditional fossil fuel-based power generation in the coming years. A common estimation is the LCOE of offshore wind power will be around €50/MWh-€60/MWh [**Error! Reference source not found.,Error! Reference source not found.,Error! Reference source not found.**], which will be lower than that of CCGT generation at €75/MWh. In the IEA's *Net-Zero Emissions Scenario* [**Error! Reference source not found.**], the LCOE of offshore wind in the EU will be $25/MWh (in 2020 price) in 2050 – same as solar, meaning offshore wind could be as economically competitive as solar PV while it enjoys much higher capacity factor (59% of offshore wind vs 14% of solar PV in 2050).

One of the key factors contributing to the reduction of the LCOE of OWE is the deployment of new supersized offshore wind turbines, which have facilitated a significant increase in scale. The larger size of these turbines has allowed for greater energy production capacity, which has led to greater economies of scale and a subsequent decrease in LCOE. Rystad Energy[19] suggested that implementing the largest – 14 MW - turbines available for a new 1 GW windfarm would result in cost savings of almost $100 million, compared to installing the currently available 10 MW turbines. WindEurope (2017) [**Error! Reference source not found.**] set turbine rating of 13 MW as baseline for the 2030 technology scenario while that of 15 MW as an upside. Nevertheless, the 15 MW offshore wind turbine prototype has already come into being in 2021 and been installed in 2022[20]. This indicates that the economics of offshore wind still hold great potential, given the significant cost savings that can be achieved through the use of the largest turbines available.

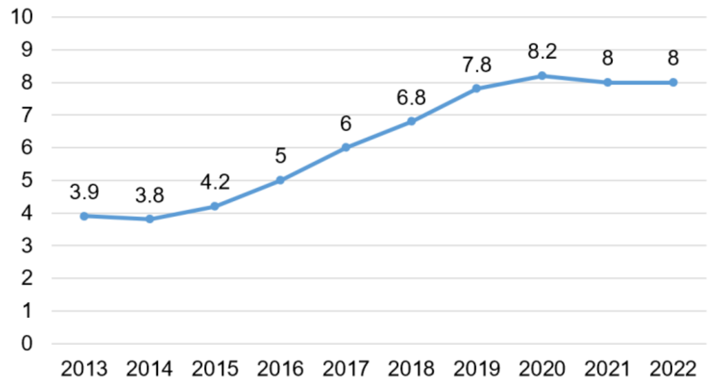

Fig 1. Average power rating of installed turbines in Europe, 2013-22 [**Error! Reference source not found.**] (MW).

2.3 Offshore wind energy potential for meeting 2030/2050 capacity targets of North Sea countries

The North Sea is a vast and shared resource with significant potential for wind energy to benefit the whole of Europe, due to its favorable environmental conditions[21,22]. Figures 2 (a) and (b) present an overview of wind resource distributions throughout Europe, indicating that the North Sea region generally exhibits higher wind potential compared to other areas in the region.

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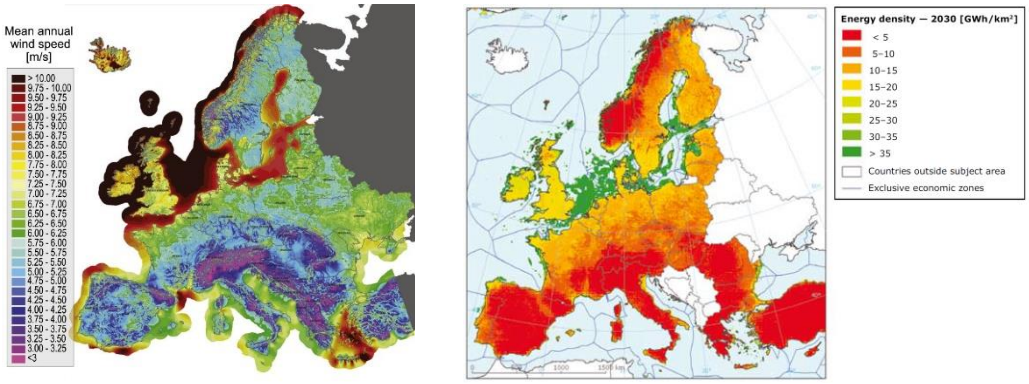
19 https://www.offshorewind.biz/2020/09/21/rystad-energy-less-is-more-if-using-14-mw-turbines/
20 https://www.vestas.com/en/products/offshore/V236-15MW
21 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0741 , p.6.
22 https://northseawindpowerhub.eu/files/media/document/NSWPH_Insights_15.09.2022_CMYK_without%20cropmarks.pdf , p.2.



(a) (b)

Fig 2. (a) Annual European onshore and offshore mean wind speeds at an 80 m height [**Error! Reference source not found.**].

(b) Distribution of wind energy density (GWh/km^2) in Europe for 2030 (80 m hub height onshore, 120 m hub height offshore) [**Error! Reference source not found.**].

Studies have examined the wind potential of the North Sea region through qualitative and quantitative analysis, and the results of which have demonstrated that this area possesses adequate wind resources and available locations for offshore wind farms to meet the 2030/2050 OWE capacity targets [**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**,**Error! Reference source not found.**] of the North Sea countries, the theoretical basis for the region's wind potential therefore is beyond the scope of this paper.

In Table 4 we present the major official documents (joint declarations) seeking to facilitate governmental cooperation towards the advancement of OWE development in the North Sea region since 2020, which also includes targets of individual country.

Table 4. Major inter-governmental declarations on offshore wind development between countries in Europe, including combined capacity targets (since 2020).

Title of documents	Initiator/ Organizer	Participants	Date	Main purpose	Offshore wind targets
The EU strategy on offshore renewable energy	European Commission	the EU and its Member States	19 Nov 2020	To position offshore renewable energy as a central element of the energy system by 2050	60 GW by 2030; 300 GW by 2050[23]
The British Energy Security Strategy	UK	UK	4 Apr 2022	Propose to accelerate the UK towards a low-carbon, energy independent future	50GW by 2030, including 5GW of floating wind[24]
Declaration of Energy	Offshore Wind	Belgium,	18 May 2022	Committed to expand the combined	Combined four

[23] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0741 , p.1-2.
[24] https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy

Ministers on the North Sea as a Green Power Plant of Europe (the Esbjerg Declaration)	Summit in Esbjerg (Denmark)	Denmark, Germany, the Netherlands		North Sea offshore wind capacity	countries: 65 GW by 2030; 150 GW by 2050[25]
Joint Statement on the North Seas Energy Cooperation	NSEC (the North Seas Energy Cooperation)	NSEC members	12 Sept 2022	To announce combined aggregate targets (non-binding) for offshore renewable energy in the entire maritime area of the NSEC region	Aggregate targets: 76 GW by 2030; 193 GW by 2040; 260 GW by 2050[26]
NSEC-UK Memorandum of Understanding on offshore renewable energy cooperation	NSEC	NSEC members, UK	18 Dec 2022	To work closely on the path towards net-zero ambition by developing offshore renewables resources in the North Seas region	EU: 60 GW by 2030 and 300 GW by 2050. UK: 50 GW by 2030 (including 5 GW of floating wind)[27]

In total, the North Sea countries have proposed OWE targets that require a minimum capacity of 124.3 GW by 2030 (excluding Sweden and Norway, as they have not yet decided their 2030 targets). This represents a 313% increase over the current installed capacity. Below is the current OWE capacities in different stages, as well as 2030/2050 targets by North Sea countries (Table 5).

Table 5. Cumulative offshore wind capacities and future deployment targets of North Sea countries in end of 2022.

Country	**Installed capacity (MW)**	**Under construction (MW)**	**Pre-construction (MW)**	**2030 pipeline (MW)**	**post 2030 pipeline (MW)**	**Sum – before 2030**	**2030 targets (GW)**	**2040 targets (GW)**	**2050 targets (GW)**
UK	13,918	6,588	7,610	22,890	27,626	51,006	50	-	-
Germany	8,055	733	2,042	18,748	0	29,578	30	-	70
Netherlands	2,829	2,299	0	11,456	7,400	16,584	21	30-50	40-70
Denmark	2,308	344	0	10,200	0	12,852	12.9	22.65	35
Belgium	2,261	0	0	3,500	0	5,761	6	8	8
Sweden	192	0	0	5,900	10,900	6,092	A specific national target hasn't been proposed yet		
Norway	6	0	0	2,000	1,000	2,006	-	30	-
France	482	1,444	1,592	0	2,500	3,518	4.4	-	40
Total	**30,051**	**11,408**	**11,244**	**74,694**	**49,426**	**127,397**	**124.3**	**-**	**-**

Notes:

(1) The 2030/50 targets of Germany, Netherlands, Denmark, Norway and France are quoted from the *Joint Statement*

[25] https://www.bmwk.de/Redaktion/DE/Downloads/Energie/20220518-declaration-of-energy-ministers.pdf?__blob=publicationFile&v=10 , p.1.
[26] https://energy.ec.europa.eu/system/files/2022-09/220912_NSEC_Joint_Statement_Dublin_Ministerial.pdf , p.1.
[27] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1125685/UK_NSEC_mou_on_offshore_renewable_energy_cooperation_in_north_seas_region.pdf , p.1.

on the North Seas Energy Cooperation dated 12 Sept 2022.

(2) The 2030/50 targets are not solely limited to the North Seas, as a portion of it will also be developed in the Baltic Sea or other sea areas.

(3) Operational and under-construction capacity source: WindEurope [**Error! Reference source not found.**] and open information.

(4) The Netherlands has an offshore wind installation target of 21 GW by 2030/31[28]. Here for the sake of convenience we put the 21 GW in the 2030 target column.

(5) Project status category adopts methodology of Global Wind Tracker[29]. Particularly, pipeline projects mean these who have been described in corporate or government plans but have not yet taken concrete steps such as applying for permits.

(6) Offshore wind farms (generally of small volume) in the Mediterranean Sea in France are not included.

The North Sea region has significant potential for achieving an offshore wind power capacity of approximately 127 GW by 2030, based on the cumulative capacity of current, under construction, pre-construction, and announced pipeline projects which are expected to commission before 2030. This capacity would amount to about 102% of the cumulative 2030 OWE targets of the North Sea countries, with the exception of Sweden and Norway, which have yet to publish their national 2030 offshore wind targets. However as of the time of writing there are only just over 7 years to deliver this capacity from pre-development.

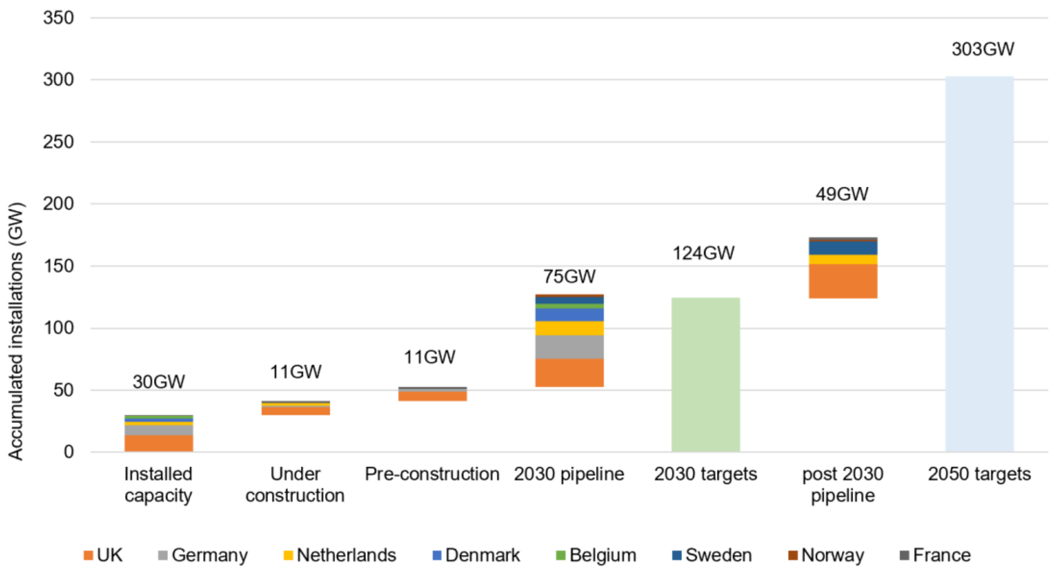


Fig 3. Illustrative path to the 2030/50 offshore wind capacity targets of North Sea countries.

The North Sea waters is expected to provide approximately 107GW of the incremental capacity, which accounts for about 73% of the total incremental capacity of the North Sea countries.

3. Key elements of policy instruments of offshore wind development process

[28] https://english.rvo.nl/information/offshore-wind-energy/offshore-wind-energy-plans-2030-2050

[29] https://globalenergymonitor.org/projects/global-wind-power-tracker/methodology/

The establishment and implementation of offshore wind farms in European countries is conducted under a comprehensive regulatory framework that incorporates both pre-existing and targeted legislative measures [**Error! Reference source not found.**]. While there may be differences in governance approaches between European countries, there is evidence of convergence in the governance instruments and practices applied to OWE development [**Error! Reference source not found.**]. To deliver an offshore wind farm in Europe, key elements typically include the allocation of seabed, the granting of development rights (consents), and subsidy mechanisms. Among them, seabed allocation in the UK and subsidies are both subject to competitive auctions.

Seabed leasing enables developers to secure the rights to build and operate wind farms in specific areas of the sea, typically through leasing agreements with government bodies responsible for managing the seabed. Mainly due to historical precedents, offshore wind leases around the world are tendered and awarded by a diverse range of organizations, including government departments and public bodies [**Error! Reference source not found.**]. In the UK, the leasing of offshore wind farm sites has undergone a significant change, with a new bidding process to set "option fees" being implemented in 2019[30]. Meanwhile, offshore wind projects in the UK and the Netherlands are required to pay a seabed rental annually.

The offshore wind project development process and site selection methods vary among the North Sea countries. In Denmark, the Netherlands, and Germany, specific project sites are identified with detailed data provided before single-stage bidding. However, in the UK, developers must conduct extensive surveys and obtain consent before entering the second stage of bidding for a power purchase agreement, despite some data being shared.

The milestone indicating the completion of the development stage and the transition to the construction phase varies among countries. Developers are obligated to acquire permits, consents, and approvals from regulatory bodies, environmental agencies, and relevant stakeholders. These include environmental permits, planning consents, construction licenses, grid connection agreements, and other necessary licenses. The primary focus of this paper is on the significant permit, referred to as "consent" within the context of this paper, required for offshore wind farm development in each jurisdiction. Generally, the attainment of such consent signifies the successful culmination of the development stage, as exemplified by the Development Consent in the UK. Obtaining these consents to a certain extent indicates the mitigation of key development risks and readiness for construction, provided that Final Investment Decisions (FID) are typically met in most instances. Table 6 provides an overview of the definition and scope of tenders and consents in North Sea countries.

Table 6. Definition and scope of tenders and consents in North Sea countries.

[30] https://www.thecrownestate.co.uk/media/3321/tce-r4-information-memorandum.pdf

Country	Definition and scope	
	Tender	Consent
UK	(1) Seabed leasing tender which grants developers the access to the seabed owned by the Crown Estate (or the Crown Estate Scotland) (2) Contract for Difference (CfD) auction which provides successful projects with stable electricity price	Development Consent: for the construction and operation of an offshore wind farm under the Planning Act 2008
Germany	To win the exclusive right to develop the projects in specified areas as well as the electricity price for the projects through competitive tender process	Plan Approval: for the construction and operation of an offshore wind farm under WindSeeG[31]
Netherlands	To win the exclusive right to develop the projects in specified areas as well as the electricity price for the projects through competitive tender process	The permit for the construction, operation, and the removal of the wind farm which is awarded soon after the tender
Denmark	To win the exclusive right to develop the projects in specified areas as well as the electricity price for the projects through competitive tender process	Construction license: grants the licensee the right to construct a wind farm which is awarded when the EIA process is completed and all other necessary documentation are delivered
Belgium	Tender to be launched	A Domain Concession and an environmental permit both in place for the construction and operation of the offshore wind farm
Sweden	Tender to be launched	An environmental permit and a permit for water activities
Norway	To win the exclusive right to develop the projects in specified areas as well as the electricity price for the projects through competitive tender process	License to construct and operate the wind farm inside the Norwegian baseline in accordance with the provisions in the Norwegian Energy Act[32]
France	To win the exclusive right to develop the projects in specified areas as well as the electricity price for the projects through competitive tender process	Environmental Authorization for the construction and operation of the wind farm under Environmental code [**Error! Reference source not found.**]

3.1 UK

The competitive allocation of seabed leases for offshore wind development in the UK was carried out through a series of official bidding processes overseen by the Crown Estate [**Error! Reference source not found.**]. To date, a total of nine rounds of open bidding have been conducted, including sites allocated for demonstration of the new offshore technologies. A more detailed overview of the leasing rounds and the status of

31 https://www.gesetze-im-internet.de/windseeg/

32 https://northseawindpowerhub.eu/sites/northseawindpowerhub.eu/files/media/document/Permitting-Study-Norway-1.pdf , p.13.

the associated projects is shown in Table 7 provided below.

Table 7. Outcomes of the UK seabed leasing rounds (capacity in MWs).

Leasing rounds	Date of grant	Seabed award		Consented		Operation		Construction		Planning		Cancelled		Decommissioned	
		No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity
Round 1	2001-04	17	1,702	14	1,188	12	1,169	0	0	0	0	3	486	2	14
Round 2	2003-11	17	7,491	15	6,337	15	5,682	0	0	0	0	2	870	0	0
Scottish Territorial Waters	2009-02	10	6,438	3	1,200	1	588	1	450	1	N.A.	7	4,253	0	0
Round 3	2010-01	24	32,200	17	19,166	5	4,668	6	8,060	8	7,334	5	9,000	0	0
Round 1 & 2 Extensions	2010-05	5	1,686	4	1,539	4	1,319	0	0	0	0	1	147	0	0
Demonstration sites	2010-08	5	219	6	219	4	157	0	0	1	58	0	0	0	0
Offshore wind extension projects	2019-08	7	3,692	0	0	0	0	0	0	6	3,352	1	340	0	0
Round 4	2021-02	6	7,980	0	0	0	0	0	0	6	7,980	0	0	0	0
ScotWind leasing	2022-01	20	27,626	0	0	0	0	0	0	20	27,626	0	0	0	0
Total		111	89,034	59	29,649	41	13,583	7	8,510	42	46,350	19	15,096	2	14

Notes:

(1) Before 2010, projects awarded through seabed leasing by TCE or TCE Scotland are collected from various resources due to a lack of official documentation.

(2) 9 zones were granted with seabed leasing rights in Round 3, where 24 projects have been found including cancelled ones.

(3) In some projects' consent decisions which are typically seen in Round 3, capacity limit was removed so the capacity column of consented projects is only for reference. Same applies in the planning projects.

(4) Planning projects incudes those who have obtained consents and those who have announced development plans (e.g., some developing projects in Round 3).

(5) Decommissioned projects in Round 1 are: Beatrice Demonstration (10MW) and Blyth (4 MW).

(6) Hywind Scotland Pilot Park offshore wind farm (30MW) and Kincardine Offshore Floating Wind Farm (50MW) were granted through separate application process, so both are not reflected in this table.

Through the Crown Estate (TCE) and Crown Estate Scotland (CES), a total potential capacity of 89GW has been granted for OWE development. As of now, 13.6GW has reached commissioning and 8.5GW is currently under construction. We calculated the period of these projects from the initial seabed grant to the point of receiving consent and subsequent commissioning during each of the leasing rounds. Our findings have yielded several noteworthy observations, which are detailed below:

a. On average, it takes approximately 8.8 years for an offshore wind energy project to reach commissioning from the date it was awarded seabed. Given the additional time required for the launch of each round and tendering process, developers can reasonably expect that it may take up to 10 years for an offshore wind farm to become operational from the conceptualization phase. See Table 8.
b. Over the last two decades, a significant number of OWE projects (totaling 15GW) have been cancelled, while many early-round projects remain in the planning stage. Even if granted seabed rights, developers still need to obtain the necessary consents prior to commencing work on new sites [**Error! Reference source not found.**]. Consequently, a few winning bidders have found unfavorable technological conditions and commercial viability, resulting in their decision to forego development of the awarded sites[33,34]. Additionally, a few projects have been denied consent due to their failure to obtain necessary follow-up consents such as environmental assessments [**Error! Reference source not found.**].
c. Among the main allocation rounds, namely Round 1, Round 2, Scottish Territorial Waters, and Round 3, there is a notable trend of longer development timelines, with projects progressing in that order. Projects awarded during the following extension round (Round 1&2 Extensions) spend significantly less time in the planning stage compared to those awarded during earlier leasing rounds. This can be attributed to the experience gained by developers in previous rounds, which has enabled them to navigate the consenting process more effectively.

Table 8. Average time for offshore wind farms to get commissioning in each leasing round.
(Note the years do not sum due to only including completed projects)

Seabed grant methods	Seabed to consent (Years)	Consent to operation (Years)	Seabed to operation (Years)	Seabed to operation (Years by ratio of capacity)
Round 1	2.8	4.7	7.4	0.6
Round 2	5.6	5	10.5	4.4
Scottish Territorial Waters	7.7	5.3	10.4	0.5
Round 3	8.1	5.9	10.8	3.7
Round 1 & 2 Extensions	3.6	3.5	7.1	0.7

33 https://www.4coffshore.com/windfarms/united-kingdom/cromer-united-kingdom-uk35.html
34 https://www.4coffshore.com/windfarms/united-kingdom/scarweather-sands-united-kingdom-uk22.html

Demonstration sites	3	4.8	5.4	0.1
Average	5.6	4.8	8.8	

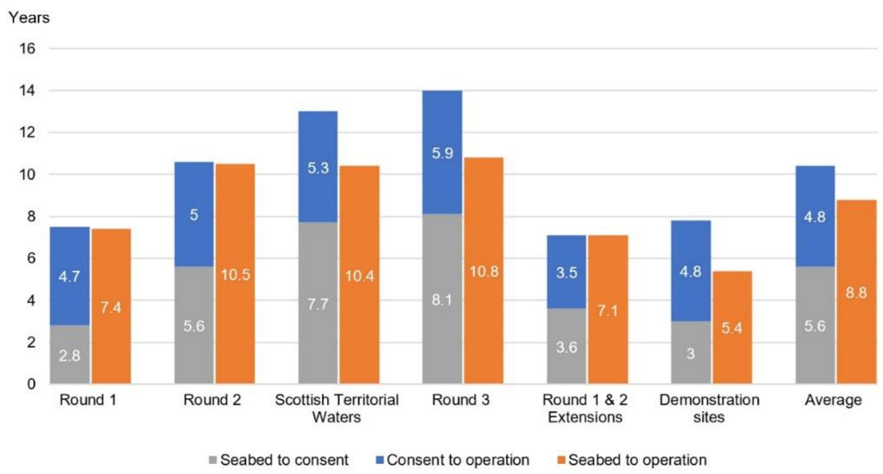


Fig 4. Illustrative cost of time for the development offshore wind farms in each leasing round.

Notably, the Round 4 and ScotWind Leasing launched in 2019 marked significant milestones in the UK government's use of seabed leasing as a policy tool to encourage offshore wind energy development, where, Round 4 became the first official offshore wind leasing since 2010, and the ScotWind leasing the first leasing process in Scottish waters since the devolution of the rights of the Crown Estate to Scotland in 2017[35]. By providing a competitive environment in which developers can secure rights to build in designated areas, the government has leveraged seabed leasing to support the growth of OWE in pursuit of national climate and energy targets.

It should be noted that winning seabed auction doesn't necessarily mean the securing of lease. TCE then will undertake a Plan-level Habitats Regulations Assessment (HRA) to assess the potential strategic and high-level impacts of the Round 4 plan on protected sites within the UK and UK offshore marine area, with specific reference to the assessment of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) [36,37]. This assessment will help determine whether to grant Agreements for Lease (AfL) to prospective developers. On entry of AfL, developers are required to pay an Option Fee Deposit as described later.

If the conditions are met and the developer exercises the options, TCE will grant the Wind Farm Lease to the developer and the Transmission Lease to either the developer or the OFTO (as appropriate)[38]. Successful developers would then commence specific environmental assessments, including a more detailed and in-depth Project-level HRA,

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35 https://www.gov.scot/policies/marine-planning/the-scottish-crown-estate/
36 https://www.thecrownestate.co.uk/media/4065/a-guide-to-hra-april-2022.pdf (Accessed: 08 August 2023).
37 https://www.thecrownestate.co.uk/en-gb/what-we-do/on-the-seabed/marine-planning/
38 https://www.thecrownestate.co.uk/media/3321/tce-r4-information-memorandum.pdf (Accessed: 08 August 2023), p.41.

to apply for development consent through the statutory planning process.

In the ScotWind Leasing known as 'plan-led', the risk of significant Plan-level HRA-related issues is mitigated by using a Sectoral Marine Plan for Offshore Wind Energy (SMP), including a Strategic Environmental Assessment, a socioeconomic assessment, and a HRA that are undertaken by Marine Scotland[39,40,41]. This process provides developers with a clear understanding of the potential constraints in each sector they bid for, thereby offering a higher level of certainty. Nevertheless, developers will still need to conduct Project-level HRAs as part of the consenting process for individual projects. Seabed Option Agreements are for up to ten years.

Developers are required to pay "Option Fees" for the proposed projects in both Round 4 and ScotWind leasing, which provide the developer with exclusive rights to develop a particular area of the seabed for a set period. During the early rounds, successful bidders were obligated to pay a one-time option fee ranging from £25,000 to £500,000, which was determined based on the size of the proposed development and approximately amounted to £2,000 to £5,000 per square kilometer [**Error! Reference source not found.**]. It was not until in the Round 4 leasing launched in 2019 that for the first-time bidders have been required to compete in a bidding process using annual option fees to determine leasing awards[42]. As announced in February 2021, the Round 4 leasing secured 8 GW of offshore wind resources contributing an Option Fee Deposit of £879m which is non-refundable[43] from winning bidders. Concerns by the industry on the limited number of available sites and high demand eventually resulted in unexpectedly high bids and the outcome of high option fees[44,45,46]. Outcome of tender process of Round 4 is shown in Table 9.

Table 9. Round 4 Leasing outcome (2021).

Project	Bidding Area	Proposed Project Capacity (MW)	Area (km^2)	Option Fee deposit paid (GBP excl VAT)	Option Fee Bid (GBP/MW/annum)
1	1	1,500	494.89	114.3m	76,203

39 https://www.crownestatescotland.com/resources/documents/scotwind-briefing-november-2022
40 https://www.crownestatescotland.com/resources/documents/new-offshore-wind-leasing-for-scotland-discussion-document , p.8.
41 https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2020/10/sectoral-marine-plan-offshore-wind-energy/documents/sectoral-marine-plan-offshore-wind-energy/sectoral-marine-plan-offshore-wind-energy/govscot%3Adocument/sectoral-marine-plan-offshore-wind-energy.pdf , p.33.
42 https://afry.com/en/insight/who-will-pay-price-entering-uk-offshore-wind-sector
43 The Crown Estate will refund the Option Fee Deposit if it terminates the Preferred Bidder Letter without any specific reason. No refund will be paid under any other circumstances.
44: https://windeurope.org/newsroom/press-releases/latest-uk-seabed-leasing-risks-raising-costs-of-offshore-wind .
45 https://www.renewableuk.com/news/551019
46 https://my.slaughterandmay.com/insights/briefings/the-winds-of-change-option-fees-for-offshore-projects

2	1	1,500	493.58	133.3m	88,900
3	2	1,500	499.62	124.6m	83,049
4	4	1,500	497.48	231m	154,000
5	4	480	125.64	44.8m	93,233
6	4	1,500	322.21	231m	154,000

Source: the Crown Estate[47]

The ScotWind leasing, on the other hand, shifted its focus to the quality of applicants' ability to deliver projects in response to the high option fees of Round 4[48], with a cap of £100,000 per km² imposed on option fees. Option Fee in ScotWind leasing is a one-off sum payable when entering Option Agreement[49]. Outcome of this round is shown in Table 10. It is worth noting that there are 14 projects with a combined capacity of 18 GW that utilize floating or mixed technology among the winning bids.

Table 10. The ScotWind leasing outcome (2022).

Zone	Area sq.km	Technology	Award capacity MW	Option fee £ M	Average option fee £/MW
E1	859	fixed	2,907	85.9	29,549
E1	859	floating	2,610	85.9	32,912
E1	280	floating	1,200	28	23,333
E2	860	floating	2,000	86	43,000
E2	200	floating	798	20	25,063
E3	187	fixed	1,008	18.7	18,552
NE2	200	floating	1,008	20	19,841
NE3	256	floating	1,000	25.6	25,600
NE4	429	fixed	1,000	42.9	42,900
NE6	134	floating	500	13.4	26,800
NE7	684	floating	3,000	68.4	22,800
NE8	330	floating	960	33	34,375
N1	657	fixed	2,000	65.7	32,850
N2	390	floating	1,500	3.9	2,600
N3	103	mixed	495	10.3	20,808
N4	161	fixed	840	16.1	19,167
W1	754	fixed	2,000	75.4	37,700
NE1	100	floating	500	10	20,000
NE1	360	floating	1,800	36	20,000
NE1	100	floating	500	10	20,000
Sum	7,903		27,626	755.2	

47 https://www.thecrownestate.co.uk/media/3920/round-4-tender-outcome-dashboard.pdf
48 https://www.crownestatescotland.com/resources/documents/scotwind-briefing-november-2022
49 https://www.crownestatescotland.com/resources/documents/2021-scotwind-offer-document

Source: Crown Estate Scotland[50,51]

Setting an option fee has a significant impact on the cost of offshore wind projects. Analysis shows that for Round 4 awarded projects, assuming a conservative development period of 6 years, option fee increases the LCOE by 22%-42%[52], as it has become an extra component of upfront fees within the investment structure, a departure from scenarios where no option fee is applied.

Robust electricity price support policies have played a pivotal role in fostering the rapid growth of the offshore industry in the UK. There have been two main subsidy mechanisms in place: the Renewables Obligation (RO) scheme and the Contract for Difference (CfD) scheme.

The RO scheme began in 2002 and was fully phased out for new applications in April 2017. It covered all operational offshore wind projects during that period and three offshore wind projects that were under construction. Under this scheme, wind farms received a Renewable Obligation Certificate (RoC) for every megawatt-hour of electricity generated. The price of RoCs was determined by the UK Office of Gas and Electricity Markets (Ofgem) and adjusted according to the Consumer Price Index (CPI). These certificates had a validity period of 20 years. In addition to the revenue from market electricity prices, wind farms received additional subsidies through RoCs, with most offshore wind projects benefiting from two RoC subsidies[53]. Currently, there are 33 offshore wind projects in the UK that enjoy RoC subsidies.

In 2012, the draft Energy Bill outlined the preliminary framework for the CfD policy[54]. This policy encompassed various renewable energy projects including offshore wind. The core of this mechanism involved determining a strike price through competitive bidding, which had to be lower than the government's reference price. Developers who won the bidding process signed CfD contracts with the Low Carbon Contracts Company (LCCC), a government-established entity. Under these contracts, if the strike price exceeded the market reference price, LCCC would compensate the project for the price difference. Conversely, if the strike price was lower than the market reference price, the developer would return the excess profits to LCCC. The strike price was adjusted annually based on the CPI, and the contracts had a duration of 15 years. Therefore, CfD provided a relatively stable electricity price.

In 2014, a total of 5 projects secured early CfD contracts through negotiation, with

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50 https://www.crownestatescotland.com/news/scotwind-offshore-wind-leasing-delivers-major-boost-to-scotlands-net-zero-aspirations

51 https://www.crownestatescotland.com/news/three-shetland-scotwind-projects-announced

52 https://ore.catapult.org.uk/blog/miriam-noonans-thoughts-seabed-leasing-4/

53 https://www.ofgem.gov.uk/sites/default/files/docs/2019/04/ro_generator_guidance_apr19.pdf , p.69.

54 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228857/8362.pdf , p.27.

subsidy prices ranging between £140/MWh to £150/MWh[55]. From 2015 onwards, five public auction rounds have been conducted. Notably, the recent 2023 auction didn't attract any of offshore wind farms to participate, though this technology was within the CfD budget pot[56]. Including the early projects, a total of 20 projects have obtained CfD, as shown in Table 11.

Table 11. Outcome of early CfD allocation and each auction round in the UK.

Project	Capacity (MW)	CfD round	CfD grant date	Subsidized capacity (MW)	Strike price ($£_{2012}$/MWh)	Project status
Beatrice	588	Early CfD	2014.05	588	140	operation
Burbo Bank Extension	258	Early CfD	2014.05	258	150	operation
Dudgeon	402	Early CfD	2014.05	402	150	operation
Hornsea 1	1,218	Early CfD	2014.05	1,200	140	operation
Walney Extension	659	Early CfD	2014.05	660	150	operation
EA 1	714	Round 1	2015.02	714	119.89	operation
Neart na Gaoithe	448	Round 1	2015.02	448	114.39	construction
Triton Knoll	855	Round 2	2017.09	860	74.75	operation
Hornsea 2	1,386	Round 2	2017.09	1,386	57.5	operation
Moray East	950	Round 2	2017.09	950	57.5	operation
Dogger Bank A	1,235	Round 3	2019.10	1,200	39.65	construction
Dogger Bank B	1,235	Round 3	2019.10	1,200	41.611	construction
Dogger Bank C	1,200	Round 3	2019.10	1,200	41.611	construction
Seagreen	1,140	Round 3	2019.10	454	41.611	construction
Sofia	1,400	Round 3	2019.10	1,400	39.65	construction
Inch Cape*	-	Round 4	2022.07	1,080	37.35	development
EA 3	1,400	Round 4	2022.07	1,372.34	37.35	construction
Norfolk Boreas*	-	Round 4	2022.07	1,396	37.35	Suspended
Hornsea 3*	-	Round 4	2022.07	2,852	37.35	development
Moray West	882	Round 4	2022.07	294	37.35	development
-**	-	Round 5	2023.09	-	-	-

Note: *project capacity undetermined. **no offshore wind projects awarded with CfD in 2023.

Offshore transmission work in the UK has been responsibility of the developers. After commission of the offshore wind farm, the transmission asset will be transferred to Offshore Transmission Owners (OFTOs) through auctions conducted by Ofgem [**Error!**

55 https://www.nao.org.uk/wp-content/uploads/2014/06/Early-contracts-for-renewable-electricity1.pdf , p.14.

56 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1143086/cfd-ar5-allocation-budget-notice.pdf

Reference source not found.]. Therefore, the cost of grid connection is borne by the developer and priced into the CfD [**Error! Reference source not found.**].

3.2 Germany

Germany's first offshore wind farm (Alpha Ventus, 60MW) was commissioned in 2010[57]. Prior to 2015, offshore wind farms in Germany enjoyed fixed tariffs (FiT) under the Renewable Energy Sources Act (EEG). In January 2017, the Law on the Development and Promotion of Wind Energy at Sea (Wind Energy at Sea Act - WindSeeG)[58] came into effect, which has undergone several revisions since then, and developers began to bid for tariffs and development rights. Unlike the UK, Germany did not have a seabed allocation process [**Error! Reference source not found.**]. Currently, Germany has carried out four rounds of offshore wind tendering (see Table 12), with a cumulative winning capacity of 5GW. Among them, 9 projects with a total installed capacity of 3.7GW have achieved zero-subsidy, which means that such projects will rely entirely on market electricity prices.

Table 12. Offshore wind auction results and project status in Germany.

No.	Project	Bid capacity (MW)	Status	Bid year	Bid price (€/MWh)	Date of commission
1	He Dreiht	900	pre-construction	2017.04	0	2025 projected
2	OWP West	240	pre-construction	2017.04	0	2025 projected
3	Borkum Riffgrund West 2	240	pre-construction	2017.04	0	2025 projected
4	Gode Wind 3	110	pre-construction	2017.04	60	2024 projected
5	Borkum Riffgrund West 1	420	pre-construction	2018.04	0	2025 projected
6	Gode Wind 4	132	pre-construction	2018.04	98.3	2024 projected
7	Kaskasi	325*	operational	2018.04	N.A.	2023.03
8	Baltic Eagle	476	under construction	2018.04	64.6	2024 projected
9	Arcadis Ost 1	247.25**	under construction	2018.04	N.A.	2023 projected
10	Wikinger Süd	10	planning	2018.04	0	2025 projected
11	N-3.7	225	planning	2021.09	0	2026 projected
12	N-3.8	433	planning	2021.09	0	2026 projected
13	O-1.3	300	planning	2021.09	0	2026 projected
14	N-7.2	980	planning	2022.09	0	2027 projected

Notes:

(1) * actual capacity of 342MW.

(2) ** actual capacity of 257MW.

57 https://www.alpha-ventus.de/english

58 https://www.gesetze-im-internet.de/windseeg/

(3) Ørsted the developer merged OWP West, Borkum Riffgrund West 2 (both awarded in 2017), and Borkum Riffgrund West 1 (awarded in 2018) into one project, named Borkum Riffgrund 3 (900MW); and merged Gode Wind 3 (awarded in 2017) and Gode Wind 4 (awarded in 2018) into a new project named Gode Wind 3 (242MW), with a weighted average winning bid price of 81€/MWh.

In all bidding rounds, 2017 and 2018 were the "transition periods" under the WindSeeG, during which only mature projects were allowed to participate in bidding. A requirement is that the awarded projects need to be commissioned before 2025. The subsidy is based on one-sided CfD for 20 years, unindexed. There have been no cases of projects who won bids yet being cancelled so far.

It has been found that the average time taken by German offshore wind projects, from initiation (application for consents) to approval, is 5.7 years. Furthermore, the average duration from approval to commission is 9.1 years, making the total average duration 13 years, which is 4-5 years longer than that of the UK. The lengthy duration from approval to commissioning is mainly due to the need for seabed surveys and obtaining grid connection agreements after project approval. In contrast, "approval" for UK offshore wind projects generally means that construction work can begin. With the introduction of the auction system, the duration from approval to commissioning has been significantly reduced as a defined commissioning timeline is enforced.

In 2022, the WindSeeG was amended to include two types of auction modes: (1) central model, i.e., auction for areas that have been preliminary investigated centrally, and (2) non-central model, i.e., auctions for areas that have not been pre-examined centrally. Both types of auctions will be held once a year starting from 2023.

For auctions under the "central model", the Federal Maritime and Hydrographic Agency (BSH) conducts basic work such as geological surveys in the selected sea areas before the launch of the tender, primarily to increase project certainty and accelerate the pre-development process. For these projects, the evaluation scheme is divided into two parts: 60% for bid value[59], namely the bidders' willingness to pay and 40% for the technical aspects. This bidding mode is expected to greatly shorten the project development process.

For auctions under the "non-central model", the government does not conduct any preliminary investigation of the relevant sea areas. Instead, winning developers are responsible for completing all the necessary work independently. For this type of project, the electricity price is the only evaluation criterion. If all eligible developers submit a zero-subsidy electricity price, the federal government will initiate a new round of "dynamic bidding process", where developers can submit bids to pay the government an amount calculated in €/MW[60], on top of the zero-subsidy electricity price. There is no upper limit on the amount of this "negative subsidy".

[59] https://www.gesetze-im-internet.de/windseeg/WindSeeG.pdf , p.28.
[60] https://www.gesetze-im-internet.de/windseeg/WindSeeG.pdf , p.19.

According to the tender notice of 2023, the award of a contract leads to the obligation to pay further fees and expenses for the implementation of the preliminary area investigation, which range from €5.6 million to €9 million[61].

The outcome of the 2023 auction indicated that all zero-bids (meaning requiring no additional subsidies) were achieved under non-central model. In addition, a total of 64 dynamic bidding rounds were carried out for area N-11.1, 65 bidding rounds for area N-12.1, 55 bidding rounds for area N-12.2 and 72 bidding rounds for area O-2.2[62]. The winning bids are shown in Table 13.

Table 13. 2023 Germany non-central offshore wind projects auction results[63].

Project	Capacity (MW)	Negative bid offer (€/MW)
N-11.1	2,000	1,830,000
N-12.1	2,000	1,875,000
N-12.2	2,000	1,560,000
O-2.2	1,000	2,070,000

The "negative subsidy" in Germany shares similarities with the seabed leasing model used in the UK, whereby developers pay an upfront fee to the government to secure the right to develop. The bidding process aims to foster competition and incentivize cost reductions in offshore wind energy, but there are significant risks associated with developing unexplored sea areas without prior surveys led by the government. As a result, the industry remains apprehensive about the negative subsidy[64,65]. Another concern is that such outcomes will favor larger and financially stronger companies[66], which could be validated in this auction – BP and TotalEnergies partitioned the auction pool.

3.3 Netherlands

In 2001, the Netherlands launched its first offshore wind energy tender [**Error! Reference source not found.**], which adopted the "Feed-in Premium" (FiP) subsidy

61 https://www.bundesnetzagentur.de/DE/Beschlusskammern/1_GZ/BK6-GZ/2023/BK6-23-006/BK6-23-006-009_bekanntmachung.pdf?__blob=publicationFile&v=3 , p.4.
62 https://www.offshorewind.biz/2023/07/12/breaking-germany-rakes-in-eur-12-6-billion-through-dynamic-bidding-offshore-wind-auction/
63 https://www.bundesnetzagentur.de/DE/Beschlusskammern/BK06/BK6_72_Offshore/Ausschr_nicht_zentral_voruntersu_Flaechen/Bekanntgabe12062023.pdf?__blob=publicationFile&v=4
64 https://windeurope.org/newsroom/press-releases/negative-bidding-in-german-offshore-wind-law-threatens-supply-chain/
65 https://www.reuters.com/business/energy/orsted-ceo-concerned-by-negative-bidding-german-offshore-wind-2023-02-01/
66 https://www.bundesnetzagentur.de/DE/Beschlusskammern/1_GZ/BK6-GZ/2022/BK6-22-326/Stellungnahmen/Stellungnahme_02.pdf?__blob=publicationFile&v=1

model. In 2007, SDE (Stimulering Duurzame Energie)[67] was introduced, to provide subsidies for renewable energy in the form of "modified feed-in tariff"[68], which essentially is a one-sided CfD. In 2009, the country held another round of tenders, and two offshore wind projects (Luchterduinen and Gemini) were awarded. During this period, developers themselves were mainly responsible for the preliminary work of site selection, survey, and application for permits for offshore wind projects[69].

In 2013, the Energy Agreement for Sustainable Growth[70] was adopted aiming at increasing OWE capacity to 3.5 GW by 2023. As a crucial component of this agreement, an upgraded version of the SDE subsidy scheme called "SDE+" was introduced, and five rounds of offshore wind energy bidding were conducted under SDE+, resulting in a total of 5 GW being awarded. The results of each bidding round are shown in Table 14. In 2019, the National Climate Agreement was adopted[71], pledging to add an additional 7 GW of offshore wind energy capacity in the Dutch North Sea between 2023 and 2030.

Table 14. Offshore wind auction results and project status in the Netherlands.

No.	Project	Capacity (MW)	Status	Winning bid year	Bid price (€/MWh)	Date of commission
1	Egmond aan Zee	108	Operational	2002.07	N.A.	2007.01
2	Prinses Amalia	120	Operational	-	-	2008.07
3	Luchterduinen	129	Operational	2009.11	N.A.	2015.09
4	Gemini	600	Operational	2009.12	168.9	2017.04
5	Borssele I & II	752	Operational	2016.07	72.7	2020.11
6	Borssele III & IV	731.5	Operational	2016.12	54.5	2021.01
7	Borssele V	19	Operational	2018.04	N.A.	2021.02
8	Hollandse Kust (zuid) I & II	770	under construction	2018.03	0	2023 projected
9	Hollandse Kust (zuid) III & IV	770	under construction	2019.07	0	2023 projected
10	Hollandse Kust (noord)	759	under construction	2020.07	0	2023 projected
11	Hollandse Kust West VI	756	planning	2022.12	0	2026 projected

67 https://ec.europa.eu/commission/presscorner/detail/en/IP_07_1992
68 https://www.iea.org/policies/4642-sde-stimulering-duurzame-energie-renewable-energy-and-chp-production-aid-scheme
69 https://www.rvo.nl/sites/default/files/2022-11/Dutch-offshore-Wind-Innovation-Guide-Edition-2023.pdf , p.16.
70 https://www.government.nl/documents/publications/2013/09/06/energy-agreement-for-sustainable-growth
71 https://www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands

12	Hollandse Kust West VII	760	planning	2022.11	0	2026 projected

Date source: 4Coffshore.

The subsidy mechanism of SDE, known as the "one-sided CfD", ensures a minimum price guarantee without imposing compensation fees during periods of high electricity prices[72].

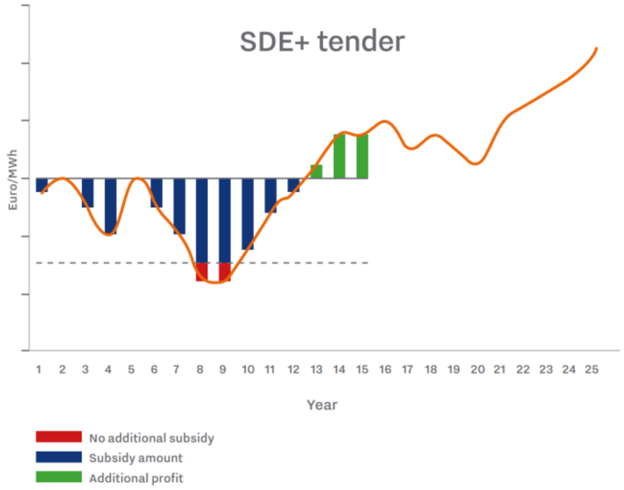

Fig 5. Illustration of the SDE+ subsidy (apply to Borssele I & II / III & IV offshore wind farms)[73].

The results of the bidding rounds suggest that only two years after the SDE+ subsidy was granted to three bidding areas (Borssele I&II, III&IV, V), the world's first zero-subsidy tender was launched for the Hollandse Kust (zuid) project (in contrast, Germany's zero-subsidy tender was conducted through a competitive bidding process). The zero-subsidy tender in the Netherlands then focused on the developers' ability to deliver the projects. Additionally, the Netherlands was the first country to introduce a "negative subsidy", where developers pay the government for the right to develop a project.

In 2021, the new Offshore Wind Energy Act came into effect[74], with the inclusion of the possibility of a financial offer in the comparative test (Articles 25a – 25c of the bill) for the application of consent. In 2022, bidders have made financial offers for the first time in the tendering of Hollandse Kust West project. The bid "Financial offer" is one of the key criteria. This was awarded a maximum of 20 points for bids exceeding 50

72 https://www.rvo.nl/sites/default/files/2021/10/Dutch%20Offshore%20Wind%20Guide%202022.pdf , p.18.

73 https://www.rvo.nl/sites/default/files/2021/10/Dutch%20Offshore%20Wind%20Guide%202022.pdf , p.18.

74 https://wetten.overheid.nl/BWBR0036752/2021-11-11#Hoofdstuk3_Paragraaf3.5

million euros[75]. The winning bidder for the Hollandse Kust West VI project, Ecowende (a joint venture between Shell and Eneco), made a financial offer of 63.5 million euros[76]. It is then reasonable to infer that in the Netherlands' offshore wind energy tender, the higher the developer's willingness to pay, the greater their chances of obtaining development rights.

In the early bidding rounds of "SDE+", the Dutch government conducted assessments of wind resources, meteorological conditions, and environmental impacts in relevant offshore areas before launching the tender to reduce investment risks for developers. The assessment results were made available to all bidders. Since the auction of the Hollandse Kust West project in 2022, the costs associated with pre-development have been borne by the winning bidder (approximately 13.5 million euros for Hollandse Kust West VI and Hollandse Kust West VII each[77,78]).

The Dutch government adhere to the "one-stop-shop" principle for permits related to offshore wind farms and the offshore grid[79]. The main pre-development process is shown in the table below:

Table 15. Main Development Process for Offshore Wind Energy in the Netherlands[80].

No.	Process	Responsible department and work scope
1	Designating the wind farm areas	The Ministry of Economic Affairs and Climate Policy and the Ministry of Infrastructure and Environment are responsible for determining offshore wind development areas (NEA, 2021; page 14)
2	Drawing up offshore wind farm tender roadmaps	The Dutch government establishes an offshore wind energy roadmap, including project development timetable, areas, expected installed capacity, bidding years, etc. (NEA, 2021; page 14)
3	Conducting studies	The Netherlands Enterprise Agency (RVO) commissions third-party to conduct environmental impact assessments (EIA) and a series of geological surveys of the proposed offshore wind development areas (NEA, 2021; page 15)
4	Installing the grid connection	TenneT, the Dutch national electricity transmission system operator, is responsible for connecting wind farms to the onshore grid (NEA, 2021; page 16)
5	Taking the wind farm site decision	The government issues a Wind Farm Site Decision, one of the most critical documents required for project construction. At this stage, developers have not yet entered, allowing for flexibility in wind farm design (NEA, 2021; page 17)

75 https://zoek.officielebekendmakingen.nl/stcrt-2022-7101-n1.html
76 https://windeurope.org/newsroom/news/the-netherlands-run-another-successful-auction-based-on-non-price-criteria/
77 https://zoek.officielebekendmakingen.nl/stcrt-2022-7101-n1.html
78 https://zoek.officielebekendmakingen.nl/stcrt-2022-7093-n1.html
79 https://english.rvo.nl/information/offshore-wind-energy/offshore-wind-energy-plans-2030-2050
80 https://www.rvo.nl/sites/default/files/2021/10/Dutch%20Offshore%20Wind%20Guide%202022.pdf

6	Organizing the tender	The RVO organizes the wind farm tender, and the Minister of Economic Affairs and Climate Policy will appoint the winner (NEA, 2021; pages 17-19)
7	Granting the permit	The winning bidder obtains permits for construction, operation, and decommissioning of the wind farm, known as project approval. Developers can immediately begin constructing the wind farm. Typically, the wind farm must be built within five years (NEA, 2021; page 19)

The award of a winning bid marks the approval for offshore wind farm construction in the Netherlands, ensuring a high level of project certainty and significantly expediting the construction process. Thus far, no awarded projects have withdrawn from the bidding process. Empirical analysis shows that the average timeline for Dutch offshore wind projects from permit application to approval is 5.1 years, and from approval to commissioning is 3.6 years, resulting in a total average duration of 7.8 years, which is notably shorter than those observed in the UK and Germany. However, the paucity of Dutch offshore wind projects has led to intense competition during the bidding process, potentially resulting in higher "negative subsidy" amounts.

The German "zero-subsidy" bid for offshore wind power in 2017 may have contributed to the Dutch government's decision to no longer provide direct subsidies for offshore wind power and shift the focus of their offshore wind power procurement process from a price-centric approach to a developer-centric approach, and as a result, the core of the Dutch offshore wind power "competition" quickly shifted from electricity price bidding to a comprehensive evaluation of developers' capabilities.

In addition, like Germany, Dutch offshore wind projects do not conduct specific seabed bidding, but winning projects are required to pay seabed leasing fees. For the portion of wind farms within 12 miles of the territorial sea, fees are paid based on the proportion of the area (see Table 16); no leasing fees are charged for areas outside the 12 miles of the territorial sea[81,82]. By comparison, wind farms allocated by Round 1 Leasing in the UK paid a rent of £0.88/MWh indexed by RPI, amounting to 2% of gross revenue [**Error! Reference source not found.**] which also applies in the Round 4 Leasing[83]. The rent for ScotWind Leasing projects will be £1.07/MWh indexed to CPI[84].

Table 16. Offshore wind farm seabed leasing fees in the Netherlands

Rental Fee Category	Payment Period	Payment Method	Fee	Indexed*

81 https://english.rvo.nl/information/offshore-wind-energy/hollandse-kust-zuid-wind-farm-zone-iii-and-iv

82 https://english.rvo.nl/information/offshore-wind-energy/hollandse-kust-noord-wind-farm-zone-v

83 See discussion in section 4.5. There is a few calculation basis but generally in our analysis, developers pay 80% of the annual production of electricity multiplied by £0.90 (CPI indexed) in the construction phase, and 2% of gross turnover in the operational phase as rental.

84 https://www.crownestatescotland.com/resources/documents/2021-scotwind-offer-document , p.10.

Seabed Reservation	pre commissioning, from end of operation to dismantling	-	€650/MW/year	Yes
Leasing fee	Operation years	Starting from the 4th year after winning the bid	€0.98/MWh (calculated on a fixed 4,000 hours per year basis)	Yes
Transmission line leasing fee	-	One-time payment	€3.17/m^2-€3.29/m^2	No

Note: *Indexation remains unknow from open sources.

3.4 Denmark

Denmark has a long history of offshore wind power development, with the world's first offshore wind farm, Vindeby (5MW, commissioned in 1991), and the first large-scale commercial offshore wind farm, Horns Rev 1 (160MW, commissioned in 2002). In 2005, Denmark launched its first offshore wind tender (Horns Rev II, 209MW), and since then, a total of 7 tenders have been held, as shown in Table 17. By 2030, Denmark plans to hold tenders for at least another 9 GW of offshore wind power projects[85]. Like Germany and the Netherlands, Denmark does not hold separate tenders for seabed leasing rights.

Table 17. Offshore wind auction results and project status in Denmark.

No.	Project	Capacity (MW)	Status	Winning bid	Bid price (€/MWh)	Date of commission
1	Horns Rev II	209	Operational	2005.06	69	2010.01
2	Rødsand II*	207	Operational	2008.04	85	2010.10
3	Anholt	400	Operational	2010.07	141	2013.09
4	Horns Rev III	407	Operational	2015.02	103.1	2019.08
5	Kriegers Flak	605	Operational	2016.11	49.9	2021.09
6	Vesterhav	344	pre-construction	2016.09	64	2023 projected
7	Thor	1000	planning	2021.12	0.01	2027 projected

Note: * The Rødsand II project was initially tendered in 2005, but the winning bidder withdrew. The DEA conducted a new tender in 2008.

In Denmark, the government furnishes a comprehensive "one-stop-shop" service for the complete life cycle of offshore wind power development, construction, and operation[86]. The Danish Energy Agency (DEA) acts as the sole liaison for developers to apply for diverse permits. As the leading agency, it synchronizes with a range of stakeholders or regulatory agencies, such as communities, environmental protection, national defense, marine, and power grid, to guarantee a streamlined and simplified administrative process for project development, significantly diminishing developer

85 https://ens.dk/en/our-responsibilities/wind-power/ongoing-offshore-wind-tenders/offshore-wind-farms-tendered-towards

86 https://ens.dk/sites/ens.dk/files/Globalcooperation/one-stop_shop_oct2020.pdf

risks. The pre-development process for offshore wind power in Denmark is shown in Table 18.

Table 18. Main Development Process for Offshore Wind Energy in Denmark[87].

No.	Process	Responsible department and work scope
1	Maritime Spatial Planning	Danish Maritime Agency takes overall responsibility to conduct Maritime Spatial Planning (MSP), to secure the appropriate sites for offshore wind farms. The DEA to carry out a fine-screening. The locations are finally ranked based on economics of the locations (DEA, 2022; page 21)
2	Decide tenders	Political Energy Agreements to decide tenders. Rødsand II, Horns Rev II, Anholt, Horns Rev III, Nearshore and Kriegers Flak were established as the result of the Energy Policy Agreement of March 2004 and the Energy Policy Agreement of February 2008 respectively[88]. Tender of Thor and Hesselø are based on Energy Agreements of 2018[89]
3	Preliminary surveys and studies	prior to the call for tender, Energinet, the Danish Transmission System Operator (TSO), assists the DEA by conducting preliminary surveys, including geophysical and geotechnical surveys, as well as metocean studies (DEA, 2022; page 25)
4	Strategic environmental survey	DEA conduct strategic survey on environmental factors with high risk up front prior to final bids
5	Grid connection	Previously, the planning, procurement, construction, and operation of offshore wind power grid connection were all completed by Energinet. According to the 2018 Energy Agreement, the transmission lines from the offshore substation and wind farm to the onshore substation are to be bid, constructed, and operated by the developers, while the onshore substation and onshore transmission lines are to be handled by Energinet (DEA, 2022; page 33-34)
6	Market and Technical dialogues	The DEA provide an opportunity for the potential bidders and the wind industry to discuss, question and suggest adjustments to the tender process. In addition, developers and technical experts are invited to provide feedback on the results of preliminary surveys for the project (DEA, 2022; page 29)
7	Tender, EIA and consent	DEA runs the tendering. The winning bidder enters the concession agreement which includes both a right and an obligation to establish (and operate) the offshore wind farm[90]. After all the specifications for the project have been decided by the winning bidder, the EIA is undertaken. When the EIA process is completed and delivers all other necessary documentation are delivered, the DEA issues the construction license (DEA, 2022; page 31)

87 https://ens.dk/sites/ens.dk/files/Vindenergi/offshore_wind_development_final_june_2022.pdf
88 https://ens.dk/sites/ens.dk/files/Globalcooperation/offshore_wind_development_0.pdf , p.8.
89 https://ens.dk/en/press/new-agreement-about-hesselo-offshore-windfarm-step-closer-net-zero-subsidies-offshore-wind
90 https://ens.dk/sites/ens.dk/files/Vindenergi/slides_-_joint_and_several_liability_0.pdf , p.5.

Since 2005, there have been several changes to the tender rules. In the first round of tenders, the evaluation factors mainly included price and construction period, and the developers conducted environmental impact assessments (EIAs) after being awarded the bid. In the Anholt project tender in 2009, the EIA was completed by the DEA prior to the tender[91], and the electricity price was the only evaluation factor. Due to a tight supply chain and strict project timeline and penalty provisions, only one bidder participated, resulting in a high price (141€/MWh) [**Error! Reference source not found.**]. In 2014 and 2015, for the Horn Rev III and Kriegers Flak projects, the DEA communicated extensively with potential stakeholders before the tender, and adjusted the construction period requirements, resulting in a significant decrease in the winning bid price (103.1€/MWh and 49.9€/MWh, respectively). As the most critical permit in the early development phase, the EIA is completed by the DEA ahead of the tender, which is advantageous to the developers. As it only includes limited constraints on project parameters such as the number of wind turbines and foundation types, the final layout of the wind farm still needs to be determined prior to construction. In the nearshore (Vesterhav) tender in 2016, residents expressed their dissatisfaction of the uncertainty of the project layout[92]. Therefore, in the Thor project (1000MW) tender in 2021, the DEA adjusted the environmental assessment procedure again. Prior to the tender, the DEA conducted preliminary environmental surveys of the relevant sea area and published the investigation results. After winning the bid, the developers are responsible for conducting a comprehensive environmental assessment, and construction permits (approvals) will only be granted after the completion of EIA. Additionally, for the first time, the Danish government required the Thor project developers to pay for the landing cables and grid connection totaling DKK 865 million (approximately €120 million euros)[93,94].

Danish offshore wind projects have an average duration of 4.4 years from preliminary work to consent, followed by an average period of 3.1 years from approval to commissioning, resulting in a combined average development period of 7.5 years, which closely aligns with the situation in the Netherlands. It is worth noting that the transfer of EIA responsibilities to developers may potentially lengthen the project approval timeline in the future.

The Danish subsidy scheme operates under a "two-way CfD" mechanism. Prior to 2021, offshore wind farms receive a variable premium that aimed at bridging the gap between the fluctuating spot price (the hourly market price) and the fixed strike price (the price agreed upon in the winning bid). In this system, wind farms were subsidized by a positive premium when the spot price was lower than the strike price. In cases where the spot price exceeded the strike price, a negative premium was not charged but rather

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91 https://ens.dk/sites/ens.dk/files/Vindenergi/offshore_wind_development_final_june_2022.pdf , p.26
92 https://ens.dk/sites/ens.dk/files/Vindenergi/offshore_wind_development_final_june_2022.pdf , p.10
93 https://ens.dk/en/press/thor-wind-farm-build-thor-offshore-wind-farm-following-historically-low-bid-price
94 https://www.ethics.dk/ethics/eo#/bfb4d610-bfa1-4bfe-8808-6deb212e27cb/publicMaterial

offset against future positive premiums[95]. When the market price is negative, the subsidy is capped at the strike price. The CfD subsidy has a duration of 50,000 hours (calculated based on total installed capacity), which translates to approximately 11-12 years, without any index adjustments[96]. Therefore, this subsidy mechanism essentially resembles a fixed electricity price (FiT), as developers don't face market price risks during the subsidy period.

In 2021, the European Union approved Denmark's new CfD subsidy plan[97] with a 20-year subsidy period, which has fundamentally changed from the previous one. For renewable energy projects tendering from 2021 to 2024, the government will use the average price of the previous year's electricity price as the reference price. If the bid price exceeds the reference price, the difference between the two is a positive premium, and the wind farm will receive the market price as well as the premium subsidy. If the bid price is lower than the reference price, the difference is a negative premium, and the wind farm will receive the market price but also need to pay the negative premium to the government[98,99]. Under this mechanism, developers and the government share the electricity price risk. The subsidy mechanism is shown in Figure 6.

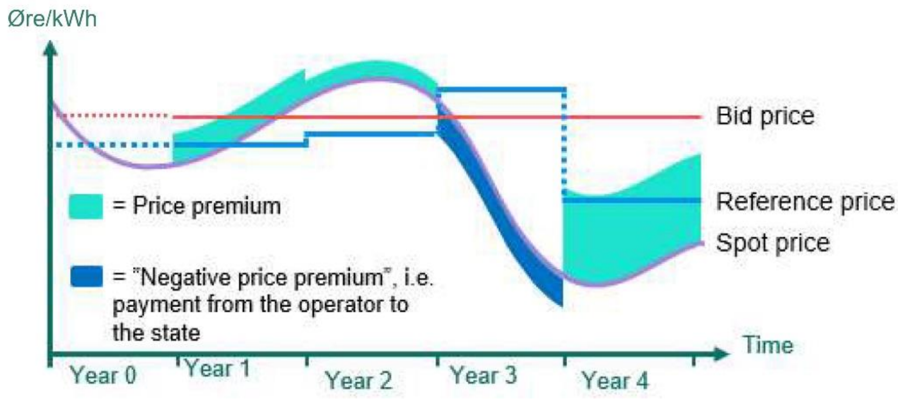

Fig 6. Principle in calculating the price premium[100]

In the 2021 auction for the Thor project, the Danish government set a floor bidding price of 0.01 øre/kWh (approximately 0.01 €/MWh) and a total subsidy cap of DKK 6.5 billion (approximately €870) over a subsidy period of 20 years. In addition, A maximum of total negative premium (i.e., "negative subsidy") is set as DKK 2.8 billion (approximately €380 million). Five out of six bidders submitted with the floor price,

[95] https://ens.dk/sites/ens.dk/files/Vindenergi/final_tender_conditions_for_kriegers_flak_english.pdf , p.34.
[96] https://ens.dk/sites/ens.dk/files/Vindenergi/offshore_wind_development_final_june_2022.pdf , p.15.
[97] https://ec.europa.eu/commission/presscorner/detail/en/ip_21_2242
[98] https://ec.europa.eu/commission/presscorner/detail/en/ip_21_2242
[99] https://ens.dk/sites/ens.dk/files/Vindenergi/subsidy_scheme_and_other_financial_issues_31march2020.pdf , p.2.
[100] https://ens.dk/sites/ens.dk/files/Vindenergi/subsidy_scheme_and_other_financial_issues_31march2020.pdf , p.6.

with RWE's Thor Wind Farm I/S won the bid through drawing of lots [**Error! Reference source not found.**], meaning that the government doesn't have to subsidize the project, on the contrary, the developer needs to pay a premium to the government (illustrated in Fig 7). This is also the world's first offshore wind power project with a "negative subsidy"[101].

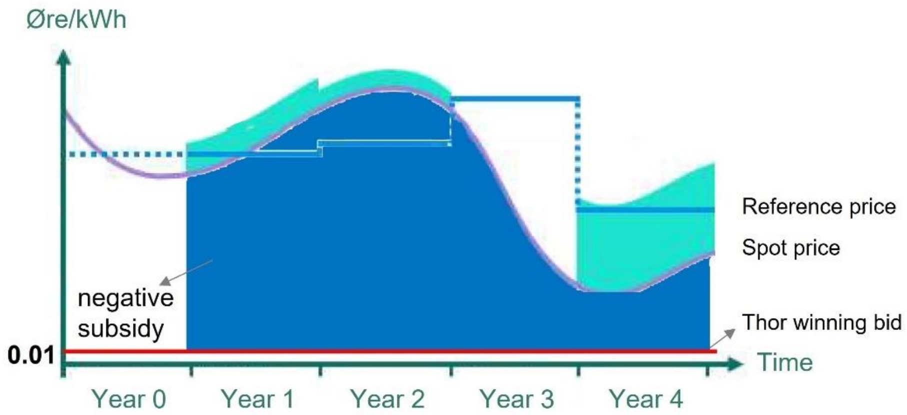

Fig 7. Illustration of the case of negative bidding for Thor offshore wind project (based on the original schematic diagram of price premium mechanism from DEA's *Subsidy scheme and other financial issues for Thor OWF*[102])

3.5 Belgium

The Belgian territory North Sea is relatively small, but it has been actively developing offshore wind power. Currently, there are 9 offshore wind farms with a total installed capacity of 2.2 GW, as shown in Table 19.

Table 19. Offshore wind farms in Belgium.

No.	Project	Capacity (MW)	Status	Date of commission
1	Thornton bank (C-Power)	325	Operational	2013.09
2	Belwind	171	Operational	2010.12
3	Northwind	216	Operational	2014.06
4	Nobelwind	165	Operational	2017.05
5	Rentel	309	Operational	2018.12
6	Norther	370	Operational	2019.06
7	Northwester 2	219	Operational	2020.05
8	Seamade (Mermaid)	235	Operational	2020.12
9	Seamade (Seastar)	252	Operational	2020.12

[101] https://www.offshorewind.biz/2022/05/26/germany-pondering-negative-bidding-in-offshore-wind-windeurope-warns-about-consequences/

[102] https://ens.dk/sites/ens.dk/files/Vindenergi/subsidy_scheme_and_other_financial_issues_31march2020.pdf , p.6.

Currently, the development rights for all offshore wind projects in Belgium are allocated by the government rather than through bidding, and they are all located in one area designated in the Marine Spatial Plan (2014-2020)[103]. In 2019, Belgium decided to award future offshore wind development rights through tendering[104]. According to the latest Marine Spatial Plan (2020-2026)[105], the Princess Elisabeth Zone covering three areas (Noordhinder North, Noordhinder South, and Fairybank) will be available for bidding, with a total installed capacity of up to 3.5 GW[106]. The first round of bidding will take place in 2024[107].

Previously, the developer was responsible for preliminary surveys[108]. The two most critical permits are the domain concession and the environmental permit. The domain concession grants the developer the right to construct and operate offshore wind farms in designated areas. After obtaining the domain concession, the developer applies for an environmental assessment of the project area, and upon obtaining the environmental permit, the project is approved. In terms of development cycle, the average time for Belgian offshore wind projects from initiation to approval is 3.3 years, and the average time from approval to commissioning is 6.3 years, with a total average duration of 9.6 years. The longer time from approval to commissioning is mainly due to the fact that the grid connection agreement was finalized after the approval (similar to the situation in Germany), while in the UK, Netherlands, and Denmark, the grid connection is usually secured after project approval, allowing for construction to commence. In particular, four later projects, Rentel, Northwester 2, Seastar, and Mermaid share the same substation - the Modular Offshore Grid (MOG) [109], whose construction began in 2018 and commissioned in 2019. An extension of the MOG will be built to accommodate upcoming projects within the Princess Elisabeth Zone.

According to the Belgian government's plan, after adopting the bidding method, the government will be responsible for conducting the preliminary survey work of the project, and the developer who wins the bid will pay the relevant fees to the government[110]. This is similar to the situation in the Netherlands and Denmark. The second phase of the MOG substation will be built and put into operation synchronously with the new project[111].

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103 https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/19094275/Summary%20Marine%20Spatial%20Plan.pdf

104 https://www.jdsupra.com/legalnews/new-belgian-framework-for-offshore-wind-64101/

105 https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/msp-2020-englishtranslation.pdf

106 https://news.belgium.be/nl/offshore-energie-kavelindeling-van-de-prinses-elisabeth-zone

107 https://economie.fgov.be/en/themes/energy/belgian-offshore-wind-energy

108 https://www.dentons.com/en/insights/articles/2019/september/16/the-way-towards-a-competitive-bidding-process-for-new-offshore-wind-farms-in-belgium

109 https://renewables-grid.eu/fileadmin/user_upload/Files_RGI/Event_material/Offshore_mini-workshop/Elia_Modular_offshore_grid.pdf

110 https://www.dentons.com/en/insights/articles/2019/september/16/the-way-towards-a-competitive-bidding-process-for-new-offshore-wind-farms-in-belgium

111 https://economie.fgov.be/en/themes/energy/belgian-offshore-wind-energy

Table 20. Support mechanism of offshore wind farms in Belgium.

Project	Capacity (MW)	Mechanism	GC Calculation basis	Subsidy terms (Years)
Thornton bank (C-Power)	325	FiP	€ 107/MWh (216MW); € 90/MWh (109MW)	20
Belwind	171	FiP	€ 107/MWh	20
Northwind	216	FiP	€ 107/MWh	20
Nobelwind	165	FiP	€ 107/MWh (45MW); € 90/MWh (120MW)	20
Rentel	309	One-sided CfD	LCOE=€ 129.8/MWh	19
Norther	370	One-sided CfD	LCOE=€ 124/MWh	19
Northwester 2	219	One-sided CfD	LCOE=€ 79/MWh	17
Seamade (Mermaid)	235	One-sided CfD	LCOE=€ 79/MWh	17
Seamade (Seastar)	252	One-sided CfD	LCOE=€ 79/MWh	17

The subsidy mechanism for wind power in Belgium was a "feed-in premium (FiP)" system based on Green Certificate (GC), which means that wind power projects receive a fixed GC on top of the market electricity price[112]. One GC is awarded for each MWh of electricity produced by a wind farm, and the Belgian transmission system operator (TSO) Elia purchases these GCs at a minimum price, which is determined in accordance with Article 14, §1 of the Royal Decree of 16 July 2002[113]. The duration of the GC purchase agreement is generally 20 years. The subsidy varies among different projects. Four projects that completed financing before May 1, 2014, received a FiP.

Projects that completed financing after May 1, 2014, receive a One-sided CfD also based on GC. The minimum GC purchase price is equal to the project LCOE, which is determined by the negotiation between the government and developer after the domain concession is granted, deducted by the adjusted reference market price[114,115,116,117], as shown in Table 20. A negotiated LCOE in a way encourages developers to strive for cost-effectiveness of the projects to obtain higher green certificate prices.

The Belgium government has decided on a two-sided CfD with a period of 20 years in the Princess Elisabeth zone tender. According to the tender principles[118], bids will be evaluated on strike price (90 out of 100 points) which will be partially indexed annually

[112] https://research.kbcsecurities.com/pdf/325F43CD-1B42-4B49-A2C1-196C659C053C.pdf , p.3-4.
[113] https://www.creg.be/nl/professionals/productie/offshore-windenergie/groenestroomcertificaten
[114] https://www.creg.be/nl/professionals/productie/offshore-windenergie/groenestroomcertificaten
[115] https://www.dentons.com/en/insights/articles/2019/september/16/the-way-towards-a-competitive-bidding-process-for-new-offshore-wind-farms-in-belgium
[116] https://cms.law/en/int/expert-guides/cms-expert-guide-to-offshore-wind-in-northern-europe/belgium
[117] https://www.iea.org/policies/3827-green-certificate-scheme-federal
[118] https://economie.fgov.be/sites/default/files/Files/Energy/Tender-principles-Princess-Elisabeth-Zone.pdf , p. 6

at 30% related to the operation and maintenance (O&M) portion, and innovation in business model (10 points).

It should be noted that the previous five projects awarded with one-sided CfD (Rentel, Norther, Northwester 2, Mermaid and Seastar) have been requested to enter a two-sided CfD, as a result of high market price recently[119,120].

3.6 Sweden

In Sweden, 75% of the total electricity generation comes from renewable energy sources, where hydropower accounts for 38% and wind power for 22%, and its onshore wind power capacity ranks fifth in Europe[121]. The first offshore wind farm in Sweden, Bockstigen (2.75 MW), began operation in March 1998, and currently, there are only four offshore wind projects with a total installed capacity of 192 MW. There have been no new projects built since 2013, although two projects (Kriegers Flak and Skåne) have received approval in 2022 and 2023, as detailed in Table 21. The Swedish government has yet to set long-term offshore wind power installation targets.

Table 21. Offshore wind farms in Sweden.

No.	Project	Capacity (MW)	Status	Date of commission
1	Bockstigen	2.75 (3.3)	Operational	1998.03 (2018.10)*
2	Lillgrund	110.4	Operational	2007.12
3	Vänern	30	Operational	2010.05
4	Karehamn	48	Operational	2013.09
5	Kriegers Flak	640	Planning	2029 projected
6	Skåne	1500	Planning	2029 projected

Note: Bockstigen project repowered in 2018.

Currently, the development of offshore wind projects in Sweden is mainly carried out by developers independently, without any project or price bidding procedures. Sweden is also considering adopting a government-led approach to screen offshore development areas, which is said to be announced in its Marine Spatial Planning in 2024 and ultimately selecting developers through bidding[122].

3.7 Norway

Renewable energy generation in Norway accounts for 98% of its total electricity production, with hydropower at 92%[123]. Despite the fact that the wind resources in the

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119 https://www.4coffshore.com/news/belgium-to-end-22irresponsible22-excess-profit-from-offshore-wind-nid27022.html

121 https://windeurope.org/newsroom/news/sweden-making-up-lost-ground-on-offshore-wind/
122 https://windeurope.org/newsroom/news/sweden-making-up-lost-ground-on-offshore-wind/
123 https://iea.blob.core.windows.net/assets/de28c6a6-8240-41d9-9082-a5dd65d9f3eb/NORWAY2022.pdf , p.24.

North Sea are extremely abundant, most of them are in deep waters. Therefore, Norway has been actively exploring floating offshore wind power technology. Currently, there are two experimental floating offshore wind power projects in Norway, Unitech Zefyros (2.3MW) and TetraSpar (3.6MW). In 2022, the Norwegian government announced that its offshore wind power installed capacity will reach 30GW by 2040.

In March 2023, Norway launched the first round of offshore wind power project tenders[124]. The two bidding areas are Sørlige Nordsjø II and Utsira Nord (for floating projects), with a total installed capacity of up to 3 GW. The projects will be supported through a two-sided CfD[125,126], for a period of 15 years. For projects in the Sørlige Nordsjø II area, the reference price is capped at 66 øre/kWh and the total state support will be capped at NOK 15 billion[127].

3.8 France

France has the highest share of nuclear power generation in the world, accounting for 68% of total electricity generation as of 2021[128]. In 2015, France passed the Energy Transition for Green Growth Act, aiming to reduce the proportion of nuclear power in the power generation structure to 50% by 2025 and increase the proportion of renewable energy to 40%[129]. In 2016, the Ministerial Order on the Development of Renewable Energy was published, planning to achieve a total installed offshore wind power capacity of 500 MW by the end of 2018 and 3 GW by the end of 2023, in addition, a capacity between 500 MW and 6 GW more shall be awarded through tenders before end of 2023[130]. Offshore wind power has become an important component of France's energy transition process.

In 2004, France started its first offshore wind tender, which failed due to excessive price of the offers and strong opposition from nearby residents and fishermen[131]. From 2011 to the present, France has conducted four rounds of offshore wind power tenders, with a total of 8 projects awarded. According to the offshore sector deal signed between the French Government and France's wind industry, France plans to organize auctions for a minimum of 2 GW of new offshore wind capacity each year starting in 2025[132].Currently, only one project (Saint-Nazaire, 480MW) has been put into operation. Details are shown in Table 22.

124 https://www.offshorewind.biz/2023/03/29/breaking-norway-opens-first-offshore-wind-tenders-for-applications/

125 The Utsira Nord area is planned to accommodate with three floating wind projects, which will be awarded to bidders in order of their evaluation results. The first two projects will receive CfD subsidies, while the third project will not receive any subsidies in this round, yet can still participate in future tendering.

126 https://www.wr.no/en/news/norwegian-government-launches-tender-rules-for-offshore-wind

127 https://bahr.no/newsletter/offshore-wind-tender-rules-for-norways-first-offshore-wind-licensing-round-2

128 https://www.iea.org/countries/france

129 https://www.planete-energies.com/en/media/article/frances-energy-transition-green-growth-act

130 https://www.legifrance.gouv.fr/jorf/id/JORFARTI000032452177

131 https://cms.law/en/int/expert-guides/cms-expert-guide-to-offshore-wind-in-northern-europe/france

132 https://windeurope.org/newsroom/news/france-commits-to-40-gw-offshore-wind-by-2050/

Table 22. Offshore wind auction results and project status in France.

No.	Project	capacity (MW)	Status	Winning bid	Bid price[133] (€/MWh)	Date of commission
1	Saint-Nazaire	480	Operational	2012.04	143.6	2022.11
2	Saint-Brieuc	496	Construction	2012.04	155	2023 projected
3	Fécamp	498	Construction	2012.04	135.2	2023 projected
4	Calvados	450	Construction	2012.04	138.7	2024 projected
5	Dieppe-Le Tréport	496	Pre-construction	2014.05	131	2025 projected
6	Noirmoutier	496	Pre-construction	2014.05	137	2025 projected
7	Dunkirk	600	Planning	2019.06	44	2028 projected
8	Normandy	1050	Planning	2023.03	N.A.	2031 projected

There are two types of offshore wind tender models in France: the traditional tender model (before August 2016) and the "competitive dialogue" model (after August 2016) [134]. Under the traditional tender model, the French Ministry of Energy is responsible for formulating tender rules (including project location, installed capacity, and technical requirements) and the final decision, while the French Energy Regulatory Commission (CRE) is responsible for the specific implementation of the tender. The scoring factors for the traditional tender model mainly include: technical capabilities (40%), bid price (40%), and environmental protection capabilities (20%). Under the competitive dialogue tender model, the French Ministry of Energy first releases a tender consultation document (including bidder qualification requirements, schedule, evaluation criteria, etc.) to select qualified bidders for competitive dialogue. Then, the tender rules are formally released to invite bidders to submit final bids, and the subsequent process is similar to the traditional tender model. The scoring factors for the competitive dialogue tender model mainly include: bid price (70%, with an upper limit of €90/MWh), business and financial capabilities (10%), offshore distance (11%), site layout and environmental input (9%) [**Error! Reference source not found.**]. In addition, in this tender, the grid connection engineering and related costs are all the responsibility of the transmission system operator RTE [**Error! Reference source not found.**].

The current development process for offshore wind in France includes the following steps: (1) the government preliminarily selects development areas; (2) the government conducts initial surveys and studies of the relevant areas; (3) a public debate is held to determine the specific development areas; (4) a bidding process takes place; (5) the winning bidder conducts detailed surveys and impact assessments; and (6) approval is granted [135]. To minimize risk for developers, the government is responsible for

133 https://ec.europa.eu/competition/state_aid/cases1/201933/269222_2088484_174_2.pdf , p.6.
134 https://cms.law/en/int/expert-guides/cms-expert-guide-to-offshore-wind-in-northern-europe/france
135 https://energie-fr-de.eu/fr/manifestations/lecteur/conference-en-ligne-sur-leolien-

conducting initial surveys of the bidding areas and publishing the results. On average, it takes 5.8 years from the start of offshore wind development in France to approval, with an average of 4.4 years from the bidding process to approval. This is mainly due to the need for the winning bidder to conduct detailed surveys and impact assessments, which can be a lengthy process, similar to the situation in the UK and Germany.

There are two types of subsidies for French offshore wind power: fixed-price feed-in tariffs (FiT) and two-sided contracts for difference (CfD).

(1) FiT
According to the previous two rounds of bidding under the traditional tendering mode, six projects were awarded with 20-year FiT subsidies, which was adjusted to industry labor costs and production price indices and adjusted for annual full-load hours achieved and final capacity installed [**Error! Reference source not found.**]. The wind farms sell electricity to the regulator (EDF d'Achat) at the award price, and the regulator receives subsidies directly from the government.

Under the traditional tendering mode, as the projects were not awarded solely based on the lowest price, the subsidy level has been relatively high. The electricity prices for the six projects range from €131/MWh to €155/MWh, significantly higher than the subsidy electricity prices in other countries in the North Sea region during the same period.

(2) two-sided CfD
The subsidy for the Dunkirk and subsequent projects awarded through competitive dialogue is a "two-sided CfD" mechanism. The calculation method is based on the generated electricity multiplied by the difference between the winning bid price and the French average day-ahead market electricity price[136]. The wind farms sell electricity to the market at market prices and receive the difference from the regulator (EDF d'Achat) on a monthly basis. The subsidy period is 20 years [**Error! Reference source not found.**]. In the recent two rounds of tenders, the weight of the bid price was increased to 70%, leading to a significant drop in the final winning bid prices, which for the Dunkirk project was €44/MWh, and for the Normandy project, it was below €45/MWh[137].

4. Comparative Discussion

4.1 Discussion on development cycle

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offshore.html?file=files/ofaenr/02-conferences/2021/210908_Offshore/Presentations/03_Martin_Salmon_MTE_OFATE_DFBEW.pdf , p.11.

[136] the average day-ahead market price in France (excluding negative price hours) weighted hourly by all wind production in France.

[137] https://www.offshorewind.biz/2023/03/27/breaking-france-selects-edf-and-maple-power-to-build-1-gw-offshore-wind-farm/

4.1.1 Development cycle of previous projects

To facilitate a comparison of development cycles among North Sea countries, we have identified three significant time nodes within the cycle: the start date of preliminary work[138] (i.e., 'start'), the date of project receiving consent (i.e., 'consent'), and the achievement of commissioning (i.e., 'commission'). As outlined in Section 3, it is evident that the development cycle differs across countries. Notably, Denmark and the Netherlands exhibit the shortest periods for projects to become operational, as illustrated in the table below.

Table 23. Development cycles of offshore wind farms in the North Sea Region.

Country	Start to consent*			Consent to commission			Start to commission		
	projects	capacity (MW)	average period (years)	projects	capacity (MW)	average period (years)	projects	capacity (MW)	average period (years)
UK	53	25,358	5.7	39	13,564	4.8	41	13,583	8.8
Germany	31	10,356	5.7	26	7,981	9.1	26	7,581	13.0
Netherlands	12	6,275	5.1	7	2,460	3.6	7	2,460	7.8
Denmark	8	2,498	4.4	7	2,154	3.1	7	2,154	7.5
Belgium	9	2,262	3.3	9	2,262	6.3	9	2,262	9.6
France	6	1,556	5.8	1	480	3.4	1	325	10.6
Average			**5.0**			**5.6**			**9.5**

Note: (1) sample of projects varies in the same country mainly due to projects are in different stages, e.g., some projects get consented might haven't reached commissioning; (2) The date of winning the seabed allocation in the UK is considered as the start date; (3) Sweden and Denmark have fewer and smaller projects, therefore they are not included in the table.

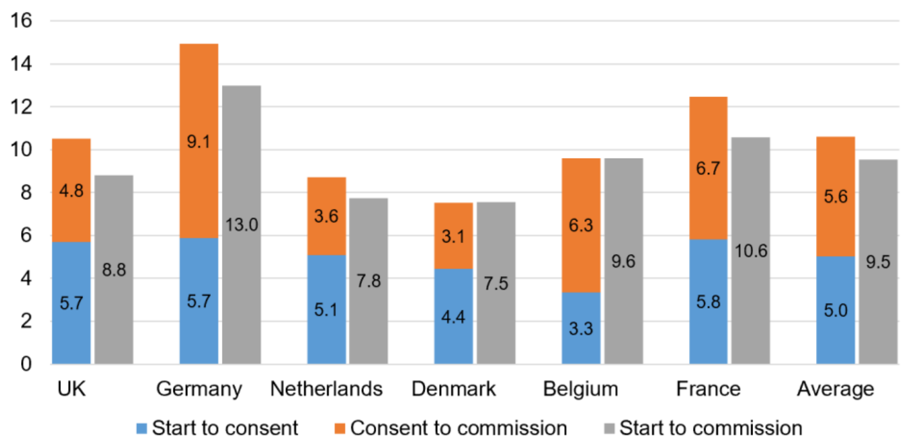

Fig 8. Indicative timeframes for offshore wind development stages in North Sea countries.

[138] Determining the exact start date for preliminary work on offshore wind projects is often challenging. However, we have made efforts to identify the earliest available source of these projects, considering the start date to be the earliest record typically sourced from the project database of 4Coffshore.com.

Notably, the offshore wind development timeline, as illustrated in Table 22, indicates that projects typically require an average duration of 9.5 years from the very beginning to commission. To expedite project development and mitigate these risks, countries such as the Netherlands and Denmark have implemented comprehensive measures, including the provision of "one-stop services." This approach involves engaging third-party entities to conduct thorough surveys and environmental impact assessments prior to the tendering phase. Furthermore, early involvement of transmission system operators in grid integration efforts has proven instrumental in enhancing project development efficiency. These exemplary practices offer valuable insights for other nations seeking to optimize their own project development processes.

Countries with fewer projects are expected to have a faster development process. To analyze the timeframe between consent and commission, we focused on the period from 2010 to 2020 when projects get consented and from 2013 to 2023 when projects get commissioning. Among the four countries (Germany, Netherlands, Denmark, Belgium) with similar project volumes during this period, the Netherlands had the shortest average duration of 3.5 years from obtaining consent to commissioning, which aligns with the typical construction period in practice. Followed with Denmark, Germany and Belgium, see Table 24. These time differences highlight fundamental mechanism variations among these countries. In France, only one project (Saint-Nazaire) obtained both consent and became operational within the specified timeframe, taking 6 years for this stage. However, it should be noted that this may not be an exception, as other projects (Saint-Brieuc, Fécamp, Calvados) that obtained consent during the same period (2016-2017) are expected to be commissioned in 2023 and 2024. The UK had the highest number of projects during this period. Considering the 2-year application period for CfD, the overall time span can be considered acceptable to some extent.

Table 24. Projects selected within similar time span.

Country	**Consent to commission**			**Range of consent dates**	**Range of commissioning dates**
	projects	**capacity (MW)**	**average period (years)**		
UK	17	8,978	5.0	Feb 2011 to Aug 2016	June 2015 to Aug 2022
Germany	5	1,349	5.4	Sep 2010 to Dec 2020	Mar 2014 to Mar 2023
Netherlands	5	2,231	3.5	Dec 2012 to Apr 2018	Sep 2015 to Feb 2021
Denmark	3	1,412	4.1	July 2010 to Dec 2016	Sep 2013 to Sep 2021
Belgium	5	1,385	6.0	Jan 2012 to Dec 2015	Dec 2018 to Dec 2020
France	1	325	6.7	Mar 2016	Nov 2022

To highlight these national differences more clearly, we take one project of each country which got consented in the same year (2012 and 2016 separately) out of the pot, which is shown in Table 25.

Table 25. Sample projects get consented in 2012 and 2016.

Countries	Project name	Capacity (MW)	Consent award date	commissioning date	From consent to operation (years)
UK	Dudgeon	402	2012-07-06	2017-10-04	5.2
Germany	Nordsee One	332	2012-04-01	2017-12-01	5.7
Netherlands	Luchterduinen	129	2012-11-01	2015-09-01	2.8
Belgium	Norther	370	2012-01-01	2019-06-01	7.4
UK	Hornsea Two	1,386	2016-08-16	2022-08-31	6.0
Netherlands	Borssele I & II	752	2016-07-01	2020-11-01	4.3
Denmark	Kriegers Flak	605	2016-12-01	2021-09-01	4.8
France	Saint-Nazaire	325	2016-03-01	2022-11-01	6.7

4.1.2 Underlying factors contributing to the differences in development cycles

The efficiency across different countries varies remarkably if we examine the timeframe from obtaining consent to commissioning. Generally, obtaining the "permit" for a project signifies that the developer has secured the right to develop, construct and operate the project. Typically, this stage should not involve significant approval process risks, as the primary risk lies in achieving financial closure from the developer's perspective. However, it has been observed that in certain countries, even after obtaining project consent, considerations regarding grid connection still arise. The situation in the UK is somewhat unique because, following the acquisition of seabed rights, a separate competitive bidding process for CfD still awaits. In contrast, other countries typically obtain project development rights and subsidies (including zero subsidy) through a single bidding process.

Table 26. Responsibilities in the development phases of North Sea countries.

Country	Before tender	Tender	Grid connection	EIA	Consent
UK	Developers	Seabed and CfD auction by Government	Developer	Developer	Developer
Germany	Central model: Government Non-central model: developer	Government	Developer	Developer	Developer
Netherlands	Government	Government	TSO	Government	Developer
Denmark	Government	Government	TSO	Developer	Developer
France	Government	Government	TSO	Developer	Developer

In most of the previous practices of North Sea countries, the development process was the responsibility of developers themselves, and obtaining consents was associated with high costs and risks, with only a few projects receiving subsidies. In contrast, the current "one-stop-shop" policy adopted by countries like Netherlands and Denmark is more proactive: led by the government, it sets long-term planning, determines wind farm locations, conducts environmental assessments, is responsible for grid connection agreements, conducts tenders, etc., and developers only need to enter the tendering stage and bear the relevant pre-development costs after winning the bid, thus effectively reducing investment risks and costs.

Environmental Impact Assessment (EIA) plays a crucial role in obtaining consents for offshore wind farms in all countries, which is typically a prerequisite for obtaining the necessary consents. In the Netherlands, the EIA process is implemented prior to the tender, allowing for a relatively short period (an average duration of 0.9 years) between winning the tender and obtaining consent for construction. In Denmark, there has been a shift in the EIA process. Previously, the EIA was completed before the tender award, based on a project description that considered the worst-case scenario for each potential environmental impact[139]. However, the current practice is to conduct the EIA after the tender, which has resulted in a somewhat slower approval process compared to before. We notice that the consent periods have increased to approximately 4 years since this change took place. For instance, the Kriegers Flak and Vesterhav offshore wind farms took 3.2 years and 4.3 years, respectively, to obtain the construction permit after winning the tender. In contrast, the approval process for previous projects only took a few months.

4.1.3 Can national 2030 OWE targets be achieved?

The gap in achieving the 2030 OWE capacity targets is outlined in Table 27. Our analysis delves into the unique circumstances of each country to outline viable pathways for achieving the set 2030 OWE targets.

Table 27. Capacity gaps towards the 2030 installation targets of North Sea countries (MW)

Country	Installed capacity	Under construction	Pre-construction	2030 targets	Gap	Pipeline*
UK	13,918	6,588	7,610	50,000	21,884	22,890
Germany	8,055	733	2,042	30,000	19,170	18,748
Netherlands	2,829	2,299	0	21,000	14,416	11,456
Denmark	2,308	344	0	12,900	9,248	10,200
Belgium	2,261	0	0	6,000	3,739	3,500
Sweden	192	0	0	-	-	5,900
Norway	6	0	0	-	-	2,000
France	482	1,444	1,592	4,400	882	0

139 https://ens.dk/sites/ens.dk/files/Vindenergi/offshore_wind_development_final_june_2022.pdf , p.26.

Note: Including consented and un-consented projects which are expected to commission before 2030

(1) UK

Development Pipelines are apparently sufficient to bridge the 2030 target gap. Among the projects allocated by the Crown Estate and Crown Estate Scotland, there remains a capacity of 52.6 GW in the development stage, excluding the canceled projects. When reviewing these projects individually, it becomes evident that there is a total capacity of 22.89 GW within the pipeline projects expected to achieve commissioning before 2030. The problem is, the 22.89 GW is still awaiting CfD auctions while only 7.46 GW within it has been consented.

There are additional concerns to consider in the context of CfD auctions. Firstly, it may not be accurate to assume that projects are guaranteed to proceed to FID with a CfD in place. Vattenfall's recent decision to halt their development efforts in the Norfolk Zone of the UK[140], suggests that exceptions can occur, albeit rarely, compared to previous CfD rounds. Secondly, questions arise when no offshore wind projects bid in the 2023 auction[141] , about which we discuss more later.

We selected the recent offshore wind projects commissioning since 2019, to calculate the time span of these projects from getting consented to commission, see Table 28. Then we estimate how much of the capacity should be consented (also allocated with CfD) in the next few years.

Table 28. Time spent per offshore wind project from getting consented to commission in the UK (commission since 2019).

Project name	Capacity (MW)	Construction period (Years)	From winning CfD to commission (Years)	From consent to commission (Years)
Race Bank	573.3	1.84	-	5.59
Galloper	352.8	1.25	-	4.85
Walney Extension	659	1.59	-	3.83
Rampion	400.2	2.83	-	4.38
Beatrice	588	2.33	-	5.36
Hornsea One	1,218	1.93	-	5.06
East Anglia One	714	1.99	5.49	6.12
Triton Knoll	860	1.99	4.37	8.55
Moray East	950	2.86	4.58	8.09
Hornsea Two	1,386	1.91	5.00	6.04

[140] https://group.vattenfall.com/uk/contentassets/d32c972ea01b43f69f7c950f197ab10f/nz-e-news-update-july-2023.pdf

[141] https://windeurope.org/newsroom/news/uks-badly-designed-cfd-auction-attracts-not-a-single-investor/

Average		**2.05**	**4.86**	**5.79** **(7.17 for CfD projects)**

Planning consents and grid connection agreements are crucial prerequisites for securing a CfD price in the UK. Currently, there are no offshore wind projects that have been developed solely on a merchant basis, indicating that all the ongoing projects in the UK's pipeline are expected to participate in CfD auctions. The frequency of auctions for funding through the CfD scheme has transitioned to an annual basis from 2023[142]. Therefore, to fill up the 21.88 GW gap, it is imperative that a capacity of 14.43 GW receives the necessary consents by the end of 2024. Moreover, at least 7.3 GW of projects should be awarded with CfD annually from 2024 to 2026.

While past experience suggests that projects awarded with a CfD tend to have a more secure path to FID, the absence of offshore wind projects in the 2023 auction, primarily due to the low maximum allowed strike price (£44/MWh, including the cost of grid connection), raises concerns about future auctions. This situation prompts consideration of two potential approaches for the government or the market: either increasing the maximum allowed strike price for offshore wind, or exploring new methods to develop projects on a 100% merchant basis, an approach that has yet to be widely adopted.

These won't be easy tasks to tackle with. Fortunately, this process still holds the potential for acceleration. As previously discussed, extension rounds in the UK present an appealing option for developers seeking to expedite project implementation. Therefore, we recommend exploring the possibilities within early allocated development zones, which could potentially accommodate extension capacities. This approach not only offers the opportunity to accelerate approvals but also requires government leadership, including the initiation of feasibility studies.

(2) Germany

To date, nearly half of the pipeline projects in Germany, accounting for a total capacity of 8.9 GW, have won through auctions but are yet to receive consent for construction. If the current tender plan which goes till 2025[143] goes well, the auctioned capacity could almost compensate for the gap of 19 GW.

Recent projects granted through tenders have needed significantly less time for development, for example, the Kaskasi project took only 2.25 years from winning the auction to commissioning (see Table 29); projects like Arcadis Ost 1 and Baltic Eagle, which won the 2018 auction, are expected to commission in 2023 and 2024, respectively. Based on this, we estimate a conservative average of 5 years from winning auctions to commissioning. In this case, the 2030 target could be achieved just by 2030.

142 https://www.gov.uk/government/news/government-hits-accelerator-on-low-cost-renewable-power

143 https://www.bsh.de/EN/TOPICS/Offshore/Offshore_site_investigations/Procedure/procedure_node.html

However, it is important to address the issue of obtaining consent for these projects in a timely manner.

Table 29. Time spent per offshore wind project from getting consented to commission in Germany (commission since 2019).

Project name	Capacity (MW)	Construction period (Years)	From winning auction to commission (Years)	From consent to commission (Years)
Arkona	385	1.42	-	12.83
Merkur	396	2.17	-	9.83
Deutsche Bucht	252	1.00	-	9.58
Hohe See	497	1.67	-	13.33
Albatros	112	1.75	-	8.42
Trianel Windpark Borkum II	200	2.08	-	12.08
Kaskasi	342	1.00	4.92	2.25
Average		**1.58**	**4.92 (1 project)**	**9.76**

(3) The Netherlands

According to the Offshore Wind Energy Roadmap 2030[144] outlined by the Dutch government, they plan to tender a total capacity of 17.4 GW between 2023 and 2027. Out of this capacity, approximately 16.7 GW is expected to reach commissioning before 2031.

Table 30. Time spent per offshore wind project from getting consented to commission in the Netherlands (commission since 2019).

Project	Capacity (MW)	Construction period (Years)	From winning auction to commission (Years)	From consent to commission (Years)
Borssele I & II	752	0.83	4.33	4.33
Borssele III & IV	731.5	1.33	4.08	4.08
Borssele V	19	0.83	2.83	2.83
Average		**1.00**	**3.75**	**3.75**

Based on an average time of 3.75 years from auction to commissioning (see Table 30), it appears that the Dutch target can be achieved almost by the end of 2030.

(4) Denmark

Currently, a capacity of 1GW has won the auction without being consented (The Thor

144 https://english.rvo.nl/sites/default/files/2022/07/WOZ-210622022062-Letter-Additional-Offshore-Wind%20Energy-Roadmap-2030.pdf , p.19.

project). The Danish government is planning to launch the tender for projects with a total capacity of around 9 GW by late 2023.

Table 31. Time spent per offshore wind project from getting consented to commission in Denmark (commission since 2019).

Project	Capacity (MW)	Construction period (Years)	From winning auction to commission (Years)	From consent to commission (Years)
Horns Rev III	407	1.83	4.48	4.25
Kriegers Flak	605	1.33	4.83	1.58
Average		**1.58**	**4.66**	**2.92**

With an average time of 4.66 years for a project to commission from auction (see Table 30), the realization of Denmark's 2030 offshore wind capacity target appears promising and may most probably be achieved by 2029, provided the tendering process is successfully implemented.

(5) Belgium

The Belgium government has outlined its intention to implement the tender of the Princess Elisabeth zone, with a total capacity of 3.5 GW, in three phases from 2024 to 2028[145].

Table 32. Time spent per offshore wind project from getting consented to commission in Belgium (commission since 2019).

Project	Capacity (MW)	Construction period (Years)	From winning auction to commission (Years)	From consent to commission (Years)
Norther	370	0.75	-	7.42
Rentel	309	1.42	-	5.83
Seamade (Seastar)	252	1.17	-	6.83
Seamade (Mermaid)	235	1.17	-	5.67
Northwester 2	219	0.75	-	4.42
Average		**1.05**	**-**	**6.03**

Given the average time of 6.03 years for a project to reach commissioning from obtaining consent (see Table 31), if Belgium intends for these projects to be commissioned by 2030, it seems they need to secure consents before 2025. Therefore, there are two viable approaches: either accelerating the tender plan or expediting the consent process within 3 years.

145 https://economie.fgov.be/en/themes/energy/belgian-offshore-wind-energy

(6) France

The lengthy consent period has been a major issue with offshore wind projects in France. This is evident from the fact that three projects (Saint-Brieuc, Fécamp, Calvados) that won the 2012 auction are still in the construction stage, indicating significant delays in the development process. Additionally, the 2014 auction winners, Dieppe-Le Tréport and Noirmoutier, have not yet entered material construction, further highlighting the challenges in obtaining timely consents.

Table 33. Time spent per offshore wind project from getting consented to commission in France (commission since 2019).

Project	Capacity (MW)	Construction period (Years)	From winning auction to commission (Years)	From consent to commission (Years)
Saint-Nazaire	480	1.50	10.58	6.67

The 2022 auction winner, Normandy (1050MW), is currently set to commission in 2031. To ensure that France meets its target, advancing the commissioning date of the Normandy project to 2030 would be a critical approach.

These timelines and considerations are based on the current understanding and industry trends. However, it's worth noting that specific project timelines and regulatory frameworks may evolve, and it is important to refer to the most up-to-date information and consult relevant authorities and industry sources for accurate and precise planning. Clearly more projects as well as tenders need to be launched on a regular basis to meet the further 2050 targets for North Sea countries.

Furthermore, the previously mentioned estimation is based on the aggregation of individual projects without accounting for joint or collaborative initiatives. It's important to note that innovative approaches like hybrid projects have arisen as economically efficient solutions for effectively integrating significant offshore wind farm capacities[146], e.g., the Kriegers Flak offshore wind farm which was built to be connected to Germany and Denmark[147]. Consequently, recommendations were made for policymakers to make decisions regarding the establishment of an Offshore Bidding Zone (OBZ), with the expectation that the tendering process would occur approximately 5-7 years before going live[148].

146 https://northseawindpowerhub.eu/knowledge/discussion-paper-a-strategy-to-establish-an-offshore-bidding-zone-hybrid-projects

147 https://windeurope.org/newsroom/news/hybrid-offshore-wind-farms-are-already-being-built/

148 https://northseawindpowerhub.eu/files/media/document/NSWPH_A%20strategy%20to%20establish%20an%20offshore%20bidding%20zone%20for%20hybrid%20projects_Discussion%20paper%20%233_Final.pdf , p.26.

4.2 Discussion on the drop-out of projects during development and planning

It is worth highlighting that a significant proportion of projects are abandoned due to environmental and technological challenges. The drop out of developers are the final risks in terms of project development. Such information is more seen in the UK because of a relatively mature industry and clear track record (originally, projects are granted through seabed allocations). Over the last two decades, a significant number of offshore wind energy projects (totaling 15GW) have been cancelled in the UK, while many early-round projects remain in the planning stage. This can largely be attributed to that developers must apply to government authorities to obtain the necessary consents prior to commencing work on new sites [**Error! Reference source not found.**]. Consequently, a few winning bidders have found unfavorable technological conditions and commercial viability, resulting in their decision to forego development of the awarded sites[149,150]. Additionally, a few projects have been denied consent due to their failure to obtain necessary follow-up consents [**Error! Reference source not found.**] such as environmental assessments[151]. See Table 34.

Table 34. Cancelled offshore wind power projects in the UK and reasons.

No.	Seabed allocation round	Project names	Planned capacity (MW)	Seabed award date	Drop out date	Reasons
1	Round 1	Cirrus Array (Shell Flats)	270	2001-04-01	2008-11-01	radar interference/ concerns about aviation
2	Round 1	Cromer	108	2001-04-01	2007-03-07	seabed problems
3	Round 1	Scarweather Sands	108	2001-04-01	2009-12-03	challenging seabed conditions, relatively poor wind
4	Round 2	London Array II	370	2003-11-01	2014-02-19	potential impact on birds
5	Round 2	Docking Shoal	500	2003-11-01	2012-07-06	impact on protected bird populations
6	Scottish Territorial Waters	Islay	680	2009-02-01	2014-03-26	streamlining and simplifying business
7	Scottish Territorial Waters	Argyll Array	1500	2009-02-01	2013-12-13	not financially viable
8	Scottish Territorial Waters	Bell Rock	700	2009-02-01	2011-01-01	radar services
9	Scottish Territorial Waters	Forth Array	415	2009-02-01	2010-11-22	strategic review

149 https://www.4coffshore.com/windfarms/united-kingdom/cromer-united-kingdom-uk35.html
150 https://www.4coffshore.com/windfarms/united-kingdom/scarweather-sands-united-kingdom-uk22.html
151 https://www.gov.uk/government/publications/thanet-extension-offshore-wind-farm-development-consent-order

10	Scottish Territorial Waters	Kintyre	378	2009-02-01	2011-03-01	proximity to airport and local communities; impact on recreational sailing
11	Scottish Territorial Waters	Solway Firth	300	2009-02-01	2011-03-18	unsuitable site
12	Scottish Territorial Waters	Wigtown Bay	280	2009-02-01	2011-03-18	unsuitable site
13	Round 3	Dogger Bank - Teesside C	1200	2010-01-01	2015-08-07	business adjustment
14	Round 3	Dogger Bank - Teesside D	1200	2010-01-01	2015-08-07	business adjustment
15	Round 3	Navitus Bay	900	2010-01-01	2015-09-11	impact on natural environment
16	Round 3	Atlantic Array	1,500	2010-01-01	2013-11-26	technical challenges including substantially deeper waters and adverse seabed conditions
17	Round 3	Celtic Array	4,200	2010-01-01	2014-07-31	difficult seabed geology
18	Round 1 & 2 Extensions	Thanet 2	147	2010-05-11	2010-10-17	business adjustment
19	Offshore wind extension projects	Thanet Extension	340	2019-08-01	2020-06-03	navigational risks

We can therefore calculate the dropout rate of each seabed allocation rounds as shown in Table 35.

Table 35. Cancelled projects in each seabed allocation rounds in the UK.

Seabed allocation round	**Award projects**	**Total award capacity (MW)**	**Cancelled projects**	**Cancelled capacity (MW)**	**Drop-out rate**
Round 1	17	1,702	3	486	28.55%
Round 2	17	7,491	2	870	11.61%
Scottish Territorial Waters	10	6,438	7	4,253	66.06%
Round 3	24	32,200	5	9,000	27.95%
Round 1 & 2 Extensions	5	1,686	1	147	8.72%
Demonstration sites	5	219	0	0	0
Offshore wind extension projects 2017	7	3,692	1	340	9.21%

Sum	85	53,428	19	15,096	28.25%

Over 1/4 of the projects (by capacity) didn't get through the development phase in the UK. Projects in Round 4 and the ScotWind leasing round are still subject to Project-level HRAs and seabed risks. In Germany, projects that are auctioned through the "central model" have a higher success rate, while those in the "non-central model" are inherently riskier. On the other hand, projects awarded through auctions in countries like the Netherlands, Denmark, and France, which are still in the development phase, are expected to progress towards operational status as risks have been thoroughly examined prior to the auction process. It should be noted that projects in the Dutch roadmap have not yet undergone government investigations, so they are not guaranteed with 100% certainty. Similarly, a portion of the announced projects in Denmark, Sweden, and Norway may also have a certain possibility of failure. As such, we propose a drop-out rate for the pipeline projects as outlined in Table 36. This is only a rough calculation due to limited information available regarding canceled projects in the past. Consequently, the results are intended solely for reference purposes and have not been applied in the calculations related to achieving the 2030 targets in Section 4.1.

Table 36. Assumption of drop-out of pipeline projects.

Country	Modes	Capacity still in development (MW)	Commission before/after 2030	Hypothesis drop-out rate	Dropped-out capacity (MW)
UK	Previous rounds	14,910	Before	20%	2,982
UK	Round 4 leasing	7,980	Before	30%	2,394
UK	ScotWind leasing	27,626	After	30%	8,288
Germany	Awarded projects	1,948	Before	0	0
Germany	Central model auction	1,800	Before	0	0
Germany	Non-central model auction	7,000	Before	20%	1,400
Germany	2024-2025 auctions	8,000	Before	20%	1,600
Netherlands	Awarded projects	1,456	Before	0	0
Netherlands	Roadmap projects	10,000	Before	20%	2,000
Netherlands	Roadmap projects	7,400	After	30%	2,220
Denmark	Awarded projects	1,000	Before	0	0
Denmark	Planning projects	4,200	Before	20%	840
Belgium	Planning projects	3,500	Before	20%	700
Sweden	Planning projects	5,900	Before	20%	1,180
Sweden	Planning projects	10,900	After	30%	3,270
Norway	Planning projects	2,000	Before	20%	400
Norway	Planning projects	1,000	After	30%	300
France	Awarded projects	2,500	After	0	0
Total		**119,120**			**27,574**
	Before 2030	**69,694**			**13,496**

	After 2030	**49,426**			**14,078**

These assumptions mean a deduction of potential installation should be considered. Take the 2030 target for example, according to government plans, we might achieve an installed capacity of 127 GW till 2030 (comparing to the 124.3 GW target, as shown in Table 5 in Section 2.3), however this number could be only 114 GW if we consider a reasonable drop-out rate.

The potential risk of drop-out in pre-construction projects should not be overlooked. The escalating costs have significantly impacted the financial viability of ready-to-build projects, especially those who were granted subsidies prior to the energy crisis. For example, the suspension of the Norfolk Boreas offshore wind farm in the UK, as mentioned in Section 4.1.3.

4.3 Discussion on designs of subsidies

Early fixed-price subsidies (FiT/FiP) provided significant support for the large-scale development of renewable energy, including offshore wind power, and stimulated the enthusiasm of developers. However, these subsidies were unable to accurately reflect the economic viability of the projects, which could lead to overcompensation and pose significant pressure on government budgets / consumer bills. Subsequently, European countries gradually transitioned to Contracts for Difference (CfD) and zero-subsidy models.

In the case of CfDs, there is also the concept of "one-sided CfD" which provides a fixed base price to the project while allowing for a premium above the market electricity price. The one-sided CfD is particularly favorable for developers. However, during the energy crises when the market electricity price becomes excessively high, such projects can generate significant profits, which violates the original intentions of the design.

Zero-subsidy projects, such as those in Germany, the Netherlands, and Denmark, also operate on the principles of CfD (whether one-sided or two-sided). Although most "zero" bids were within market expectations, they also indicate a malfunctioning of the CfD subsidy mechanism in these countries. The initial design goal of "zero-subsidy" was to promote the improvement of project technology and economic viability through competitive bidding, ensuring that the market electricity price at normal levels could cover the project's LCOE (and of course a reasonable return). However, "zero-subsidy" projects have obtained a windfall through high market electricity prices (as shown in Figure 9) due to the unexpected energy crisis. Therefore, most European countries have now introduced windfall taxes targeting renewable energy generation companies to control electricity prices and bring them back to normal levels. The question is whether this exceptional and undesirable wartime situation of expectedly high prices and consequent supernormal profits taxes will persist long enough to threaten offshore wind investment.

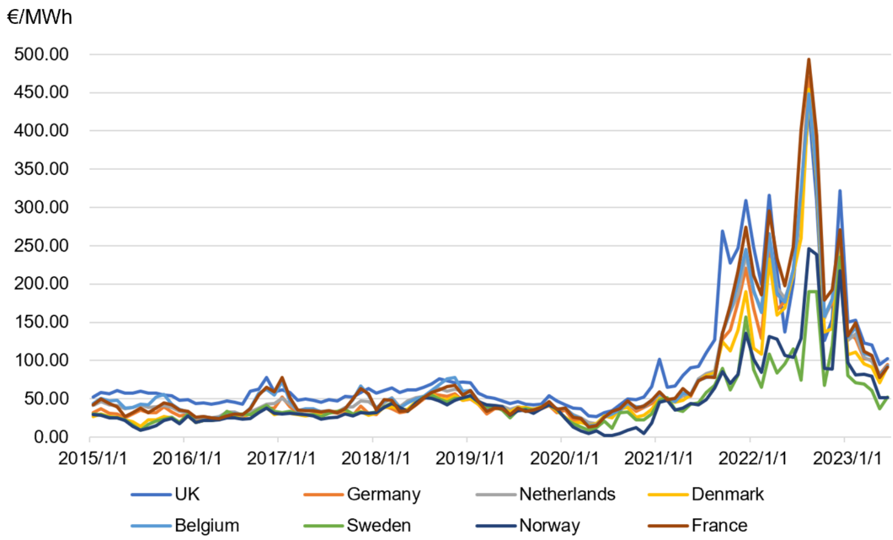

Fig 9. Monthly market electricity price trends (in €/MWh) in North Sea countries since 2015.

Source: https://ember-climate.org/data-catalogue/european-wholesale-electricity-price-data/

https://www.ofgem.gov.uk/energy-data-and-research/data-portal/wholesale-market-indicators

The two-sided CfD mechanism provide with projectable stable cash flow for offshore wind farms which is safe from fluctuations of market price. However, if we look at the UK CfD outcomes from the third auction round (delivery year 2023-2025), the strike price has been "inverted" with market prices, with the strike price being lower than the market price for quite a long term, especially significantly lower than the market price since the outbreak of energy crisis (averaging £100/MWh-£300/MWh), which has deviated from the initial CfD design that the government and developers share the electricity risks, as is shown in Fig 10.

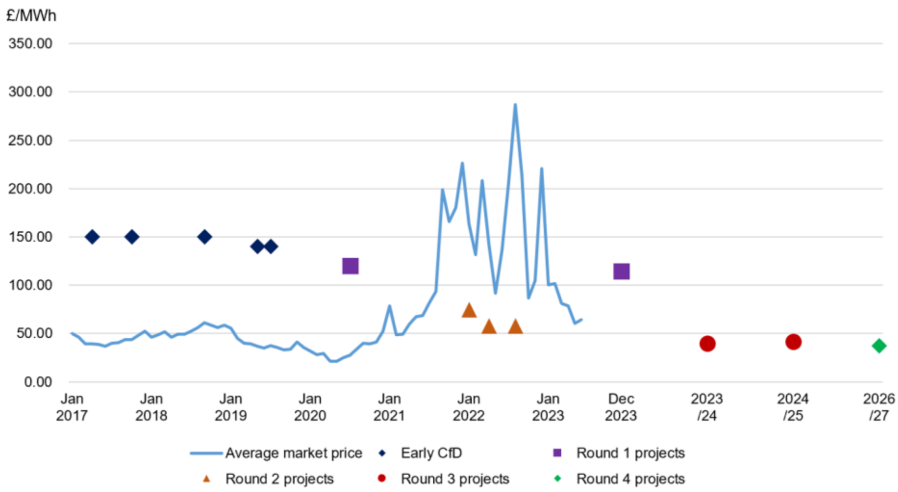

Fig 10. UK market electricity price and CfD strike prices (in 2012 price).

Note: CfD supported projects before Jan 2023 are situated at the dates when they commissioned. After that, delivery years (when projects are expected to commission).

In order to obtain a CfD and thus obtain better financing conditions for the project, developers were bidding lower prices. The strike price for the fourth round of CfD was £37.35/MWh (in 2012 prices), with the current price around £50/MWh, which is interestingly, lower than the 2030 LCOE predicted by WindEurope [21]. Therefore, it appears that the UK offers the lowest support payment for any wind farm [**Error! Reference source not found.**], which is quite counterintuitive for wind farms are seeking 'support' via CfDs.

Denmark's new "two-sided CfD" mechanism sets limits on government subsidies and developers' "negative premium". The actual tendering outcome, however, indicates that developers fully bear the risk exposure of the "negative premium". It could be inferred the rationale lies in that market price revenue in the future can compensate for the "negative subsidy" part and have a surplus throughout the entire operation cycle of the project, but it also means that the project faces short-term operational financial risks (almost no income but payment to the government in the first four years of the project) and long-term electricity price risks (market electricity prices may not remain high in the long term). Therefore, it requires a strong balance sheet for developers.

Apart from those who adopt two-sided CfDs, countries inevitably will end up with zero or negative subsidies. It also applied to the recent UK CfD model that offshore wind farms are receiving negative subsidy in essence. All this suggests the start of subsidy-free offshore wind in the high price location of Europe [**Error! Reference source not found.**].

Two-sided CfDs are favored by investors mainly because: (1) CfD-subsidized projects provide enough certainty to allow long-term investment which is required for deployment at scale and a decrease of cost of capitals[152]. (2) It is financially bankable (at least for the time being), which is evaluated by multiple industrial practices. (3) It is indexed so the price will in most cases escalate, a huge protection for investors.

The long-term value and predictability for investors makes CfD-subsidized projects more appealing. On the other hand, governments do not overpay for the generated electricity by setting a maximum price that bidders can offer, which is seen in all tenders with CfDs.

4.4 Discussion on designs of auctions

A well-designed tender has the potential to foster robust competition, encourage project optimization, and drive cost reduction. Countries such as Germany, Denmark, and Norway have transitioned from developer-driven applications to a government-led

152 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1076185/CfD_evaluation_phase_3_final_report.pdf , p.5.

tendering process, while Belgium and Sweden have plans to initiate their own tendering procedures. Consequently, future offshore wind projects in the North Sea region will predominantly rely on competitive bidding for project allocation. Notably, governments have played a pivotal role in shaping the evaluation criteria of tenders, exemplified by the UK's establishment of a maximum CfD cap, the Netherlands' emphasis on "zero-subsidy" bids, Denmark's imposition of a minimum bidding price, and France's adoption of competitive negotiation methods.

Table 37. Offshore wind tenders launched and future tenders of North Sea countries.

Country	**Number of successful auctions implemented before end of 2022**	**Total capacity awarded (MW)**	**2023 and future tenders**
UK - seabed	9	89,034	Celtic Sea Floating Offshore Wind, specific date unknown
UK - CfD	4	19,990	Annually since 2023
Germany	4	5,065	Total tender capacity is 8.8 GW in 2023; Two tenders scheduled in 2024 and 2025 with a total capacity of 8 GW
Netherlands	7	6,155	Tenders scheduled in 2023, 2025-2026 with a total capacity of 17.4 GW
Denmark	7	3,172	9 GW to be tendered in late 2023
Belgium	0	0	Tender of the Princess Elisabeth zone with a total capacity of 3.5 GW will be implemented from 2024 to 2028
Sweden	0	0	-
Norway	0	0	First tender launched in 2023 with a total capacity of 3 GW
France	4	4,566	-

In terms of evaluation criteria, the French offshore wind tender offers valuable insights. Initially, electricity price constituted 40% of the scoring criteria, but despite intense competition, bid prices did not exhibit a significant downward trend. However, after revising the tendering model, the weight assigned to the electricity price factor was increased to 70%, leading to substantial reductions in winning bid prices.

The imposition of a bid cap is problematic. It could result in all bidders submitting the same bid at the capped price. This was observed in the Option Fee structure in the ScotWind Leasing process. Furthermore, determining an "appropriate" cap in the context of the highly unpredictable economics of offshore wind farms would pose significant challenges. Similarly, the dynamic bidding process in Germany employed for non-centrally pre-examined areas tenders showcased a progressive bidding level without a cap.

The transition of policy selection in tender and subsidy among countries is summarized in Table 38.

Table 38. Comparison of offshore wind tender and subsidy mechanisms in North Sea countries.

Countries	Tender methods	Subsidy	Currently adopted evaluation criteria for subsidies	Ceiling price applied	Indexation
UK	Seabed; Subsidy	RO->two-sided CfD	lowest bids within budget, considering delivery years*	Yes	CPI
Germany	No tender->subsidy tender->development rights + subsidy	FiT->one-sided CfD->Zero bid, negative bid	Central model: bid price (60 points), Contribution to decarbonization (10 points), total output (10 points), noise exposure (10 points), contribution to securing skilled workers (10 points). Non-central model: electricity price and negative bid (if all bidders submit with zero-subsidy)	No	No
Netherland	development rights +subsidy	FiP->One-sided CfD->Zero bid, negative bid	financial offer (20 points), certainty of realization (40 points), contribution to energy supply (40 points), contribution to ecology (100 points)	No	No
Denmark	No tender-> development rights + subsidy	Two-sided CfD-> new CfD (negative bid)	lowest price	Yes	No
Belgium	No tender->development rights +subsidy	FiP->one-sided CfD->two-sided CfD	strike price (90 points), innovation in business model (10 points)	Yes	partially indexed at 30%, related to the O&M portion
Sweden	No tender-> development rights + subsidy	-	-	-	-
Norway	No tender-> development rights + subsidy	Two-sided CfD	lowest bid price[153]	Yes	N.A.
France	development rights + subsidy	FiT-> two sided CfD	bid price (70%), business and financial capabilities (10%), offshore distance (11%), site layout and environmental input (9%)	Yes	N.A.

Note: *The award process in the UK is relatively intricate, but in general, projects scheduled for specific delivery years whose combined bids fall within the allocated budget will be granted.

4.5 Discussion on the market competition and newcomers

As the offshore wind power installation targets in the North Sea region gradually become clear, competition in this market has intensified significantly. Information from

153 https://bahr.no/newsletter/offshore-wind-tender-rules-for-norways-first-offshore-wind-licensing-round-2

winning bidders (Table 39) suggests that these auctions have attracted a diverse range of investors, including well-established renewable energy companies like Orsted, RWE, Vattenfall, SSE, as well as financial investors like GIG, ESB. Notably, this market has witnessed the entry of new developers with backgrounds in oil and gas, such as TotalEnergies and BP (Round 4 Leasing, UK, 2021 and Shell (with Hollandse Kust West VI, Netherlands, 2022). This influx of new entrants underscores the growing allure of the offshore wind sector in the region.

Table 39. Part of winning bidders of the offshore wind tenders in North Sea countries since 2018.

Countries	Tenders	Winning bid year	Winners
UK	Round 4 Leasing	2021	RWE, EnBW, Offshore Wind Limited, Total, BP, GIG
UK	ScotWind Leasing	2021	SSE, Vattenfall, Scottish Power, Northland Power, Falck Renewables, Ocean Winds, Offshore Wind Power, Magnora, DEME, Total, BP, Shell, GIG, ESB
Germany	2019-2022 auctions	2019, 2021, 2022	Ørsted, RWE, EDF, Innogy, Vattenfall, Iberdrola
Germany	2023 auction: Non-central	2023	BP, TotalEnergies
Netherlands	2018-2022 auctions	2018, 2019, 2020, 2022	Vattenfall, Eneco, RWE, Shell
Denmark	2021 auction	2021	RWE
France	2019-2023 auctions	2019, 2023	EDF

4.6 Discussion on the financial impact of negative bids

The competitiveness of bids also indicates developers' willingness to pay for the right to build and operate offshore wind farms, rather than receiving subsidies or support payments. The rental option fee for the UK seabed can be considered as a form of "negative subsidy", as well as the difference that offshore wind farms have to pay to the government under the CfD scheme; the Netherlands uses "negative subsidies" as a scoring item in the bidding process; Denmark uses the CfD mechanism to design "unexpected" negative subsidies. The comparison of negative subsidy levels in various countries is shown in Table 40.

Table 40. Negative subsidies for offshore wind farms.

Country	Round/project	Capacity (MW)	Winning bid	Average Negative bid	Negative bid per unit
UK	Round 4	7,980	2021.02	£879m/year	£110k/MW/Year
UK	ScotWind Leasing	27,626	2022.01	£37.76m	£27.3k/MW
Germany	2023 auction – central model	1,800	Late 2023	N.A.	N.A.

Germany	2023 auction – non-central model	7,000	2023.07	€3.15bn	€1.8m/MW
Netherlands	Hollandse Kust West VI	756	2022.12	€63.5m	€84k/MW
Denmark	Thor	1,000	2021.12	€380m	€380k/MW

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Among these cases, the negative bid in the non-central model auction in Germany is the highest. The Option Fees for the Round 4 lease in the UK rank as the second highest, when considering a conservative 6-year development period, resulting in a negative subsidy of approximately £660,000 per MW. The third highest is associated with the financial offer in Thor project in Denmark, although it is subject to a cap set by the government.

(1) UK

We use a weighted average cost of capital (WACC) of 4.5%, a capacity factor of 51% and a project life of 30 years, to analyze the impact of option fees on the revenue and construction cost of offshore wind projects.

In Round 4 leasing, Option Fees are calculated as the Option Fee Bid (CPI indexed) multiplied by the total Project Capacity, which will be paid annually for three to ten years. During the pre-generation period (i.e. during construction), the rent payable by the developer under the Wind Farm Lease will be the lower of the annual option fee instalment (CPI indexed) and the base rent (being the minimum output multiplied by £0.90 (CPI indexed)). The rent will be paid when the wind farm starts generating (which will be the greater of 2 per cent of gross turnover, the minimum output multiplied by a fee based on 2 per cent of the average project revenue over the previous two years, and the base rent). Rental under Transmission Lease will be a nominal £1,000 per annum whilst the wind farm is operational[154]. According to Round 4 official guidelines[155], the development phase (before material construction) would take about 7 years which mainly include 5-year licensing and consenting processes and 2-year procurement and CfD application, and the construction phase would take about 3 years. The impact of Option Fees on revenues could then be calculated using the following assumptions (Table 41).

Table 41. Key assumptions for calculating the NPVs of Option fees and revenues.

Assumptions	**Value**	**Units**
capacity factor	51%	
project life	30	Years
discount rate	4.50%	

[154] https://www.thecrownestate.co.uk/media/3368/20191009-osw-r4-bidders-info-day-pm-published.pdf, p.56
[155] https://www.thecrownestate.co.uk/round-4/

strike price (2012 real price)	37.35	£/MWh
Development period (low case)	5	Years
Development period (base case)	7	Years
Development period (high case)	10	Years

Table 42. NPVs of Option fees compared to revenues per MW for Round 4 leasing projects (in 2012 price).

Project	**Capacity (MW)**	**Option fee £/MW/annum**	**Revenue/MWh NPV £/MWh**	**Low case**		**Base case**		**High case**	
				2030 Option fee paid FV £/MWh	**Ratio**	**2032 Option fee paid FV £/MWh**	**Ratio**	**2035 Option fee paid FV £/MWh**	**Ratio**
1	1,500	76,203	38.25	5.49	14.36%	8.01	20.95%	12.23	31.98%
2	1,500	88,900	38.25	6.41	16.76%	9.35	24.44%	14.27	37.31%
3	1,500	83,049	38.25	5.99	15.66%	8.73	22.83%	13.33	34.86%
4	1,500	154,000	38.25	11.10	29.03%	16.20	42.34%	24.73	64.64%
5	480	93,233	38.25	6.72	17.58%	9.81	25.63%	14.97	39.13%
6	1,500	154,000	38.25	11.10	29.03%	16.20	42.34%	24.73	64.64%

In the base case (as shown in Table 42) which developers are expected to complete the development in 7 years, total Option Fees paid amount to 20%-42% of the projects' total revenue.

BEIS gives the 2025 projected cost of an offshore wind farm (excluding the infrastructure assumed to be the OFTO part) as £1,630,000/MW (2018 price) with a 51% capacity factor [**Error! Reference source not found.**], which could transfer to £1,480,000/MW in 2012 price. The Option Fee paid in Round 4 will raise the investment cost by 29%-45% and the LCOE by 18%-31%. The findings are in line with other analysis[156].

The Option Fee in the ScotWind Leasing is a one-off sum payable when entering Option Agreement, the impact of which on projects' revenue would be a range of 0.12%-1.95% and will raise the investment cost by 0.23%-3.68%, adopting same assumptions as above.

(2) Germany

Negative bid occurred in 2023 auction under the non-central model. According to the Federal Network Agency of Germany[157], 90% of the bid will go towards reducing electricity costs which shall be paid over a period of 20 years in equal installments to the transmission system operator from the commissioning date, and 10% of the bid will into marine conservation and the promotion of environmentally friendly fishing which shall be paid into the federal budget within one year.

156 https://ore.catapult.org.uk/blog/miriam-noonans-thoughts-seabed-leasing-4/

157 https://www.offshorewind.biz/2023/07/12/breaking-germany-rakes-in-eur-12-6-billion-through-dynamic-bidding-offshore-wind-auction/

Assuming a stable market price of €80/MWh commissioning from 2030 for the four projects, capacity factor of 51%, project life of 30 years, discount rate of 4.5%, without a consideration of indexation, the NPVs of the bid could be calculated, see Table 43.

Table 43. NPVs of dynamic bid compared to revenues per MW for projects under non-central tender model (in 2023 prices).

Project	**Capacity (MW)**	**Negative bid offer (€/MW)**	**2030 Negative bid paid NPV (€/MWh)**	**2030 Revenue NPV (€/MWh)**	**Ratio**
N-11.1	2,000	1,830,000	17.99	80.00	22.49%
N-12.1	2,000	1,875,000	18.44	80.00	23.05%
N-12.2	2,000	1,560,000	15.34	80.00	19.17%
O-2.2	1,000	2,070,000	20.35	80.00	25.44%

The negative bid could also transfer to a raise of 27%-33% of the projects' construction cost assuming \$3,739,000/MW (2021 price) and 18%-23% of LCOE assuming \$81/MWh (2021 price).

(3) Netherlands
Assuming a stable market price of €80/MWh commissioning from 2026 for the Hollandse Kust West VI project, the negative bid (€63.5m) could transfer to 1.65% of the project's total revenue, a raise of 4.62% of its construction cost assuming \$2,449,000/MW (2021 price), and a raise of 2.57% of the LCOE assuming \$59/MWh (2021 price).

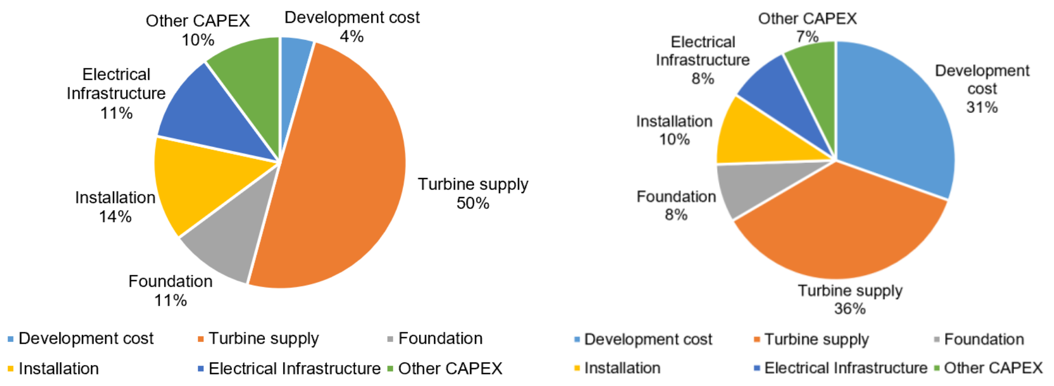
(4) Denmark
Assuming a stable market price of €80/MWh commissioning from 2027 for the Thor project, the negative bid (€380m) could transfer to 7.78% of the project's total revenue, or 20% of its construction cost assuming \$2,289,000/MW (2021 price), or 15.25% of the LCOE assuming \$41/MWh (2021 price).

Indeed, the emergence of negative bids in offshore wind auctions has significant implications for the economics of these projects. The traditional calculation of Development Expenditure (Devex) as a percentage of the overall project cost may be fundamentally altered by these negative bids. According to the NREL study in 2022, Devex accounted for a mere 2.3% of a normal offshore wind project's CAPEX in 2021 [**Error! Reference source not found.**]. Similarly, the LCOE model provided by Santhakumar (2022) estimated development costs at 4.44% of the total CAPEX [**Error! Reference source not found.**]. However, if a project were to bid with a negative bid of 1mm €/MW, which is around the level of negative bid of recent auctions in Germany and Denmark, the development cost could increase significantly, accounting for up to 30% of the total CAPEX (shown in Figure 11). This substantial shift in the proportion of development costs highlights the impact of negative bids on project economics and emphasizes the need for further evaluation and adjustment of financial models in the offshore wind industry.

Paying negative subsidies over an extended period, as under the annual Option Fee in the UK and the 20-year negative bid in Germany, will be implicitly another problem for developers. They may face difficulty in securing affordable long-term financing due to project timeline uncertainties, which can lead to reliance on short-term loans with less favorable interest rates, thereby compounding financial challenges.
The interaction between strike prices and fees is substantial. Governments need to think carefully about the balance between extracting offshore rent via fees and charging lower strike prices. Taxing rents and keeping them as general taxation gives flexibility on the use of the revenue. Reducing rent taxation and allowing electricity consumers to benefit directly from lower CfD prices has the additional advantage of imposing less financial risk on investors and not allowing a bidding process which results in well financed bidders being able to discourage less well capitalized bidders, raising price-cost markups for consumers.

Table 44. Indicative CAPEX breakdown for an EU offshore project.

Cost Categories	**Cost for a regular project (mm €/MW)**	**Ratio**	**Cost for a project bearing negative bid (mm €/MW)**	**Ratio**
Development cost	0.12	4.44%	1.12	30.43%
Turbine supply	1.33	49.75%	1.33	36.14%
Foundation	0.29	10.65%	0.29	7.88%
Installation	0.36	13.54%	0.36	9.78%
Electrical Infrastructure (Until Landfall)	0.31	11.47%	0.31	8.42%
Other CAPEX	0.27	10.15%	0.27	7.34%
Total CAPEX	**2.68**	**100.00%**	**3.68**	**100.00%**



(a) (b)

Fig 11. Indicative variation of development cost of a regular project (a) and (b) applying negative bid of 1mm €/MW.

5. Conclusions

5.1 Offshore is playing a pivotal role in the Net-zero transition of North Sea countries.

The offshore wind sector has experienced remarkable expansion over the last decade, with installed capacity reaching fivefold increase of ten years ago. A significant step forward in this evolution has been the substantial reduction in the costs associated with OWE projects, underscoring the potential for offshore wind to stand as a more competitive option against conventional power generation technologies. The emergence of zero-bids in countries like Germany, the Netherlands, and Denmark further exemplifies that OWE can be economically viable without additional subsidies. The combination of technological developments, mounting installed capacity, and decreasing costs reflects the robust maturity and competitiveness of the offshore wind industry, providing a strong foundation for achieving the ambitious capacity objectives set by North Sea countries.

5.2 Competitive auctions for development rights and CfD support mechanisms have been widely adopted.

A paradigm shift in the acquisition of OWE project development rights as well as the grant of subsidies is observable through competitive bidding process. This transition promotes cost reduction and project optimization, fostering an environment that welcomes global investors of various sizes to participate in the open bidding processes. The competitive process akin to a “beauty contest” also imply that the latter stages of the bidding cycle is largely reserved for industry giants.

A marked convergence is witnessed within subsidy mechanisms, notably the ascendancy of the two-sided CfD model. In addition to the UK, countries including Denmark, Belgium, Norway, and France have embraced the two-sided CfD approach in recent OWE tenders. Meanwhile, Germany and the Netherlands have adhered - so far - to the one-sided CfD model, where zero-bids are more likely to happen. The widespread adoption of CfD signals a shift towards a standardized and effective subsidy mechanism across countries.

It is essential to highlight that while CfD mechanisms hold promise, they need to continue to evolve as exemplified by the potential design issues observed in the 2021 Danish offshore auction, and the 2023 UK CfD auction. There remain issues around the degree of indexing value of bid caps and floors and the extent that non-price criteria should be used to determine auction results.

5.3 2030/50 OWE installation targets are possible but challenging with the optimization of approval process remaining the priority.

Countries bordering the North Sea have displayed a strong commitment to expanding their offshore wind capacity in accordance with their national goals. Strategic alignment of tender designs with their long-term plans establishes a supportive framework, ensuring a coherent and seamless expansion of OWE capacity.

Our analysis, derived from project-to-project insights, underscores that the 2030 OWE installation targets of North Sea countries (with an absence of Sweden and Norway targets) is attainable under optimal conditions, encompassing the sum of operational, to-be-built, in-construction, and pipeline projects. Getting to 2050 targets is even more challenging than reaching 2030 targets, given the sustained and increased commitment that this requires.

For 2030, the pre-construction projects as well as announced pipeline projects still confront substantial uncertainties. Rising financing and supply chain costs facing the sector is making permit holders reevaluate the project financial viability of currently awarded but not constructed projects, leading to some project suspensions. Furthermore, unconsented and unsubsidized projects could exacerbate the capacity gap by 10 GW/140 GW towards the 2030/2050 OWE targets, considering potential drop-out rates.

In response, strategic measures are needed to facilitate the progress towards these targets. For instance, achieving the UK's 2030 targets necessitates consenting approximately 14.4 GW of capacity by end-2024, complemented by annual CfD auctions of no less than 7.3 GW before 2026. Overall, achieving national 2030 targets will be quite challenging. A key prerequisite is the need for governments to optimize the tendering and approval procedures. Government-led pre-tender development endeavors - e.g., in the Netherlands - have been proven effective in accelerating development cycles. This is therefore recommended for all countries.

5.4 Negative bids will have profound implications on the offshore wind economics.

Four categories of negative subsidy are defined within this study. In the case of UK Round 4 leasing, seabed leasing fees may constitute over a third of the project's life-cycle revenue, leading to a raise of the investment cost and the LCOE by a comparable proportion. Similar scenarios are observed in Germany and Denmark's tenders. Perceived as an additional burden for developers, large up front or early project payments have also raised concerns within the industry that such practices might inevitably benefit larger and financially resilient companies.

The emergence of offshore wind as a significant source of rent for the state, similar to oil and gas franchises, raises questions of the best way to extract this rent and what to do with it. This rent should be extracted in a way that does not jeopardise the achievement of 2030 and 2050 targets. It will be a question for individual countries as to whether this rent is collected for the purposes of general tax revenue, returned directly to all or a subset of electricity consumers via reduced electricity bills or hypothecated towards supporting decarbonisation more generally.

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