REPORT

OFFSHORE WIND SUBSIDIES IN THE EU, NORWAY, AND THE US

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Foreword

Menon Economics, commissioned by NHO, has carried out an analysis of the state of public support programmes for green technologies in Europe and the USA, in view of recent changes to the respective subsidy regimes. The study, which is the third in a series of three reports, focuses on the offshore wind industry. The series also covers the battery and hydrogen industries.

The Inflation Reduction Act has been hailed as one of the world's largest subsidy programs for green technologies, having significantly improved investment profitability across industries in the USA. This public support programme prompted the EU to respond quickly, relaxing existing state aid rules and allowing Member States more flexibility to provide state aid. The analysis delves into the public support programmes in both regions and examines their implications on investment profitability.

The analysis was led by Jonas Erraia. The analytical team consisted of Piotr Śpiewanowski, Einar S. Wahl, Henrik Foseid. Even Winje provided quality assurance.

Menon Economics is a research-based analysis and advisory company at the intersection of business economics, economics, and industrial policy. We offer analysis and advisory services to companies, organisations, municipalities, counties, and ministries. Our main focus is on empirical analysis of economic policy, and our employees have economic expertise at a high scientific level.

We thank NHO for an interesting project. We also thank all interviewees for their valuable input during the process. The authors are responsible for all content in the report.

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Executive summary

Offshore wind energy deployment is undergoing a significant expansion, with a remarkable annual growth rate of 20 percent. As a result, its contribution to national energy mix is rapidly gaining importance. Furthermore, the significance of offshore wind power is expected to surge even higher in the future due to the scarcity of suitable land for renewable energy generation.

Currently, China holds the leading position in the offshore wind industry, accounting for 44 percent of the world's installed capacity, which is equivalent to 25.6 GW. The United Kingdom is the second-largest market, contributing a 23 percent share in the global capacity, followed by several EU countries, which collectively represent 28 percent of the global capacity. As of April 2023, offshore wind projects in the United States and Norway remain largely limited to small-scale initiatives. However, there are expected to be significant increases in the deployment of offshore wind technology worldwide. The EU has announced plans to achieve around 110 GW of offshore renewable generation capacity by the end of the decade, while the US administration has set a target of 30 GW.

Europe's offshore wind growth can be attributed to a wide range of subsidies, with the European Union utilising twelve different instruments. These instruments vary in scope, from supporting research and development to innovation, infrastructure, and wind farm construction. The most crucial support instrument for offshore wind has been the various forms of feed-in-tariffs offered through a competitive process to the lowest bidder. However, as offshore technology costs have decreased, some favourable offshore wind projects in Europe are being built without subsidies.

Looking to the future, the EU is proposing to subsidise all energy projects through two-way contracts for differences, a financial tool that provides revenue stability for electricity generators. This approach aims to support the deployment of renewable energy projects while maintaining cost-effectiveness.

Offshore wind development in the US has been slower compared to Europe, but this could change with the implementation of the IRA for offshore wind projects. This important policy instrument offers additional financial support, with developers having the option of choosing between a production subsidy or an investment subsidy. The IRA builds on an existing mechanism but increases the level of support and extends the period for which support is offered. The production subsidy under the IRA provides a bonus payment of up to 2.9 cents per kWh of electricity generated. However, the preferred subsidy mechanism will likely be the investment subsidy, which has been increased to up to 40 percent of the investment costs under the IRA. This option offers the highest net present value of subsidies of the two choices. The highest level of subsidy will be available only to projects that meet specific criteria, such as the use of domestically produced equipment.

The impact of subsidies on profitability is, however, mitigated by the mechanism used in allocation of land leases. Offshore land leases are assigned through competitive auctions and the net present value of subsidies is taken into account when bidders make their offers.

IRA has also instituted production and investment tax credits for offshore wind equipment manufacturers. This may lead to an increase in equipment production capacity and result in lower costs for operators.

Renewable energy is also supported indirectly through carbon pricing mechanisms that increase the costs of fossil-based electricity and in consequence higher electricity market prices. Such a mechanism (EU ETS) is in place in the EEA which with the prevailing prices of emission allowances contributes to EUR 30 to EUR 75 per MWh higher electricity prices than they would be in the absence of the mechanism. In contrast, carbon pricing mechanisms in the US exist only in some states, and the current levels of carbon prices are significantly lower than in the EU.

Apart from financial support, a transparent and efficient permitting process is essential for the rapid deployment of offshore wind projects. Recently, the EU has taken steps to ensure that renewable energy projects are granted permits in a timely and efficient manner. The EU has agreed to designate one or more "renewables go-to areas" and ensure that the permit-granting processes for renewable energy projects in those areas do not exceed two years. This streamlined process aims to support the deployment of renewable energy projects while maintaining environmental safeguards. In contrast, similar provisions do not exist in the US, where historically permitting processes have been lengthy.

Overall, the effect of the IRA on the Norwegian offshore wind industry is expected to be limited for several reasons. Firstly, the electricity markets in Europe and the US are not interconnected, which means that offshore wind farms in these two regions do not directly compete with each other in the electricity market. Secondly, the difference in subsidy regimes between the US and Europe is relatively small. Thirdly, the offshore wind ambitions in the US are modest compared to the planned growth in other regions.

The implementation of the IRA is expected to positively impact the deployment of offshore wind projects in the US, thereby benefiting European and Norwegian manufacturers of offshore wind equipment. However, the policy's effectiveness could be reduced by local content requirements that favour manufacturers based in the US. To qualify for higher levels of subsidies, there is a gradual increase in the share of local content, reaching 55 percent by 2028. Nonetheless, this provision still allows EU and Norwegian manufacturers to supply 45 percent of the market. After considering both factors, we conclude that the market for these manufacturers would have been considerably smaller in a counterfactual scenario without the IRA.

Furthermore, these provisions may also incentivise Norwegian equipment manufacturers to establish production facilities in the US, allowing them to benefit from production subsidies while complying with local content requirements. Despite the potential negative impact of local content requirements for some European equipment manufacturers, the overall positive effects of IRA due to faster market growth are likely to outweigh these consequences for the majority of European equipment manufacturers.

Finally, the widespread adoption of zero-marginal cost energy sources, such as offshore wind electricity, is expected to impact electricity prices. However, the impact of the IRA public subsidies for offshore wind and other renewable energy on average electricity prices is likely to be modest. Studies show that the total effect would amount to 5 percent lower electricity prices across US states by 2040.

Introduction

In 2022, the global offshore wind energy capacity increased by about 20 percent, bringing the total capacity to nearly 58 GW. China now accounts for 44 percent of the global capacity, with 25.6 GW installed. The United Kingdom is the second-largest market, with a 23 percent share in the global capacity. The European Union, with a combined capacity of around 16 GW, makes up approximately 28 percent of the global capacity. Germany leads the EU with half of the capacity, followed by the Netherlands, Denmark, and Belgium, which also have significant capacity.[1] As of April 2023, only small-scale offshore wind energy projects are present in the United States and Norway.

The US Department of Energy predicts that the global offshore wind energy capacity will increase to approximately 273 GW by 2031, a nearly fivefold increase from current levels. The EU Member States have recently declared an aim to install around 111 GW of offshore renewable generation capacity by the end of this decade, which is almost twice as much as their original target of 60 GW stated in the EU Offshore Renewable Energy Strategy. The US 2030 target, on the other hand, is set at 30 GW. While Norway has not explicitly set a 2030 target, the government has announced the first competitions for offshore wind, with a total capacity of at least 2.8 GW, including at least 1.4 GW designated for floating wind. [2,3]

Nearly all existing capacity and the vast majority of the planned capacity will be met through bottom-fixed offshore wind. However as there are limited sites suitable for development of offshore wind, it is expected that floating wind technology will gradually increase in importance.

The global expansion of offshore wind energy is accompanied by a reduction in costs. In fact, the levelised cost of electricity for fixed offshore wind has already halved since 2015 and currently stands at around USD 80 per MWh, with a global range of USD 61 per MWh to USD 116 per MWh depending on project-specific factors. According to leading research institutions and consulting firms, the levelised cost of fixed-bottom offshore wind energy is expected to reach an average of USD 60 per MWh by 2030.[4] Unlike fixed offshore wind, there is a lack of comparable data available for floating wind due to the absence of full-scale projects.

Offshore wind has traditionally received subsidies through various variants of feed-in tariff premiums allocated through competitive auctions. As the costs of offshore wind have declined, the level of subsidies offered by governments has decreased accordingly. This has resulted in the emergence of "zero-subsidy bids," in which wind farms compete to sell their electricity at wholesale prices without government subsidies. To date, more than 2.5 GW of zero-subsidy capacity has been successfully bid into European offshore markets. Similarly, recent auctions of offshore lease areas around New York, North Carolina, and California have generated over USD 5 billion in revenues for the US authorities.

The rest of the report is organised as follows. In the next section we briefly outline the differences between the EU and US subsidy regimes for offshore wind energy. Subsequently, we provide details of subsidy regimes in US under IRA as well as summarise the subsidy programmes available to offshore wind in Europe. Finally, we touch upon the possible consequences of the subsidy regimes for the Norwegian offshore wind industry.

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[1] *https://wfo-global.org/wp-content/uploads/2023/03/WFO_Global-Offshore-Wind-Report-2022.pdf*

[2] *https://www.regjeringen.no/no/tema/energi/landingssider/havvind/sorlige-nordsjo-ii/id2967231/*

[3] *https://www.regjeringen.no/no/tema/energi/landingssider/havvind/utsira-nord/id2967232/*

[4] *https://www.energy.gov/sites/default/files/2022-09/offshore-wind-market-report-2022-v2.pdf*

A brief introduction to public support for green technologies

Public support programs play a crucial role in promoting emerging technologies or industries that offer public benefits but are faced with market barriers. The production and implementation of renewable energy, for instance, require public subsidies to offset the cost differential between these alternatives and fossil fuels. As technology matures, the amount of subsidies needed to bridge the gap decreases. Although US and EU take in general different in determining the value of subsidies for most industries, in the case of offshore wind, the two regions do not differ much in practice. This is due to auction mechanisms utilised in the two regions to determine either the level of subsidy or the gross prices of land lease in EU and US respectively.

In the **United States**, federal support programs such as the Inflation Reduction Act (IRA) offer fixed levels of subsidy for net-zero technologies. These subsidies can take the form of direct payments per unit produced for production subsidies or a fixed percentage of investment costs for investment subsidies. Although the level of subsidies may differ among technologies and change over time, they are pre-determined and do not account for potential changes or factors that could affect regional differences in project profitability. While this approach has the benefit of low administrative burden, it carries a high risk of over- or under-compensation. However, this issue is not applicable to offshore wind. This is because offshore land leases are allocated through a competitive auction, thus the received price reflects the (expected) value of electricity generation at the leased site taking into account the eligible subsidies.

Public support programs for green technology in **Europe** are generally more complex and fragmented than in the US. While the IRA subsidies primarily focus on mass deployment of green technologies, the main objective of EU programs has traditionally been research and innovation. This distinction is in part due to the European Union's strict state aid rules, which aim to prevent unfair competition between Member States. These regulations require that state aid must not unduly distort competition in the single market and must be necessary and proportionate.

Furthermore, state aid rules in the EU allow Member States to allocate funds proportionally to the funding gap, or the difference between the total costs of a project or investment and the amount of private funding available to finance it. While this approach is complex for most products and services, it is far easier in the case of commodities with well-functioning markets as in the case of electricity. In such instances, the quantity of state aid required to bridge the funding gap can be established through a competitive auction. These auctions are widely used across EU Member States, where competitors vie to offer the lowest subsidy required to initiate the project. The auction mechanism guarantees the required profitability for the supported projects, thus minimising the amount of public funding required to achieve the national goals of renewable energy deployment.

Indirect support for green technologies can also be facilitated through the adoption of different carbon pricing mechanisms. These policies raise the costs of using fossil fuel-based technologies, but not for their environmentally friendly counterparts. When fossil-free products compete with fossil-based technologies in the electricity market, such policies can result in higher market prices, which ultimately favour green energy producers.

When it comes to carbon policies, the EU and US have adopted different approaches. The EU has implemented the world's largest emissions trading scheme (EU ETS), where carbon prices can soar up to EUR 100 per tonne of CO_2. This implies that electricity generated from gas and coal would incur additional costs of over EUR 30 per megawatt-hour (MWh) and over EUR 75 per MWh, respectively.[5] Conversely, the US does not have a federal carbon pricing policy in place, although some states have implemented various forms of carbon pricing. However, these policies are generally established at significantly lower levels than those currently witnessed in Europe.

When comparing subsidy schemes across different regions, it is important to understand that the objective of industrial policy is not solely to maximise the value of public support, and subsidies are not the primary determinant of investment decisions. There are various reasons for this. Firstly, subsidies can differ significantly in their design, making some easier to obtain or more extended than others. Secondly, investment decisions are influenced by multiple factors beyond just subsidies, such as local production costs, resource and labour availability, and expected demand. Thirdly, if subsidies surpass the necessary level to incentivise the desired production, they become inefficient, and taxpayers bear the additional cost.

However, the relative size of subsidies still plays a role since, all else being equal, companies aim to maximise their profits and may select regions with higher subsidies to locate their production facilities. Therefore, while subsidies should not be the sole factor considered, they can significantly impact a company's decision-making process.

[5] *Extrapolated from EU Commissions estimates presented in https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_5202. The actual levels of emissions and thus emission costs vary between individual power plants.*

IRA and the offshore wind industry

Offshore wind has been on the US government's agenda for several years. In March 2021, the Biden administration announced targets for offshore wind deployment in the US. In this context, a goal of installing 30 GW of offshore wind in the US by 2030 was presented.[6] For 2050, the Biden Administration has set a target of 110 GW. Although not as ambitious as the EU goals, it still marked a change in US attitude towards offshore wind production, which has lagged far behind European countries.

The IRA has reinstated the investment tax credits and production tax credits that where available for renewable energy producers who constructed their facilities before 2022. The credits have also been enhanced in several ways. Firstly, a provision that previously reduced credits by 40 percent will not continue. Secondly, new provisions have been introduced to increase the subsidies if certain criteria are met by the operators. Additionally, the IRA has instituted production and investment tax credits for offshore wind equipment manufacturers. This may lead to an increase in equipment production capacity, resulting in lower costs for operators.

Brief introduction to the IRA

IRA is the largest investment in green energy in US history. The legislation was signed into law by President Biden on 16 August 2022. It provides incentives to accelerate the green transition in the US, with USD 369 billion allocated for investments in energy security, renewable energy, and zero-emission technologies. The incentives include tax credits and subsidies for production in areas such as renewable energy, carbon storage, hydrogen, zero-emission fuels, batteries, and electric vehicles.

The IRA reflects the US administration's commitment to achieving a green transition and positioning the United States as a major producer of renewable energy and green technology. Additionally, the Act supports the US's ambition to reduce dependence on China and Asia for critical minerals and components, with some subsidies requiring US content or production within the country.

Within the offshore wind sector, IRA includes public support to both developers of offshore wind projects and manufacturers of equipment for offshore wind projects. It is crucial to note that subsidies provided to project developers can also have an impact on equipment manufacturers, and vice versa. The following chapters outline the key elements of the IRA that affect these two groups.

Offshore wind – direct subsidies

Under the IRA, offshore wind operators can choose between two kinds of subsidies. The first is production tax credits (PTC), which is a direct subsidy per unit of energy produced. This subsidy has been in place for some renewable energy sources, including wind, since 1992.[7] The second is investment tax credits (ITC), which is a subsidy granted in proportion to the investment cost. Both the ITC and the PTC are provided as direct tax relief in the form of a tax credits. This is not a deduction from taxable income, but rather a direct deduction from tax

[6] *https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/*

[7] *https://sgp.fas.org/crs/misc/R43453.pdf*

payable. The tax credits do not in practice differ substantially from a direct cash payment, as the IRA introduced the possibility to transfer unused credits to an unrelated taxpayer in the exchange for cash.[8]

IRA increases the level of subsidies available to offshore wind developers. IRA reinstates investment and production tax credits for offshore wind facilities under the Internal Revenue Code sections §45 (PTC) and §48 (ITC), which had expired December 31st, 2021, extending those provisions to 2032.[9,10] In addition IRA enhances the tax credits by implementing two provisions that enable options for higher subsidies.

In Table 1 we summarise the magnitude and requirements of the above-mentioned provisions for investment and production tax credits.

Table 1: Most important provisions under IRA subsidising offshore wind facilities

Type of support	Subsidy	Requirements
Electricity produced from certain renewables resources (§45) / Clean Electricity Production Credit (§45Y)	0.52 cent per kWh (2022 USD) produced over 10 years. Adjusted for inflation.	
	2.6 cent per kWh (2022 USD) produced over 10 years. Adjusted for inflation.	Wage requirements and use of apprentices.
	Increased by 10 percent if: - *Local content* - *Energy community*	If local content requirements are met **or** located in an energy community. Can be stacked.
Energy Credit (§48) / Clean Electricity Investment Credit (§48E)	6 percent of investment cost.	
	30 percent of investment cost.	Wage requirements and use of apprentices.
	Additional 10 percentage points if: - *Local content* - *Energy community*	If local content requirements are met **or** located in an energy community. Can be stacked.

[8] *https://www.taftlaw.com/news-events/law-bulletins/how-the-inflation-reduction-act-changes-the-way-energy-tax-credits-are-calculated-and-monetized*

[9] *Starting in 2025, the tax credits for electricity produced from certain renewable resources will be replaced by new technology-neutral credits under section 45Y and 48E for all zero-emission electricity generation. However, the transition in 2025 does not change subsidies for the offshore wind industry, as this technology is already included in the existing provisions. These tax credits are set to be phased down over a 3-year period after 2032 or when U.S. power sector greenhouse gas emissions decline to 25 percent of 2022 levels, whichever occurs later.*

[10] *The reinstatement of these credits also discontinued the reduction in credits that are in effect for wind farms constructed between January 2017 and December 2021, as this was supposed to be a down phasing period before the supposed end date in 2021.*

The production tax credit base level has been reinstated to 2.6 cents per kWh (2022 USD), for the first 10 years of electricity generation. As production tax credit was being phased down before IRA, a wind production facility constructed today receives 66 percent more base credits than a similar facility constructed in 2021 would have.[11,12]

In addition to reinstating the production tax credit, the IRA implemented two new requirements, and two options for higher subsidies. The additional requirements implemented are the use of apprentices[13] and wage requirements.[14] If these are not met, the credits are reduced by 80 percent. The two options for higher subsidies both constitute a possible ten percent increase to the base credits. The first option is a local content bonus. The local content bonus for offshore wind facilities requires wind turbines to be constructed from iron and steel products produced in the United States, and that manufactured products must satisfy a domestic content threshold of 20 percent, which gradually increases to 55 percent in 2028. The second option requires the wind farms onshore substation to be located in an energy community according to IRS guidance.[15] If requirements and options for higher subsidies are met, the total production tax credit amount to 3.1 cent per kWh (2022 USD).

The investment tax credit base level is 30 percent of investment costs.[16,17] This is much higher than before IRA when investment credits were being phased down and a facility constructed in 2021, which would have received tax credits only for 18 percent of investments costs.[18] The investment tax credits are also subject to an 80 percent decrease, after the ratification of IRA, if the use of apprentices or wage requirements are not fulfilled. The two options for higher subsidies are also attainable for recipients of investment tax credits. If the facility meets the local content requirements, the producer receives an additional 10 percentage points of ITC. The same is true for locating the onshore substation of the facility in an energy community. This means that the ITC for offshore wind producers may cover up to 50 percent of investment costs. The investment tax credits and production tax credits both have clauses that make them mutually exclusive to the offshore wind producer.

The net present value of subsidies under the two schemes is affected by the load factor of wind turbines and total capital expenditure (CAPEX) of a windfarm. A higher load factor and lower capital expenditure increase the viability of choosing production tax credits, while the opposite is true for investment tax credits.

In Figure 1 we show estimated amount of subsidies garnered through investment tax credit compared to the production tax credit at different load factors. However, the figure does not include differences in capital costs between the two modes of project financing. Subsidy payment in the early project phase through ITC reduces project risk and thus lowers the cost of capital.

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[11] *https://www.taxnotes.com/research/federal/usc26/45*

[12] *https://www.taxnotes.com/research/federal/usc26/45Y*

[13] *Apprenticeship requirements are "total labour hours of the construction, alteration, or repair work with respect to such facility is equal to 15 percent and performed by qualified apprentices".*

[14] *Wage requirements are "wages at rates not less than the prevailing rates for construction, alteration, or repair of a similar character in the locality as determined by the Secretary of Labor"*

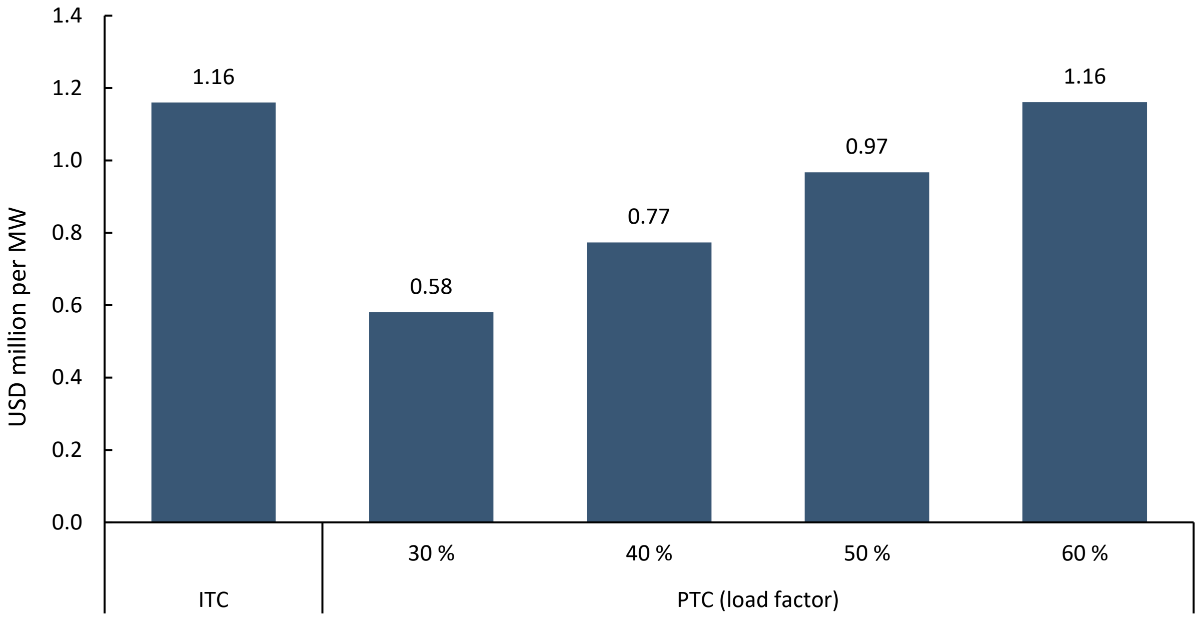
[15] *https://www.lw.com/admin/upload/SiteAttachments/IRS-Clarifies-Rules-for-Energy-Community-Bonus-Tax-Credits.pdf*

[16] *https://www.taxnotes.com/research/federal/usc26/48*

[17] *https://www.taxnotes.com/research/federal/usc26/48E*

[18] *https://www.energy.gov/sites/default/files/2023-04/eere-wind-weto-funding-taxday-factsheet-fy23.pdf*

Figure 1: Subsidies per MW of capacity for ITC and PTC



On Figure 1 we assume a CAPEX of USD 2.9 million per MW of capacity and a conservative 5 percent discount rate to account cost of capital in real terms.[19] Under those realistic assumptions the net present value of subsidies under ITC equals USD 1.16 million per MW. For the subsidies received through PTC to match that level, the load factor would need to reach 60 percent, which is unrealistic for an offshore wind farm. Thus, ITC is the preferred subsidy regime for offshore wind farms.

Those calculations have been carried out with the assumption that wage, use of apprentices and local content requirements are met. Hence, it is optimal for offshore wind producers to choose investment tax credits instead of the production tax credits at the present time. However, as offshore wind production is still not a fully mature technology, it is likely that the capital expenditures are going to be reduced over the coming years, and load factors may increase as the platforms can be located in more wind-exposed areas. This will change the net present value of the two credits and may lead to PTC being more profitable than the ITC.

Indirect subsidies

American offshore wind producers can also benefit from indirect subsidies. IRA introduced subsidies for offshore wind equipment manufacturers. Furthermore, some states introduced carbon policies benefitting all producers of zero-emission electricity.

Equipment manufacturers

Similar to offshore wind farm developers, equipment suppliers to offshore wind farms have the choice between either an investment tax credit or a production tax credit. In Table 2, we summarise the magnitude and requirements of these credits.

[19] *https://guidetoanoffshorewindfarm.com/wind-farm-costs*

Table 2: Provisions under IRA subsidising offshore wind equipment manufacturers

Type of support	Support	Requirements
Qualifying Advanced Energy Project Credit (§48C)	6 percent of investment cost in new or upgraded factories.	Application based.
	30 percent of investment cost in new or upgraded factories.	Application based. Wage requirements and use of apprentices.
Advanced Manufacturing Production Credit (§45X)	PTC per unit of produced offshore wind component. Subsidy varies between components, see Table 3.	Production must take place in the USA (no wage or use of apprentice requirements).

The Qualifying Advanced Energy Project Credit (§48C)[20], is an investment subsidy available to equipment manufacturers who construct new, or upgrade existing, factories. This subsidy can be granted at either a 6 percent or 30 percent level, depending on whether wage and apprenticeship requirements are met. It's worth noting that the ITC under section 48C is granted through a competitive application process and awarded to the projects that demonstrate the highest level of commercial viability, domestic job creation, and net impact in avoiding or reducing air pollutants or greenhouse gas emissions. The subsidies will be available until its budget of USD 10 billion is depleted. However, these USD 10 billion are not exclusively designated to offshore wind equipment producers but also include other low-carbon technology producers, such as fuel cells, CCS, and other advanced energy property designed to mitigate greenhouse gas emissions.

Certain manufacturers of wind equipment have the option to choose the Production Tax Credit (PTC) instead of the Investment Tax Credit (ITC) through the Advanced Manufacturing Production Credit (§45X) [21] under the IRA. Unlike the ITC, which is application-based, the PTC is available to all equipment manufacturers. The amount of subsidy provided varies depending on the component. The PTC under this provision provides subsidies for produced units until the end of 2032, with a gradual reduction of subsidies by 25 percentage points per year starting in 2030. Table 3 below list the eligible components and the amount of production subsidy provided per MW of installed capacity of the wind turbine for which the component is designed. The percentages in the table are approximations of how large these subsidies are in relation to the 2022 cost of the parts.[22] A requirement to receive this type of production support is that the production must take place in the United States. However, there are no requirements related to wages, use of apprentices or local content.

[20] *https://www.taxnotes.com/research/federal/usc26/48C*
[21] *https://www.taxnotes.com/research/federal/usc26/45X*
[22] *https://guidetoanoffshorewindfarm.com/wind-farm-costs*

Table 3: Components subsidised under Advanced Manufacturing Production Credits (§45X)

Component	Subsidy per MW installed capacity	Estimated share of production costs
Turbine blade	USD 20 000	39 %
Nacelle	USD 50 000	10 %
Turbine tower	USD 30 000	35 %
Foundation (bottom fixed)	USD 20 000	6 %
Foundation (Floating)	USD 40 000	Unknown
Offshore wind vessel	N/A	10 % of sales cost

CO_2 Emission Allowances and Renewable Portfolio Standards

Offshore wind electricity is produced at close to zero marginal cost, whereas the market prices are set by the system-wide marginal producers, which in the US are typically fossil-fuel based power plants. As a result, policies that increase the costs of fossil-based electricity production can indirectly support the growth of renewable electricity.

One notable example of such policies is the implementation of carbon pricing mechanisms that impose costs for CO_2 emissions. However, there are currently no federal-level carbon pricing policies in place in the US. Several states, such as California and those in the Northeast,[23] have implemented their own carbon pricing mechanisms. California has a full-scale cap and trade system that is comparable to the EU Emissions Trading System (ETS), albeit covering fewer sectors than its European counterpart. Currently, the carbon price in California is below USD 30 per tonne of CO_2,[24] which translates into a cost increase of approximately USD 10 per megawatt-hour (MWh) for electricity produced from gas (assuming a 50 percent efficiency) and about USD25 per MWh for electricity produced from coal (assuming a 40 percent efficiency).[25]

The Regional Greenhouse Gas Initiative (RGGI) is another market-based initiative undertaken by multiple north-eastern states to cap and reduce CO_2 emissions from the power sector.[26] In the latest auction, the RGGI carbon price was USD 12.5 per tonne of CO_2,[27] which translates into a cost advantage of about USD 4 per MWh for zero-emission energy sources compared to gas and about USD 10 per MWh compared to coal energy sources.

Furthermore, some states have implemented Renewable Portfolio Standards (RPS), which require a certain percentage of electricity sold by utilities to consumers to come from renewable sources. This has given rise to the formation of markets for renewable energy certificates (RECs) that also benefit zero-emission sources. Multiple factors determine the pricing of RECs. RECs issued in already low-carbon grids are typically cheaper than those in areas with a high fossil energy predominance.

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[23] *Those states are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia.*

[24] *https://carboncredits.com/carbon-prices-today/*

[25] *Extrapolated from EU Commissions estimates presented in https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_5202 The actual levels of emissions and thus emission costs vary between individual power plants.*

[26] *https://www.rggi.org/program-overview-and-design/elements*

[27] *https://www.rggi.org/auctions/auction-results/prices-volumes*

Finally, it's worth noting that there exist several federal clean air power sector programs aimed at reducing air pollution, particularly sulphur dioxide (SO_2) and nitrogen oxides (NOx).[28] These programs also benefit renewable energy, particularly in regions with a high share of coal-based electricity generation.

Offshore wind auctions in the US

Leasing and development of offshore wind energy resources in the United States is managed by The Bureau of Ocean Energy Management (BOEM). BOEM's leasing process and activities for offshore wind facilities are designed to promote responsible and sustainable development of the industry.

Since BOEM and its predecessor organisation first published renewable energy regulations in 2009, the agency has conducted 11 offshore wind lease auctions and now manages 27 active commercial leases.[29] In 2022 the agency held 3 auctions, that sold 13 leases. These were the first auctions since 2018 and marked a major step forward for offshore wind power in the United States. The auctions in 2022 also marked a huge increase in the price of leases, as the areas in the New York Bight sold for a combined USD 4.37 billion or USD 2.3 million per km^2 or approximately USD 0.8 million per MW capacity. This compares to a price of 0.3 million per km^2 in 2018. The other auctions in 2022 where in North Carolina and California, which attained a price of USD 0.7 million and USD 0.5 million per km^2 respectively.

The process of approval for commencing an offshore wind project is very time consuming. An example of this are the five lease areas outside of California that were auctioned off in December 2022. Starting from the BOEM's initial request for interest in 2016, it took close to seven years before the relevant auctions. Moreover, before construction can commence, the lessee is required to undergo a site assessment and submit a construction and operations plan to the BOEM. In reality, this means that the entire process, from the BOEM's announcement of a request for interest to the start of construction, can span over a decade. Such a prolonged and burdensome regulatory process has raised concerns among investors and has been perceived as a deterrent to capital investment in the industry.[30] The IRA did not implement any changes to offshore lease areas. However, BOEM has taken note of the overly burdensome process and did in the start of 2023 announce some reduction in regulatory procedures, as well as establishing a more frequent announcement of future leasing schedules.[31]

An important effect of the lease auctions is that they act as a counterweight to potentially excessive subsidies. If the PTC and ITC subsidies described above exceed the funding gap, competitive bidding by developers will put upward pressure on the lease prices, hence mediating the effect of subsidies. In addition to the mediating effect on subsidies, the auctioning process leads to only the most efficient producers ending up with producing, as they will have the potential to out-bid other operators.

Another important factor that affects the price of lease areas is that individual states have issued differing offshore-wind-specific procurement goals. This means that some states are willing to arrange mechanisms that offer price stability for offshore wind operators through power purchasing agreements and offshore renewable energy certificates. The fixed price guaranteed under both contracts tend to expose the contract parties to less

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[28] *https://www.epa.gov/power-sector*

[29] *https://www.klgates.com/BOEM-Proposes-Regulations-to-Improve-Offshore-Wind-Lease-Auction-Processes-and-Project-Development-Timelines-1-20-2023*

[30] *https://www.klgates.com/B OEM-Proposes-Regulations-to-Improve-Offshore-Wind-Lease-Auction-Processes-and-Project-Development-Timelines-1-20-2023*

[31] *https://www.regulations.gov/document/BOEM-2023-0005-0001*

risk of wholesale electricity price fluctuation.[32] The price of lease areas is higher if they deliver energy to states that are willing to procure long term agreements for energy from offshore wind at higher prices. This might be one of the reasons for the exceptional high prices of the New York Bight areas, as New York has set substantial goals for the procurement of offshore wind energy.[33]

[32] *https://www.nrel.gov/docs/fy22osti/78951.pdf*

[33] *https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/NY-Offshore-Wind-Projects*

Public support for offshore wind industry in the EU

The EU Member States have recently declared an aim to install around 110 GW of offshore renewable generation capacity by the end of this decade. To speed up deployment the European Commission uses twelve different instruments.[34] Those instruments vary and scope ranging from support of research and development to innovation, infrastructure, and construction of wind farms. The most important support instrument for offshore wind have been various forms of feed-in-tariffs offered through a competitive process to the lowest bidder. However, as the costs of offshore technology have progressively decreased, more offshore wind projects in Europe are being built without subsidies.

An essential factor for the rapid deployment of offshore wind is a transparent and efficient permitting process. Recently, the Member States of the European Union have agreed to designate one or more 'renewables go-to areas' and ensure that the permit-granting processes for renewable energy projects in those areas do not exceed two years.[35] In addition, renewable energy in Europe benefits greatly from carbon pricing mechanisms that increase the costs of fossil-based electricity. Since fossil-based electricity is typically the marginal producer setting market prices, this leads to higher prices for renewable energy producers. Currently, with the prevailing prices of emission allowances, electricity prices are EUR 30 to EUR 75 per MWh higher than they would be in the absence of the mechanism.

Offshore wind – direct subsidies

State aid for offshore wind in the EU is awarded by individual Member States according to common EU guidelines - EU Guidelines on State Aid for Climate, Environmental Protection and Energy (CEEAG).[36] CEEAG, revised in February 2022, generally allow for aid amounts covering up to 100 percent of the funding gap where aid awards are based on competitive bidding. The aid may be awarded in technology-specific auctions.

The highly recommended and soon-to-be obligatory approach for public support in the energy sector is through two-sided contracts for differences (CfD), which are awarded via competitive auctions. This proposal was recently put forth in the March 2023 reform of the EU electricity market design. As per the proposed rules, this mechanism should be applied to all public support for new investments in infra-marginal and must-run renewable and non-fossil electricity generation, including offshore wind. Additionally, Member States will be mandated to redirect any excess revenues to benefit consumers.[37] Two-sided CfDs will fully replace other auction mechanisms that were commonly used in the previous decade to support offshore wind and other renewable energy sources. Those mechanisms included as one-sided contracts for differences[38] and feed-in-tariff premium.[39]

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[34] Those are Horizon Europe, EU Innovation Council, EU Innovation Council, LIFE – Clean Energy Transition sub-programme, European Maritime Fisheries and Aquaculture Fund, BlueInvest, Innovation Fund, Cohesion policy funds, Connecting Europe Facility – Transport, Connecting Europe Facility – Energy, InvestEU Fund, Modernisation Fund, Renewable Energy Financing Mechanism

[35] https://www.consilium.europa.eu/en/press/press-releases/2022/12/19/repowereu-council-agrees-on-accelerated-permitting-rules-for-renewables/

[36] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022XC0218(03)

[37] https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1591

[38] A one-sided contract for differences is a financial agreement between a renewable energy producer and a buyer that guarantees a minimum price for the electricity produced over a specified period. If the market price exceeds the agreed price, the energy producer receives the market price.

[39] A feed-in-tariff premium is a type of incentive for renewable energy production where a premium is added to the existing feed-in-tariff (typically the spot price) for each unit of renewable energy generated.

In the context of renewable energy production, a two-way CfD is a financial tool to provide revenue stability for electricity generators. It involves a contract between a generator and a public entity, usually the State, that sets a strike price for the electricity produced. The generator then sells the electricity in the market and settles with the public entity the difference between the reference price and the strike price. This ensures that the generator receives a stable revenue for the electricity it produces, while also limiting its revenue when market prices are high. In a two-way CfD, if the market price is lower than the strike price, the generator receives the difference; if the market price is higher than the strike price, the generator pays back the difference. At the same time the mechanism can guarantee maximising value of the electricity produced not only maximising the volume produced.

According to the new rules, price will continue to be the lead criterion for allocating public support to wind energy projects, but not the only one. The European Commission decided to allow for up to 30 percent of non-price-based criteria to be introduced to national auctions.

One reason why individual Member States are willing to contract offshore wind is due to the Renewable Energy Directive of 2018 which established an EU-wide binding renewable energy target of at least 32 percent by 2030. In March 2023, EU through its REPowerEU plan provisionally agreed to increase this binding target to 42.5 percent with ambition to reach 45 percent. REPowerEU would almost double the existing share of renewable energy in the EU, bringing the total renewable energy generation capacities to 1 236 GW by 2030.

We present the outcomes of historical auctions and recent regulations in Norway, Sweden, Germany, Denmark, and France later in a separate section later in this document.

Indirect subsidies

EU Emissions Trading System

The EU Emissions Trading System (EU ETS) is the largest carbon pricing mechanism in the world. It sets a cap on total emissions of greenhouse gas emissions in certain sectors in the European Union, including the power sector. Power plants within the scope of the EU ETS need to surrender one emission allowance for each tonne of CO_2 they emit, with allowances being auctioned or allocated for free by Member States. The EU ETS encourages the use of low-carbon technologies, such as offshore wind energy, by increasing the costs associated with emitting CO_2. This incentivises electricity producers to increase investment in renewable energy sources, like wind or solar. The higher market prices for fossil-based electricity resulting from the EU ETS lead to increased revenues for offshore wind producers.

The prices of allowances in the ETS change depending on carbon market fundamentals, policy and regulatory developments, market participants' behaviour, external factors, and market sentiment and investor confidence. The market price has recently surpassed 100 EUR per tonne of CO_2. According the EU Commission, this increase in price has resulted in an additional cost of 30 EUR per MWh for gas-powered electricity generation and over 75 EUR per MWh for coal-powered generation, due to the emissions intensity of fossil-based electricity production.[40] However, it's important to note that the pass-through of these prices to electricity prices is not

[40] https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_5202 The actual levels of emissions and thus emission costs vary between individual power plants.

complete and estimated at about 60 percent.[41] The pass-through is expected to be lower for wind-weighted electricity prices, i.e. the prices that the wind producers receive on average. Those are typically lower than the average market price, due to correlation in production levels caused by regional wind conditions.[42]

Subsidies to equipment manufacturers

Equipment for offshore wind is considered a strategic net-zero technology and as such the industry is eligible for state aid. In the recently established Temporary Crisis and Transition Framework manufacturing plants can receive in certain regions up to 35 percent of the investment cost covered by state aid if state aid is necessary to cover the funding gap. For Norway the maximum allowed state aid intensity ranges between 15 and 20 percent. According to the Net Zero Industry Act, the EU aims at equipment manufacturing production capacity to cover at least 40 percent of the needs of offshore wind deployment in the EU. This goal, however, does not seem overly ambitious, as of 2023 around 40 percent of towers, 30 percent of nacelles and 15 percent of blades deployed globally are produced in the EU, a region that have about 28 percent share in global offshore wind capacity.

Temporary Crisis and Transition Framework

On March 9, the European Commission introduced new measures, to further accelerate investments in key sectors for the transition towards a net-zero economy, enabling investment support for the manufacturing of strategic equipment including batteries. This was done by extending and re-diverting the "*Temporary Crisis and Transition Framework*" (TCTF). The new rules apply also to EEA countries including Norway[43] and are applicable until 31 December 2025.

The first possibility of increased state support in the TCTF is increased freedom for Member States to design schemes where companies can receive aid to green tech production facilities. This aid is to be capped at a certain percentage of investment costs, which is a function of the company size, as well as the location of the project as shown in Table 4. According to the latest regional state aid map, the areas that qualify for regional aid as "c-regions" cover 25 percent of Norway's total population.[44] The Norwegian state aid map does not specify any "a-regions".

Table 4: Maximum state aid amount and state aid intensity under the Temporary Crisis and Transition Framework.

	Maximum amount			Maximum intensity[45]		
	Non-assisted areas	c-regions[46]	a-regions	Non-assisted areas	c-regions	a-regions
Large enterprises	EUR 150 million	EUR 250 million	EUR 350 million	15 %	20 %	35 %
Medium sized enterprises	EUR 150 million	EUR 250 million	EUR 350 million	25 %	30 %	45 %
Small enterprises	EUR 150 million	EUR 250 million	EUR 350 million	35 %	40 %	55 %

[41] *For example Fabra and Reguant (2014)*

[42] *The gap between average electricity and wind-weighted electricity prices is set to increase with increased wind capacity.*

[43] *https://www.eftasurv.int/state-aid/state-aid-rules-ukraine-crisis*

[44] *https://www.eftasurv.int/newsroom/updates/esa-approves-norways-regional-aid-map-2022-2027*

[45] *Calculated as nominal aid amount / eligible costs.*

[46] *A regional aid map can be found here: https://competition-policy.ec.europa.eu/state-aid/legislation/modernisation/regional-aid/maps-2022-2027_en*

In addition, Member States can grant even higher aid intensities if the aid is provided via tax breaks, loans or guarantees.

Moreover, in exceptional cases, where there is a real risk of investments being diverted away from Europe, Member States are now allowed to offer public support exceeding aid intensity thresholds shown above. In such situations, Member States may provide either the amount of support the beneficiary could receive for an equivalent investment in that alternative location (the so-called 'matching aid') or the amount needed to incentivise the company to locate the investment in the EEA (the so-called 'funding gap') whichever is the lowest.[47] The new regime allowing matching subsidies, which can be either cash or tax breaks, will be open until 2025. Subsidies for approved projects can run for longer time periods. This rule applies only to investments taking place in assisted areas. Large parts of Norway classify as assisted areas due to low population density.

However, the single market concerns mentioned earlier remain in place. National authorities are required to assess the specific risks of the investment not taking place within the EEA and the potential risk of relocation from other EEA countries before granting state aid. As a result, the process is likely to be time-consuming and administratively complex. Moreover, the decision to award state aid to projects is at the discretion of individual EEA Member States, and each application must be approved by both the national government and the European Commission. This results in considerable uncertainty regarding the availability of state aid for projects seeking funding.

Net Zero Industry Act

On March 16th, the European Commission put forward the Net Zero Industry Act (NZIA), which aims to ensure that the EU has the necessary production capacity to meet 40 percent of its deployment requirements for strategic net-zero technologies by 2030. The prosed definition of strategic net-zero technologies covers several technologies within the hydrogen value chain, including electrolysers, fuel cells, and carbon capture and storage.

The Act also proposes improvement in conditions for investment in net-zero technologies by reducing the administrative burden and simplifying permit-granting processes to increase planning and investment certainty. The Act also proposes to improve the use of already existing public support schemes, without providing new funds.[48] The Act incorporates a novel concept of "net-zero strategic projects," which will be accorded priority status to facilitate expeditious permitting processes. These projects may be regarded as being of overriding public interest for permitting purposes, subject to fulfilling the conditions enshrined in EU law. One of the main objectives of this provision is to accelerate the deployment of renewable electricity projects, which is a crucial step in overcoming one of the primary barriers to scaling up green hydrogen production.

The Act encompasses provisions targeted at the development and implementation of education and training programs to reskill and upskill the workforce required for net-zero technology industries. These provisions are designed to ensure that the industry has access to the necessary skills and expertise for a sustainable future. Additionally, the European Commission has introduced the Critical Raw Materials Act, which aims to enhance access to vital minerals necessary for the mass production of green technologies, including batteries.

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[47] *https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1563*
[48] *https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1665*

Europe's offshore wind landscape: National strategies and subsidised projects

Level of deployment of offshore wind varies significantly between the European countries. While Germany and Denmark have in total installed over 10 GW of offshore wind capacity, in many other countries with long coast lines such as Norway, Sweden or France, offshore wind is still in its infancy. This is likely to change, however, in this decade as all those countries have announced ambitious plans.

Historically offshore wind has been subsidised through various variants of feed-in tariffs and feed-in premiums in line with the past versions of the CEEAG. As the costs of the technology decreased increasing number of projects have been commenced without state support. However, as already mentioned, the financing mechanism is likely to change in the future as the European Commission proposes that all renewable energy projects in the future should be subsidised through two-way CfDs. This mechanism is already in use in a number of countries.

Norway

The Norwegian government has ambitions of allocating areas for 30 GW of offshore wind generation by 2040. In late March of 2023, the government announced the first competitions for the areas Sørlige Nordsjø 2 and Utsira Nord. The winner of the first round will be announced later in 2023.[49]

The Norwegian government has announced that they plan to primarily allocate offshore wind generation areas through an auction based two-sided CfD. However, specific requirements and details are still pending final approval from the government. The Norwegian government has emphasised the necessity of state aid or subsidies for developing offshore wind at Utsira Nord, where floating offshore wind solutions are the only relevant alternative. Despite their high costs and complex structures, it is the only realistic alternative when considering the water depths in the given area. The Norwegian government has stated their readiness to provide state subsidies commensurate with the political significance of a successful offshore wind delivery.[50]

As of today, however, only small scale and demonstration wind farms have been commission in Norway, as summarised in Table 5.

Table 5: Offshore wind farm projects in Norway with site exclusivity year after 2018. Source: 4COffshore

Name	Revenue Mechanism	Site exclusivity year	MW	CAPEX (EURm)
TetraSpar Demonstrator - Metcentre	-	2018	3,6	18
Hywind Tampen	-	2020	91,5	434
SeaTwirl S2	Research Grant	2020	1	6
FLAGSHIP - Metcentre	-	2020	11	35

While both the **SeaTwirl S2** and **FLAGSHIP – Metcentre** have received site exclusivity, they are yet to be realised.

[49] *https://www.regjeringen.no/en/aktuelt/regjeringen-gar-videre-i-sin-satsing-pa-havvind/id2949762/*

[50] *https://norway.dlapiper.com/en/news/norwegian-government-implements-next-steps-new-offshore-wind-industry*

Germany

The German government has set a goal for 2030 of reaching a total installed capacity of 15 GW for offshore wind energy installations. To achieve this goal the European Commission has approved, under EU State aid rules, a German operating aid scheme to further develop offshore wind energy generation in Germany. The new scheme will have a total budget of EUR 1.5 billion and will replace the earlier scheme approved in 2017.[51]

The amendment has increased the targets for installed capacity of offshore wind energy installations and introduced a new tender procedure for different types of sites in the German Exclusive Economic Zone. This new tender procedure, referred to as an 'open door'-procedure, allows bidding for sites that have not been centrally pre-investigated by the German government. The introduction of this procedure is expected to increase and speed up offshore wind development.[52, 53]

The aid is paid as a market premium that is obtained on top of the market price for the electricity. The premium is a gliding premium: it corresponds to the difference between a reference value and the market price of the electricity. [54] The market premium is calculated by subtracting a reference market price from a strike price. If the market premium results in a negative value, the market premium is set to zero.[55] Jensen et.al.[56] refer to the support regime as a one-sided CfD.

The current regime in Germany struggles to cope with zero subsidy bids and high electricity prices. As a result of steep learning curves, standardisations and economies of scale, there has been a steep decline in costs, resulting in zero-subsidy bids which were not foreseen in the market one-sided regime.

The table below lists the current offshore wind farm projects in Germany with tender year starting in 2018 that has been approved. The listed projects are supported through a one-sided CfD.

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[51] *https://commission.europa.eu/news/state-aid-commission-approves-modified-german-support-scheme-offshore-wind-energy-2021-03-29_en*

[52] *https://www.cleanenergywire.org/factsheets/german-offshore-wind-power-output-business-and-perspectives*

[53] *https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7836*

[54] *https://ec.europa.eu/competition/state_aid/cases1/202117/287664_2269643_173_2.pdf*

[55] *https://www-gesetze--im--internet-de.translate.goog/eeg_2014/anlage_1.html?_x_tr_sl=de&_x_tr_tl=en&_x_tr_hl=de&_x_tr_pto=wapp*

[56] *https://www.nrel.gov/docs/fy22osti/78951.pdf*

Table 6: List of offshore wind farm projects in Germany with site exclusivity year starting in 2018. Source: 4COffshore

Wind Park Name	Site exclusivity year	MW	Revenue per MWh (EUR)
Kaskasi	2018	342	46,6
Arcadis Ost 1	2018	257	46,6
Borkum Riffgrund 3	2018	913	0
Gode Wind 3	2018	253	81
Baltic Eagle	2018	476	64,6
Windanker	2021	300	0
North Sea Cluster - Nordsee Two	2021	433	0
Gennaker*	2019	927	-
North Sea Cluster - Gode Wind	2021	225	0
Wikinger Süd	2018	10	0

All projects awarded through a one-sided CfD.
** Unspecified revenue mechanism*

The German offshore wind project Borkum Riffgrund 3 was the first large-scale offshore wind project to be awarded with bids of 0 Euro per MWh. This was made possible by several one-cost drivers, including the installation of highly efficient wind turbines, good site conditions and high wind speeds, and anticipated revenue stabilising corporate purchasing power agreement (CPPA) with corporates. In fact, five auctions with nearly 2GW of total capacity ended up with zero bids since 2018.[57]

Denmark

Denmark has been on the forefront of offshore wind development and holds the record for the longest history of tenders for offshore wind generation worldwide. The establishment of the first offshore wind farm in Danish waters dates back to 1991, off the coast of Vindeby. Today, Denmark has successfully built and operated 13 offshore wind farms.

In 2005, Denmark initiated its first competitive offshore wind energy auction for Horns Rev. Subsequently, eight more auctions were conducted, resulting in approximately 3.2 GW of project capacity. Over time, significant changes have been made to the auction process, which is determined through a political procedure involving the national parliament. In the early auctions, single-item sales with fixed sizes were common, and the permitting procedure included free access to the seabed. The Danish Energy Agency is responsible for managing the auctions and granting permits for research, construction, and operation. Since 2010, no support has been provided during hours of negative spot prices. The support level awarded to successful bidders is now paid out as a two-sided Contracts for Difference (CfD). Additionally, all auctions use static sealed-bid formats with 'pay-as-bid'[58] pricing.[59]

The Renewable Energy Act of Denmark was introduced in 2009 and contained schemes to promote development of wind farms on land and offshore. For offshore wind, the provisions generally apply to turbines that are

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[57] *https://orsted.com/en/media/newsroom/news/2021/12/20211201449611*
[58] *In a sealed-bid 'pay-as-bid' auction, auction participants pay their reported demand for each unit they obtain, without knowing other participants bids. https://www.odyssee-mure.eu/publications/policy-brief/auctions-energy-efficiency-res.html*
[59] *https://www.nrel.gov/docs/fy22osti/78951.pdf*

installed following a tender process. In addition to tenders, one could up until February of 2023, obtain permits for construction and operation of offshore wind farms in Denmark through the so-called 'open door' procedure.

Under the open-door procedure, a licence application would be submitted on the project developer's own initiative. The open-door procedure provided the developer with greater flexibility than it else would have, giving them the opportunity to choose the location and capacity of the farm, with a fixed premium of 25 øre/kWh on top of the market price.[60] However, the Danish Government chose to put a hold on the open-door scheme in February of 2023 due to concerns about its compatibility with EU state aid rules and regulations.[61]

The table below illustrates the two projects given site exclusivity after 2018 in Denmark. In relation to the construction of the largest wind farm in Denmark yet – **Thor** – the Danish Government rolled out the use of two-sided CfDs which will guarantee a stable settlement price for power generated by the farm. The winning bidder was awarded a 20-year contract through the scheme, and the strike price will be adjusted annually to keep up with changes in the electricity prices. This was the first auction with a negative subsidy. The strike price was set at EUR 0.01 per MWh and the generator pays back the difference between the market price and the strike price until the agreed cap of EUR 372 million is met.[62] The **Aflandshage** project was granted site exclusivity in 2019 and is awarded through the Danish open-door scheme.

Table 7: Offshore wind farm projects in Denmark with site exclusivity year after 2018. Source: 4COffshore

Name	Revenue Mechanism	Site exclusivity year	MW	Revenue per MWh (EUR)
c*	Two-sided CfD	2021	1000	Negative subsidy
Aflandshage	Variable feed-in premium	2019	266.5	N/A

** 0,01 EUR in revenue per MWh*

Sweden

Sweden is a major renewable energy producer and one of the largest net exporters of energy in Europe. In 2021, Sweden had a total 12 GW of installed capacity from roughly 4 700 wind turbines. In 2021 alone, Sweden installed 2 GW of new wind energy capacity.[63] Most of the wind power installed is land based, with just under 200 MW of installed offshore wind capacity. As of April 2023, the Karehamn offshore wind farm, commissioned in 2013, is Sweden's last commissioned offshore wind farm. Sweden has not run any auctions or offered any form of public financial support for offshore wind.[64]

In August of 2022, the Swedish government announced important plans regarding their offshore wind developments. The government has identified three potential areas which is particularly suitable for offshore wind generation. The announcement has resulted in a 15 GW portfolio applying for permits to produce electricity within 2030.[65]

[60] *https://ens.dk/en/our-responsibilities/wind-power/offshore-procedures-permits*

[61] *https://www.europarl.europa.eu/doceo/document/P-9-2023-000385_EN.html*

[62] *https://www.reuters.com/business/energy/denmark-pick-winner-big-offshore-wind-tender-lottery-2021-11-25/*

[63] *https://iea-wind.org/about-iea-wind-tcp/members/sweden/*

[64] *https://windeurope.org/newsroom/news/sweden-making-up-lost-ground-on-offshore-wind/*

[65] *https://w3.windfair.net/wind-energy/pr/41690-windeurope-offshore-sweden-wind-farm-lost-ground-announcement-government-potential-baltic-sea-gigawatts-grid-electricity-net-exporter*

There are several on-going projects in Sweden. However, none of them has been awarded support through an auction mechanism. The projects in pipeline off the coast of Sweden have the potential to yield a substantial power generation. The Swedish Kriegers Flak[66] offshore wind farm project may be the first new offshore wind farm in Sweden, as it has secured a permit, although final investment decision is yet to be made. The project is planned to have 640 MW of installed capacity in close proximity to the Danish Kriegers Flak. The Utposten II offshore wind project secured site exclusivity in 2021 and could yield a production capacity of 500 MW upon completion. The construction of Utposten II is expected to start in 2025.[67] Södra Victoria could be a 2 GW offshore wind farm. Södra Victoria expects to obtain necessary permits in 2024/2025, subject to the permitting process, with expected operation in 2027/2028.[68] The Skåne offshore wind farm project is currently at a concept/early planning stage and received site exclusivity in 2019. The farm is expected to have installed capacity of 1.5 GW.[69]

France

The first offshore wind park in France – Saint-Nazaire – entered service in November of 2022 and has an installed capacity of 480 MW. Right after the park started operation, the French government launched tenders for two new ones. Both tenders are bottom-fixed and will yield a total capacity of 2.5 GW. Developers' application was submitted in February of 2023 and projects will be awarded at the end of 2023 or early 2024. Furthermore, European Commission has recently approved a EUR 2.1 billion scheme for development of a 230-270MW floating offshore wind farm.[70] By 2030, the French government intends to have allocated 20 GW, which translates to 18 GW of operational offshore wind farms within 2035.[71]

The tendering of renewable projects in France was started in 2004 by France National Regulatory Agency. The initial tenders used sealed bids and pay-as-bid pricing. The first two offshore wind tenders in 2011 and 2013 were awarded feed-in-tariffs with 20 years support duration, implying that all electricity produced is paid via power purchase obligations through EDF, which is compensated directly from the state budget.[72]

In 2017, the auction process was modified by introducing a competitive dialogue phase and consultation before the final terms of reference were defined. In addition, the support scheme was changed to a two-sided CfD. Under this new scheme, the offshore wind farm must sell its energy on the market and then receive monthly payments from EDF. The support duration is still 20 years.

The table below summarises the awarded project of the 2017 tender call. As mentioned, there has only been awarded tender call since 2018, where the winning bid was EUR 44 per MWh. The tender had eight prequalified bidders, ranging from 44 EUR per MWh to EUR 61 per MWh.

Table 8: Offshore wind farm projects in France with site exclusivity year after 2018. Source: 4COffshore

Name	Revenue Mechanism	Site exclusivity year	MW	Revenue per MWh (EUR)	CAPEX (EURm)
Dunkerque	Two-sided CfD	2019	598	44	1 400

66 Kriegers Flak refers to a reef located in the Baltic Sea, north of Rügen and south of Skåne.

67 https://www.gem.wiki/Utposten_wind_farm

68 https://www.offshorewind.biz/2021/12/20/rwe-working-on-1-6-gw-offshore-wind-project-in-sweden/

69 https://subscribers.4coffshore.com/dashboard/owf/overview/details.aspx?windfarmid=se56

70 https://ec.europa.eu/commission/presscorner/detail/en/ip_23_284

71 https://windeurope.org/newsroom/news/france-launches-two-new-offshore-wind-tenders-more-needed/

72 https://www.nrel.gov/docs/fy22osti/78951.pdf

Expected effects of the IRA on the Norwegian offshore wind industry

Regional electricity markets are unique in that they often operate in complete isolation from one another. Unlike most markets, changes in electricity production or regulation in one region, such as Europe or the United States, have no immediate impact on the prices or profitability of other regions.[73] This market segmentation restricts the avenues through which changes in investment conditions in one region can impact investment decisions in another region. Nevertheless, there are certain channels through which market spillovers can transpire. Additionally, the market for offshore wind equipment is more interconnected, making it more susceptible to being influenced by regional policies to a greater extent.

Comparison of EU and US public support regimes

Despite differences in public support regimes between the US and EU for offshore wind projects, the overall profitability of these projects is similar once subsidies are taken into account. In the US, there is a fixed threshold for nominal aid, which limits the investment or fixed production tax credit per unit of energy, while the EU has no limits on state aid as long as it is offered through a competitive auction. However, this difference is not likely to be significant in practice, as technological advancements have resulted in cost reductions that have enabled Europe to award subsidies through competitive auctions that are well below the limits set by US rules. In fact, an increasing number of favourable offshore wind projects in Europe are being commissioned with zero-subsidies. In the US, the level of subsidies is effectively determined through a competitive auction, as potential subsidy revenues are factored into the price paid for land lease in a public auction.

One important difference in design of subsidies is that the EU subsidy scheme substantially reduces the costs of capital through risk reduction. The European Commission has proposed a reform to the electricity market design that mandates all public support for new investments in offshore wind and other renewable and non-fossil electricity generation to be in the form of two-way CfDs.[74] This approach provides revenue stability and shields the industry from price volatility significantly reducing risk. However, this proposal is still pending approval by the Member States. In contrast, in the US, the responsibility of offering long-term price stabilising contracts to offshore wind developers falls on individual states or local utilities, with no established guidelines in place. This lack of a standardised approach may result in increased uncertainty and potential risks for offshore wind projects, which could impact capital costs.

Due to higher wholesale electricity prices in Europe than in the US, offshore wind projects in that region require lower subsidies.[75] The difference in electricity prices is predominantly due to higher CO_2 allowance and natural gas prices in Europe. At the same time, investment costs are comparable between Europe and the United States according to reports from the US Department of Energy.[76] However, investment costs are site-specific and vary significantly within both regions.

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[73] *This statement is correct in the short to medium run. In the long run some adjustment take place through reallocation of energy-intensive industry to regions with low- cost electricity increasing demand for electricity and hence price level.*

[74] *https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1591*

[75] *https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0951&rid=5*

[76] *https://www.energy.gov/sites/default/files/2022-09/offshore-wind-market-report-2022-v2.pdf*

Additionally, another significant cost component is the administrative burden and uncertainty associated with the timeline and decision-making process for offshore wind projects. This challenge is significant in both Europe and the United States, although Europe has made strides in simplifying permitting rules and shortening decision times. However, despite the progress made, the administrative burden and uncertainty still remain significant factors that need to be considered when evaluating investments in offshore wind projects in both regions.

The combination of historically more generous subsidies in Europe, along with other favourable factors, has resulted in a faster deployment of offshore wind compared to the US. However, the recent provisions of the IRA in the US, which have increased subsidy levels, along with significant cost reductions in offshore wind technology, are expected to partially offset the less favourable market conditions due to lower wholesale electricity prices. As a result, the deployment of offshore wind in the US is likely to accelerate. Nevertheless, it's important to note that the overall goal of achieving 30 GW of offshore wind capacity by 2030 in the US is less ambitious compared to the combined goal set by the EU Member States.

Implication for electricity prices

The widespread adoption of zero-marginal cost energy sources, such as offshore wind electricity, is expected to have an impact on electricity prices. However, research conducted by Blistine *et al*. (2023)[77] in their modelling of the US electricity system suggests that the impact of the IRA public subsidies for renewable energy on average electricity prices is likely to be modest. The analysis shows that due to these subsidies, retail electricity prices will be lower compared to a scenario without them, with the difference increasing over time as more renewable energy is connected to the grid. However, the impact is projected to remain relatively modest, reaching approximately 5 percent on average across US states by 2040. It is important to note that the analysis includes all provisions of the IRA, not just those specific to offshore wind. There are several reasons for this relatively low impact of renewable energy subsidies on electricity prices that we discuss below.

The magnitude of impact of renewables on electricity prices depends on the scale of deployment relative to the size of the energy system, which varies significantly between Europe and the United States. In the EU, the target generation capacity of 110 GW by 2030 would be sufficient to cover approximately 20 percent of the current EU electricity consumption. On the other hand, the impact of offshore wind deployment in the United States is expected to be smaller, at around 4 percent. This is because the 2030 offshore wind deployment target in the US is less than one-third of that in the EU, while electricity generation in the US is about 60 percent larger than in the EU. There will be, however, differences in the impact of offshore wind on electricity prices in individual countries and regions due to bottlenecks in transmission system between individual countries or subregions. It is, however, uncertain if the deployment goals will be met. In the past permitting has led to significant project delays. Although recently the EU has proposed measures to reduce the permitting time, similar measures have not yet been taken in the US.

Offshore wind is just one of many renewable technologies that will affect prices. According to EU analysis, renewable sources in total are expected to provide more than two thirds of the EU's electricity in 2030. However, fossil fuels are expected to still set electricity prices during a significant number of hours.[78] It is also important to consider the equilibrium between demand and supply when assessing the impact of offshore wind energy expansion on pricing in the market. This requires taking into account electricity demand, which is expected to

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[77] *Bistline J., Mehrotra N. and Wolfram C., (2023), Economic Implications of the Climate Provisions of the Inflation Reduction Act, Brookings Papers on Economic Activity.*
[78] *https://energy.ec.europa.eu/system/files/2023-03/SWD_2023_58_1_EN_autre_document_travail_service_part1_v6.pdf*

rise significantly in the coming years despite improvements in energy efficiency. The push for electrification in various sectors is anticipated to outpace the reduction in demand resulting from efficiency gains. To put the growth of offshore wind energy in Europe into perspective, the projected capacity by 2030 would be insufficient to meet the electricity requirements for achieving the European Commission's goal of producing 10 million tonnes of hydrogen alone, highlighting the magnitude of anticipated electrification in multiple sectors.

Implication for the Norwegian offshore wind industry

IRA provision on offshore wind energy in the US is expected to have limited impact on the potential of the Norwegian offshore wind industry for several reasons. Firstly, the electricity markets in Europe and the US are not interconnected, which means that offshore wind farms in these two regions do not directly compete with each other in the electricity market. Secondly, the difference in subsidy regimes between the US and Europe is relatively small. Thirdly, the offshore wind ambitions in the US are comparatively modest compared to the planned growth in other regions.

Faster deployment of offshore wind in the US may have, however, some indirect effect on the Norwegian offshore industry. One potential mechanism is through access to capital. Higher global demand for capital for financing offshore wind can lead to higher capital costs, especially for the less profitable projects. This is not likely to be a problem in the short run as most auctions in Europe are oversubscribed.

Accelerating the deployment of offshore wind energy in the US may indeed contribute to some extent to technological advancements and cost reductions. However, despite this anticipated acceleration, the US will likely remain relatively modest in terms of global scale, with projected electricity generation reaching around 30 GW in 2030, accounting for just over 10 percent of the anticipated global capacity. As a result, the impact on technological progress is not expected to be significant.

The IRA provision is expected to have a positive impact on European and Norwegian offshore wind equipment manufacturers by enabling rapid deployment of offshore wind projects. However, this effect may be mitigated by the local content provisions embedded in the regulations, which favour US-based manufacturers, particularly for equipment, through substantial production subsidies. The local content requirements in the US are capped at 55 percent, which still leaves a significant portion of the market for products produced in the EU and in Norway. Without the IRA, the market for these manufacturers would have been much smaller in a counterfactual scenario.

Nevertheless, these provisions may also incentivise Norwegian equipment manufacturers to establish production facilities in the US, allowing them to benefit from production subsidies while complying with local content requirements. Despite the potential negative impact of local content requirements for some European equipment manufacturers, the overall positive effects of IRA due to faster market growth are likely to outweigh these consequences for the majority of European equipment manufacturers.

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