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REPORT

Offshore Wind Deployment in Germany

Facts and Policy Lessons (update June 2020)

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This paper has been produced with the support of a program of the German Federal Ministry for Economic Affairs and Energy (BMWi) to facilitate its energy policy dialogue with the United States and other countries. Responsibility for the content lies exclusively with the authors. BMWi does not necessarily share the views expressed in this paper.

Suggested Citation

Piria, Raffaele; Magdalena Magosch and Jakob Eckardt 2020: Offshore Wind Deployment in Germany. Facts and Policy Lessons. Berlin: adelphi.

Imprint

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Photo credits:	Senvion int, 62M152 (Wikimedia Commons) CC BY-SA 4.0
Status:	April 2019, largely updated in early June 2020

Introduction

The **United States are beginning offshore wind deployment from a favorable position**. They can take advantage of **technology learning, economies of scale**, and **cost reductions achieved in Europe** during the last two decades. In addition, they benefit from **policy learnings** in a field where trial and error is costly, and an urgent transition to a more sustainable energy supply system is needed.

This paper aims at providing an introductory overview of offshore wind deployment in Germany. It includes an analysis of the trends, challenges and drivers of offshore wind (OFW) deployment in Germany as well as a summary of policy lessons focusing on target setting, support schemes, maritime spatial planning, and grid connection.

This updated version of the paper originally produced for the New England-Germany Energy Transition Forum that took place at the Harvard Law School in Cambridge (Massachusetts) in May 2019 within the framework of the US-German energy policy dialogue. This early June 2020 update comes in advance of a (virtual, due to the ongoing pandemic) delegation trip of US experts in regards to offshore wind deployment in Germany.

Update on 2019-2020 trends and developments for offshore wind in Germany

Most data in the following chapters has been updated in early June 2020. This section provides a summary of trends and new events occurring in the last 12 months, which led to the increase of the German OFW target for 2030 from 15 GW to 20 GW and to the introduction of a 40GW target by 2040.

Pushed by the increasingly tangible effects of climate change and by a strong pressure from public opinion and voters, **climate change raised to the top of the German and European political agenda in 2019**. The German Federal Government supports the plan of the European Commission to **increase the EU's climate targets** from the current goal of at least 40% greenhouse gas emissions reduction by 2030 in comparison with 1990, to a higher level of a 50%-55% reduction. At the same time, Germany also brought forward a strengthening of its own climate and energy policies.

Looking back at the **last decade, Germany's greenhouse gas emissions shrank by 14.5 %**, from 942 MtCO_2eq in 2010 to 805 (provisional data) MtCO_2eq in 2019 (BMU 2020). Most of the reductions were achieved in the energy sector, by far the main source of greenhouse gas emissions in Germany. **Coal power generation in Germany shrank by 35%** from 263 TWh in 2010 to 171 TWh in 2019, **nuclear generation shrank by 47%**, from 141 TWh to 75 TWh and combined gas and oil generation shrank by 2%, from 98 TWh to 96 TWh. In the same timeframe, **renewable energy generation increased by 132%**, from 105 TWh in 2010 to 244 TWh in 2019. Throughout the decade, Germany has been a net electricity exporter (AGEB 2020, ISE 2020).

After an intensive public debate, in **January of 2020 the government adopted a proposal for a coal-exit law**, currently being debated in Parliament. The law proposal foresees the withdrawal of circa 14 GW out of 44 GW of coal capacities by the end of 2022 and a further 13 GW to be withdrawn by 2030, with the rest set to be gone by 2038 at latest (CLEW 2020). In parallel, the **nuclear phase out will be completed** with the gradual shutdown of the last six nuclear reactors (8.5 GW) by the end of 2022.

The **share of renewable generation** in Germany's gross power consumption increased from 17% in 2010 to **43% in 2019**. The government's target is to **achieve 65% by 2030**, and a further strong increase in the following decades. Although the increasingly ambitious **energy efficiency policy framework** is likely to further improve the efficiency of traditional electric appliances, overall power consumption is likely to increase, due to the counteracting effects of electrifying transportation and the heating sector. This creates further **pressure to accelerate the expansion of renewables** and notably offshore wind generation capacities. The recent slowdown of the expansion of onshore wind power was one of the triggers for the German policy makers' **increased attention for offshore wind**.

On **May 11 2020**, the German Federal Government, the five coastal States and the three affected transmission system operators (TSO) signed a **milestone "More Electricity from the Sea" agreement** (BMWi 2020) to **increase the 2030 offshore wind target** (see chapter 2.1 below) from the previously 15 GW **to 20 GW** (BMWi 2020). Taking into account the current 7.5 GW (see chapter 1.3) offshore wind in operation, the MES agreement implies a **massive speed up of deployment** in the coming decade. To overcome the practical, planning (see chapter 2.3), and regulatory (see chapters 2.2 and 2.4) challenges related to this change, the MES signatories committed to providing the financial, human, and material resources for a concerted effort.

On **June 3 2020**, just a few weeks after signing the MES agreement, the Federal Government tabled a **proposal to amend the offshore wind law**, sparking an intense debate among stakeholders and policy makers. The government proposal not only embraces the increased 2030 target, for the first time it sets a **40 GW offshore wind target for 2040**. It further proposes a **reform of the auction system**, opening the possibility for negative subsidy prices, or in other words for project developers to pay for the right of building and operating an offshore wind plan (Tagesspiegel, June 4 2020). Key aspects of the heated debate about this proposal are summarized in the respective sections of chapter 2 below.

In January 2020, Germany took over the rotating presidency of the **North Seas Energy Cooperation** (NSEC), a cross-border cooperation project between ten countries and the European Commission to **coordinate the expansion of offshore wind energy, grid infrastructure, and cross-border power trade** in the North Sea region. In the second half of 2020, Germany will also hold the presidency of the European Council.

Germany seeks to use these roles to move forward joint offshore wind energy projects. One of them is being proposed by the TSO Tennet, whose North Sea Wind Power Hubs project intends to create artificial islands, on which up to 15 GW of wind capacity are to be installed. The islands could potentially be connected to several countries (BMWI 2020a).

Executive Summary

The German experience shows that policy makers need to find the balance between policy adaptability and strategic continuity. German offshore wind policies recently experienced significant changes: a shift from a fixed feed-in tariff to a feed-in premium determined by auctions, and a shift from decentral project development and permitting regime to a centralized pre-development of offshore wind sites by a public agency, including grid connections. However, the continuity of the political consensus on the strategic goals of the German energy transition has helped to create positive framework conditions for large private investments in project development, infrastructure and the supply chain. A constructive collaboration between private sector and policy makers at all levels - from the EU to the local authorities - was essential in achieving the cost reductions that make offshore wind a main resource for the energy transition.

The massive reduction in policy support costs for offshore wind in Germany has been mainly driven by technological progress, economies of scale, competitive pressure through the auction system, and regulatory de-risking. However, the fact that a few bids don't require any subsidies anymore does not necessarily mean that offshore wind deployment investments in general no longer require policy support, especially in regions where the supply chain has to be built and local/regional economies of scale have not yet emerged.

During the early phase of offshore wind deployment in Germany, the grid connection and the permitting regime led to uncertainties, delays, and hence additional costs. Moreover, there was a lack of coordination in offshore grid planning since grid connections were applied for by the individual project developers. The new regime is based on centralized maritime spatial planning coordinated by a federal agency, simultaneously taking into account offshore wind development and grid connections. In this process, economic risks of the offshore wind project investors have been reduced and partly socialized. This policy change has not only improved the prospects of intensive utilization of the scarce German offshore wind resources and reduced the risk of stranded investments, it also contributed to a massive reduction in the required financial support through de-risked project development.

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List of Abbreviations

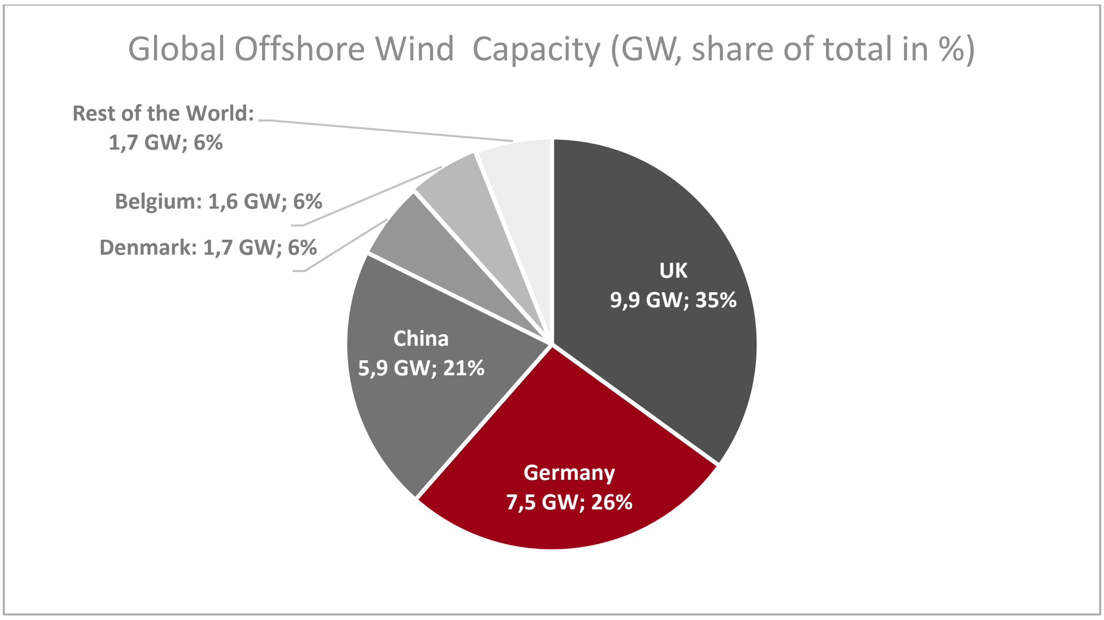
BNetzA	Federal Network Agency (Bundesnetzagentur)
BMWi	German Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie)
BSH	German Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie)
EEG	Renewable Energy Sources Act
EEZ	Exclusive Economic Zone
EU	European Union
FiT	Feed-in Tariff
LCOE	Levelized Cost of Electricity
MES	More Electricity from the Sea agreement of May 11, 2020
MSP	Maritime Spatial Planning
NSEC	North Seas Energy Cooperation
O&M	Operation and Maintenance
OFW	Offshore Wind
R&D	Research and Development
TSO	Transmission System Operator
UK	United Kingdom
US	United States of America

1. Offshore wind in Germany: facts and figures

1.1 Europe and Germany's leading role in offshore wind

Operating 78% of the 28.3 GW global offshore wind capacity, Europe is the leader in the booming global offshore wind (OFW) sector. Germany has the second largest OFW capacity in the world (7.5 GW, 26.5% of the total), behind the UK and ahead of China.

Figure 1: Global Grid-Connected Offshore Wind Capacity, end of 2019



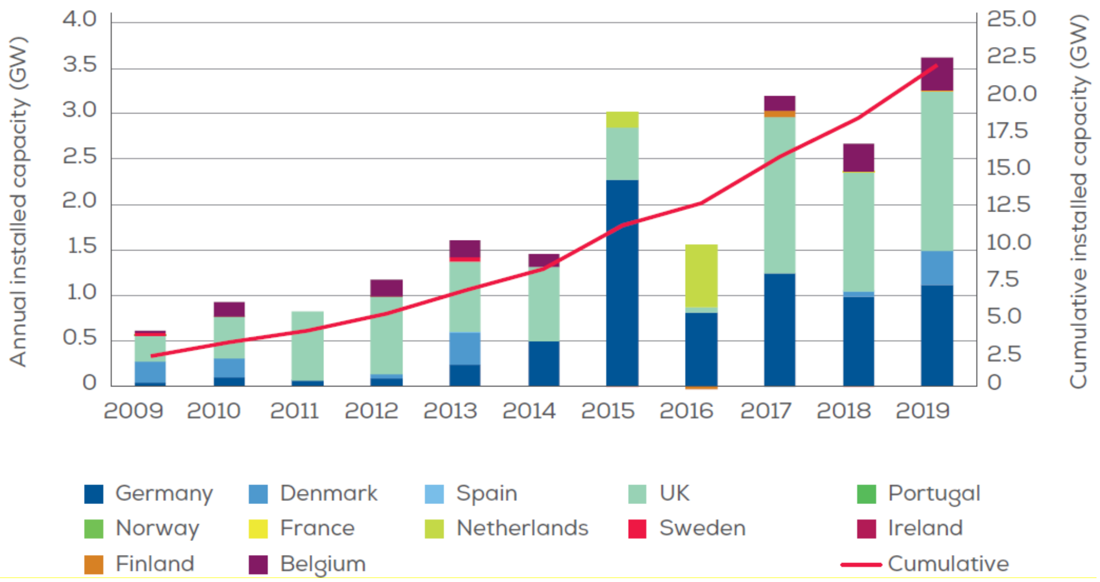
Source: IRENA 2020, own illustration

In 2019, OFW generated 67 TWh in the EU, supplying 2.3% of the EU's gross electricity generation (WindEurope 2020). By comparison, wind including onshore provided 417 TWh/15% and all renewables provided 1166 TWh/34.6% (Agora Energiewende & Sandbag 2020).

77% of all European OFW capacity is currently located in the North Sea (16.9 GW), followed by 13% in the Irish Sea (2.9 GW), 10% in the Baltic Sea (2.2 GW) and less than 1% in the Atlantic Ocean (0.02 GW) (WindEurope 2020a). The first projects in the Mediterranean Sea are currently being developed.

After a pioneering phase starting in the early 1990s, OFW deployment gained momentum at the end of the 2000s. Annual capacity additions exceeded 0.5 GW for the first time in 2009. During the period 2015-2019, average annual additions in Europe were over 2.8 GW, almost half of which was in Germany. For reasons discussed below, OFW deployment in Germany started later than in the UK, the Netherlands, and Denmark, but Germany has been catching up rapidly.

Figure 2: OFW capacity additions, cumulative capacity in Europe by country



Source: WindEurope 2020a

1.2 Specific challenges and drivers in Germany

OFW deployment in German waters faces particularly challenging conditions. Notwithstanding these challenges, a number of reasons explained below soured the German government's attitude toward promoting OFW deployment.

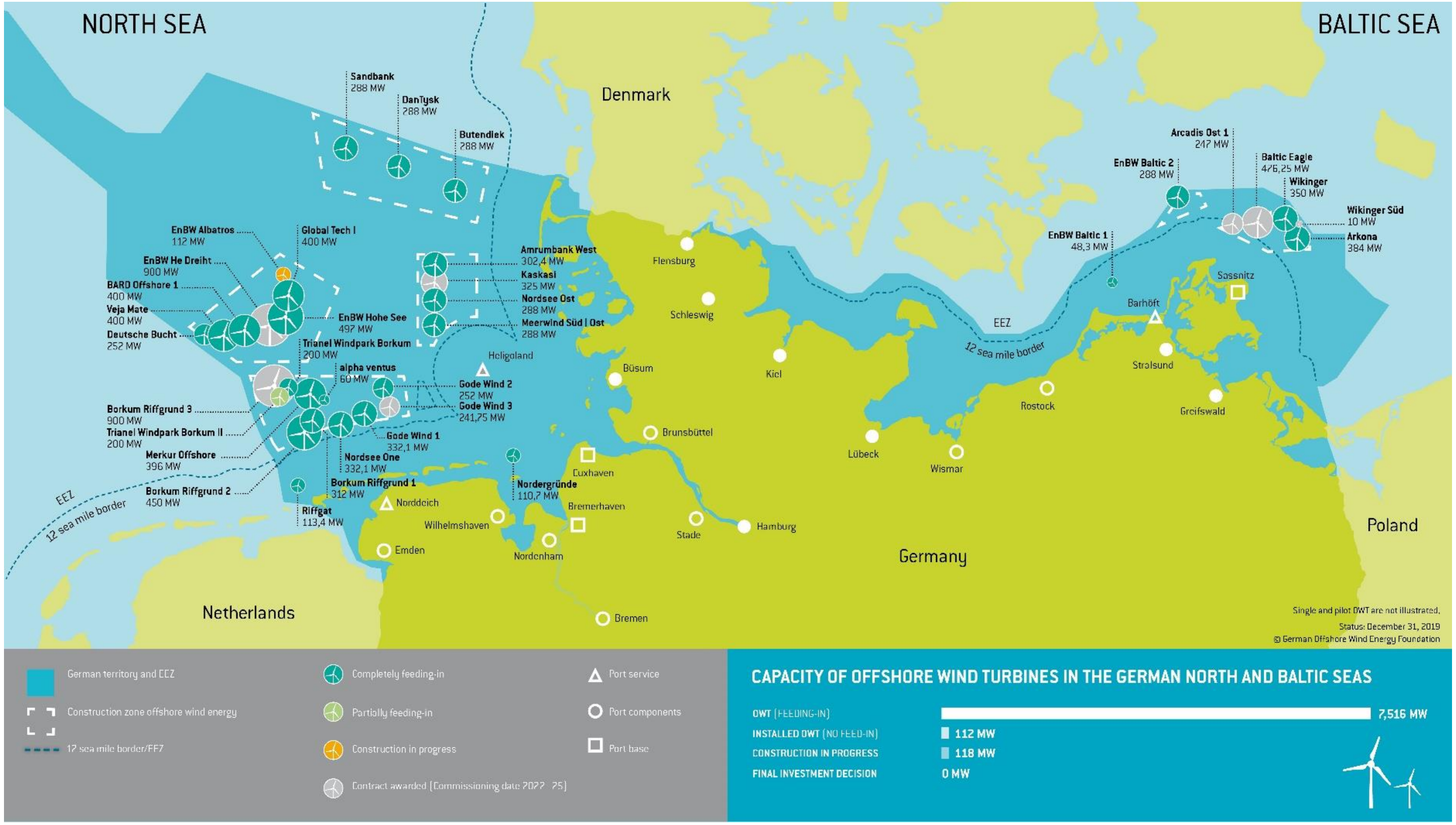
Challenging conditions

OFW deployment in Germany started under more challenging conditions than in other OFW frontrunner countries, amongst them:

- Limited space for OFW development in comparison with the UK, Denmark or the US
- Most potential sites much further from shore
- Deeper waters
- Difficult routing of the cables for shore connection due to national parks
- Particularly challenging maritime spatial planning

An underlying problem is Germany's relatively small exclusive economic zone (EEZ) at sea. Compared to the German land mass, population, and power consumption, the German EEZ is substantially smaller than those of other OFW leading countries. More than 90% of German potential OFW capacity is located in the North Sea (see figure 3). Only a minor share is located in the Baltic Sea, where wind speeds are lower (IWES 2017).

Figure 3: Overview Map of Offshore Wind Energy in Germany, as of December 31, 2019



Source: German Offshore Wind Foundation

Due to the concave form of the German North Sea coast, the German EEZ has a “Duck’s Bill” profile. Nature conservation (Wadden Sea National Park) and waterways rule out OFW development in the areas closer to shore. Even further offshore, OFW deployment is restricted by various competing uses, including existing subsea infrastructure (data and power cables, gas pipelines), military and fishing zones, and sea bed areas contaminated by unexploded munitions from the world wars. On the other hand, most of the remaining surface offers very good wind conditions and water depths accessible for bottom-fixed offshore wind turbines.

Figure 4 shows that Germany’s OFW capacity intensity – defined here as the ratio of the OFW capacity in operation to the EEZ surface on the continental shelf, without taking into account other countries’ oversea territories – is far higher than those of the UK and Denmark. Admittedly, the size of the EEZ on the shelf is only a very rough proxy for assessing the technical offshore wind potential of a country. Nevertheless, the result of this simplified approach aligns with that of a study conducted on behalf of WindEurope on the technical OFW potential of EU countries, which supports the approach (BVGassociates 2017).

The figures in figure 4 suggest that Germany’s offshore wind deployment is subject to different conditions, and show how large the potential in the UK and US may be.

Figure 4: EEZ shelf area and OFW capacities in selected countries, end of 2018

	UK	Germany	Denmark	US
OFW Capacity in operation	8.3 GW	6.4 GW	1.4 GW	0.03 GW
EEZ (only continental shelf, without overseas territories)	207,808 mi^2	21,800 mi^2	39,345 mi^2	294,906 mi^2
Ratio (capacity density)	40 kW/mi^2	294 kW/mi^2	35 kW/mi^2	0.1 kW/mi^2

Source: IRENA 2019, Claus et al. 2014, own calculations

Drivers of OFW deployment in Germany

For the reasons discussed above, during the early phase of offshore wind development, the cost and risk gap between the best offshore and onshore wind resources in Germany was even higher than in other countries such as Denmark and the UK, which were able to start developing their OFW potential in shallow waters and closer to shore. Nevertheless, the energy strategy of the German Federal government had already defined offshore wind energy as one of its top priorities in 2010. Building upon an installed capacity of just 0.06 GW at the end of 2009, it set targets of 10 GW by 2020 and 25 GW by 2030 (see chapter 2.1 below for the subsequent developments on offshore wind targets), and began implementing a set of policies able to trigger largescale deployment.

This focus on OFW has been mainly driven by the following aspects:

- High capacity factors: In 2018, German OFW plants achieved, on average, 40% full load hours, with individual parks ranging between 30% and 52% (ISE 2019). The capacity factors have increased over time thanks to the higher quality of the wind resources farther from shore and to technological advances (IRENA 2018b). By 2022, the average capacity factor of new OFW projects is expected to reach 50% (IRENA 2018a).
- Higher predictability than onshore wind, enabling OFW plants to earn higher revenues on the electricity markets and to become an important provider of balancing power. OFW forecasting is expected to further improve (IWES 2017).
- Technology development, industrial leadership and (regional) economic growth were key drivers for OFW support at EU level, by the German Federal government, the coastal federal states in northern Germany, as well as municipalities. German and European companies are market leaders in both the key technical components (turbines, foundations, subsea cables) and know-how based services such as specialized logistics, transport, and insurance. A significant share of the value chain (assembling large components, installation, grid connection, O&M) is inherently local and thus creates jobs in the regions of deployment, independently of where the components are manufactured. Up to 35% of all labor requirements are in the deployment regions (IRENA 2018a, p.7-8).
- OFW in Germany enjoys higher acceptance than onshore wind. This factor is becoming more and more relevant, as onshore wind penetration has reached significant levels in many European regions with good wind resources. Although the German population's general support for the energy transition, including wind energy in the own neighborhood, remains overwhelmingly high, local opposition is becoming more vocal. Land availability, restrictive permitting rules in some Federal states, time-consuming permitting processes, and frequent legal actions have recently become the main barriers to growth for onshore wind in Germany. (MLU 2014; Piria 2014; Pfluger et al. 2017; FA Wind 2019). The growing difficulties in expanding onshore wind in Germany have been one of the reasons for Germany's May 2020 decision to increase the 2030 offshore wind target from 15 GW to 20 GW.
- Last, but absolutely not least, Germany enjoys a stable, cross-party consensus on ambitious climate targets and on the transition to a power system based on renewable energy sources. Offshore wind's huge technical and economic potentials make it an essential element of all deep decarbonization scenarios for Germany and Europe (Pfluger et al. 2017, EC 2018). Depending on the assumptions, most of the scenarios based on achieving the EU's ambitious climate target for 2050 (80%-95% GHG emission reductions by 2050 relative to 1990) model wind (onshore and offshore) shares around 51%-56% (EC 2018), some of them up to 60%. In Germany, OFW potential is limited by the maritime spatial planning of the Federal Maritime and Hydrographic Agency (BSH). Taking into account this restriction, the technical OFW potential in the German EEZ amounts to 57 GW, able to generate 238-267 TWh per year, depending on technological assumptions (IWES 2017). This corresponds to 47%-53% of net electricity demand in 2018 (IWES 2019). A recent study shows that the productivity (full load hours) of OFW plants can decrease tangibly, if the OFW plants are located too close to each other. This calls for cross-border planning of the countries around the North Sea (Agora Energiewende et al. 2020). Plans for the large-scale production of green hydrogen in the North Sea region are being developed. The high capacity factors of OFW fit well with the requirements of

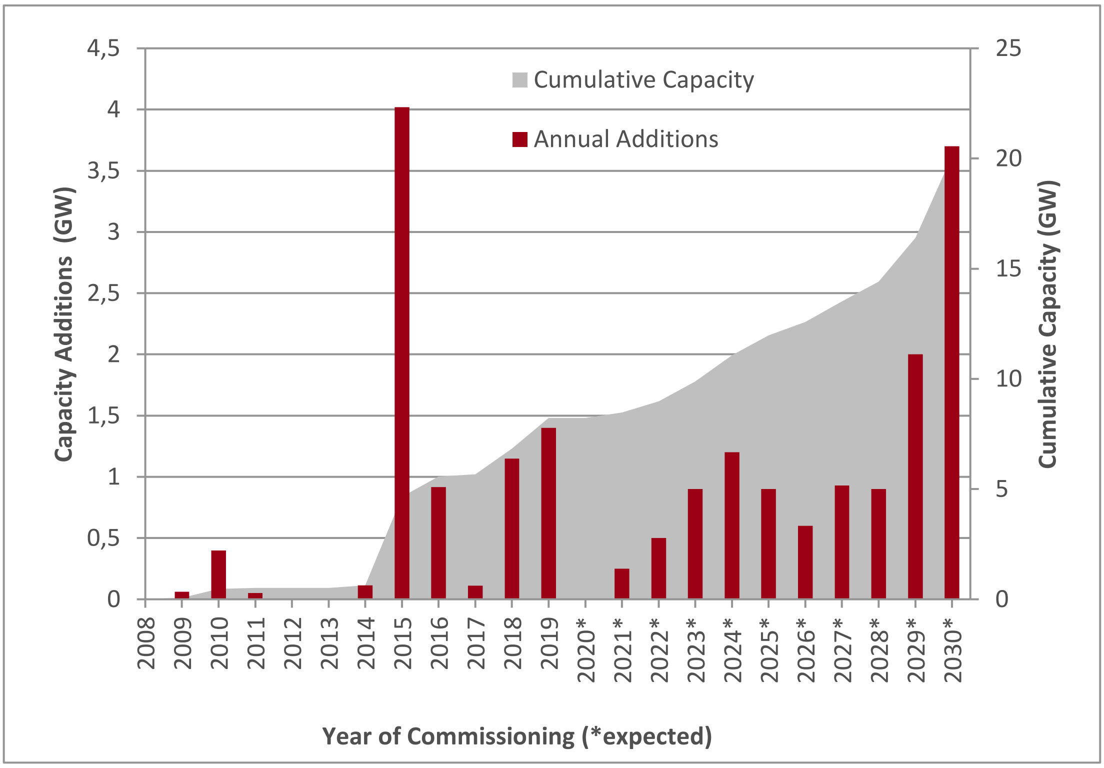
electrolyzers, which can be located onshore close to the landing points of the connection cables, or on artificial islands close to the offshore wind plants.

1.3 Offshore wind deployment and generation

The first test OFW plant in Germany was commissioned at the end of 2009. Just nine years later, total OFW generation capacity in operation reach9d 7.5 GW. Additionally, at the end of 2019, 112 MW turbines had been fully erected, but were not yet operating (Deutsche WindGuard 2020).

The net electricity generation by OFW plants in Germany was 24.4 TWh in 2019 (2018: 18.8 TWh), contributing nearly 5% of Germany's public grid net electricity demand (the latter includes grid losses, but does not include internal consumption by thermal power plants). Similar to onshore wind, OFW in Germany generates roughly 50% more energy in the winter months than in the summer months. The seasonal trend fits well with lower consumption and higher solar generation in the summer (ISE 2020).

Figure 5: Net offshore grid connection capacity in Germany



Sources: Deutsche WindGuard 2020 (*expected commissioning)

Figure 5 shows that at the end of 2019, the net grid connection capacities for present and future offshore wind plants were 8.2 GW, i.e. slightly larger than the 7.5 GW generation capacity already in operation. Concerning the future development, the chart is based on expectations from before the OFW target increased to 20 GW, as decided in May 2020. Its implementation will imply additional offshore grid connection capacities (see chapter 2.4 below).

A further 3.1 GW of generation capacities were awarded in the two tendering rounds of 2017 and 2018 and are expected to be commissioned between 2021 and 2025, which will bring total OFW capacity to 10.8 GW (Deutsche WindGuard 2020).

1.4 Grid expansion and system integration

Germany's best wind resources – both offshore and onshore – are concentrated in the northern part of the country, where a significant share of the hard coal and lignite generation facilities are also located. However, important industrial and population centers with heavy electric loads are in the south.

Thus, the German power system has experienced increasingly frequent north/south bottlenecks, sometimes leading to curtailment of wind plants in the north, expensive balancing requirements in the south, and undesired power flows affecting the grids of neighboring countries. While the federal government and the transmission system operators are pursuing an ambitious grid expansion program, including several additional AC and DC north-south lines, its implementation is proving to be slower than desirable.

OFW deployment in Germany is thus dependent not only on the timely connection of the OFW plants to shore, but also on the successful expansion of the onshore grid and/or on the timely development of alternative flexibility solutions, both domestically and abroad.

Within Germany, the design of the power market has been and is being further adapted to facilitate the usage of existing flexibility and to trigger investment in additional sources of flexibility, including demand response, flexible operation of fossil plants, and storage. In the longer term, the production of synthetic fuels based on electricity will increase power system flexibility and support the decarbonization of the transportation sector.

At the international level, the increasing interconnection capacity between the German power system and Scandinavia, with its large hydropower capacities, is helping to integrate OFW and other variable renewables from northern Germany and other regions in Central Europe. The NordLink 1.4 GW HVDC cable directly connecting Germany and Norway is scheduled to be commissioned in 2020 (TenneT 2019), adding to several connections already existing between Scandinavia and the continent. In 2020, the Combined Grid Solution Project, the world's first connection between OFW plants in two different countries will create an additional interconnection between eastern Denmark and Germany (Energinet 2020).

1.5 Key trends

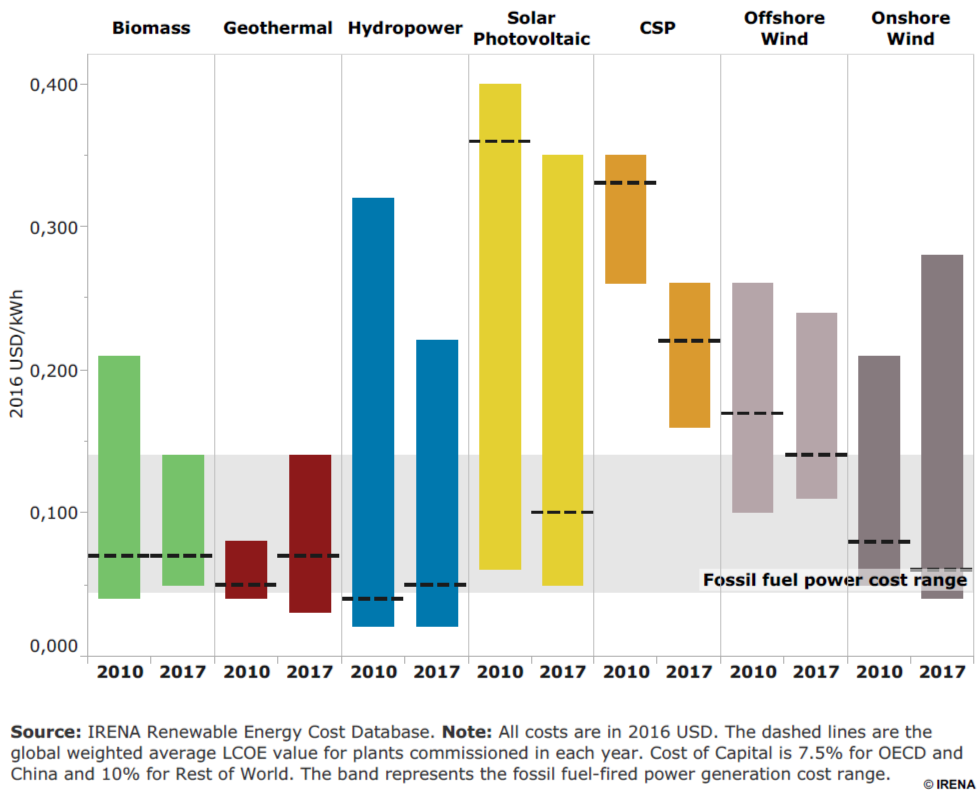
Global trends

As the second largest market for offshore wind at the global level, Germany contributes to shaping, while also being affected by, global industry trends, such as:

- <u>Larger turbines, larger wind farm sites and projects</u> (Wind Europe 2019a, IRENA 2018a) help to reduce costs and trigger economies of scale. German offshore wind parks commissioned in 2018 had an average hub height of 106 m, generator capacity of 7.12 MW and a rotor diameter of 158 m. These properties are expected to increase to 145 m, 13 GW, and 230 m by 2030 and to 165 m, 15 GW, and 240 m by 2050. (Deutsche WindGuard 2018a, IWES 2017).

- Sites tend to be further from shore and in deeper waters. Comparing projects commissioned in Europe in 2018 with those of 2017, this trend was reversed. However, considering the project pipeline in Europe, it will continue in the coming year (Wind Europe 2019a).
- Increasing experience in construction, logistics, O&M, insuring and financing of OFW plants supports the reduction of the levelized cost of electricity (LCOE).
- The rapidly decreasing LCOE (see Figure 6 below) has reduced the cost gap between offshore and onshore wind, and between OFW and fossil generation (IRENA 2018, see Figure 6 below).
- As the best onshore wind resources have already been developed in some countries, increasing climate and energy policy ambitions are leading to more attention being paid to the strategic need to develop OFW potential.

Figure 6: Global LCOE of utility-scale renewable power technologies 2010-2017



Source: IRENA 2018d

1.6 Specific German trends

As seen above, the development of offshore wind in Germany, and similarly in Belgium, is characterized by scarcity of space and particularly intense competition with other usages. This has influenced the regulatory framework (see chapter 2) and contributes, among others, to the following trends:

- The area of permitted and potentially permissible OFW sites is comparably small, but in some cases, there are several sites relatively close to each other.
- As a consequence, OFW in Germany are designed with narrow spacing between turbines, often relatively high turbine specific power, and have considerably higher capacity density (MW/mi^2) than in other countries (Deutsche WindGuard 2018). In the long term, if the entire OFW potential in German waters were developed, the density of turbines may degrade the wind resource, leading to shrinking full load hours (Agora Energiewende et al. 2020).
- Wind parks under construction in German waters in 2018 were, on average, further away from the coast than in other European countries (WindEurope 2018, p. 22).
- So far, there has been little interest in floating turbines in German waters, given the scarce space and water depths accessible to bottom-fixed turbines.

2. Offshore Wind Policies in Germany

This chapter focuses on policies and regulations shaping OFW deployment in Germany: policy targets, the evolution of support schemes, maritime spatial planning, and grid connection.

2.1 Targets

In 2010, the energy strategy of the German federal government defined OFW as one of its main priorities for the first time. Starting from an installed capacity of just 0.06 GW in 2010, it set a target of 25 GW by 2030, followed by an intermediate target of 10 GW by 2020. The main drivers were climate action, technology development and reducing dependency on energy imports.

The rationale for offshore wind was further reinforced by the decision made in 2011 to accelerate the nuclear phase-out. However, in the early 2010s, OFW deployment turned out to be slower and more difficult than expected, while cost reductions had not yet sufficiently materialized. In 2014, the target was reduced to 6.5 GW by 2020 (now over-achieved) and 15 GW by 2030. This goal was the legal basis for the volumes of offshore wind tenders so far.

In October 2019, the Federal Government approved a new Climate Protection Programme for 2030, including an increase of the 2030 offshore wind target from 15 GW to 20 GW. The Programme was approved by Parliament at the end of 2019. Its implementation was confirmed by the MES agreement (BMWi 2020) signed on May 11, 2020 by the Federal government, the five coastal States and the three affected TSOs. It is very likely that the Parliament will approve the increase that is included in the amendment to the Offshore Wind law tabled by the Federal Government on June 3, 2020 (BMWI 2020b).

The law draft also proposes including, for the first time, a 2040 target. With 40 GW, it assumes a further, massive speed up of deployment during the 2030s. Industry and environmental NGOs focusing on climate change welcome the 40 GW target. However, NGOs focusing on (maritime) nature protection are more critical and call for concluding a consultation concerning maritime nature protection, at the beginning of which a range of potential offshore wind deployment in German waters between 28 GW and 50 GW had been set (Tagesspiegel June 2 2020).

2.2 Support schemes

Soft loans/financing schemes

OFW deployment in Germany has been and is being supported by soft loan schemes offered by the state-owned development bank KfW. Its current program supports up to 10 offshore wind projects, each with a loan of up to €700 million ($788 million US) under privileged conditions. The KfW loans can be combined with loans or guarantees from EU funds, federal state government funds, and commercial banks (KfW 2019).

Regional/ local policies

The coastal federal states (Lower Saxony, the Hanseatic City of Bremen, The Hanseatic City of Hamburg, Schleswig-Holstein and Mecklenburg-Western Pomerania) and municipalities have also offered support to incentivize the creation and expansion of local elements of the offshore wind value chain. The support may include investments in public infrastructure, facilitation for spatial planning, training facilities, promoting public acceptance, and direct financial incentives.

Evolution of the main federal support scheme for offshore wind generation

The only offshore wind park online in Germany in 2010 was the 60 MW test plant Alpha Ventus, promoted by a consortium of utilities and accompanied by research institutes supported by public R&D funds. Until then, the feed-in tariff (FiT) had not been sufficient to trigger investments in commercial OFW generation.

Multiple amendments to the Renewable Energy Sources Act (EEG) between 2008 and 2014 gradually increased the FiT for OFW energy up to 15.4 €ct/kWh, at times with an optional increased remuneration model for the first years of operation (up to 19.4 €ct/kWh), offset by a reduction in the following years. The increased FiT was intended to support technological development and included a degression component: the later the projects went online, the lower the remuneration. At times, there also was a differentiation of the FiT according to water depth and distance to shore (SOW 2016). This regime triggered the first generation of commercial OFW plants in Germany.

In 2014, the EEG was reformed from a fixed feed-in tariff staggered according to technologies and other criteria ("produce and forget") to a feed-in premium system: the plant (>1MW) operators received a premium on top of the wholesale electricity market price.

An additional major reform came into force in 2017, affecting renewables in general, and with a focus specifically on offshore wind, based on a new dedicated Offshore Wind Law approved in 2016. Since 2017, the feed-in premium for medium and large-sized renewable plants is no longer determined by law, but by technology-specific tenders. Throughout all EEG reforms, investor protection has been ensured: the plant operators receive the support that was valid at the time of commissioning.

The long fixed feed-in tariff phase from the 1990s through 2014 had been essential to create the investment volumes needed to bring down the costs of renewables in Germany and globally. The 2014 and 2017 reforms reduced the policy costs borne by electricity users, and helped align the operation of renewable plants with the power system's needs by exposing them to wholesale electricity market prices. On the one hand, these reforms significantly increased the economic risks for renewable plants operators. On the other hand, as described in more detail below, offshore wind operators and project developers benefited from substantial regulatory de-risking regarding the liability for connection delays or failures and regarding the maritime spatial planning process from 2013 onwards (see chapter 2.3 and 2.4).

Thus, it is important to note that the very steep reduction in the support intensity for OFW between 2013 and 2018 in Germany is not only a consequence of technological development, cost reductions, and the competitive pressure introduced by the switch to tenders, but also of regulatory de-risking.

Concerning OFW, the 2017 reform introduced:

- a transition period for OFW projects that in August 2016 already held a permit or were in advanced phases of permitting, with planned commissioning in 2021-2025.
- a 'central model' for future projects to be pre-developed by the Federal Maritime Hydrographic Agency, planned to be completed in 2026 or later.

The transition period consisted of two pay-as-bid tender rounds held in April 2017 and April 2018, for 1,550 MW each. The project developers bid for the feed-in premium and a guaranteed grid connection. The premium was granted by 20 year contracts.

Interpretation of the zero support bids in the 2017 and 2018 auctions

In the first round, held in April 2017, the awarded bids ranged from 0.00 to 6.00 €ct/kWh, with a weighted average of 0.44 €ct/kWh. In the second round, held in April 2018 they ranged from 0.00 to 9.83 €ct/kWh with a weighted average of 4.66 €ct/kWh (BnetzA 2019).

There were two reasons for the higher average support in 2018 as compared to 2017. First, there were fewer bids, as the auction was open only to existing projects that had not been awarded in 2017. Second, at least 500 MW had to be awarded to projects in the Baltic Sea, where wind conditions are less favorable. The rationales for the latter were both a more balanced development of the power system, avoiding an excessive concentration of offshore feed-in into the same region, and regional economic development (BNetzA 2018).

The sensational zero support bids attracted global attention and require some elucidation. If the bidders fail to meet financing and construction milestones, and ultimately if they fail to commission the project on time, they lose up to 100% of the 100 €/kW guarantee that they must deposit in advance. This penalty level is certainly high enough to exclude thoughtless bids, but not to exclude strategic bidding and, thus, the risk of awarded projects not being built. The Danish company Ørsted, which in the two tenders was awarded three projects for a total of 900 MW at €ct 0.00, as well as other projects with higher bids (Ørsted 2018), repeatedly declared that they would not build the projects if the macroeconomic environment turned out to be inappropriate (Harman 2018). In fact, the economic viability of the project does not only depend upon macroeconomic and political factors influencing the revenue side, i.e. future electricity prices, such as economic growth, gas, coal and CO_2 prices, coal phase out path and future power market design. It also depends upon assumptions on future reductions in offshore wind technology and construction costs, as the projects do not need to be commissioned before the mid-2020s.

In reality, the company did not bid to construct, but only for an option to construct OFW plants with a timely connection to shore guaranteed by the state and paid for by electricity consumers. The cost of the option is the sum of the penalty, the transaction costs, and the development costs that will have occurred by the final investment decision. The bidders accepted the risk of bearing these costs in exchange for the opportunity to build and run (or later on sell) the project.

This points to one of the main drawbacks of auction systems for renewables deployment. Auction systems with (excessively) low penalty levels have led to high non-built shares. However, (excessively) high penalties may reduce the level of competition, as they may discourage participation in the tenders. They also increase the bid prices, as the developers must price the risk constituted by the penalty. From an energy policy point of view, the risk of projects not being built is particularly problematic in the case of offshore wind, as failed projects can create stranded assets (connection cables) and block the development of scarce sites, which, due to the very long lead times, can remain unused for a long period.

After Germany, zero subsidy offshore bids also occurred in an auction in the Netherlands in December 2017. In this case, the costs for the grid connection are also not borne by the OFW project developer. Moreover, the conditions were particularly favorable, as the Dutch government had committed to phasing out coal power plants and to introducing a carbon floor price, i.e. a minimum price in case certificate prices in the EU Emission Trading Scheme are low (WindEurope 2017).

In conclusion, the massive reduction in policy support costs for offshore wind in Germany has mainly been driven by the cost reductions achieved by technological progress and economies of scale, by the competitive pressure introduced by the auction systems, and by regulatory de-risking. However, the fact that some (few) bids required zero subsidy does not imply that OFW deployment investments no longer require policy support, especially in regions such as the East Coast of the US, where the supply chain still needs to be built and local/regional economies of scale have not yet emerged.

Future auctions under the new 'central model'

The next tendering rounds for offshore wind capacity in Germany are scheduled to take place beginning 2021, for projects that will begin operating between 2025 and 2030.

Unlike the transitional model, project sites eligible under the new 'central model' will be predeveloped exclusively by the German Federal Maritime and Hydrographic Agency (BSH) and not by private companies, as discussed in more detail in the next chapter.

To reflect the substantially higher investment by the public hand, the guarantee that project developers must deposit will double to 200 €/kW. For a 300 MW plant, this amounts to €60 million ($67.5 million). This will further discourage strategic bidding.

The volumes of future tenders will be determined by the difference between the 2030 target and the capacity in operation in 2020. Given the increase of the target decided in 2019-20, it will take some time for the BSH to develop the additional projects. This means that the volume of the tenders is likely to be higher in the second part of the decade.

Current debate on the government's bid pricing proposal of June 3, 2020

Adapting to the increased 2030 OFW target was not the only ground for the law amendment proposal tabled by the Federal Government on June 3, 2020. Another main reason was that the zero support bids submitted in 2017 and 2018 (see above) had not been foreseen by the legislator and made a change necessary. According to the currently still valid legal framework, the lowest bid of the auction of April 2018 (i.e. zero €/ct support) determines the highest allowed bid in future auctions. Consequently, only zero bids could have been submitted in the future. The law proposal of June 3 cancels this clause and introduces decreasing maximum bid values, from 7.3 €ct/kWh for the auctions of 2021 to 6.2. €ct/kWh for the auctions in 2023.

At the same time, in case of more than one zero support bid, the law proposal foresees a second auction round, during which bidders may offer positive sums to obtain the right to build the auctioned OFW plant, which would come close to a concession fee. The offshore wind and electricity sector associations are heavily protesting against this clause. Some companies are considering legal action in case of approval. Their argument is that with the previous reform of 2017 the government had de facto confiscated the rights of project developers on specific projects, to auction them at a later point. In exchange for that, the developers had obtained the right to be awarded the projects by submitting bids at the lowest possible price (Tagesspiegel June 4 2020)

Offshore wind and electricity industry associations also ask for switching the current support scheme to a scheme based on Contracts for Differences, in order to reduce the price risks carried by the project developers, arguing that the deployment speed up implied by the increased OFW targets requires such a de-risking.

2.3 Maritime Spatial Planning

The increasingly intensive utilization of marine space requires strong maritime spatial planning that balances competing uses as well as nature conservation. In Germany, state authorities are responsible for coastal waters (12 nautical miles). The federal government is responsible for maritime spatial planning (MSP) in the EEZ, where, however, nearly all OFW resources are situated. The responsible agency, the Federal Maritime and Hydrographic Agency (BSH), defines priority areas for competing uses such as shipping, sand and gravel mining, fisheries, military, power and telecommunications cables (BSH 2019a).

As OFW began to emerge as a new important use potentially claiming a large part of the EEZ, it took some time before the MSP procedures were adjusted accordingly. Given the fact that the German EEZ is relatively small and particularly crowded (see chapter 1.2 above), the slow introduction of centralized planning contributed to a slowdown in OFW deployment in the early 2010s (see chapter 1.3).

At the beginning of OFW deployment in Germany, the BSH only accepted applications for highly developed projects. Developers had to investigate wind and sea bed resources, as well as potential competing uses and nature conservation concerns, before applying for permission from the BSH. Thus, project developers – who had to plan wind farm capacity and siting individually – faced the necessity of significant investments and high uncertainty before permitting. In some cases, different developers submitted plans within the same or overlapping areas, resulting in early application submission being a decisive factor for approval (Deutsche WindGuard 2018a). This regime increased the risk of stranded (project development) investments. Moreover, it did not allow for efficient use of scarce OFW resources.

A first step in substantiating MSP in terms of more specific sectoral planning for OFW purposes was the introduction of the *Spatial Offshore Grid Plan* 2013/14, updated for 2016/17. It defined the siting of transformer platforms and subsea cable corridors or routes. For the first time, this was conducted in a centralized and coordinated manner, reducing the risk of stranded investments (see chapter 2.4).

In 2017, concurrent with the switch to auctions (see chapter 2.1), the Wind Energy at Sea Act marked a profound change in MSP towards a ‘central model’, integrating OFW deployment and offshore grid planning. Since 2017, the BSH has been responsible for the development, specification, and preliminary investigation of OFW areas (BSH 2019c). In its *Site Development Plan*, the BSH now spatially and temporally defines OFW development areas. This includes determining specific OFW sites and clusters and timing the development and construction of OFW capacities at each site, as well as siting transformer platforms and routing grid connections. The criteria include existing and planned grid connections, proximity to the coast, cost-efficient power generation, and account for the energy and climate goals of the federal government (BSH 2019c).

The next step is a preliminary investigation of the defined sites, commissioned by the BSH via public tenders on behalf of the German energy regulator, the Federal Network Agency (BNetzA). BSH decides on the suitability of a site examining environmental, subsoil, wind and oceanographic conditions (BSH 2019d). The results of these investigations, including a strategic environmental assessment, are made available to the participants of the competitive tenders (see chapter 2.2).

According to the MES agreement signed in May 2020 (BMWi 2020), BSH will update the Site Development plan by the end of 2020, in order to accommodate the accelerated deployment needed to achieve the increased 2030 OFW target. The Federal Government and the coastal states committed to speed up the planning and approval procedures.

Summing up, maritime spatial planning has been adapted to the ambitious OFW deployment targets of the federal government. Under the new regime, a federal agency, the BSH, coordinates the allocation of sites for OFW deployment with coherent planning of OFW generation and grid expansion. The BSH has taken over activities and risks that were previously carried by individual project developers. Hence, this system change not only improved the chances of intensive usage of German OFW resources and reduced the risk of stranded investments. It also de-risked OFW project development, thereby potentially contributing to a further reduction in the required financial support.

2.4 Grid connection

In the early phase of OFW deployment in Germany, the timely synchronization of OFW plant construction and grid connection proved to be one of the main challenges. Over the years, the regulatory regime has evolved to address this issue.

Since 2006, the two transmission system operators (TSOs) operating the grid along the North Sea and the Baltic sea coasts have been responsible for planning, constructing and operating the connections from the offshore transformer stations to the main onshore grid. The TSOs pass the costs on to electricity consumers via grid charges.

Prior to 2013, OFW project developers could only claim a grid connection after reaching an advanced stage of completion. The TSOs were obliged to deliver the connection within 30 months, but were often not able meet this deadline (BMWi n.d.). Reasons for the delays included supply chain limitations and lack of experience in dealing with the technical challenges. Moreover, there was legal uncertainty concerning the liability should a completed wind park not be able to generate electricity due to a missing or damaged grid connection. As the guaranteed rate of return of the TSOs did not cover such potential liabilities, the TSOs faced difficulties in financing the connections.

From 2013 onwards, the liability issue has been clarified: the TSOs bear economic losses from the 11th day of interruption onward, and may pass these costs on to electricity consumers. For this purpose, the German government introduced a small 'liability levy'[1] (BMWi 2015).

Moreover, as seen above (chapter 2.3), the regulatory regime before 2013 was based upon individual planning and siting by each project developer. This resulted in the construction of individual lines without a comprehensive strategy. Therefore, the German government decided to implement more centralized and coordinated planning of offshore grid connections intended to guide further OFW deployment. Since 2013, the Federal Maritime and Hydrographic Agency (BSH) has released the S*patial Offshore Grid Plan* twice defining the location of transformer platforms and sea cable routes, clustering existing offshore wind farms, and taking into account planned projects and competing uses (BMWi n.d.).

Based on this spatial plan, the TSOs develop the *Offshore Grid Development Plan,* which covers a period of 10 years and includes a schedule for connecting specific projects. TSOs are obliged to realize these projects according to the schedule. The *Offshore Grid Development Plan* is subject to public consultations and must be approved by BNetzA, the regulatory agency (BMWi 2015).

In 2017, a further change in the regulatory regime regarding offshore grid connection was implemented simultaneously to the switch to tenders. Moving forward, only projects awarded via the tenders were to be entitled to a grid connection (BNetzA 2019).

However, in early 2019, the German parliament additionally enabled the realization of a new OFW pilot project in the Baltic Sea by providing the legal basis for the TSO to implement grid connections outside of the tender procedure.

The MES agreement signed in May 2020 foresees that the TSO will use in the future the new 525kV technology that carries twice the amount of power compared to the conventional 320 kV technology. This will allow to reduce the number of connections to shore needed. A process will be established to verify that the 525 kV technology complies with an environmental regulation concerning the heating of the seabed and surrounding environment by power cables. The BNetzA has determined that, in order to connect 20 GW OFS by 2030, three additional connection lines will need to be built, on top of those already planned before.

In summary, during the early phase of OFW deployment in Germany, the grid connection regime led to uncertainties, delays, and therefore to additional costs. Moreover, as grid connections were applied for by individual project developers, there was a lack of coordination in offshore grid planning. The new regime is based on centralized planning simultaneously taking into account OFW development and grid connections. In this process, economic risks to the OFW project investor have been reduced and partly socialized.

[1] From 2019 onwards, this liability levy has been merged with the costs of offshore grid expansion that had been part of the general grid charges to this point. This new 'offshore grid levy' is also borne by electricity consumers.

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