FIVE ESTUARIES OFFSHORE WIND FARM

10.20.5 TECHNICAL NOTE: NUMBER OF WIND TURBINE GENERATORS

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DEFINITION OF ACRONYMS

Term	Definition
dDCO	Draft Development Consent Order
WTG	Wind Turbine Generator
CFD	Contract for Difference

1. DOCUMENT SCOPE

1.1.1 This technical note is provided to explain the methodology behind the maximum number of wind turbine generators stated within the draft Development Consent Order.

2. MAXIMUM DESIGN SCENARIOS

2.1 RCHDALE ENVELOPE BACKGROUND

2.1.1 The Rochdale Envelope is a well-documented concept that is adopted for offshore wind projects across the UK. A Guidance Note on the application of the Rochdale Envelopment published by the UK Planning Inspectorate is provided in Annex A for ease.

2.1.2 The adoption of this approach is necessary for offshore wind projects because a DCO must be secured before a project can enter the Contracts for Difference auctions which is the most common route to market in the UK. There is also no guarantee a project will succeed in the first auction the project can enters. This means there can be a significant length of time between the DCO planning application and the WTG selection.

2.1.3 This, combined with the speed of technological development, varying market supply constraints, and necessity for projects to economically viable and competitive means that the only way offshore wind projects can progress is through the use of the Rochdale Envelope in planning applications.

2.1.4 This approach to flexibility is expressly set out in NPS EN-3 which states at paragraph 2.8.74:

Owing to the complex nature of offshore wind farm development, many of the details of a proposed scheme may be unknown to the applicant at the time of the application to the Secretary of State. Such aspects may include:

• the precise location and configuration of turbines and associated development;

• the foundation type and size;

• the installation technique or hammer energy;

• the exact turbine blade tip height and rotor swept area;

• the cable type and precise cable or offshore transmission route;

• the exact locations of offshore and/or onshore substations;

2.1.5 To demonstrate how commonplace this approach is, a list of example projects has been compiled by the Applicant indicating the maximum number of WTGs consented in the DCO, and the final "as built" number of WTGs. This is provided in Annex A.

2.1.6 This approach has been well tested in the UK planning system. Because it has been demonstrated to be successful it has been subsequently adopted in other Jurisdictions where the Developer must apply for the planning permission such as the US system (BOEM 2017).

2.2 ROCHDALE ENVELOPE APPLICATION

2.2.1 The Rochdale Envelope is assessed in the Environmental Impact Assessment (EIA) process through the definition of worst-case scenarios or maximum design scenarios (MDS) for each impact. Each chapter of the Five Estuaries (VE) Environmental Statement (ES) sets out the maximum design scenario for all potential impacts on a receptor.

2.2.2 These maximum design scenarios are often mutually exclusive, i.e. it would not be possible to construct the project to the maximum extent of all parameters. However, by selecting and assessing the MDS for each impact, it ensures that whatever the final design of the project, the worst-case impacts will have been considered, and a project built within the Rochdale Envelope will not lead to any greater impacts than those set out in the ES. This approach has been tried and tested through every offshore wind NSIP application.

2.2.3 The assessment of landscape impacts is no different. The MDS is set out in Table 10.17 of the Seascape, Landscape, Visual Impact Assessment chapter [APP-079] and concludes that for operational impacts the worst-case would be the largest turbines, noting specifically that 'The potential effect that results from additional WTGs of smaller size is considered to be outweighed by the larger height and scale of the 399 m WTGs, with the overall area occupied by WTGs being equal.'.

2.3 EXPLANATION OF THE MAXIMUM PARAMETERS

2.3.1 Table 1 in the draft Development Consent Order (dDCO) [APP-024] displays the maximum physical parameters of the project. These parameters have been selected as it is these physical characteristics that impact the environment.

2.3.2 These parameters are the maximum worst case and do not directly relate to a specific WTG as they must allow for future WTGs that may be available to the applicant when the WTGs are procured. The Applicant has selected these values considering current WTG models and future market trends in WTG size.

2.3.3 The maximum swept area defined, has been calculated considering the number of turbines of any particular size, necessary to generate the maximum capacity of the wind farm. The flexibility to deliver that maximum capacity through different turbine models (with different blade lengths) is central to the competitive procurement strategy and the commercial business case for the project. It is fundamental to the project's competitiveness in a bid for a Contract for Difference.

2.3.4 The Applicant has been asked how the relationship between Maximum number of WTGs works in relation to the other parameters, for example the maximum swept area, rotor diameter etc. This is illustrated in Table 1.

2.3.5 In Table 1 It can be observed that when rotor diameter decreases but the maximum swept area remains the same from, the number of WTGs increases. This reflects the rationale that smaller WTGs produce less power and hence to maintain the same total output more are needed.

2.3.6 To assist the reader a worked example is provided explaining the calculation presented in Table 1:

$$Total\ Swept\ Area\ (m^2) = \ Swept\ Area\ per\ WTG\ (m^2)\ \times Number\ of\ WTGs$$

$$Similarly$$

$$Total\ Swept\ Area\ (m^2)\ /Swept\ Area\ per\ WTG\ (m^2) = \ Number\ of\ WTGs$$

$$Swept\ Area\ per\ WTG\ (m^2) = \ \pi r^2$$

$$where\ Radius\ (r) = D/2,\ and\ \pi = the\ constant\ pi$$

$$For\ the\ example\ where\ Rotor\ Diameter\ (D) = 340\ m^2$$

$$Swept\ Area\ per\ WTG\ (m^2) = \pi\ (340/2)^2$$

$$Swept\ Area\ per\ WTG\ (m^2) = 90{,}792.028\ \textit{(3 decimal places)}$$

$$4{,}194{,}340/90{,}792.03 = 46.197\ \textit{(3 decimal places)}$$

The number of WTGs must be an integer, hence rounding down, the number of WTGs is 46.

2.3.7 The maximum total swept area remains the same in all cases. This is accordingly the secured controlling parameter that means the Applicant could not produce a wind farm that is DCO compliant that has, for example, 79 “large” WTGs.

2.3.8 It should be emphasised that Table 1 is provided as an example only, and this is not an exhaustive list of the combinations of WTG rotor diameter or number of WTGs that could be used on the project within the MDS.

Table 1: Illustration of the Total Swept Area across various Rotor Diameter scenarios

Maximum Total Swept Area (m^2)	Rotor Diameter (m)	Swept Area per WTG (m^2)	Number Of WTGs (Rounded down)
4 194 340	360	101 787.6	41
4 194 340	350	96 211.3	43
4 194 340	340	90 792.0	46
4 194 340	330	85 529.9	49
4 194 340	320	80 424.8	52
4 194 340	310	75 476.8	55
4 194 340	300	70 685.8	59
4 194 340	290	66 052.0	63
4 194 340	280	61 575.2	68
4 194 340	270	57 255.5	73
4 194 340	260	53 092.9	79

2.3.9 The other parameters in Table 1 of the proposed Development Consent Order [AS-032] have been calculated by the Applicant considering the worst case for any other the potential configurations. For example, the maximum total seabed footprint area including scour protection has been calculated from considering the maximum size of the scour protection necessary for each of the proposed foundation options (section 1.6 in APP-069; noting that GBS has been removed), and then considering the maximum number of WTGs (79).

2.4 VISUAL IMPACT

2.4.1 With regards to specifically the visual impact it is further noted, as was stated by the Applicant's SLVIA representative in ISH3, that whilst it has been established that the tallest turbines are considered as the worst case, there is in reality little variance in the level of impact within the assessed envelope that would be appreciated with turbines at least 37km offshore, and certainly not of the degree that it would change the conclusions of the assessment. Wirelines have been produced to indicate the difference in height between turbines with a tip height of 399m and 370m; these are provided for information only.

2.4.2 For the purposes of EIA two indicative array layouts were produced, one with the maximum number of larger turbines allowed within the swept area calculation (which equated to 41 at the original tip height of 399m LAT), and one with the maximum number of turbines at a nominal lower height (noting that the turbines could ultimately be shorter than the 324m tip height referred to, but could never be more numerous than 79).

2.4.3 On that sliding scale there could be up to 46 WTGs at 370m LAT tip height, a figure that has always been within the assessed maximum design scenario, and therefore does not affect the worst case assessment.

2.5 IMPLICATIONS OF RESTRICTIONS TO THE PROJECT

2.5.1 The Applicant would consider it unreasonable to not be able to utilize the Rochdale envelope approach. This would cause significant harm as the Applicant would not be able to optimize the project design to reduce the Levelized Cost of Energy (LCOE) and hence would not be able to compete on a level playing field with other offshore wind projects in Contracts for Difference (CFD) auctions.

2.5.2 The entire application has been prepared on the basis that the Rochdale Envelope has been fully assessed and is fully available for these commercial reasons. The swept area aggregate limit provides an effective control across the entire spectrum of possible turbine choices, coupled with the other parameter limits. This is entirely standard across the UK offshore wind sector and the Applicant would strongly resist any attempt to fetter its flexibility for turbine selection within the DCO parameters.

REFERENCES

[1] BOEM 2017; Phased Approaches to Offshore Wind Developments and Use of the Project Design Envelope; OCS Study BOEM 2017-057. https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/Phased-Approaches-to-Offshore-Wind-Developments-and-Use-of-Project-Design-Envelope.pdf

ANNEXES

ANNEX A – CONSENTED PROJECTS AND PARAMETERS

The following tables sets out a selection of offshore wind DCOs and their controlling parameters (where they relate to turbine dimensions and numbers). Whilst there are some minor variations, it is clear that all these projects have been consented with an envelope approach and combination of parameters to define the maximum design scenario which are entirely in line with those proposed for Five Estuaries.

A second table below provides an example of the range of number of WTGs actually constructed and how this varies from the consented value.

PROJECT	TURBINE PARAMETER						
	Max tip height	Max rotor diameter	Max hub height	Max number of WTGs	Max swept area	Minimum spacing	Minimum blade draught
Five Estuaries Offshore Wind Farm (proposed)	x	x		x	x	x	x
Sheringham and Dudgeon Offshore Wind Farms (2024)	x	x		x	x	x	x
Norfolk Vanguard (as amended) (2023)	x	x	x	x		x	x
East Anglia TWO (2022)	x	x	x	x		x	x
Hornsea Four (2023)	x	x		x		x	x

OFFSHORE WIND FARM	Number of WTGs Consented	Number of WTGs Built	Year Consent Granted	Year Commissioned
Seagreen	Up to 150	114	2014	2023
Hornsea 2	Up to 360	165	2016	2022
Triton Knoll	Up to 288	90	2013	2022
Moray East	Up to 186	100	2014	2022
EA1	Up to 240	102	2016 amendment	2020
Hornsea 1	Up to 332	174	2014	2020
Beatrice	Up to 84	84	2014	2019
Rampion	Up to 175	116	2014	2018
Galloper	Up to 140	56	2013	2018
Race Bank	Up to 206	91	2012	2018
Walney Extension	Up to 207	87	2014	2018
Dudgeon	Up to 168	67	2012	2017
Burbo Bank Extension	Up to 69	32	2014	2017
Humber Gateway	Up to 83	73	2011	2015
Westermost Rough	Up to 80	35	2011	2015

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