Technical Study

MSP as a tool to support Blue Growth

Roundtable discussion paper: Offshore Wind Energy, 11/12 October 2017

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Author: Bodil Skousen & Diletta Zonta, Ecorys

European MSP Platform Consortium Contractors:

with Thetis, University of Liverpool, NIMRD, and Seascape Consultants

Offshore Wind

1 Introduction

Overall size of the sector and industry structure

Mature ☐ Growing ☒ Emerging ☐

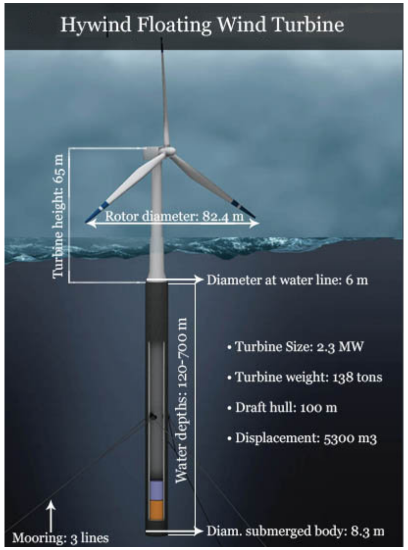


Figure 2: Dimensions of a floating wind turbine. [Source](#).

Offshore wind capacity has significantly increased since 2000. In 2016, 12 631 MW of offshore wind energy was deployed in Europe. The UK accounted for 41%, followed by Germany with 25%, Denmark with 10%, the Netherlands with 9%, Belgium with 6% and Sweden with 2%.There has been a dramatic increase in the average capacity of offshore wind farms from just 46.3 MW in 2006 to 379.5 MW for installations under construction ten years later. Increased capacity will be supported by bigger hubs although this may not result in proportionally larger space requirements: compared to todays' hubs of 90 meters high, future ones will be around 125 meters high and blades spanning 190 meters. This process is expected to continue as costs fall, and as

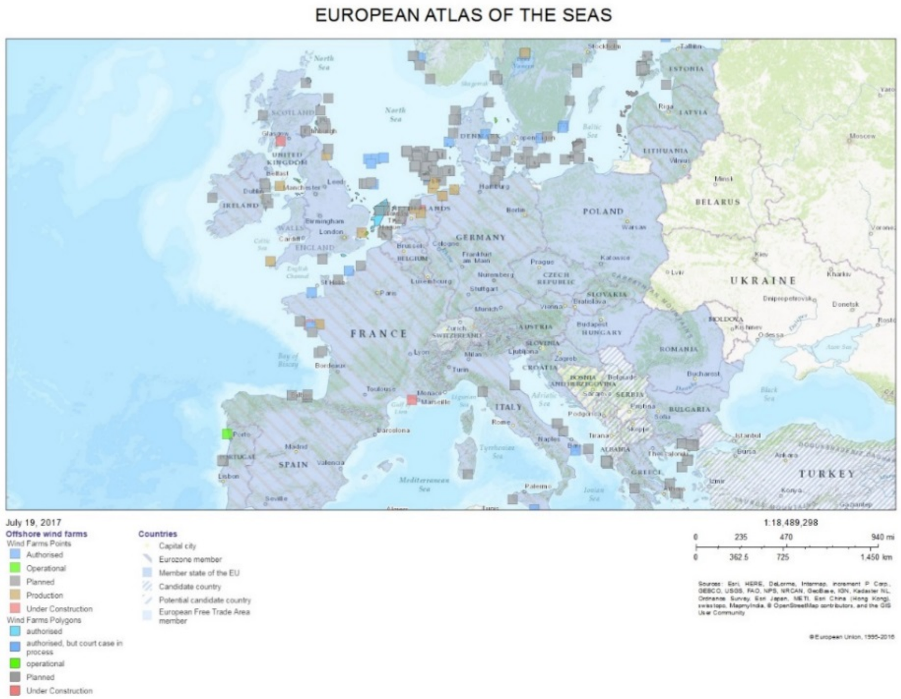


Figure 1: Planned and existing offshore wind farms in Europe. Source: European Atlas of the Seas.

countries look for ways to increase their low-carbon electricity options to help meet emission reduction targets[1].

One wind turbine needs around 1km2 of space vis-à-vis another one, depending on its size, potential (6MW/km2)[2] and type of foundation.

Floating offshore wind turbines are reaching a high technological readiness level. The sector foresees that larger wind turbines with a capacity of 12 to 15 MW can be installed as floating turbines, enabling countries such as Norway, Portugal and Spain to have offshore wind turbines. Projects have already been planned in Ireland, Portugal, France and United Kingdom.

[1] Germany, Belgium, Denmark and industry pledge huge EU offshore wind expansion [retrieved 28 June 2017], http://af.reuters.com/article/commoditiesNews/idAFL8N1J343E
[2] Source: European Atlas of the Seas

<table>
<tr><th colspan="3">Time horizons</th><th colspan="2">Spatial characteristics</th></tr>
<tr><td>Seasonal</td><td colspan="2">Yes</td><td>Place based</td><td>Yes</td></tr>
<tr><td>Planning horizon</td><td colspan="2">2050</td><td>Linear</td><td>No, except for grids and connected cables</td></tr>
<tr><td>Development time</td><td>7-10 years</td><td>Development of individual projects</td><td>Distance to shore and water depth</td><td>Near shore installations requiring more traditional onshore turbines with a maximum capacity of 1-2 MW

Deep-sea installations in bigger distance to the shore lines for which offshore turbines with a capacity of 5-10 MW and over are best suited. Larger distances to the coastline favors floating wind foundations.

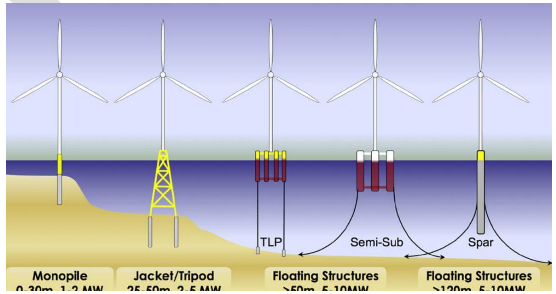


Figure 3: Offshore wind turbines are mounted on at least five different types of foundations, Source.

Grid connectivity puts (economic limits) to the distance in sea.</td></tr>
<tr><td rowspan="2">Lifetime of installation</td><td rowspan="2">25 years on average3.</td><td rowspan="2">Average economic/technical lifespan, although several factors influence its life expectancy and location: wind conditions, seabed, available infrastructure</td><td>Moving</td><td>No</td></tr>
<tr><td>Land Sea interaction</td><td>Yes</td></tr>
</table>

[3] European Commission, "Energy sectors and the implementation of the Maritime Spatial Planning Directive", 2015.

2 Relevance

Status in each Sea Basin (Table 1[4])

Sea Basin	Presence	Potential	Comments
Atlantic	◆◆◆	➡➡➡	Considerable activity
Baltic Sea	◆◆◆	➡➡➡	Considerable activity
Black Sea	◆	➡	No activity
East Med	◆	➡	No activity
North Sea	◆◆◆	➡➡➡	Considerable activity
West Med	◆	➡	No activity

Legend: ◆ = low presence ◆◆ = medium presence ◆◆◆ = high presence
➡ = none /limited potential ➡➡ = medium potential ➡➡➡ = high potential

Status in EU Country (Table 2[5])

Sea Basin	Country	Presence	Potential	Comments
Atlantic	Ireland	◆◆◆	➡➡➡	Floating wind planned, Arklow Bank
Atlantic	Portugal	◆◆	➡➡➡	Floating wind planned
Atlantic / North Sea	United Kingdom	◆◆◆	➡➡➡	e.g. North Hoyle, Walney, Telford, Hywind Scotland Floating Turbines
Atlantic / West Med	France	◆◆	➡➡➡	Floating wind planned, Sea Reed -Groix
Atlantic / West Med	Spain	◆◆◆	➡➡➡	Islas Canarias
Baltic Sea	Sweden	◆◆	➡➡	Utgrunden, Trolleboda

[4] Table based on expert judgment and assessment of the sources quoted throughout the document.
[5] Table based on expert judgment and assessment of the sources quoted throughout the document. **Note: No information was found for the status at the following countries: Estonia; Finland; Latvia; Lithuania; Poland; Bulgaria; Romania; Croatia; Cyprus; Greece; Slovenia; Italy; Malta.**

Baltic Sea / North Sea	Denmark	◆◆◆	➡➡➡	Horns Rev, Mejlflak, Samsoe, Vindeby
Baltic Sea / North Sea	Germany	◆◆◆	➡➡➡	Gode Wind, Notos, OWP Albatros, Kaikas, Seawind, Neptune, Kriegersfalk, Borkum Riffgrund
North Sea	Belgium	◆◆◆	➡➡➡	Thortonbank Windfarm, Belwind Windfarm, Northwind Windfarm
North Sea	Netherlands	◆◆◆	➡➡➡	Gemini

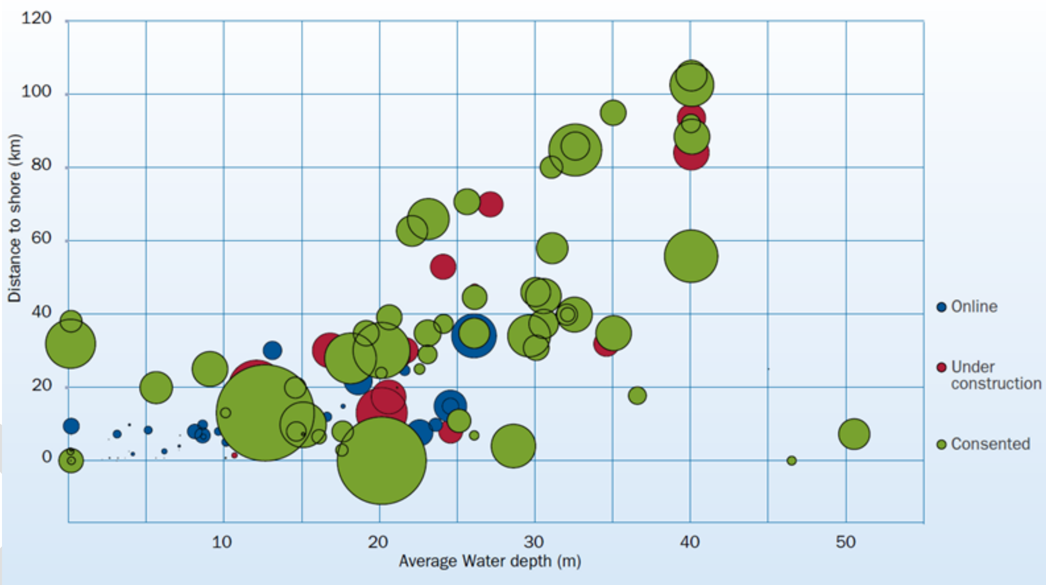
Legend: ◆ = low presence ◆◆ = medium presence ◆◆◆ = high presence
➡ = none / limited potential ➡➡ = medium potential ➡➡➡ = high potential

3. Status and evolution Analysis

Drivers

- ✓ *Political incentives*: The EU climate and energy framework in 2014 set a target to reduce emissions by 40% below 1990 levels by 2030, which was reaffirmed in the Paris Agreement. In this framework, the share of renewable energy is to reach 27% of total EU-wide energy. Energy security is another reason behind the political push towards more renewable energy. In light of recent geopolitical developments, the fact that the EU imports more than half of the energy it consumes and the volatility of fossil fuel prices, a stable and ample supply of energy is vital for economic growth.
- ✓ *Cost reduction:* The offshore wind leveled costs have come down in recent years but in order to become more competitive, significant cost reductions will still be required for utility-scale offshore wind power plants in order to achieve –at least- parity with the leveled cost of energy (LCoE) related to conventional methods based on fossil fuels.

Figure 4: Average water depth and distance to shore of wind farms[6]



- ✓ *Synergies with and advantages compared to onshore wind technology:* the scarcity of suitable onshore sites with consistent and abundant wind characteristics and increased predictability as a result of accurate forecast data make offshore wind an increasingly attractive alternative[7].

[6] Source: EWEA (bubble size represents the total capacity of the wind farm) online. http://www.ewea.org/

[7] EY, Offshore wind in Europe: Walking the tightrope to success, 2015, p. 6

- ✓ *Energy price regulation (Feed in tariffs):* One of the big drivers in the up scaling of offshore wind energy has been feed in tariffs. This policy mechanism was firstly introduced in Germany to accelerate investment in renewable energy technologies providing a long term security, whereby every kilowatt-hour generated from renewable energy receives a fixed feed-in tariff[8].

Barriers & Bottlenecks

Note: *Direct spatial implications* would be those which already hold a spatial characteristic; *Indirect spatial implications* would be those which might occur or not depending if we solve the barrier/bottleneck or not.

Barriers & Bottlenecks	Direct spatial implications	Indirect spatial implications	Comments
Public acceptability			The closer wind parks are built to the shore, the more they might be perceived as polluting the horizon by coastal inhabitants. On the other hand, an advantage of offshore wind farms compared to onshore installations is that there is no perceived noise pollution and that it has more limited impact on the landscape (loss in scenery).
Depth of the sea			By the end of 2013, operational wind farms were in an average water depth of 16 m in Europe. Technological advances might enable even deeper water installations, although environmental impacts will have to be identified including on marine species[9].
Technological advancement			There are currently no technological synergies between floating foundations and conventional turbines foundations.
Infrastructure and transmission/distribution capacity			There are still technical and financial challenges in grid connection and integration. Considerable investments will be required in onshore and offshore grid infrastructure in order to accommodate for the large expected expansion in variable generation capacity from offshore renewable energy projects. Without increased capacity in manufacturing, a shortage of high voltage (HV) subsea cables is likely.

[8] Ecorys, Study on Lessons for Ocean Energy Development, Annexes to the Final Report, 2017, p. 53
[9] Bailey et al. "Assessing Environmental Impacts of Offshore Wind Farms: Lessons Learned and Recommendations", 2014.

Port facilities			Adequate ports facilities will need to be adapted to the needs of the sector for building and maintenance. MSP should take these new shipping lanes into account. Furthermore, when developing an area, a temporary non-shipping zone is being implemented for a few years.
Regulatory conditions			Complex regulatory framework and permitting processes. The EU average for the administrative lead time of an offshore wind energy project is 18 months.
Investment consideration			As the offshore renewable energy sector is very capital intensive, securing investment is still considered as a challenge, notably where planning and licensing are uncertain. Problems with the construction, severed power cables, changes in the price of electricity, storms or an end of governmental subsidies are all among the factors that have to be accounted for in any decision to invest. Moreover, an end of governmental subsidies would also mean that authorizing entities would have less leverage on investment. Nonetheless, this risk profile is constantly lowering, leading to more favorable commercial loans conditions. Developments in the cost of offshore wind energy will play a crucial role in determining future trends: the cost of offshore wind energy is expected to fall by 25-40% in the next decades. Dependency on public research funding is still rather high in terms of market developments towards more floating wind foundations.

Trends

Offshore wind capacity has significantly increased since 2000. This is expected to grow as costs fall, and as countries look for ways to increase their low-carbon electricity options to help meet emission reduction

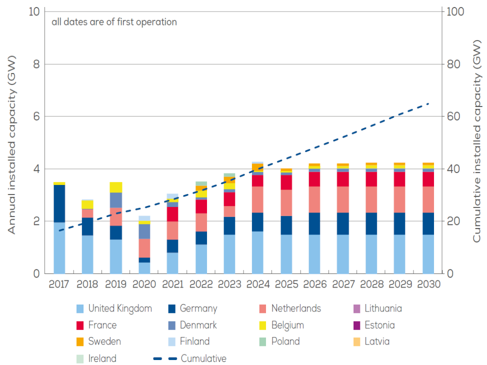
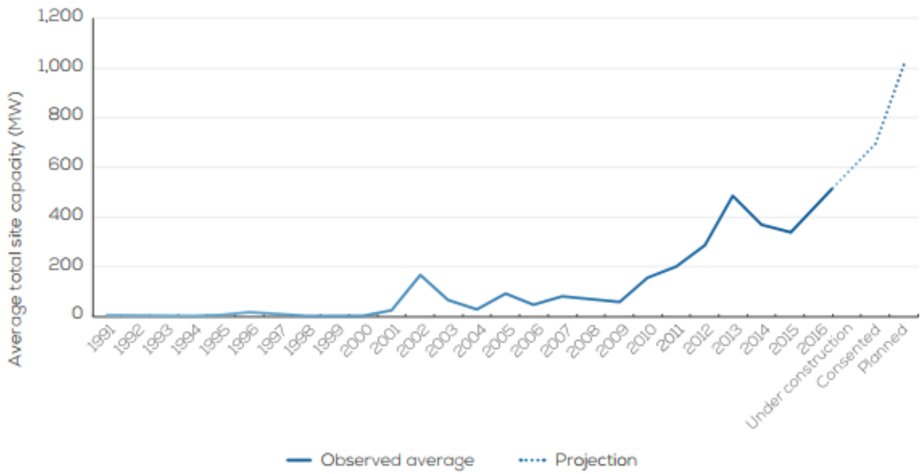


Figure 5. Installed capacity in a baseline scenario to the end of 2030 for the EU Member States in all sea

targets[10]. By 2020, the offshore wind total installed capacity is expected to be 23 GW, as a result of an estimated annual rate of deployment of 3 to 3.5 GW per year between 2017 and 2019[11]. This would represent around 2% of EU's total electricity consumption. By contrast, a 2014 Commission communication put this at 3%, or 43 GW of installed capacity[12]. The sector foresees that a cumulative total capacity of 64 GW will be installed across Europe by the end of 2030[13]. .

- ✓ The OECD report[14] on the ocean economy classifies offshore wind energy as an activity with long-term growth both in terms of business and employment perspectives. In the most optimistic scenarios, there could be almost 400GW of installed capacity by 2030 and approximately 900GW by 2050.
- ✓ According to Wind Europe, offshore wind is expected to produce 7% to 11% of EU's electricity demand by 2030, with 64 GW installed capacity across Europe by the end of 2030[15]
- ✓ Wind turbines are getting larger (up to 8-10 MW installed), hence allowing for more capacity with a given number of turbines installed – thus contributing to the strong decline of LCOE[16].

Figure 6. Average size of offshore wind farm projects (MW) – source in footnote 13



[10] Germany, Belgium, Denmark and industry pledge huge EU offshore wind expansion [retrieved 28 June 2017], http://af.reuters.com/article/commoditiesNews/idAFL8N1J343E
[11] JRC, JRC Wind Energy Status Report 2016 Edition, 2017; European Wind Energy Association, Wind energy scenarios for 2020, 2014
[12] DG MARE (2014), Blue Energy, Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond.
[13] Wind Europe, Unleashing Europe's offshore wind potential – A new resource assessment, 2017, p. 19
[14] The Ocean Economy in 2030, OECD, 2017.
[15] Wind Europe, Unleashing Europe's offshore wind potential. A new resource assessment, June 2017
[16] "Study on the Establishment of a Framework for Processing and Analysing Maritme Economic Data in Europe", COGEA, 2017.

- ✓ Wind farms are getting further offshore, with consequent increasing water depths and export cable lengths[17].
- ✓ The offshore wind industry is expected to drive down costs across all elements of the supply chain and become cost-effective vis-à-vis alternative sources of energy, including traditional ones such as oil and gas and alternative renewables[18].
- ✓ Floating farms are expected to begin to take off in the next decade, "reaching cruising altitude in the mid-2020s and a big boom in 2030-35"[19].

The rated capacity of offshore wind turbines has grown 62% over the past decade. The average rated capacity of turbines installed in 2016 was 4.8 MW, 15.4% higher than in 2015. 8 MW turbines were installed and sending power at sea for the first time in 2016, reflecting the rapid pace of technological development[20].

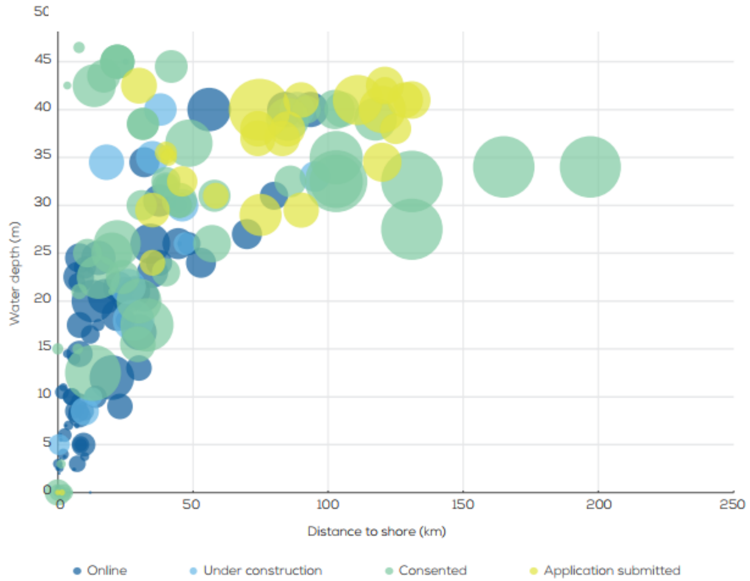
[17] "Study on the Establishment of a Framework for Processing and Analysing Maritme Economic Data in Europe", COGEA, 2017.
[18] The Ocean Economy in 2030, OECD, 2017.
[19] Bruno Geschier words, chief marketing officer at Ideol
[20] Wind Europe, The European offshore wind industry – Key trends and statistics 2016, Page 27 – technological development trends

4 Spatial consequences of future trends

Implications

The continued expansion of offshore wind has major implications for MSP. In addition to the need for more space, the general trend is that projects are being carried out in deeper waters and further away from the shore. It is estimated that a wind turbine producing 6MW needs approximately 1km^2 of space in relation to another one[21]. At the same time, the continuous energy dependency of the EU will push for the development of new energy sources, such as offshore wind energy, and the creation of an offshore grid projection (hub based), which will entail technical, economic, legal and spatial implications[22]. As offshore wind has increased significantly, there is existing experience in cross border MSP, e.g. North Sea[23].

Figure 7. Average water depth, distance to shore of bottom-fixed, offshore wind farms by development status



Further developments of the offshore wind farm industry will have to take into consideration other marine uses and their stakeholders. Potential co-use examples of continental shelves will need to be investigated in order to minimize the potential cumulative impacts that many activities might pose to the social and ecological areas where uses occur. As such, despite immature, some are proposing the co-use of offshore wind energy platforms together with aquaculture (especially longlines) or with conservation and recreational purposes (the use of the platforms as artificial reefs or as FADS- Fish Aggregating Devices)[24].

This use of offshore wind platforms as multi-purpose platforms with aquaculture is still at the research /project phase with no business running yet. Various projects worldwide, pioneered in Germany and later accompanied by other European projects, such as in Belgium, The Netherlands, Norway, as well as other international projects in the Republic of Korea and the USA, to name a few, started to invest in robust technologies and to investigate in system design

21 DG MARE, Energy sectors and the implementation of the Maritime Spatial Planning Directive. Information for stakeholders and planners, European Commission, 2015, p. 10
22 See for example the Energy Island from TENNET as a practical example of this concept: https://www.tennet.eu/our-key-tasks/innovations/north-sea-infrastructure/
23 Political Declaration on energy cooperation between the North Seas Countries
24 Bela H. Buck & Richard Langan, Aquaculture Perspective of Multi-Use Sites in the Open Ocean The Untapped Potential for Marine Resources in the Anthropocene, 2017

needed that species can be farmed to market size in high energy environments (Buck et al., 2017). However, market studies have shown that, if the willing of the co-using sectors is there (along with financial support), these solutions might be happening quite soon in our marine environments.

Relationship with other sectors

Many potential implications between offshore energy and other maritime activities exist. Due to the development of offshore wind both in terms of technology and deployment, the sector brings spatial competition vis-a-vis other (mature) maritime activities. Spatial overlap of offshore wind energy with other maritime activities has already been observed in some sea basin, i.e. the North Sea.

The matrix below indicates the potential Offshore Wind sector´s compatibility (synergies and conflicts) with other marine sectors (Legend: red = potential conflicts; green = potential synergies).

		Shipping	Ports	Tourism & Recreation	Oil & Gas Extraction	Pipelines & Cables	Fishing	Aquaculture	Marine Renewables	Marine Aggregates	Conservation
Offshore Wind	Synergies										
	Conflicts/Risks										

The growth of fixed offshore infrastructures is believed to increase the potential risks to the safety of navigation for the **shipping** sector, especially given higher traffic density, but also through other aspects (e.g. interference of wind turbines with radar). Offshore installations will be dependent on the capacity of **ports** to provide logistics services, which in turn have spatial and infrastructural consequences. Offshore wind farms are in some cases perceived to spoil coastal scenery, by having potential spatial overlap with **recreational** activities (i.e. kayaking and marine tourism).

Especially in the North Sea overlaps with **offshore oil and gas** activities are present. Siting of offshore wind turbines brings difficulties with regards to seismic surveys and exploration drilling and production. However, both sectors can share equipment, installations, infrastructure and draw upon similar knowledge and skills. **Cables** and grids are necessary to bring energy to the land and to connect one wind farm to another.

Potential spatial restrictions and displacement effects on **fishing** vessels and fish populations. The phase of establishing an offshore wind farm would affect fisheries given that fishing vessels would be prevented from fishing inside the area occupied by wind power installations or within a certain distance of turbines. The safety zone surrounding wind farms would imply spatial implications with recreational and commercial fisheries as well as with shipping, demanding vessels to adhere to restricted navigation requirement. Nevertheless, in some countries fishing is allowed in areas close to windfarms under certain conditions. Gear types used for fishing activities might also be restricted in order to protect submarine cables or pipelines transmitting energy (see Cables and Pipelines factsheet for more information).

Commercial deployment of **tidal and wave energy** would have spatial implications requiring offshore space, although many synergies exist in terms of use of equipment, installations, infrastructure and skills base.

Recommendations in MSP

(After the conference)

5 Resources / Actors / References

Actors

Name of Actor	Type of Actor	LINK	Short explanation
Wind Europe	Association	https://windeurope.org/	The association represents the entire value chain, from utilities/developers to manufacturers, banks, insurance companies an research institutes. Members include the national wind energy associations of all the countries in Europe.

ENTSO-E	European network of Transmission System Operators	https://www.entsoe.eu/about-entso-e/Pages/default.aspx	The network represents 43 electricity transmission system operators (TSOs) from 36 countries across Europe, aiming at further liberalization of the gas and electricity markets in the EU.
Europacable	Association	http://www.europacable.eu/	The organisation represents all European manufacturers of submarine power cables – across all voltages and for both AC and DC

Projects and Initiatives

Name	Type of Project	Duration	LINK	Short explanation
Political Declaration on energy cooperation between the North Seas Countries	North Seas Cooperation	2016-2019	https://ec.europa.eu/energy/en/topics/infrastructure/north-seas-energy-cooperation	North Seas region countries (Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, the United Kingdom, Norway and Sweden) aim to further strengthen their energy cooperation with regard to offshore wind energy.
Good Practice WiND (Intelligent Energy Europe)			https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/ gpwind_good_practice_guide_gp_wind_en.pdf	

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