SHEPHERD+WEDDERBURN

RESPONSE TO DEADLINE 5 SUBMISSIONS ON BEHALF OF

(1) BARROW OFFSHORE WIND LIMITED (REF: 20049595) (2) BURBO EXTENSION LTD (REF: 20049590) (3) WALNEY EXTENSION LIMITED (REF: 20048542) (4) MORECAMBE WIND LIMITED (REF: 20049596) (5) WALNEY (UK) OFFSHORE WINDFARMS LIMITED (REF: 20049592) (6) ØRSTED BURBO (UK) LIMITED (REF: 20049589) (THE "ØRSTED IPs")

IN CONNECTION WITH THE Application by Morgan Offshore Wind Limited for an Order Granting Development Consent for the Morgan Offshore Wind Farm

Introduction

1.1 This submission is provided in accordance with Deadline 6 of the examination timetable for the application by Morgan Offshore Wind Farm Limited (the "**Applicant**") for an Order under the Planning Act 2008 (the "**Act**") granting Development Consent for the Morgan Offshore Wind Farm (the **"Project**").

1.2 We represent six owners of operational offshore windfarms in the East Irish Sea (as set out relevant representations RR-005, RR-007, RR-023, RR-032, RR-043, RR-044), who we refer to together as the "**Ørsted IPs**".

1.3 In this submission, the Ørsted IPs respond to a number of points raised in the Applicant's deadline 5 submissions relating primarily to wake effects.

2. GHG assessment

2.1 The Applicant has provided a calculation of net effects on greenhouse gas emissions [REP5-041] ("**GHG Note**"). The Ørsted IPs consider the approach taken to the GHG Note is flawed and as such does not assist decision making in respect of the Project. The Ørsted IPs critiques of the assessment are set out in detail below, but in summary, the key issues are:

2.1.1 the assessment assumes that the Ørsted IPs developments will cease operating at 24 years, ignoring the most likely scenario in which the Ørsted IPs decide to operate their assets beyond their initial 20-25 year design life, and thus underestimates wake loss; and

2.1.2 the only mitigation scenario assessed (removal of 50% of a generic array area) is so unrealistic that the assessment fails to provide any helpful information regarding the realistic consequences of implementing mitigation for wake effects.

2.2 It is noted that these issues have been raised in other examinations of which the Applicant is aware and were flagged in the Ørsted IPs' deadline 5 submission [REP5-057]. It is therefore disappointing that the Applicant has chosen not to prepare the GHG Note in line with these comments. In contrast, the Wake Report commissioned by the Ørsted IPs has used reasonable parameters (and has not sought to maximise predicted wake effects). The Ørsted IPs have also ensured the Wake Report has been updated in response to reasonable feedback by the Applicant [REP5-059c].

2.3 It is also notable that the Applicant for the Morecambe Offshore Windfarm has recently produced a GHG assessment which does account for lifetime extensions of the Ørsted IPs' assets.

Methodology

2.4 The GHG Note does not provide an assessment of the realistic worst-case scenario in terms of the effects of the Project on GHG emissions.

2.5 At paragraph 4.2.2.2 of the GHG Note, it is recorded that in relation to scenario a (business as usual) "*Lifetime energy production has been calculated based on the earliest decommissioning dates for each project"*.

2.6 This scenario ignores the potential for the Ørsted IPs' assets to operate beyond their initial 20-25 year design life. As highlighted on a number of occasions in this examination, and most recently, in the Ørsted IPs note on decommissioning dates (provided to the Applicant on 19 February and submitted alongside this submission) it is entirely feasible (and in fact likely) that the Ørsted IPs' assets will continue to operate beyond the 'earliest possible' decommissioning dates utilised in the Applicant's assessment. There is no requirement in any of the consents or marine licenses for the Ørsted IPs to decommission after 25 years of operation.

2.7 It is irrational for the Applicant to have assumed otherwise, especially in light of the number of occasions the Ørsted IPs have raised this issue. The Applicant is well aware of the Ørsted IPs' position in respect of the lifetime of their assets and has refused to utilise this information to produce a meaningful assessment which would assist the examining authority and Secretary of State.

2.8 As the Ørsted IPs have already indicated, the scale of the collective impacts of the Project will have a material impact on decision making regarding lifetime extensions (which, in the case of the Ørsted IPs developments, is expected to be 10 years). Therefore, the "business as usual"

assessment in the GHG Note should have encompassed the scenario where lifetime extensions of existing assets occur. This would require the annual figure to be multiplied by a further ten years. This would be one realistic scenario. This could be compared to the current assessment which is premised on no lifetime extension. This would provide a carbon assessment of circumstances where the continued co-existence was not achieved.

2.9 Against this background, the 'business as usual' scenario assessed in the GHG Note is not likely to be realistic. Rather, the Applicant has selected its best-case (and, in the Ørsted IPs' opinion, unrealistic) scenario for assessment. This approach does not aid decision making and fails to provide the evidential basis for properly evaluating the net GHG emissions as required by the relevant EIA Regulations.

2.10 Further, it is reiterated that the level of impact anticipated is likely to impact decision making in respect of continuing to operate the assets beyond the initially anticipated 25-year lifetime. Therefore, a realistic worst-case scenario would cover 10 years of total loss of energy generation from each asset.

Maximum Design Scenario

2.11 The GHG Note does not provide any detailed information regarding the assumed maximum design scenario for the Project. Therefore, it is unclear what scenario has been tested. In contrast, the scenarios assessed in the Wake Report are realistic and test different scale turbines.

Energy production

2.12 As recorded at 4.2.2.3 of the GHG Note, the Applicant has used average historic production data to assess lifetime production. A more realistic estimate could be developed using best projections of future wind resource, as utilised in the Wake Report.

2.13 As a result, the Ørsted IPs consider there is a fundamental inaccuracy to the basis of the assessment undertaken in the GHG Note.

Mitigation

2.14 Scenario (c), which calculates one potential mitigation comparison for wake effects based on a "generic model", is inappropriate as it draws broad conclusions without making use of readily available site-specific inputs or analysing real world mitigations.

2.15 The Applicant has undertaken a simple sensitivity analysis regarding separation distance, which deals with spatial mitigation only and ignores a number of other potential mitigatory measures.

2.16 The layout scenarios assessed reduces the Project's array area by 50% and increases the density of turbines within the array area (rather than removing any turbines). The Applicant has not modelled a scenario whereby the density of turbines is reduced and has only assessed an extreme scenario.

2.17 However, rather than engage meaningfully on this matter, the Applicant has chosen to assess a wholly unrealistic mitigation scenario. Therefore, it is not helpful in developing an understanding of realistic mitigation scenarios and does not assist in decision making. The Applicant's conclusion that "…*the implementation of mitigation by the Morgan Generation Assets to reduce the potential wake effects on the Ørsted IPs projects would not result in a net benefit in terms of emissions*" is based on modelling of a single, highly unrealistic mitigation scenario.

2.18 The Applicant has not approached this exercise in good faith, that is to genuinely attempt to understand what mitigation options could be implemented to address this issue. In contrast, the Ørsted IPs have updated the wake report in response to genuine critiques from the Applicant.

3. Comments on Wake Report [REP5-014]

3.1 The Applicant has responded to the Wake Report provided at deadline 4 [REP4-049].

3.2 It is noted that an updated Wake Report was provided at deadline 5 [REP5-059c], which utilises the DCO boundary for the Project (rather than the PEIR boundary). This addresses one of the Applicant's critiques as set out in section 1.1.3 of their comments. As noted in the Ørsted IPs' deadline 5 submission [REP5-059], contrary to the Applicant's expectations, the predicted wake

effects have worsened slightly as a result of this amendment. This is due to the conservative approach Wood Thilsted took to the assessment.

3.3 At deadline 5, Wood Thilsted also provided an addendum addressing the independence of the assessment, modelling choices and baseline definition. Wood Thilsted have prepared an updated addendum addressing the Applicant's critiques regarding the confidentiality of inputs and annual variability, which is submitted alongside this document. Ørsted A/S has also prepared a document which responds directly to comments made about the assessment of wake effects and industry understanding of its relevance to decision making in respect of assets, which is provided at **Appendix 1**.

3.4 It is noted that the Applicant has not submitted any substantive evidence disputing the outcomes of the Wake Report. The Ørsted IPs commissioned this assessment as a result of the Applicant's refusal to undertake an assessment of the wake effects of the Project. The Applicant has failed to engage with the Ørsted IPs on an approach to assessing the wake effects of the Project which it would be satisfied with and instead has chosen to make relatively trivial critiques of an assessment undertaken by independent experts. The Ørsted IPs reiterate that the Wake Report carried out by Wood Thilsted remains the best evidence before the examining authority regarding the wake effects of the Project. It is noted that the Applicant for the Morecambe Offshore Wind Project has acknowledged, in respect of the same assessment, that the parameters utilised were reasonable.

3.5 In their comments to the Wake Report [REP5-014]) the Applicant states that " *…those theoretical [wake] effects are only one of a number of influences on an existing project's energy yield, and those effects are likely to be insignificant in comparison to some of those other influences, such as annual variability in wind direction and strength and wake effects within and between adjoining wind farms*".

3.6 The Applicant is correct that wind resource available to an offshore wind farm will vary from year-to-year in the range of ±5% of the average production. Outlier years can result in fluctuations that extend outside this range. However, the Applicant's conclusion is misleading as it ignores two fundamental points. Firstly, whilst variations in wind direction and speed will change the effect experienced in a particular year, the effects over several years will average out to the impacts predicted in the Wake Report. It is equally likely that the wake effect will be higher or lower than the average in any given calendar year. Secondly, it is very important to note that the wake losses predicted as a result of the Project would occur in both low and high wind years. It would impact the Ørsted IPs' developments in every year post commissioning of the Project, resulting in a long-term average effect as estimated in the Wake Report. The wake effect is not in any way mitigated by wind resource variability.

3.7 It is also irrelevant that the additional wake caused by the Project is lower than the internal wake effect and the wake effect between existing projects. This "baseline" wake effect, which was included in the Wake Report analysis, has already been modelled and included in the investment decisions and ongoing production expectations from the Ørsted IPs' assets. The wake effect caused by the Project is in addition to this baseline wake effect.

4. Comments on the Applicant's response to the Ørsted IPs DL4 submissions [REP5-009] and [REP5-008]

4.1 The Applicant has made comments in respect of the Ørsted IPs' approach to wake loss which the Ørsted IPs wish to respond to.

Previous applications involving wake effects

4.2 In its response to deadline 4 submissions [REP5-008] the Applicant has dismissed the examples the Ørsted IPs have provided of wake effects being considered in previous examinations because in none of those examples "*have undertaken a quantified wake effects assessment as part of their Environmental Impact Assessment as Ørsted are suggesting should be the case*". The Applicant states that if the NPS-EN3 required wake effects on existing wind farms to be assessed "*that would have become a well-established practice in the industry by this point*".

4.3 This is a very narrow reading of the examples referred to. As the Ørsted IPs have previously explained [REP5-057], wake effects have been raised in previous planning applications for offshore windfarms and are not a novel issue. However, in those examples, the parties have

come to a private resolution (either because it has been demonstrated that effects will be immaterial or because mitigation has been agreed) such that the provision of an assessment in an examination has not been necessary.

4.4 Further, most recently in respect of the Awel y Mor application, it was determined that paragraph 2.6.179[1] did require the applicant for the offshore windfarm to undertake an assessment of wake effects on existing windfarms and their failure to do so was a failure to comply with that paragraph. As a result, a requirement was imposed to ensure the Applicant assessed and mitigated the wake effects of the development. This decision is being described as setting a "precedent" by the UK Government in Clean Power 2030 Action Plan.[2] In light of this example in particular, the Applicant's view that "*The relevant NPS policies have not historically been considered to require wake assessment"* is simply incorrect.

4.5 The Applicant has taken the approach of refusing to engage on this issue and as a result the Ørsted IPs' only option has been to commission an assessment and provide that information to the examination.

4.6 The Ørsted IPs wish to respond to a particular point made by the Applicant regarding the Hornsea Two application. In REP5-008, the Applicant states that it considers the 40% wake loss figure alleged in respect of Hornsea Two figure "*is considerably greater than the figures provided by the Ørsted IPs".* The Ørsted IPs do not consider this is necessarily correct, as it is unclear whether the figures raised in that application related to internal and external wake effects. The wording used in Hornsea One's submissions ([REP5-058]) is *"…Project Two may increase wake losses on Project One by approximately 40%"*. An internal analysis carried out by the Ørsted IPs reveals that at Walney Extension, the cumulative effects of the Project along with the Mona and Morecambe projects will increase total wake losses by 31% and external wake losses by 75%.

4.7 Regardless, the Ørsted IPs do not consider that any difference in the precise percentage of estimated wake loss is relevant to the point in dispute – which is whether previous applications indicate that wake effects are an issue which should be addressed under the NPS-EN3.

<u>Industry awareness of wake effects</u>

4.8 As outlined in the Ørsted IPs deadline 4 submission [REP4-048], growing industry awareness regarding the extent of wake effects between windfarms is the key factor as to why this matter is being raised in respect of the Round 4 projects. The Applicant denies that there has been a "*material shift in knowledge*".[3]

4.9 The Ørsted IPs reiterate their view that the industry's understanding of wake effects has evolved. As noted at deadline 4,[4] the majority of the research provided by the Ørsted IPs on this issue is from the last 5 years. Additionally, it is noted that in the last 5 years both Ørsted and RWE (two of the largest offshore wind operators in Europe) and in collaboration with DNV, have made public statements demonstrating that industry knowledge of this issue is evolving considerably. In 2019, Ørsted issued an announcement regarding its long-term financial targets in which it highlighted that the negative impacts of wake effect had been underestimated (publication provided as **Appendix 2**). Following this announcement, further work was undertaken to understand actual observed wake impacts, the results of which were presented by Ørsted in 2023.[5] Following this, in 2024, RWE/DNV presented its own report regarding the implications of long-distance wake effects from large offshore clusters. This report is referred to in the Wake Report and is attached at **Appendix 3**. Further, the UK Government has recently recognised the importance of wake effects in the Clean Power 2030 Action Plan, describing it as an "*emerging issue*".[6]

---

1 It is noted that paragraph 2.6.179 of the version of the NPS-EN3 which applied at the time to the Awel y Mor application contains the same requirement as paragraph 2.8.197 of the current NPS-EN3.

2 At page 84.

3 [REP5-009] at REP4-048.12.

4 [REP4-048].

5 See [REP3-069].

6 At page 84.

4.10 As has been set out during the examination, the impacts of wake effects is particularly relevant to life extension consideration. The importance of life extension has been specifically highlighted in by the UK Government in the Clean Power 2030 Action Plan (as explained in [REP5-057]).

4.11 RenewableUK, the trade body representing renewables sector in the UK, this week highlighted (in its publication "Developing effective end-of-life policy frameworks for UK offshore wind")[7] that "*UK's existing offshore wind farms present a unique opportunity to leverage existing infrastructure and sites towards achieving clean power and energy security*"[8]. That publication identifies that an average of 900MW per year risks being decommissioned during the 2030s which could increase to around 2.4GW by the 2040s.[9] This reinforces the importance of life extensions.

Ørsted IPs' position regarding applicants' responsibilities

4.12 The Applicant has stated that "*based on the Ørsted IPs presentation of the potential for effects up to 100 km downwind of an offshore wind farm (REP3-056) there is nowhere within the Round 4 Northern Wales and Irish Sea bidding area that would not have the potential for effects as outlined by the Ørsted IPs*". In response, the Ørsted IPs note that their position is that where there is potential for wake effects, applicants should engage with asset owners to assess those effects and, where necessary resolve any concerns. If effects are likely to be immaterial, mitigation may not be required. It is noted that four Ørsted-owned entities have recently dropped their concerns regarding wake loss in the examination of the Outer Dowsing Offshore Windfarm (EN010130).

4.13 As noted in previous submissions,[10] wake impact is determined by many factors and needs to be assessed by a competent analyst. Distance is only one factor relevant to wake effects - it is important to also consider the specific wind resource and the number and type of wind turbines. In the case of the Project, the crucial factors in this analysis are the direction of prevailing wind and size of the Applicant's development which would not be the case for all future wind farm areas.

5. Responses to ExQ2

5.1 The Ørsted IPs wish to comment on one of the Applicant's responses to the second written questions of the examining authority ("**ExQ2**") [REP5-015]**.**

5.2 In response to question INF2.4, the Applicant acknowledges that is has considered the expected energy yield of the Project but is "*not able to consider, any potential wake effect impact on nearby consented or operational projects"*. Further, in response to INF2.8 the Applicant states that it "*is unable to model the impacts of any mitigations on the Ørsted IPs projects for the same reasons it is unable to model any wake effects on the Ørsted IPs with any appropriate certainty and robustness*".

5.3 The Ørsted IPs do not accept that modelling of these impacts is 'not possible' from a technical perspective. The Ørsted IPs consider it is highly likely that, as part of predicting the energy yield of the Project, the Applicant has modelled wake impacts from the Ørsted IPs assets on the Project. In modelling terms, it is straightforward to consider the effects in reverse. The Wake Report contains the key information required to undertake such an assessment.

5.4 Additionally, it is highlighted that the Applicant has undertaken an assessment of mitigation in the GHG Note. However, as outlined above, it has chosen to model an extreme mitigation scenario using a generic model which does not assist in developing the parties understanding of possible solutions.

5.5 As has been stated numerous times in this examination, the Ørsted IPs are willing to engage with the Applicant on an approach to modelling wake effects which would overcome concerns regarding uncertainty of any inputs/parameters.

---

7 Issued in February 2025.

8 At p 3.

9 At p 8.

10 In particular, in response to the first written questions of the examining authority INF1.4(iv) [REP3-053].

6. Ecology submissions

6.1 The Ørsted IPs remain concerned regarding the exclusion of Barrow Offshore Windfarm from the Applicant's ornithology cumulative effects assessment. For the reasons set out in previous submissions, and in detail in the note on decommissioning dates submitted alongside this document, there is nothing requiring Barrow Offshore Windfarm to decommission or cease operating at 2030. Therefore, it should be included in the Applicant's cumulative effects assessment.

6.2 The Applicant has stated, in response to the Ørsted IPs deadline 4 submission [REP5-009], that it will include Barrow in updated ornithological assessment clarification data which was submitted at deadline 5. While it is acknowledged that Barrow has been included in this data, it is not clear how this information has been considered in its reporting on the Project (for example, the report to inform appropriate assessment and cumulative effects assessment chapter).

6.3 The Ørsted IPs request that the Applicant clarifies whether Barrow has been considered in the aforementioned documents for the purposes of its reporting.

Shepherd & Wedderburn LLP

27.02.2025

Appendix 1 – Ørsted response

Ørsted summary of position on future viability and wake assessment

Introduction

1.1 Ørsted commissioned the Wake Report for two major reasons. Firstly, to evidence that wake effects have a material impact on other wind farms that cannot be ignored and secondly, to demonstrate that modelling wakes is feasible and not an obscure, untrustworthy science, as argued by the Applicant, but an essential tool that underpins all investment decisions in the wind industry.

1.2 As the Applicant knows more about their own development than any third parties our preference is for the Applicant to assess impact in line with NPS-EN3. Their continued refusal to comply with the policy forced us into commissioning an independent consultant, Wood Thilsted (**WT**), to assess the wake effect.

1.3 WT have used their expertise and professional judgment to create a reasonable set of assumptions and have calculated the wake effect on that basis. We believe it is still possible for the Applicant, and indeed their responsibility, to apply their detailed knowledge of the development of the project to strengthen the analysis of the wake effect on other wind farms caused by the project.

Impact of wake effect on Irish Sea developments future viability

1.4 The Applicant appears to assume the only relevant effect of the project is the immediate impact on energy generation at individual developments. UK offshore wind projects have historically been developed with government-sponsored market support. This support typically guarantees developers minimum electricity prices via Contracts for Difference (**CfDs**) and Renewable Obligation Certificates (**ROCs**) but are time limited.

1.5 As a result, late life developments will face greater uncertainties and pressure on profit margins due to volatile revenues coupled with the ageing nature of the assets pushing operating costs up. In such an environment, it is entirely possible that a 5% reduction in electricity production could accelerate the decision to decommission early.

1.6 As part of their 2023 annual report[1], The Crown Estate published a study of the benefits of life extension along with a comparative analysis of different offshore wind project types. They summarise their finding as such: "*while new developments contribute highly to security of affordable energy, a life extended project scores much higher in terms of the efficiency of materials and space, and minimising environmental impact*". This conclusion underscores the importance of properly assessing wake to facilitate the future co-existence of the projects.

1.7 The Applicant's approach ignores that the unmitigated effect of the project is such that it is likely to be a material factor in long-term decision making regarding such generation assets. Therefore, the generation at risk is not merely immediate reductions canvassed in the Wake Report, but could (a) shorten the life and result in the loss of the entire output of the generation assets; or (b) stop the generator from pursuing a lifetime extension of the existing generation assets.

[1] Page 24 of the "UK Offshore Wind Report 2023" by the Crown Estate.

Critiques of the Wake Report

1.8 WT have prepared two addendums to the Wake Report, which address technical criticisms made by the Applicant. The first addendum was provided at deadline 5 [REP5-059d] and an updated addendum is submitted alongside this submission. We do not seek to repeat the responses made in the addendum here. However, the Ørsted IPs wish to respond to a small number of issues raised.

Reliability of modelling

1.9 The Applicant has argued that there is no industry standard approach to assessing wake effects, that numerous models to predict wake are used in the industry, and that from these models a wide range of wake loss estimates may be expected. Therefore, in the Applicant's view "*the results of any alternative modelling approach may substantially differ from those presented in the Report, so the output values in the Report must be viewed in that context of significant uncertainty.*"[2]

1.10 The Ørsted IPs consider this characterisation does not accurately reflect the industry's understanding and ability to deal with this issue. Developers such as Ørsted and the Applicant would not be able to calculate business cases for the purpose of price auctions or take investment decisions if the Applicants assertions were true.

1.11 Offshore wind developers routinely undertake wake assessments of their developments. An accurate understanding of energy yield, which is inextricably linked with wind resource and wake, is fundamental to any business case for such development. While certain assumptions must be made in carrying out such assessments, these can and are made on an educated basis to provide a range of robust likely outcomes.

1.12 The modelling tool utilised for the Wake Report (DNV WindFarmer:Analyst) is the most common tool used by developers and is broadly accepted in the industry to produce reliable results.

1.13 The accuracy of the wake model used in the Wake Report has been extensively validated by DNV as mentioned in the final paragraph of section 1.2 of the Wake Report. These validations show that the wake model produces results which closely predict actual losses experienced on operational wind farms, and not one of endless possible outcomes as suggested by the Applicant.

1.14 As with any model, the wake model used in the Wake Report will have an uncertainty which has been established through the extensive validations on operational projects. The inputs to the wake model will also contain uncertainties. The industry is very capable of understanding and characterising these uncertainties hence the Applicants assertion that each different approach has equal validity shows a fundamental misunderstanding of the effect. Wake impacts can be evaluated taking consideration of the uncertainty of the analysis

1.15 As the Wake Report looks at the comparative difference between two scenarios where the only thing changing is the addition of neighbouring wind farms, many of the modelling

[2] [REP5-014].

and input uncertainties will be identical and cancel each other out reducing the inherent uncertainty in the wake analysis.

Ørsted
27.02.2025

Appendix 2 – Ørsted announcement regarding wake effects

Company announcement
No. 28/2019

Ørsted
Kraftværksvej 53
Skærbæk
DK-7000 Fredericia

www.orsted.com
Company registration no.
(CVR no.) 36 21 37 28

29 October 2019

Ørsted presents update on its long-term financial targets

At our Capital Markets Day on 28 November 2018, Ørsted presented a number of long-term financial targets. These targets are based on estimates of capital and operational expenses, production forecasts, outcome of offshore auctions, expected long term power prices, interest rates and other factors that are all inherently dynamic and subject to uncertainty. Given the combined impact of an adjustment of our offshore wind production forecasts and certain key positive and negative developments since the Capital Markets Day, as described below, we will give an update on the long-term targets.

On the negative side, three factors have added pressure on our long-term targets. The first factor relates to our offshore production forecasts.

We have been running a comprehensive project, which was finalised and presented to our Board of Directors today, to upgrade the models and processes we use to forecast the energy production from our offshore wind farms based on our access to extensive production data from our asset portfolio. The project has involved advanced analysis of a long list of variables impacting our production, and we have developed new proprietary models to forecast our expected energy production.

The project has led us to conclude that our current production forecasts underestimate the negative impact of two effects across our asset portfolio, i.e. the blockage effect and the wake effect.

The blockage effect arises from the wind slowing down as it approaches the wind turbines. There is an individual blockage effect for every turbine position and a global effect for the whole wind farm, which is larger than the sum of the individual effects. Our new wind simulation models show that we have historically underestimated these blockage effects. This finding is also supported by industry consultant DNV GL's recent report on blockage, which indicates that this effect is more broadly underestimated.

The second effect is the wake within wind farms and between neighbouring wind farms. There is a wake after each wind turbine where the wind slows down. As the wind flow continues, the wake spreads and the wind speed recovers. This effect, with wind turbines shielding and impacting each other, has been subject to extensive modelling by the industry for many years, and it is still a highly complex dynamic to model. Our results point to a higher negative effect on production than earlier models have predicted.

With respect to wake effects between neighbouring wind farms, we are in the process of developing a new model capable of more accurately predicting wake effects over longer distances. We have, among other things, leveraged a first-of-its-kind advanced radar system collecting three-dimensional data on the wind flow. The new model, which is still being refined, suggests a slower wind speed recovery and higher wake effects. At the same time, we have now factored in a more extensive offshore wind build-out in the different basins, which will increase the wake effect from neighbouring wind farms. As the global offshore wind build-out accelerates, the whole industry will see higher wake effects from neighbouring wind farms.

Over the years, we have benchmarked our internal production estimates against third-party views from industry experts. In comparison, most third-party production estimates have been trending towards a more positive view than ours. Therefore, we believe that underestimation of blockage and wake effects is likely to be an industry-wide issue.

While there is still uncertainty involved, it is clear that the production forecast adjustment arising out of our analysis has a negative effect on our financial estimates (see status below).

The higher-than-forecasted blockage and wake effects have also been embedded in our actual historical production numbers, but they have been captured in more broadly defined deviation buckets, such as wind contents, availability, curtailments and effects of ramp-up of new capacity being either behind or ahead of schedule. We have until now not had the data and the advanced analytics models to do a more granular breakdown of the production deviation. The new tools leveraging all our production data, including large new assets built over the past couple of years, have given us more detailed insight into the blockage and wake effects and other underlying production impacts. It is this analysis that has led us to conclude that the blockage and wake effects have been underestimated.

While the production adjustment is negative we are convinced that Ørsted's access to data and advanced analytics will be a driver of our long-term competitive advantage. We will, of course explore how the recent findings may translate into improvements to our design and lay-out of future wind farms.

The second key negative development since the Capital Markets Day is the lower feed-in tariff in Taiwan, where we had to accept a 6% reduction and a cap on full-load hours for our Changhua 1 &2a projects. Thirdly, we

have raised the CAPEX estimate for the Deepwater development portfolio in the US, mostly related to the transmission assets.

In terms of positive developments since the Capital Markets Day, we now expect slightly lower capital expenses on some of our construction projects. Secondly, lower interest rates have led to lower return requirements on our offshore transmissions assets in the UK, which leads to lower transmission charges. Thirdly, we have seen higher than budgeted availability on one of our newer wind turbine platforms, which positively impacts some of our assets.

Fourth and finally, in addition to the ongoing optimisation of our projects, we are taking measures to reduce our annual overhead cost base by DKK 500-600 million between 2020 and 2022, recognising that tight cost control remains an imperative in a competitive market environment. Roughly half of the cost reductions will be fall-away costs relating to the simplification of our structure following the divestment of our Danish downstream assets, and half will come from reductions across our staff functions, both internal and external spend.

The combined impact of these key developments since the Capital Markets Day leads to the following status on the long-term financial targets:

- Average growth in site EBITDA: ~20% for 2017-2023. Unchanged
- Average return on capital employed (ROCE): ~10% for the period 2019-2025. Unchanged
- Unlevered lifecycle IRR, capacity-weighted average for seven named offshore wind projects won in competitive tenders (Borssele 1 & 2, Hornsea 2, German Cluster 1, Gode Wind 3 & 4, Greater Changhua 1 & 2a, Greater Changhua 2b & 4 and Revolution Wind). The target is reduced from 7.5-8.5% to 7.0-8.0%
- Share of contracted and regulated EBITDA, average 2019-2025 of ~90%. Unchanged.

Lifetime load factor of 48-50% for a defined European offshore wind portfolio and construction and development projects is reduced to around 48% due to the adjustment of production forecasts.

The CAPEX and OPEX multiples communicated at the Capital Markets Day remain unchanged.

The information provided in this announcement does not change Ørsted's previously announced financial outlook for the 2019 financial year or the expected investment level announced for 2019.

For further information, please contact:

Media Relations
Martin Barlebo
+[redacted]

Investor Relations
Allan Bødskov Andersen
+[redacted]

Appendix – RWE/DNV study

[redacted]te

RESOURCE &TECH

NOVEMBER 14–15 | AUSTIN, TX

C. RODAWAY [1], K. GUNN [1], G. SMITH [2], D. DUNSMORE [2], K. SINCLAIR [2], C. MONTAVON [2], E. TRAIGER [3],

1. RWE Renewables UK Ltd, Swindon, United Kingdom
2. DNV Services UK Ltd, London, United Kingdom
3. DNV Energy USA Inc, Medford, United States of America

DNV

RWE

Big cluster & far-field wakes - an assessment of multi-fidelity models against North Sea wind farms' SCADA data

BACKGROUND

With the steady build-up of wind farms in the North Sea and US Eastern Seaboard, the impact of cluster wakes on wind farm annual energy production (AEP) increases over time. Wake effects over large distances / clusters is an increasingly emergent risk to LCoE.

The effect of cluster wakes is investigated for the object wind farms of Amrumbank West (ARB) and Triton Knoll (TK), operating in different parts of the North Sea.

OBJECTIVE

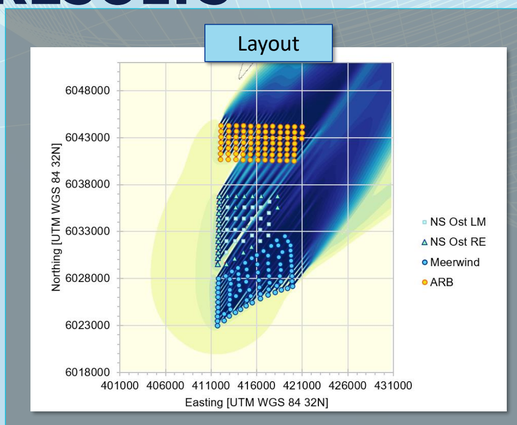
- ❑ Better understand (and reduce) uncertainty and bias of turbine interaction losses for tomorrow's wind farms.
- ❑ Assess the suitability of a range of wake models (from fast engineering models for wakes and blockage to higher fidelity CFD) in their ability to capture pattern of production (PoP) seen in SCADA data
- ❑ Focus on wind directions where the object wind farm is partly in the wake of an operating wind farm.

METHODS

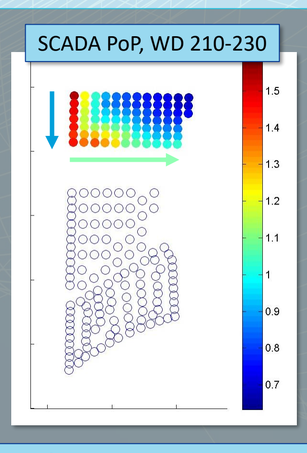
- ❑ Carefully process (clean, filter) SCADA data from two wind farms operating in the North Sea.
- ❑ Filter 10 minutes records for high windfarm availability (100% for ARB, 95.6% for TK of the turbines operating)
- ❑ From the filtered time series, derive PoP from the average power of each individual turbine.
- ❑ Compare (with SCADA) the PoP obtained from models such as the EVM + LWF [1], VV [2], and DNV and RWE CFD solutions [3, 4].

RESULTS

Layout



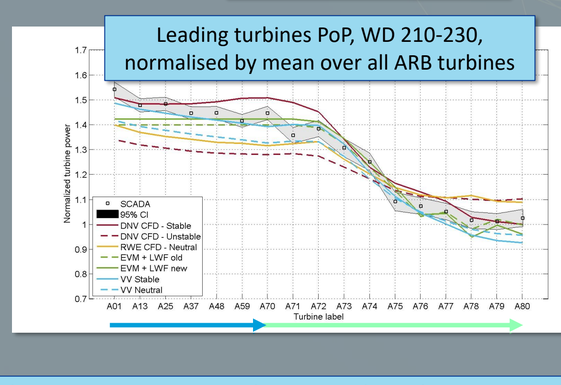
SCADA PoP, WD 210-230



SCADA data filtered for

- WS between ~6.5 and 8.5 m/s
- Median turbine wind direction between 210-230
- 100% of turbines operating
- Uncertainties from bootstrapping analysis

Leading turbines PoP, WD 210-230, normalised by mean over all ARB turbines



Model PoP - SCADA PoP (red = power over-estimate, closer to 0 = better)

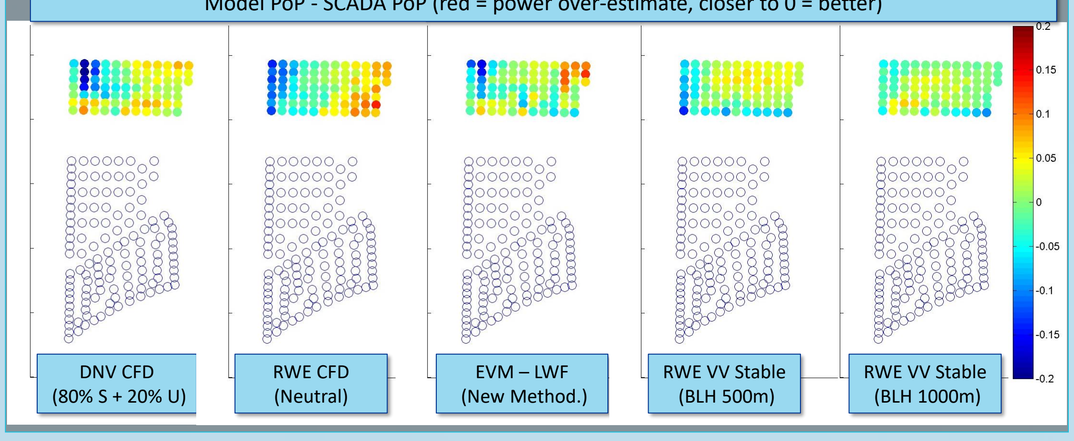
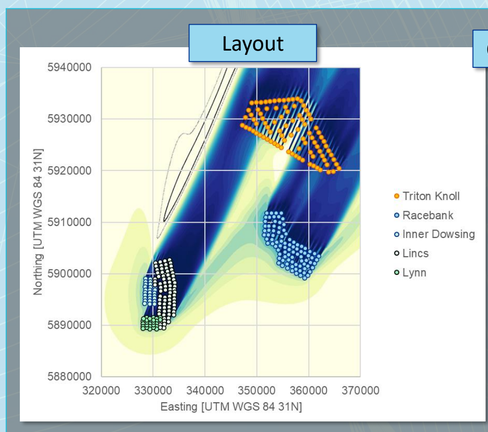
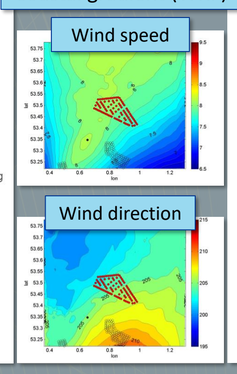


Figure 1: Amrumbank West results

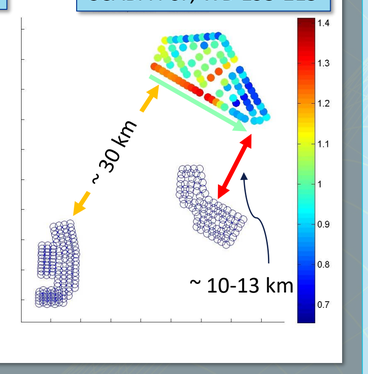
Layout



Coastal gradient (WRF)



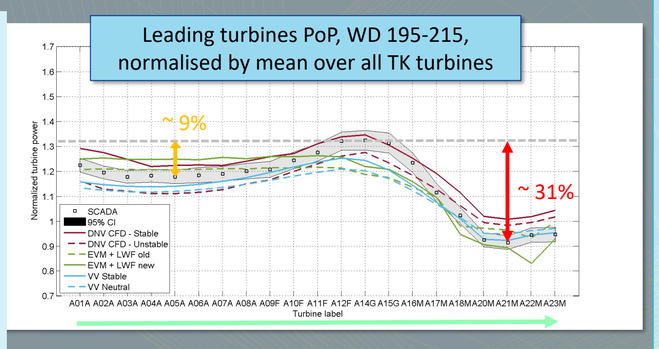
SCADA PoP, WD 195-215



SCADA data filtered for

- WS between ~6.5 and 9.5 m/s
- Median turbine wind direction between 195-215
- 95.6% of turbines operating
- Uncertainties from bootstrapping analysis
- Corrected for coastal transition (WRF background)

Leading turbines PoP, WD 195-215, normalised by mean over all TK turbines



Δ = Model PoP - SCADA PoP (red = power over-estimate, closer to 0 = better)

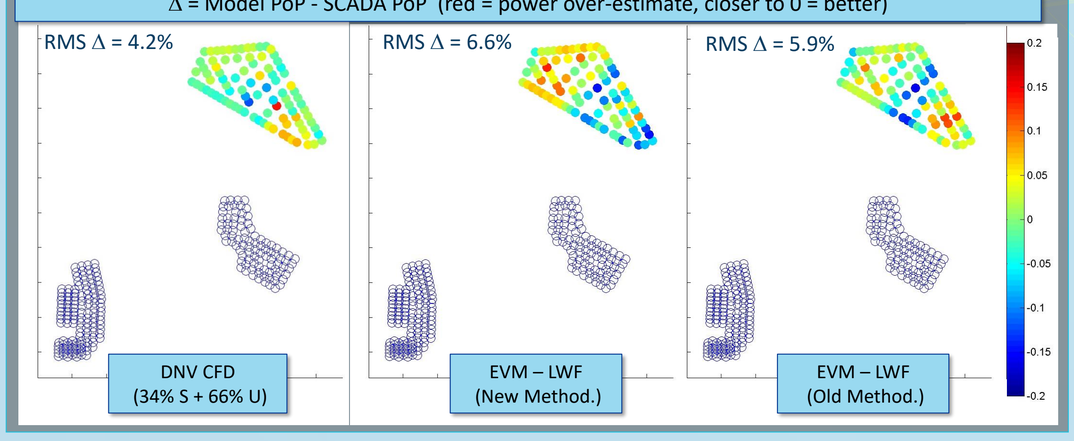


Figure 2: Triton Knoll Results

RMS Δ = root mean square of difference between model and SCADA PoP

CONCLUSIONS

While it was known from previous work that wind farm wakes can persist for distances over 50 km, when atmospheric conditions are stable, the current work demonstrates that cluster wakes can be detected in the SCADA data of offshore wind farms, without limiting the investigation to stable conditions. At TK, on the plateau of the thrust curve, the effect leads to a variation in turbine power of approximately 31% for leading turbines, when the distance between TK and the upstream cluster varies between 10-13 km (65 – 85 rotor diameters) **. For the larger distance of roughly 30 km, the variation in power across the leading turbines is approximately 9%. The magnitude of the effects will be significantly less once aggregated over the site wind speed distribution.

The EVM + LWF model appears to capture the wakes from the neighbours reasonably well for the leading turbines (improved after the methodology change [5]), but despite this, still tends to under-estimate the wake effects deeper in the array. RWE's VV model shows very good agreement with the measured PoP when set up with stable conditions (Obukhov length of 125 m) using a boundary layer (BL) height of 1000 m. The high-fidelity CFD models can capture the PoP with good accuracy for the leading turbines and throughout the array, when driven with appropriate boundary conditions.

Both the CFD and VV also reveal high sensitivity of the results to modelled stability conditions (surface stability, boundary layer height). To feed these high-fidelity models with the required inputs, there is a need to develop/test robust methodologies (either from meso-scale models or new measurement campaigns) to characterise the site stability conditions and boundary layer height.

The validation and the assessment of the effect in AEP terms is ongoing.

** Latest results removing effects in the SCADA data at TK that can be attributed to coastal gradients.

REFERENCES

1. WindFarmer 5, Theory Manual", GL Garrad Hassan, January 2013.
2. OWA GloBE: Background & Motivation, OWA GloBE: Experimental Design, WESC 2023.
3. Bleeg, J.; Purcell, M.; Ruisi, R.; Traiger, E. "Wind Farm Blockage and the Consequences of Neglecting Its Impact on Energy Production". Energies 2018, 11, 1609.
4. Rodaway, C. , Far-Field Turbine Interactions A Novel Hybrid RANS CFD Approach for Modelling Large Clusters, WESC 2023.
5. Williams, B., Far-distant offshore wakes: how far is too far and are we getting it right?, Wind Europe Technology Workshop, 2022. Available from https://windeurope.org/tech2022/proceedings/.

CONTACT

[redacted]