

**RWE Renewables UK Dogger Bank  
South (West) Limited**

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**Dogger Bank South Offshore  
Wind Farms**

**Addendum to Wake Effects - Response to ISH3  
Action Points**

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## Glossary

Term	Definition
Annual Energy Production (AEP)	The calculated amount of energy a project will produce, typically given in gigawatt-hours per year. See also Capacity Factor.
Capacity Factor	The ratio of energy produced (or predicted to be produced) at a wind farm vs the energy it could produce if it ran at full capacity 100% of the time. Convertible to an AEP by multiplying wind farm-capacity by hours per year.
Dogger Bank South (DBS) Wind Farms	The collective name for the two Projects, DBS East and DBS West.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement (ES).
EV DAWM	A wake model which extends a model developed by Ainslie in 1998 with a Deep Array Model attempting to account for the effects of large wind farms.
TurbOPark	A wake model developed by Orsted.
The Applicants	The Applicants for the Projects are RWE Renewables UK Dogger Bank South (East) Limited and RWE Renewables UK Dogger Bank South (West) Limited. The Applicants are themselves jointly owned by the RWE Group of companies (51% stake) and Masdar (49% stake).
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South Offshore Wind Farms).
Wake	The area of reduced windspeed behind a wind turbine caused by the removal of momentum and energy by the wind turbine.

## Acronyms

Acronym	Definition
AEP	Annual Energy Production
AP	Action Point
DBA	Dogger Bank A wind farm (under construction)
DBB	Dogger Bank B wind farm (under construction)
DBC	Dogger Bank C wind farm (pre construction)
DBS	Dogger Bank South
EIA	Environmental Impact Assessment
ES	Environmental Statement
EV	Eddy Viscosity
DAWM	Deep Array Wake Model

# 1 Introduction

1. This document provides further results to those presented in Table 2 of **Wake Effects - Response to Issue Specific Hearing 3 (ISH3) Action Points** [REP4-099]. The modelling has been repeated to report the results of all wind farms included in that model and also broadened to include Outer Dowsing and Dogger Bank D. Apart from the inclusion of these two additional wind farms, the approach remains as described in the previous report.

# 2 Context

2. As discussed in **REP4-099** and suggested by previous responses in relation to wake effects, DBS has the largest impact on DBA. This is because DBS is closest to DBA and is located in the primary wind direction for DBA.
3. Further, **REP4-099** demonstrates how the impact for DBA is not significant. Therefore, the impact on any other wind farm, being smaller, will also be not significant.
4. Note that although the interannual variability at each wind farm has not been calculated (only for DBA), the Applicants believe the value to be similar for all wind farms in the region, approximately 5.4%.
5. Finally, it must be understood that the uncertainty on wake impacts for the other wind farms within the simulation are much higher than those for DBA, for several reasons:
  - The wind regimes (speeds, directions, turbulence) are different, so the underlying assumptions do not hold as well;
  - The impact of atmospheric conditions that are poorly understood (both in terms of the true value, and the impact they have on the wakes) have a much larger impact when the wakes travel over a large distance. This is because these conditions have more time to act, such as: turbulence, stability, and gravity waves;
  - In some cases, the wakes travel “through” an intermediary wind farm. Thus, the operation of the intermediary farm can significantly impact the wakes from the first farm in a manner wake models are not well validated to capture; and
  - The overall percentages are smaller and closer to the limit of numerical accuracy of the model.

# 3 Model Scope

6. In **REP4-099** the wind farms included in the model were all those wholly or partially within 100km, and consented (Dogger Bank A, B and C, Sofia, and the Hornsea projects, see **Figure 1**).

7. Wind farms outside of this 100km range are unlikely to have a modellable impact, or feel an impact from DBS (as is clear from the impacts reported in **Table 2**). In addition, two unconsented projects have been included:
8. Dogger Bank D, being later in the development lifecycle, has less information (layout, turbine type) available. The Applicants have attempted to make reasonable assumptions about layouts and turbine types which may be used. Nonetheless uncertainty on this remains higher than for consented projects.
9. Outer Dowsing is outside the distance that would normally be considered in wake studies. Further, to reach Outer Dowsing, the wakes would need to flow through Hornsea projects further reducing both the impact and increasing uncertainty. Reasonable assumptions have also been made here, however, the extreme distance makes these results even more speculative than at DBD.
10. Other wind farms which are further away and smaller in installed capacity are neglected as their impact (both impact on and impact from DBS) will be smaller than those presented in **Table 2**. Standard modelling approaches would be to exclude wind farms which would have an impact this far below the expected uncertainty limits of the model.

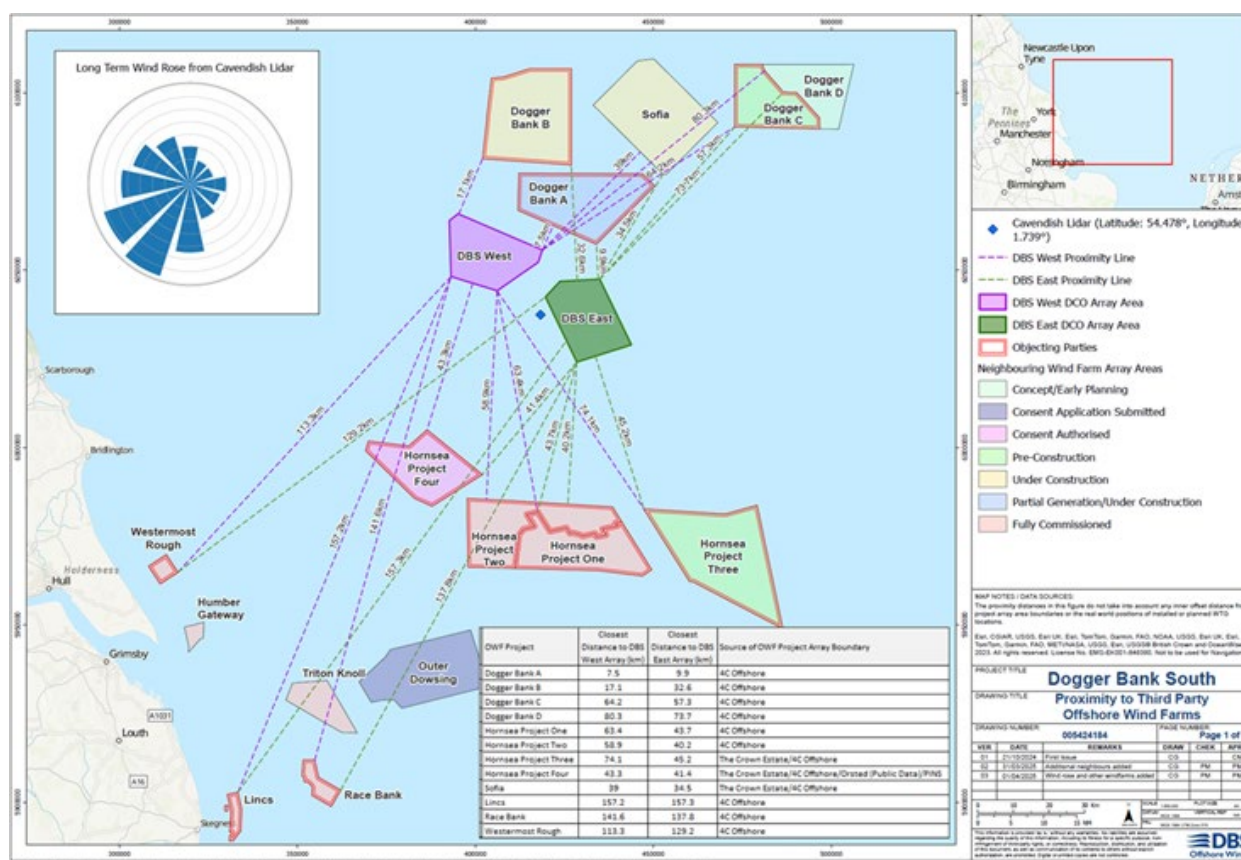


Figure 1: Map of wind farms and wind rose

11. Below are updates to figures and tables presented originally in **REP4-099**.

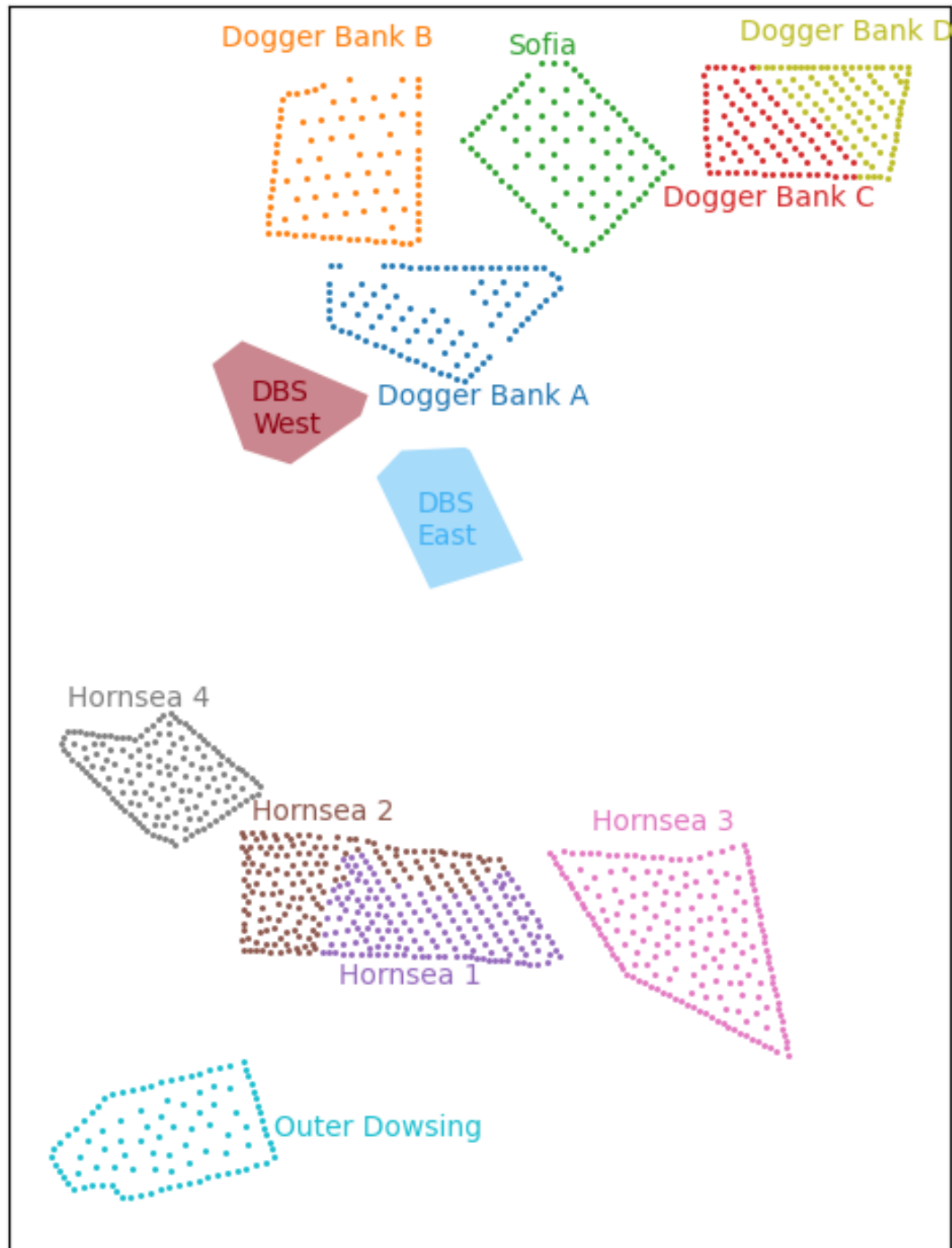


Figure 2: Layouts considered in modelling (Updates to Figure 2 of REP4-099)



**Table 1: Wind Farm Parameters for additional wind farms (Updates to Table 1 of REP4-099)**

Wind Farm	Turbine Type	Power Curve Source	Turbine Capacity (MW)	Wind farm Capacity (MW)	Rotor Diameter (m)	Number of Turbines	Hub height (m)	Layout source
Outer Dowsing	Vestas V236	Vestas non-project specific	15	1500	236	100	152	RWE Generated
Dogger Bank D	Fictitious turbine	RWE forecast	21.5	2000	280	93	160	RWE Generated

## 4 Results

12. Results for the impact of DBS are given in **Table 2**.

**Table 2: Results for wake impact of DBS on other wind farms**

Impact of DBS	EV DAWM	TurbOPark + Correction	VV 3.4	Comment
DBA	1.9%	1.9%	2.1%	Results Cluster around 2%
DBB	0.4%	0.3%	0.7%	DBB is closer than the farms below and receives both direct and indirect wake, thus it is more uncertain than DBA but more certain than for the farms below.
DBC	0.0%	0.0%	0.1%	High uncertainty both due to distance and intervening wind farms
DBD	0.0%	0.3%	0.0%	
Outer Dowsing	0.0%	0.3%	0.1%	
Hornsea 1	0.3%	0.6%	0.7%	
Hornsea 2	0.0%	0.7%	0.8%	
Hornsea 3	0.0%	0.3%	0.4%	
Hornsea 4	0.0%	0.7%	0.8%	

13. It should be noted that while EV DAWM performs reasonably well at shorter ranges, it is known that its performance worsens the further wakes travel. EV DAWM is a less-appropriate model to use for the farms assessed here, but it was included for compatibility with the previous assessment performed.

14. It should also be noted that Hornsea 4 is now delayed and may be built after DBS. The results in **Table 2** include the effects of Hornsea 4, but it is appropriate to also report the potential wake effect Hornsea 4 will have on DBS for reference, which is given in **Table 3**. (The Applicants have noted that the relevant Orsted IP has withdrawn its objection relating to wake effects in its D5 submission but have nevertheless included information in this addendum for completeness.)

**Table 3: Results for the impact of Hornsea 4 on DBS**

Impact on DBS	EV DAWM	TurbOPark + Correction	VV 3.4	Comment
Hornsea 4	0.0%	1.2%	1.2%	The impact of HS4 on DBS is higher than the reverse.

## 5 Mitigation

15. In **REP4-099** it was shown that mitigation of wind farm wakes on DBA was not available given the tests of reasonableness explained. Although equivalent studies have not been carried out for the other farms, the conclusions therein hold true here.

## 6 Discussion and Conclusions

16. This report is an addendum to **Wake Effects – Response to ISH3 Action Points [REP4-099]**, and the discussion and conclusions from that report hold, only the numerical results have been updated.
17. As shown in **Table 2**, the impact of DBS on projects other than DBA are far smaller than at DBA. The decision to exclude projects further than 100km away from DBS is supported by the results. (It is not reasonable to expect specific assessment to be carried out for projects beyond 100km generally and particularly in the light of the results of those for nearer projects which have been presented in this addendum.) Results provided in **Table 2** highlight a far greater spread of results than the assessment completed for Dogger Bank A provided in **REP4-099**. This is due to the much greater uncertainty in other variables introduced by greater differences between wind farms referenced in other submissions.
18. Thus, as for DBA, the impact in EIA and planning terms for all wind farms included in this addendum is that effects are not significant.

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