TECHNICAL ANNEX

Data gathered:

- Publicly available data (Belgium, Denmark, Estonia, Finland, Germany, Latvia, the Netherlands, Poland, Spain, Sweden) on MSP Zoning Areas (sq. km) obtained from the EMODnet Map Viewer. Areas used to calculate the amount of space available correspond to those labelled as Wind Farms and/or Ocean Energy Facilities.
- Member States non-binding pledges for 2030 and 2040.
- EU Member States' maritime area from the European MSP Platform (European Commission).
- Paris Agreement Compatible (PAC 2.0) scenario data for offshore wind for 2030 and 2040.

Methodology:

Key points of methodology:

Maritime Spatial Plans:

- Out of the 22 EU coastal Member States, 19 have a maritime spatial plan in place. The three that do not (Croatia, Greece and Portugal) are under Infringement Procedures for delays in finalising their plans. However, only 10 of the 19 plans are available for consultation in the EMODnet Human Activities geoportal, where data is harmonised across borders to ensure the compatibility of plans. This brief focus mainly on the 10 plans available for consultation in the EU platform.
- Apart from Germany, where both the current maritime spatial plan and Site Development Plan for 2023 are considered, the data used are the ones available in the national Maritime Spatial Plans. If Member States have allocated space outside the MSP process and this is not reflected in the plan's data, then it is not included in the analysis.
- Finally, the Maritime Spatial Planning Directive only requires Member States to update their plans once every ten years. However, most Member States set shorter timelines to revise their plans, which can include changes in the overall strategic objectives and spaces allocated to each sector. The data collected corresponds to the size (square kilometres) of polygons labelled as wind farms or ocean energy facilities in the existing present plan. In this brief, WWF focused on the plan that is currently in place, with the aim of providing clear recommendations when space needs to be expanded in the next national Maritime Spatial Plan.
- In depth analyses of the individual national Maritime Spatial Plans are available in the EU reports produced by WWF between 2022 and 2024.

Paris Agreement Compatible (PAC) scenario data:[1]

- The Paris Agreement Compatible (PAC) scenario is an EU energy scenario aligned more closely with the Paris Agreement's objective of limiting global warming to 1.5°C than the EU's existing targets. The PAC scenario consortium consists of Climate Action Network (CAN) Europe, European Environmental Bureau (EEB), Renewable Grid Initiative (RGI), and REN21; and the PAC project has been developed by CAN and EEB, with the most recent modelling being done by Climact.
- The PAC scenario is based on three key objectives:
    1. 100% renewable energy supply by 2040;
    2. At least 65% gross greenhouse gas emissions (GHGs) reductions by 2030;
    3. Net-zero emissions by 2040.
- The PAC scenario bases its analysis and figures on a significant decrease in energy demand (halving energy demand by 2040 compared to 2015 levels), which explains why the absolute quantity of GW needed for offshore wind energy is relatively low in the PAC scenario. For each kilowatt-hour (kWh) that we fail to reduce on the demand side we will need to compensate by increasing supply by one kWh, through installing additional solar and wind capacities.
- The PAC scenario uses two methodologies to calculate the amount of offshore wind energy needed by 2030, 2035 and 2040 to achieve the three objectives described above on time: Pathways Explorer (PE) and Python for Power System analysis (PyPSA). The former is an energy demand modelling tool (climate and energy) and cannot model storage and transmission. The latter is a supply-side tool, which models these missing parts i.e. storage and transmission, based on cost-optimisation. In this brief, the PyPSA data are used and therefore reflect storage and transmission capacities.
- It should be noted that because of the nature of the model and the source data the figures in the PAC scenario may not align in every case with recent real-world data or with what may be possible and desirable, and it does not necessarily represent WWF views on the appropriate level of offshore wind for a specific country.

Power density:

- The power density (or capacity density) of an offshore wind farm is how much energy is produced per km² (MW/km²). Notably, the nominator (the total area) includes the vast space between the fundamentals of the wind turbines. Technical-economic issues (e.g., applied taller wind turbines, reduced wake losses), regulatory frameworks (e.g., % of the sea dedicated to renewables), and the size of the European Economic Zones (the smaller the EEZ, the more dense are the wind farms, e.g., Belgium) influence the capacity density, which is therefore different depending on the sea basin and country.
- In 2018, the European Commission identified a power density range of 5 MW/km² to 5.4 MW/km² following studies in European sea regions.[2] The industry is using an average of 5 MW/km² and the Commission has specific data per Member States and sea basins. In this briefing, we use the Commission's latest data at a sea basin level, and when no data is available, we refer to the industry average.
- Breakdown of the data used:
    - North Sea and the Baltic Sea: European MSP Platform's data on the extrapolated 2030 and 2040 average power density by sea basin. Extrapolated (or projected) data assume technological development of offshore wind farms as of today.
    - Atlantic: European MSP Platform's data on the current average power density (no extrapolated 2030 data available).
    - Mediterranean and Black Sea: current EU average power density provided by WindEurope (no specific data available as no commercial scale projects operating).

[1] Wired for Climate Neutrality – A Paris Agreement Compatible (PAC) roadmap for power grids
[2] European Commission, Capacity Densities of European Offshore Wind Farms

The below calculation methodology was followed for the 10 identified Member States:

- The space allocated by these Member States in their MSP for offshore wind were compared to the calculated space needed to achieve their non-binding pledges for 2030 and 2040, as well as the PAC projections for 2030 and 2040.
- The data for allocated space are retrieved from the EMODnet Human Activities geoportal. For space required by 2030 and 2040, the Member States' pledges were divided by the respective projected power density of the sea basin: 7 MW/km² for the North Sea in 2030 and 8 MW/km² in 2040, 9 MW/km² for the Baltic Sea, and 4 MW/km² for the Atlantic.
- The same calculation methodology was applied to the 2030 and 2040 PAC scenario data.
- In the case of Germany, our space calculations are based both on the 2021 Maritime Spatial Plan and the Site Development Plan for 2023, the latter is regularly reviewed and provides additional and updated information for sites being developed after 2026. In some cases, there is a difference between the space allocated in 2021 and the one referenced in 2023. This may be because the space initially allocated was not enough, relocated after discussions with other users of the sea or because projects will not occupy all the space designated in the national Maritime Spatial Plan. For this exercise, we used the largest space allocation, whether it is in the national Maritime Spatial Plan or Site Development Plan for 2023. We expect the Site Development Plan for 2024 (expected to be finalised by the end of 2024) to include additional areas, as there is a momentum to install at least 70 GW in German waters.

For the other 12 coastal Member States:

- The level of their pledges in MW has been divided by the power density of their sea basin to get the space Member States would need to allocate to reach their 2030 and 2040 pledges.
- For the Mediterranean and Black sea countries, considering that we do not have perspective on the power density, this report uses the industry average of 5 MW/km².

Results

Table 1. Focus on the 10 Member States with available data, including the space they have already allocated for offshore wind, non-binding 2030 and 2040 pledges, and PAC scenario projections for 2030 and 2040[3], and the calculated space needed for each category. The potential (in MW) of the space allocated as well as the 2022 installed capacities are also included for information.

Member State	2030 non-binding pledges (MW)	Space needed to achieve 2030 pledges (sq. km)	2040 non-binding pledges (MW)	Space needed to achieve 2040 pledges (sq. km)	2030 PAC (MW)	Space needed to achieve 2030 PAC (sq. km)	2040 PAC (MW)	Space needed to achieve 2040 PAC (sq. km)	Space allocated for OW (sq. km)	MW potential using 2030 power density by sea basin	2022 installed capacity (MW)
Belgium	6,000	857	8,000	1,000	4,270	610	5,567	696	522	3,652	2,260
Denmark	13,200	1,650	19,000	2,375	4,807	601	33,209	4,151	15,793	126,346	2,300
Estonia	1,000	111	3,500	389	200	22	200	22	1,781	16,032	0
Finland	1,000	111	5,000	556	67	7	18,655	2,073	4,070	36,628	70
Germany	30,500	3,813	60,000	7,500	30,000	3,750	30,000	3,750	5,681	45,448	8,055
Latvia	400	44	400	44	130	14	130	14	1,649	14,837	0
Netherlands (low range - high range)	21,000	3,000	30,000 - 50,000	3,750 - 6,250	11,300	1,614	50,160	6,270	4,469	31,281	2,460
Poland	5,900	656	10,900	1,211	5,900	656	5,900	656	2,311	11,554	0
Spain (low range - high range)	1,000 - 3,000	250 - 750	N/A	N/A	2,745	686	2,745	686	4,951	19,804	5
Sweden	700	78	N/A	N/A	1201	133	7,160	796	2,236	11,182	190
Total	**80,700 - 82,700**	**10,570 - 11,070**	**136,800 - 156,800**	**16,825 - 19,325**	**60,620**	**8,095**	**153,726**	**19,114**	**43,462**	**316,763**	**15,340**

[3] See the box above and the technical annex for commentary on the PAC scenario projections

Table 2 - Focus on the other 12 coastal Member States, including 2030 and 2040 non-binding pledges and the projected space needed to achieve those, 2030 and 2040 projections for the PAC scenario are also included[4]

Member State	2030 non-binding pledges (MW)	2040 non-binding pledges (MW)	2030 PAC (MW)	2040 PAC (MW)	Space needed to achieve 2030 pledges (sq. km)	Space needed to achieve 2040 pledges (sq. km)
Lithuania	1,400	2,800	700	700	156	311
France (low range)	2,300	4,200	5,668	17,406	575	1,050
France (high range)	2,300	7,500	5,668	17,406	575	1,875
Ireland (low range)	500	7,000	3,500	10,939	125	1,750
Ireland (high range)	1,000	7,000	3,500	10,939	250	1,750
Portugal	10,000	10,000[5]	130	130	2,500	2,500
Croatia	510	1,200	0.00151	0	102	240
Italy	4,500	4,500	896	2,516	900	900
Greece	2,700	10,000	0.000356	5,489	540	2,000
Malta	50	400	N/A	N/A	10	80
Cyprus	100	100	N/A	N/A	20	20
Slovenia	0	0	0.0006	0	0	0
Bulgaria	0	0	0.00173	0	0	0
Romania	1,000	N/A	1,201	7,160	200	N/A
Total	**23,060 - 23,560**	**40,200 - 43,500**	**12,095.0042**	**44,340**	**5,128 - 5,253**	**8,851 - 9,676**

[4] See the box above and the technical annex for commentary on the PAC scenario projections
[5] The Portuguese government is currently revising its 2030 and 2040 non-binding pledges. If approved, the new ambition will be 2 GW of offshore wind by 2030 and potentially 10 GW by 2040.

Table 3 - Focus on the 22 coastal Member States European Economic Zones (EEZ), the percentage allocated for offshore wind, and the projections for 2030 and 2040 in the PAC scenario[6]

Member State	Marine area[7] (territorial waters and EEZ as defined by UNCLOS) (sq. km)	% of offshore wind areas in the marine area (sq. km)	% of marine area to achieve non-binding 2030 pledges	% of marine area to achieve non-binding 2040 pledges	% of marine area to achieve PAC 2030	% of marine area to achieve PAC 2040
Belgium	3,454	15.1%	24.82%	28.95%	17.66%	20.15%
Denmark	105,000	15.0%	1.57%	2.26%	0.57%	3.95%
Estonia	36,500	4.9%	0.30%	1.07%	0.06%	0.06%
Finland	83,210	4.9%	0.13%	0.67%	0.01%	2.49%
Germany	56,400	10.1%	6.76%	13.30%	6.65%	6.65%
Latvia	28,357	5.8%	0.16%	0.16%	0.05%	0.05%
Netherlands (low - high range)	58,000	7.7%	5.17%	6.47% - 10.78%	2.78%	10.81%
Poland	36,306	6.4%	1.81%	3.34%	1.81%	1.81%
Spain (low - high range)	1,029,228	0.5%	0.02% - 0.07%	N/A	0.07%	0.07%
Sweden	130,000	1.7%	0.06%	N/A	0.10%	0.61%
Lithuania	6,370	N/A	21.98%	43.96%	2.44%	4.88%
France (low - high range)	371,096	N/A	0.61%	1.17% - 1.99%	0.15%	0.28% - 0.50%[8]
Ireland (low - high range)	490,000	N/A	0.10% - 0.20%	1.43%	0.03% - 0.05%	0.36%
Portugal	350,635	N/A	2.85%	2.85%	0.04%	0.04%[9]
Croatia	31,479	N/A	1.62%	3.81%	0.32%	0.76%
Italy	85,858	N/A	5.24%	5.24%	1.05%	1.05%
Greece	92,095[10]	N/A	2.93%	10.86%	0.59%	2.17%
Malta	9,0371	N/A	0.06%	0.44%	0.01%	0.09%
Cyprus	112,208	N/A	0.09%	0.09%	0.02%	0.02%
Slovenia	1,66.9	N/A	0.00%	0.00%	0.00%	0.00%
Bulgaria	40,610	N/A	0.00%	0.00%	0.00%	0.00%
Romania	25,688	N/A	3.89%	N/A	0.78%	N/A

[6] See the box above and the technical annex for commentary on the PAC scenario projections
[7] These figures refer to the total marine area. From a legal and technical point of view, wind farms can be deployed only on a part of this area.
[8] For France, the marine area excludes the Outermost Regions. Mainland France has 5,100 km of coastline and its EEZ (Atlantic, Channel, North Sea and the Mediterranean Sea) represents 371,096 km^2.
[9] For Portugal, the marine area excludes the Outermost Regions (i.e. includes only the continental waters). Depending on the new targets currently being discussed (2 GW of offshore wind by 2030 instead of 10 GW), these figures may change.
[10] For Greece, the area included in this brief corresponds to the Greek territorial sea out to 6 nautical miles zone as mentioned in the European MSP Platform. In 2021, Greece expanded its territorial sea to 12 nautical miles in the Ionian Sea by law 4767/2021 (doubling the maritime space of the territorial sea in the western part of the country). The government has also proclaimed a very small partial EEZ by virtue of a bilateral maritime delimitation agreement with Egypt (ratified by law 4717/2020).

For more information

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