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Ørsted IPs – Deadline 1 Submission

This submission is made in relation to the examination of the Dogger Bank South Offshore Wind Farm Project (the "**Project**") and is made on behalf of Hornsea 1 Limited, the collective of Breesea Limited, Soundmark Wind Limited, Sonningmay Limited and Optimus Wind Limited (together, the "**Hornsea 2 Companies**"), Orsted Hornsea Project Three (UK) Limited, Orsted Hornsea Project Four Limited, Lincs Wind Farm Limited, Westermost Rough Limited and Race Bank Wind Farm Limited (together, or in any combination, the "**Ørsted IPs**").

The purpose of this submission is threefold, namely:

- To provide comments on the Applicant's Responses to the Relevant Representations **[PDA-013]** of the Ørsted IPs;
- To respond to the Examining Authority's Supplementary Agenda Questions for Issue Specific Hearing 2 **[EV5-002]** directed at the Ørsted IPs; and
- To summarise the interactions and concerns that are specific to Orsted Hornsea Project Four Limited.

The Ørsted IPs also wish to note that they have received from the Applicant a draft Statement of Common Ground relating to Orsted Hornsea Project Three (UK) Limited and Orsted Hornsea Project Four Limited, which the Applicant intends to submit at Deadline 2 of the examination of the Project following the Ørsted IPs' review of this document. The Ørsted IPs will therefore review this document, including whether it should be expanded to cover all of the Ørsted IPs.

Comments on the Applicant's Responses to the Relevant Representations

The Ørsted IPs note that in relation to Hornsea 1 Limited, the Hornsea 2 Companies, Lincs Wind Farm Limited, Westermost Rough Limited and Race Bank Wind Farm Limited, the Applicant did not provide anything other than an acknowledgment of each Relevant Representation for those Ørsted IPs.

The Applicant has provided a response to the Relevant Representations of Orsted Hornsea Project Three (UK) Limited and Orsted Hornsea Project Four Limited, and those Ørsted IPs have responded in turn in the table below.

Ørsted IP	Applicant's Comment on Relevant Representation	Ørsted IPs' Response
Orsted Hornsea Project Three	The Applicants acknowledge these comments and will engage with Orsted Hornsea Project Three (UK) Limited to discuss matters raised.	**Engagement** The Ørsted IPs welcome ongoing engagement with the Applicant in relation to the Project.

Ørsted IP	Applicant's Comment on Relevant Representation	Ørsted IPs' Response
(UK) Limited	In relation to interference with wind speed or wind direction, National Policy Statement EN-3 (paragraph 2.8.44) recognises that offshore wind development will occur in or close to areas where there is other offshore infrastructure. Hornsea Three is situated at a separation distance of ~45km from the Projects at the closest point. The project boundary requirements in The Crown Estate's Round 4 Information Memorandum specified that no offshore wind projects could be located within 7.5km of an existing offshore wind farm. In making this stipulation, The Crown Estate took account of minimising impacts on other licensed activities in reaching that conclusion. The Applicants note the separation of the DBS Projects from Hornsea Three greatly exceeds the 7.5km separation distance. Further, the Applicants note the findings of a recent report produced by Frazer Nash (2023). This report found that at separation distances of greater than 20km farm-to-farm wake loss effects were at, or below, 0.6% as a percentage of Gross Annual Energy Production.	**NPS EN-3** In relation to National Policy Statement EN-3, the Ørsted IPs refer to paragraph 2.8.197 which states that "*the applicant should undertake an assessment of the potential effects of the proposed development on such existing or permitted infrastructure and activities"*. Therefore, the Ørsted IPs consider that the Applicant should undertake a wake assessment to identify any effects of the Project on the energy yield of other offshore wind farms. This assessment must calculate the 'net' benefit – i.e. accounting for renewable energy generation losses arising from impacts to other offshore projects, as well as potential new generation from the Project. **The Crown Estate** In relation to The Crown Estate's ("**TCE**") stipulation regarding the 7.5km separation distance, the Ørsted IPs refer initially to TCE's Responses to ExQ1 of the examination of the Outer Dowsing Offshore Wind (Generating Station) Project ("**TCE's OD Submission**"), at Appendix 1 of this submission, in which TCE stated that the 7.5km separation distance "*was used for the purpose of processing project proposals in the tender only, being higher than the 5km buffers that are specified within the seabed lease agreements (introduced in Round 3); this was for the purpose of de-risking the Round 4 tender by providing additional mitigation and assurance to participants through limiting proximity*". In TCE's OD Submission, it was also acknowledged that "*inter-farm wake effects can extend beyond these buffer distances*". The Ørsted IPs also refer to the Offshore Wind Leasing Programme Array Layout Yield Study (the "**Frazer-Nash Study**"), prepared for TCE in 2023, the purpose of which was *"…maximise the energy production from the portfolio of existing and future wind farms"*. TCE is trying to optimise the UK seabed to find some balance between the size of future offshore wind development zones and how far they should keep them apart (buffers). TCE is seeking to maximise the production from the entire portfolio and not only for new lease areas. The Frazer-Nash Study takes some generic, theoretical offshore wind farm pairs and looks at the balance in total production based on different densities and separation buffers – asking whether the "portfolio" production increases when development

Ørsted IP	Applicant's Comment on Relevant Representation	Ørsted IPs' Response
		zones are smaller and further away from each other (reducing the neighbour wake effect) versus larger wind farms which are closer to each other (the larger leases would allow lower turbine density inside the development zones reducing the internal wake effect). The Frazer-Nash Study should be interpreted as saying that, relative to the internal wake losses, the neighbour wake losses are not as significant for large separations. Hence, in the context of the TCE's goal to maximise the portfolio production of total seabed of the UK, new developments should not be forced into very small array areas with very high turbine density as in this case the internal wakes will dominate relative to neighbour wakes. The Frazer-Nash Study does not comment on the distances over which wake losses will occur, however in section 2.2 it mentions that *"Ørsted … have shown evidence from their own portfolio of offshore wind production data that the method reproduces long range wakes well up to 50km separation"*. Additionally, the Ørsted IPs highlight that the Frazer-Nash Study was based on a theoretical, unrealistic regular grid wind farm pair orientated directly North-South and not aligned with the principal wind direction. Therefore, it should not be relied on to predict the likelihood of actual wake losses for the Ørsted IPs' projects. Further, in TCE's OD Submission, it is stated that the Frazer-Nash Study "*summarises modelling applied to generic/hypothetical wind farms and does not replace the need for project-specific analysis*". In summary, the Frazer-Nash Study cannot be used to determine whether there is an impact on existing wind farms. The Ørsted IPs consider it would be quite straightforward for the Applicant to model the real-world situation for the Ørsted IPs as a result of the Project and requests that the Applicant does so. **<u>The Ørsted Wind Europe Technology Workshop 2023 Presentation</u>** The Frazer-Nash Study refers to a presentation delivered at the Wind Europe Technology Workshop 2023 by Ørsted's Nicolai Nygaard. That presentation used operational data from 37 offshore wind farm pairs located in Northern Europe to demonstrate the neighbouring wake effect through the reduction of power generated by front row turbines. The presentation demonstrates that when a wind farm is in the wake of a neighbour at a distance of 30km you can

Ørsted IP	Applicant's Comment on Relevant Representation	Ørsted IPs' Response
		expect a power reduction of just under 10%, whereas at 50km the reduction is still about 5% of the available power. It should be noted that the paper provides these impacts for a wind speed of 8m/s. The presentation also shows how the wake impact varies depending on the wind speed, the stability of the atmosphere at the time of the observation and also the size, distance, shape and density of the neighbour wind farm. The Project will have an impact on the energy yield of the Ørsted IPs. In order to properly understand the effects of a development, the specific environment and relevant developments should be carefully considered. This issue is not only important in terms of impacts experienced by other sea users such as the Ørsted IPs but is a matter of good design. It is also relevant to the degree of climate change benefit the Project offers – the impacts of the Project on loss of energy generation at the Ørsted IPs' developments is relevant to evaluating the benefits of the Project in terms of emissions reductions and climate change benefits.
Orsted Hornsea Project Four Limited	The Applicants acknowledge these comments and confirm that parties are actively engaged in discussions regarding ongoing cooperation relating to interactions between projects and the Applicants are working to reach agreement with Orsted Hornsea Project Four Limited on matters raised where applicable. In relation to interference with wind speed or wind direction, National Policy Statement EN-3 (paragraph 2.8.44) recognises that offshore wind development will occur in or close to areas where there is other offshore infrastructure. Hornsea Four is situated at a separation distance of ~41km from the Projects at the closest point. The project boundary requirements in The Crown Estate's Round 4 Information Memorandum specified that no offshore wind projects could be located within 7.5 km of an existing offshore wind farm. In making this stipulation,	As above.

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	The Crown Estate took account of minimising impacts on other licensed activities in reaching that conclusion. The Applicants note the separation of the DBS Projects from Hornsea Four greatly exceeds that 7.5km separation distance. Further, the Applicants note the findings of a recent report produced by Frazer Nash (2023). This report found that at separation distances of greater than 20km farm-to-farm wake loss effects were at, or below, 0.6% as a percentage of Gross Annual Energy Production.	

Responses to the Examining Authority's Supplementary Agenda Questions for Issue Specific Hearing 2

The Ørsted IPs note that only one of the Examining Authority's questions was directed at any of the Ørsted IPs, which was ISH2.2.1 on wake loss directed at (amongst other parties) Orsted Hornsea Project Three (UK) Limited and Orsted Hornsea Project Four Limited. The Ørsted IPs wish to note that whilst wake loss was not directly referenced in the Relevant Representations of all of the Ørsted IPs, it is indeed a relevant consideration for all of the Ørsted IPs' projects. The Ørsted IPs have therefore responded collectively in turn in the table below.

Number	Question / Clarification	Ørsted IPs' Response
ISH2.2.1	Describe your understanding of wake loss, what effects it can have and how is it assessed. What factors determine the effects from	Wake loss refers to lost energy from a turbine or wind farm as a result of the reduction in wind speed caused by an upstream wind turbine or wind turbines. Wind turbines extract energy from the wind, leaving a slower moving area of air immediately behind the turbine after the wind has passed through it. Gradually, this slower moving air mixes with the faster moving air around it and returns to the original ambient wind speed, which is known as wake recovery. If a second downstream wind turbine is placed behind the first upstream one, and the wind speed has not recovered to the ambient wind speed, the second wind turbine is said to have experienced a wake loss – a reduction in energy produced compared to what it would have produced if the first turbine was not present. Turbine to turbine wakes within a wind farm are usually called internal wakes. Equally, the same concept can be applied on a wind farm scale, where one wind farm can wake another. This is typically referred to as external wake. Similarly, external wakes cause energy losses on downstream wind farms which

Number	Question / Clarification	Ørsted IPs' Response
	wake loss, such as wind patterns and strength? Is wake loss static throughout a month or year and what factors affect the severity of wake loss?	would not occur if the upstream wind farm was not present. This reduction in energy available in the wind to a downstream wind farm is the principal effect of wake loss. Wake impacts are determined by many factors and are typically assessed through wake models as part of an energy yield assessment. These assessments are commonplace in the wind industry and are conducted through a mix of in-house software, specialist consultants and open-source models. Wake models are validated against operational data to ensure agreement with real world conditions. Wake impacts can additionally be observed directly through wind speed measurements, operational wind farm production patterns and satellite monitoring. An important factor which determines the impacts from one wind farm to another is the distance between the wind farms, as the longer the distance the more opportunity for the wake to recover towards the original wind speed. There is no specific distance where wakes stop having an impact – academic evidence demonstrate wakes can extend up to 90km downstream in the offshore environment; however, this is not the only factor and wake impacts depend on more than the distance between the assets alone. Other important factors include nature of the wind resource (as illustrated by the wind rose and wind speed distribution), turbine characteristics and atmospheric conditions. A brief description of each factor is provided below: • **Turbine characteristics** – the larger and denser the turbines in the wind farm causing the wake, the higher the wake impact on neighbouring wind farms; • **Wind rose** – illustrates how often the wind blows from each direction and the wind speed. It predicts whether the wind direction that causes a wake from one asset on another is a common occurrence; • **Wind speed distribution** – how often different wind speeds occur. This is important because the turbine response and hence the strength of the wake depends on the incoming wind speed; and • **Atmospheric conditions** – such as air density, ambient turbulence and atmospheric stability. These are important factors to consider as they affect the duration of the wake. Turbulence describes frequent wind speed changes due to obstacles in the flow or due to air movements from thermal effects. Wakes are dissipated faster in high turbulence environments where there is more mixing between the slow-moving wake and fast moving un-waked wind. Atmospheric stability describes the thermal stratification whereby layers of air with different temperature and density characteristics sit on top of each other. For unstable atmospheres, warm air sits at the surface and rises resulting in more turbulent mixing and hence reduced wake duration. Stable atmospheres describe the opposite; cooler air at the surface is prevented from rising by warmer air above, reducing turbulence and increasing wake duration. The offshore environment is both low turbulence, due to the absence of obstacles, and frequently a stable atmosphere due to the

Number	Question / Clarification	Ørsted IPs' Response
		cooling effects of the sea on the air above, hence causing wakes to propagate much further relative to, say, onshore wind farms. Wake loss is not static throughout a wind year. As described above, it will vary according to the wind speed, wind direction and atmospheric conditions at any one moment in time. However, wake loss is typically expressed as a percentage, which indicates the loss that is expected to occur in an average wind year. Hence, in any given year, the exact wake loss will vary depending on the exact mix of wind and atmospheric conditions experienced – however, the lifetime of a project will even these out and result in the percentage wake loss being experienced on average.

Interactions and Concerns of Orsted Hornsea Project Four Limited

The Ørsted IPs consider that it would be helpful, at this stage in the examination of the Project, to summarise the concerns of Orsted Hornsea Project Four Limited in relation to the interactions between the Project and the Hornsea Four Offshore Wind Farm ("**Hornsea Four**").

Hornsea Four and the Project directly overlap, with the potential for simultaneous construction activity both offshore and onshore across both projects. Such interactions include an offshore crossing in a constricted area and an onshore construction access road being shared between Orsted Hornsea Project Four Limited, the Applicant and National Grid.

Therefore, it is clear that engagement is required between Orsted Hornsea Project Four Limited and the Applicant to manage these interactions, as protective provisions and a commercial agreement will be required to protect the interests of Orsted Hornsea Project Four Limited. In the interests of proactivity and collaboration, this engagement is already underway in relation to protective provisions for the benefit of Orsted Hornsea Project Four Limited and the Heads of Terms for a cooperation agreement between the parties.

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APPENDIX 1

TCE'S SUBMISSION IN THE EXAMINATION OF THE OUTER DOWSING OFFSHORE WIND (GENERATING STATION) PROJECT

Please see below The Crown Estate's response to Outer Dowsing Offshore Wind (Generating Station) Examination - Question ExQ1 OG 1.2 of the Examining Authority's written questions and requests for information, issued on 6th November 2024.

1. Can the Crown Estate clarify if the minimum 7.5km distance requirement between Leasing Round 4 projects takes the potential for wake effects into account?

- The buffer/stand-off between wind farms (unless developers consent to closer proximity) is a separation distance to enable developers to develop, operate and maintain wind farms by allowing for a range of factors including amongst other matters, wake effects, navigation, and safety.
- The 2019 Information Memorandum ahead of Offshore Wind Leasing Round 4 set out the requirement that "Projects may not be located within 7.5 km of an existing offshore wind farm (meaning a wind farm at any stage of development which has been awarded an agreement for lease or lease from The Crown Estate) unless the owner of the existing offshore wind farm has given its written consent".
- This 7.5km was used for the purpose of processing project proposals in the tender only, being higher than the 5km buffers that are specified within the seabed lease agreements (introduced in Round 3); this was for the purpose of de-risking the Round 4 tender by providing additional mitigation and assurance to participants through limiting proximity.
- The Crown Estate acknowledges that inter-farm wake effects can extend beyond these buffer distances. TCE also notes that the spatial and temporal variability of wind speed means that it is complex to accurately predict the wake impact on nearby wind farms, which may depend upon factors beyond distance – e.g. prevailing wind direction and wind farm layout.
- The location of a wind farm within an area of seabed leased from The Crown Estate is for developers to decide and design for, subject to obtaining the necessary consents and The Crown Estate's approval.

2. The Crown Estate is invited to comment on the purpose of the Offshore Wind Leasing Programme Array Layout Yield Study and any implications for the project.

- As outlined in the Introduction section of the Offshore Wind Leasing Programme Array Layout Yield Study by Frazer-Nash published on the Marine Data Exchange in November 2023: "The objective of this present study is to provide generic evidence to support TCE's design of future offshore wind leasing programmes from an aerodynamic loss perspective. Specifically, the influence of key PDA (project development area) design parameters on wind farm production are assessed using an updated engineering wake model with more realistic accounting of farm-to-farm wake and farm blockage effects"
- The report summarises modelling applied to generic/hypothetical wind farms and does not replace the need for project-specific analysis.

- The published report included findings on inter-farm wake effects for generic scenarios. As with any technical evidence, this can be beneficial to the sector to inform decision-making and analysis; appropriate selection and application of this or other studies and evidence to specific projects is for developers to determine.
- As this report was completed during 2023 it has no direct link to the buffer zones set out in the 2019 Information Memorandum for Offshore Wind Leasing Round 4.