From: Brenstrum, Anna
To: Mona Offshore Wind Project
Cc: Innes, Colin; Waddell, Keira
Subject: EN010137 – Mona Offshore Windfarm deadline 7 - submissions on behalf of the Ørsted IPs [SWLLP-LEGALDIV.FID5260048]
Date: 14 January 2025 21:41:40
Attachments: [redacted]

Good evening,

Application by Mona Offshore Wind Limited (the "Applicant") for an Order Granting Development Consent for the Mona Offshore Windfarm (the "Project")

Submission on behalf of (1) Barrow Offshore Wind Limited (ref: 20048546) (2) Burbo Extension Ltd (ref: 20048544) (3) Walney Extension Limited (ref: 20048542) (4) Morecambe Wind Limited (ref: 20048547) (5) Walney (UK) Offshore Windfarms Limited (ref: 20048545) (6) Ørsted Burbo (UK) Limited (ref: 20048543) (the "Ørsted IPs")

We represent the above Interested Parties (who for convenience we refer to as the "Ørsted IPs") who are taking part in the examination for the Project in respect of the issues raised in their relevant representations and written representations.

In accordance with examination deadline 7, please find **attached** on behalf of the Ørsted IPs:

- Closing submission;
- Response to deadline 6 submissions; and
- An updated version of the wake assessment report by Wood Thilsted, provided at deadline 5 [REP5-120].

If you have any questions in respect of the above submissions, please let me know.

Kind regards
Anna

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COMMENTS ON DEADLINE 6 SUBMISSIONS AND FURTHER POST-DEADLINE EVIDENCE ON BEHALF OF:

(1) BARROW OFFSHORE WIND LIMITED (REF: 20048546) (2) BURBO EXTENSION LTD (REF: 20048544) (3) WALNEY EXTENSION LIMITED (REF: 20048542) (4) MORECAMBE WIND LIMITED (REF: 20048547) (5) WALNEY (UK) OFFSHORE WINDFARMS LIMITED (REF: 20048545) (6) ØRSTED BURBO (UK) LIMITED (REF: 20048543) (THE “ØRSTED IPs”)

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

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1. Introduction

1.1 We represent six owners of operational offshore windfarms in the East Irish Sea (as set out relevant representations RR-004, RR-007, RR-047, RR-087, RR-088 and RR-090), who we refer to together as the "**Ørsted IPs**" for the purposes of this submission.

1.2 At deadline 6 ("**DL6**") of the examination timetable for the application by Mona Offshore Wind Farm Limited (the "**Applicant**") for an Order under the Planning Act 2008 (the "**Act**") granting Development Consent for the Mona Offshore Wind Farm (the **"Project**"), the Applicant filed a number of documents regarding the wake effects of the Project, which the Ørsted IPs wish to respond to.

1.3 In this submission, the Ørsted IPs respond briefly to points raised in the following deadline 6documents:

1.3.1 the Applicant's comments on the Ørsted IPs responses to ExQ2 [REP6-117];

1.3.2 the Applicant's response to the December hearing action points [REP6-081];

1.3.3 the Applicant's response to ISH6.10 of the December hearing action points [REP6-082]; and

1.3.4 the Applicant's response to the wake loss assessment report [REP6-130].

1.4 The Ørsted IPs also respond to an additional submission by the Applicant ('Technical Note Calculation of Net Effects on GHG Emissions' ("**GHG Note**")) [AS-033]), accepted by the examining authority on 10 January 2025. This submission was provided following examination deadline 6 on 20 December 2024, and three working days before the final examination deadline.

2. Responses to Deadline 6 submissions on wake loss

2.1 It is noted that a number of points raised by the Applicant in its DL6 submissions have already been addressed in the Ørsted IPs DL6 submissions [REP6-147]. The Ørsted IPs do not seek to repeat those points, but wish to respond to some of the other points raised.

<u>Relevance of wake impacts on the Ørsted IPs developments</u>

2.2 In the Applicant's comments on the Ørsted IPs responses to ExQ2 [REP6-117], the Applicant has stated that the Project will not impact on the management of the Ørsted IPs developments in the near-term and would only be relevant to long term decision making. The Applicant goes on to state its understanding is that "*in reality it may not be relevant for decision making regarding any of the IPs assets"* and "*Any potential in-direct affect from Mona for some of the most marginal of the Ørsted IPs assets would be at most of minor relevance to decision making in the long-term."*

2.3 First, the Ørsted IPs wish to clarify their position is <u>not</u> that the Project will not impact on their developments in the short term. The Ørsted IPs consider, based on the results of the wake assessment undertaken by Wood Thilsted [REP5-120] (the "**Wake Report**") that their developments will be materially impacted by the Project once it is operational. However, as outlined in their response to ExQ2 [REP5-118], the wake effects are of a degree that they are also likely to impact the Ørsted IPs' long-term decision-making regarding the relevant assets.

2.4 Second, the Ørsted IPs absolutely reject the assertion by the Applicant that the predicted wake effects of the Project would not be relevant or would be of minor relevance to the Ørsted IPs' decision making.

2.5 Ørsted IPs' DL6 submission outlined how a lack of compensation or mitigation of the wake effects could indeed threaten coexistence: *"(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"* (Appendix 1, paragraph 1.7 [REP6-147). This response was provided by Ørsted A/S, from an internal industry perspective. Ørsted has been very particular with the way in which these concerns have been expressed. They reflect a considered evaluation of the consequence of the effects identified. This is based on their experience of operating a portfolio of offshore windfarms.

2.6 The Applicant's statement that wake impacts may not be relevant to the Ørsted IPs' long-term decision-making is pure assertion and is not based on any evidence presented to the ExA. Further, it is not for the Applicant to say what factors would be relevant to decision-making by another business.

2.7 It is noted that, objectively, the scale of impact predicted on Annual Energy Production (between 0.8%-1.7% from the Project alone, and up to 5.2% cumulatively) is significant. It is reasonable to expect that this effect would be relevant to decisions by any owner of generation assets. In the Awel y Mor decision, 2% reduction in energy production was considered sufficient to justify the imposition of a Requirement to assess and mitigate the wake effects of that development.

Viability of mitigating wake effects

2.8 In the Applicant's response to action point 12 of the December hearing action points [REP6-081], it has stated that there are no appropriate measures which could be implemented to mitigate the wake effects of the Project.

2.9 The Applicant has stated that any mitigation measures would have a disproportionate impact on the Project and that "*Given the low levels of impact the Orsted IPs have predicted from Mona on their projects, the scope for any mitigation to reduce impacts is correspondingly small.*"

2.10 First, the Ørsted IPs note that the level of impact at their developments cannot reasonably be described as "small". As noted above, the cumulative effects of the Project on AEP are predicted to be up to 5.2%, and the Project-alone effects are predicted to be up to 1.7%.

2.11 Further, the Ørsted IPs consider the Applicant is not in a position to state that implementing mitigation measures would be disproportionate, having not undertaken any assessment of the Project's wake effects or realistic potential mitigation measures. This is particularly true in light of the potential for the Project to impact long-term decisions regarding the lifetime of Ørsted IPs' developments. The Applicant's claims regarding the effectiveness of mitigation measures are not based on any realistic assessment or evidence, which is characteristic of the Applicant's approach to this matter throughout the examination.

2.12 The Ørsted IPs consider that, if there are genuinely no appropriate mitigation measures to be implemented, the Applicant must consider how to provide compensation for the effects. As outlined in their DL6 submission, the Ørsted IPs understand that this is an issue which is regularly dealt with by applicants and incumbent developers - often resolved through negotiation.

Critiques of the Wake Report

2.13 The Applicant has responded to the Wake Report in its DL6 submission [REP6-130]. The Applicant's critiques were responded to in the addendum prepared by Wood Thilsted and submitted at DL6 [REP6-147] as well as the Ørsted IPs' DL6 submission.

2.14 We do not seek to repeat those responses here, however, in response to the Applicant's concern that the Morgan PEIR boundary was used in the Wake Report, we note that the Wake Report has been updated using the Morgan DCO boundaries and is submitted alongside this submission. There are no changes in the impacts predicted from the Project as a result of this minor update, however there are very small changes to the cumulative impacts driven by minor changes to the Morgan wake effect (overall increasing by 0.04% from 1.64% to 1.68%). In the initial version of the Wake Report the independent consultant had opted not to place turbines in the area of Morgan closest to the Orsted IPs hence the change to the boundary had an insignificant impact.

3. Response to GHG Note

3.1 The Applicant shared the GHG Note with the Ørsted IPs on 9 January. The Ørsted IPs note the Applicant held back updating its GHG assessment in response to the Wake Report until three working days before the end of the Examination.

Methodology

3.2 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.

3.3 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"*.

3.4 This scenario ignores the potential for lifetime extensions of the Ørsted IPs' assets. As highlighted on a number of occasions in this examination, several of these assets do not require additional consents to continue operating. Additionally, as highlighted in the Ørsted IPs' deadline 6 submission [REP6-147] the Crown Estate has highlighted that, life extended offshore wind projects score more highly (in terms of efficiency of material and space and minimising environmental impact) than new development.

3.5 Further, 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 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.

3.6 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.

Maximum Design Scenario

3.7 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.

3.8 In contrast, the scenarios assessed in the Wake Report are realistic and test different scale turbines.

Energy production

3.9 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.

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

Mitigation

3.11 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.

3.12 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.

3.13 The layout scenarios assessed reduces the Project's array area by 50% and increasing 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 provided a assessment of an extreme scenario.

3.14 As a result, the Applicant's attempt to assess a scenario where the wake effects of the Project are mitigated is highly unrealistic. Therefore, it is not helpful in developing an understanding of realistic mitigation scenarios and does not assist in decision making.

Late provision of the GHG Note

3.15 We note that the provision of important new evidence shortly before the final deadline in an examination is not in line with good practice. Regrettably, as a result of the Applicant's approach to this issue throughout the examination, this information is being provided at a stage where there is no longer any meaningful opportunity to engage with it.

3.16 The GHG Note appears to have been prepared in a rushed manner and contains fundamental limitation which prevent it from providing a realistic assessment of the net GHG effects of the

Project. As a result, the Ørsted IPs do not consider it provides any meaningful assistance to the decision-making process.

3.17 In conclusion, the Ørsted IPs remain of the opinion that the Applicant has provided insufficient information to inform the Examining Authority and by extension the Secretary of State. The GHG Note, although a step in the right direction, contains many limitations and, at the time of writing, has not been tested. The Ørsted IPs believe that this is too little too late, and that it does not compensate for the Applicant's lack of engagement on this topic throughout the examination. The Examining Authority is thus left with the invidious task of assessing a key aspect of the application without access to realistic information.

Shepherd & Wedderburn LLP

14.01.2025

SHEPHERD+ WEDDERBURN

DEADLINE 7 SUBMISSIONS ON BEHALF OF:

(1) BARROW OFFSHORE WIND LIMITED (REF: 20048546) (2) BURBO EXTENSION LTD (REF: 20048544) (3) WALNEY EXTENSION LIMITED (REF: 20048542) (4) MORECAMBE WIND LIMITED (REF: 20048547) (5) WALNEY (UK) OFFSHORE WINDFARMS LIMITED (REF: 20048545) (6) ØRSTED BURBO (UK) LIMITED (REF: 20048543) (THE "ØRSTED IPs")

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

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CONTENTS

1. Introduction

1.1 This submission primarily addresses the Ørsted IPs' position in relation to wake loss and briefly summaries their position in respect of shipping and navigation, ecology and aviation.

1.2 The Ørsted IPs recognise that this is the last deadline and therefore new evidence should not be submitted. The Ørsted IPs have responded separately to matters raised by the Applicant at Deadline 6. The Applicant raised concerns regarding certain aspects of the modelling of the Morgan scheme. This has resulted in a revised version of the Wood Thilsted report. It does not alter the assessment relating to Mona, but there are minor differences relating to the cumulative findings.

1.3 Throughout this examination, the Ørsted IPs have also raised concerns regarding shipping and navigation, ecology and aviation. The Ørsted IPs consider their concerns as outlined in previous submissions largely represent their position on these matters. However, for completeness, the Ørsted IPs summarise their key submissions on those matters below, and respond to a small number of points arising from the Applicant's deadline 6 submissions:

1.3.1 In respect of shipping and navigation, the Ørsted IPs have sought to be specifically engaged on the shipping and navigation risks arising from the development and how those will be managed. The Ørsted IPs seek a formal commitment to ensuring the Ørsted IPs have the opportunity to review the Outline Vessel Traffic Management Plan ("**OVTMP**") pre-submission to the Licensing Authority, pre-construction in the interests of navigational safety within the vicinity of the Ørsted IPs assets, in the absence of details being provided on where the Applicant's construction and operation ports will be located. The Ørsted IPs are not satisfied that the provision in the OVTMP to consult with "existing sea users" as part of the Marine Navigation Engagement Forum provides adequate certainty that they will be consulted with nor is this considered a meaningful mechanism for engagement pre-construction. Therefore, the Ørsted IPs seek to be specifically named as consultees in that document pre-submission to the Licensing Authority. Additionally, in light of the cumulative risks to shipping and navigation at their developments, the Ørsted IPs also expect close co-operation on the Marine Pollution Contingency Plan and Emergency Response Co-operation Plan to ensure mutually beneficial outcomes. Furthermore, the Ørsted IPs do not believe the Applicant has confirmed that the changes in allision risk that directly impact the Ørsted IP's assets specifically remain within ALARP parameters, and whether additional mitigations are required for those projects to achieve ALARP status.

1.3.2 The Ørsted IPs have raised a number of concerns regarding the Applicant's ecological assessments which are largely resolved. However, the Ørsted IPs remain concerned regarding the exclusion of Barrow Offshore Windfarm from the Applicant's cumulative effects assessment. The Ørsted IPs acknowledge that the Applicant has undertaken to update its cumulative effects assessment and in-combination assessment to include Barrow Offshore Windfarm at deadline 7 [REP6-116]. While this is a positive development, the Ørsted IPs note that, given the late provision of this information, the Ørsted IPs have not had an adequate opportunity to consider this information or the Applicant's approach to updating the assessments. This is unsatisfactory.

1.3.3 In respect of aviation, two of the Ørsted IPs (Walney Extension Limited and Burbo Extension Limited) have raised concerns regarding the impacts of the Project on the radar mitigation solution being developed in respect of Warton Aerodrome. The Ørsted IPs are content to rely on their previous submissions in respect of this matter.

1.4 The balance of this submission summarises the Ørsted IPs' position in relation to wake effects. The Ørsted IPs raised concerns regarding wake loss in June 2023. The Ørsted IP's have sought to engage with the Applicant over the assessment of the wake losses and offered to find practical ways of sharing confidential information such as the power curves of the existing turbines. The Applicant has refused to engage with the matter and a range of defensive arguments have been put forward. Those arguments initially contained in the Environmental Statement related to Crown Estate Leasing Round distances and the Frazer Nash report commissioned by the Crown Estate. The Crown Estate have recently made submissions to the Outer Dowsing Offshore Windfarm Examination. The lines of argument presented by the Applicant were undermined and put in a proper context by the Crown Estate. Neither the leasing distances nor the study are an effective proxy for the requirement to undertake appropriate individual assessment. The Crown Estate acknowledged that distance was just one factor in understanding wake effects and that the underlying wind characteristics were critical. This is the issue with the proposed Irish Sea projects. They sit directly within the prevailing wind direction of the majority of the existing projects. Subsequent to that the Applicant's non-engagement has almost entirely been predicated on the word "close" in paragraph 2.8.197 of NPS-EN-3. The Applicant's approach is misconceived and would result in a misinterpretation of EN-3. It is clear when the document is read as a whole that the Applicant's interpretation could not possibly be sustained. In particular, it is impossible to reconcile the "narrow" construction with paragraphs 2.8.261 and 2.8.347. It is clear the policy objective of co-existence requires a proper understanding of how any new proposal will impact on existing and consented projects.

1.5 In the absence of the Applicant engaging in any meaningful way with the issue, the Ørsted IPs commissioned an independent wake assessment. This has used industry accepted approaches to provide a prediction of the likely effects of this development in combination with the other applications either decided or currently at application stage within the Irish Sea. The Applicant has sought to argue with some of the matters around the edge of the assessment, but in essence they have failed in any way to undermine the fact that this is the best evidence before the Examination on this issue. The Applicant does not appear to substantially dispute that the effects are within the range of what might be anticipated.

1.6 The outcome of the assessment is that there would be clear and meaningful effects on the Ørsted IPs' assets from the proposed project, both individually and cumulatively with other application-stage and consented projects proposed in the Irish Sea.

1.7 The Secretary of State's reasoning associated with the Awel Y Mor decision related to a yield impact of a maximum of 2% for a five-year period on the Rhyl Flats project. The objector acknowledged that this level of impact would not impact upon the ongoing viability of this project. In that context, the Secretary of State agreed with the reasoning of the ExA in relation to the policy analysis and considered that appropriate action should be taken to ensure that the scheme properly took into account and minimised wake loss in the final design. The scale of impact on some of the Ørsted IPs' assets is more than double this and, in addition, Ørsted have confirmed that the scale of impact is such that it could impact in a material way upon the life extension decisions in respect of the existing projects. Life extension is currently being further examined by the Crown Estate and it is acknowledged as being one of the most sustainable forms of continuing the availability of renewable electrical capacity.

1.8 The Applicant has chosen not to put forward any suggestions for dealing with or mitigating the wake effects identified. It also rejects that any requirement should be applied. The argument advanced is that any impact on the application would result in a greater loss than any benefit. This argument is entirely predicated on the line that the only effect that the application would have would be the marginal annual loss deriving from the impact. However, that is not the case and there is a risk, given the scale of impact, that extensive years of generation could be lost entirely due to the economic impact. Again, at no stage has the Applicant sought to quantify in any meaningful sense the argument that has been put forward. It is an assertion and is not supported in evidence before the Examination. It is notable that it is only the Applicant that can meaningfully assess the operational impact or change in layout that may result from appropriate mitigation to reduce wake effect. The Applicant has chosen not to engage with this at all. As a consequence, it is wholly uncertain as to whether any layout or operational changes could mitigate the effect. Furthermore, the Applicant has not entered into any contractual arrangement to offset or mitigate the effects. Against that background, the ExA and the Secretary of State will be left to try and resolve the issue. The lack of information in relation to this matter is entirely due to the Applicant's position. As identified above, the Secretary of State has already held that a maximum impact of 2% on yield should be subject to a requirement to mitigate in terms of layout. The Applicant's approach is not consistent with the terms of EN-3. Within this policy framework there is a requirement to assess likely effects and also to consider mitigation.

2. Decision making in terms of the Planning Act 2008

2.1 The decision making in respect of this application requires to be undertaken in terms of section 104 of the Planning Act 2008. This requires that, in deciding any application, regard must be had to any National Policy Statement which has effect. In the context of the current application, it is likely that up to three National Policy Statements would be relevant (EN-1, EN-3 and EN-5). In addition, the Secretary of State is also obliged to decide the application in accordance with the relevant National Policy Statement except to the extent to which one of the sub-sections (4) to (8) in relation to section 104 may apply.

Marine Plans

2.2 In addition to the National Policy Statements, sub-section (2) also identifies that there are other documents and information which should also be taken into account in the decision making. This includes, under sub-section (aa) appropriate Marine Policy documents. The Welsh National Marine Plan will be relevant. In terms of this plan, paragraph 16 confirms that where there is the potential to affect this plan area then the Welsh Plan applies, but where a decision has the potential to affect another marine plan area then it should be taken in accordance with or with regard to other relevant Marine Plans as well. Policy ECON-02 specifically deals with the issue of co-existence. The text supporting the policy at paragraph 104 confirms that proposals should set out how co-existence with other activities have been assessed and how co-existence will be achieved. The Applicant’s failure to properly assess impacts on other sea users is not consistent with this policy.

2.3 As identified above, notwithstanding the project is located within Welsh waters, the Welsh Marine Plan also identifies the potential for effects beyond its boundaries. The Ørsted IP assets are located within the North West inshore and North West offshore Marine Plan area. This document recognises the value of the existing offshore wind farms that are already operating in the area. It also incorporates policies relating to co-existence including NW-CO-1 (page 22). It requires an approach to assessment ensuring that “*Proposals that may have significant adverse impacts on, or displace, existing activities must demonstrate that they will in order of preference (a) avoid, (b) minimise and (c) mitigate -adverse impacts so they are no longer significant. If it is not possible to mitigate significant adverse impacts, proposals must state the case before proceeding.*”. This is consistent with the policy aim set out in the adjacent column. This requires conflicts to be managed and may require minimisation of footprint or optimising it where it is not feasible to minimise.

2.4 The Marine Plan is further supported by a technical annex. At the bottom of page 26 there is a highlighted box which confirms that the individual Marine Plan Policies must not be read in isolation and that the Marine Plan must be read as a whole. The annex provides a specific section on co-existence at section 5.2. It goes on to discuss generally the concept of co-existence and, under paragraph 106, advises that the application of policy must be supported by an overall assessment of the range of existing activities. This reinforces the need for proper assessment by the Applicant of the issue. It is only by appropriate understanding that the policy can actually be applied. The Ørsted IPs have already made extensive submissions at previous deadlines about the co-existence policies contained within EN-3. The Marine Policy Statement and Marine Plans incorporate important policies recognising the particular importance of co-existence in the marine environment. This emphasis is not surprising given the legislative terms of the Marine and Coastal Access Act 2009. Section 69 sets out the matters that have to be considered in the determination of a Marine Licence. This confirms that the licensing authority is obliged to have regard to the need to prevent interference with legitimate uses of the sea. Co-existence is a concept that is inherent in the marine legislative framework.

2.5 In addition to the Marine Plan considerations, it is considered that the scale of impact that the application would have, both individually and cumulatively, on the Ørsted IPs assets would also engage section 104(2)(d) of the 2008 Act. In particular, the scale of impact on existing assets, most of which would be above the NSIPs thresholds, is likely to be both important and relevant to the Secretary of State’s decision. This is also further supported by the prior decision making of the Secretary of State in respect of the Awel Y Mor decision.

2.6 The Secretary of State will also have to consider sub-sections (iv) to (viii). This requires consideration under sub-section (vii) as to whether or not the adverse impact of the proposed development would outweigh its benefits. As identified in the evidence, there is a very real material risk that the individual and cumulative impacts may impact on the continued existence of the operation of the Ørsted IPs’ assets. It is not therefore just the marginal loss that requires to be taken into account, but this potential impact as well. The Applicant has chosen not to put forward any mitigation and therefore the full impact should properly be weighed under that paragraph. This paragraph requires a weighing up of all the issues, but in the context of wake loss it would have to be evaluated on an unmitigated basis.

3. EN-3

3.1 As identified in prior submissions, it is considered that the Applicant's construction of paragraph 2.8.197 is not justified when EN-3 is construed appropriately. It is wholly inconsistent with the relevant Marine Plans. It would also be wholly inconsistent with the text on mitigation contained in paragraphs 2.8.261 and 2.8.262. The Ørsted IPs sought to engage with the Applicant prior to submission and the Applicant has ignored the issue in conflict with 2.8.341 to 2.8.348. Paragraph 2.8.347 on the likely effects on future viability is strongly phrased and confirms that it should be given substantial weight in the decision making. Simply put, the Applicant has failed in all aspects of the application process and that is a factor to which substantial weight should be given to in the decision-making process. The Applicant's final line of argument is the larger scale of new generation should prevail over the effects on existing projects. This line of argument fails to acknowledge the importance of co-existence within the policy framework and would if applied undermine long term investment in the sector.

4. Implications for decision making

4.1 The Applicant's current position is that there should be no requirement for any mitigation or compensation. Such a position could have profound implications for existing operational offshore windfarms.

4.2 To date, adjacent offshore wind farm projects have typically had a common owner, either in full, or in part through JV ownership. This joint ownership has facilitated fair and amicable wake-loss mitigation and compensation outcomes. As the UK seabed becomes more crowded with new wind farms and different owners, and as our industry's understanding of the extent of far-field wake effects matures, a clear need has emerged for mitigating or compensating wake effects. Importantly, any framework must develop the status quo and establish a level playing field to enable the successful long-term coexistence of the many new offshore wind farm projects that do not, and that will not, have a common owner. In addition, the framework should ensure that wake generated by new wind farms neither prevents lifetime extensions, nor reduces the potential operational lifetime of existing assets, such that existing wind farms can continue to deliver green energy to the grid.

4.3 The need for a UK-wide framework is highlighted in the wake-loss case-study presented on page 84 of HMGs 'Clean Power 2030 Action Plan'. The precedent that is established through the Applicant's DCO, and through subsequent Lease Round 4 DCOs, will form the basis of this framework. Without a supporting precedent, developers will have no choice but to respond to an increased level of uncertainty by increasing the assumptions of future wake loss that inform their business decisions. Lenders and investors financing projects will seek assurances that remove uncertainties before committing their capital. Developers will price in a risk-premium at all stages of a project's development, from entering the seabed lease to bidding for CfDs. To avoid UK energy bill payers incurring unnecessary cost increases, an appropriate framework is required. For the benefit of the UK offshore wind sector and UK energy consumers alike, developers must be enabled to price projects competitively and to deliver the UK's offshore wind build-out as cost effectively as possible (43-50GW by 2030 as set out in the Clean Power 2030 Action Plan and 65GW-140GW by 2050 under the Balanced Pathway Scenario of the 6th Carbon Budget).

5. Conclusion

5.1 The Applicant has chosen to not assist the ExA or the Secretary of State by providing any detailed information on the assessment of wake effects or the potential benefits and disbenefits of providing realistic mitigation through the further design of scheme. The Applicant, just prior to the final deadline lodged a Technical Note: Calculation of Net Effects on Greenhouse Gas Emissions. This considered theoretical mitigation. At paragraph 4.2.4.1 the Applicant concedes "*This exercise does not seek to accurately replicate or reflect the real world situation in the Irish Sea*". The report went on to describe in paragraph 4.2.4.2 that the mitigation modelled could not be accommodated. These are significant limitations to the value of the study in respect of the restricted scenarios considered. As a minimum, the Applicant should be required to take wake loss into account in terms of the final design of the project. The difficulty for decision making is that the extent to which this might potentially reduce the effects is unknown. On that basis the decision making will have to be undertaken applying the modelled predictions. That is the best and only evidence available. The Ørsted IPs have confirmed that the predicted level of impact could materially impact the future viability of projects. This does not conform to the long-established policy objective of co-existence. The ExA and Secretary of State should apply significant negative weight to the issue in the decision-making balance. In addition, the threat to future viability should also be properly accounted for in terms of the Environmental Impact Assessment of the proposal both individually and cumulatively. This is a legal requirement of schedule 4 sub-paragraph 5 (f). This is legal requirement because it is part of the mandatory requirement of the regulations. This is a topic which that was included in the Applicant's EIA under the heading of "Climate Change". The net emissions of the Mona windfarm should properly account for the consequences of yield losses and the impact on future viability of other projects. The Applicant's Technical Note "Calculation of the Net Effects on Greenhouse Gas Emissions" only looked at the predicted annual loss and failed to model the consequences of the early closure of plant due to viability. It is therefore a "best case" analysis and fails to model the effects on viability. The scale of the collective impact has the potential to be significant. At this stage this remains unquantified.

5.2 The above circumstances derive from the Applicant's persistent failure to engage with the updated evidence on wake effects. This is now soundly based on evidence derived from the actual experience of operating offshore windfarms. The Applicant's approach fails to comply with EN-3 and is not consistent with the decision making undertaken in respect of the Awel Y Mor project in September 2023.

5.3 A failure to address this wake loss issue appropriately will not only impact upon existing operational windfarms but will also create a climate of uncertainty and risk for future development.

Shepherd & Wedderburn LLP
14.01.2025

WOOD THILSTED

Wake Impact Assessment report

Irish Sea Cluster - Ørsted

P0253-C2021-CA-REP-001-2

Ørsted

REVISION HISTORY

Rev	Date	Description	Author	Checker	Approver
1-1	3rd December 2024	Issue for DCO hearing assessment	MCA	BDQ	NEL
1-2	14th January 2025	Update of report following change to the PEIR boundary for Morgan and correction to capacity values for Burbo Bank.	MCA	CCO	NEL

LIST OF ACRONYMS

The following table lists some of the acronyms used in this report.

Abbreviations	Definition
AEP	Annual Energy production
BoP	Balance-of-Plant
CFD	Computational Fluid Dynamics
DCO	Development Consent Order
EPA	Energy Production Assessment
ERA5	ECMWF Reanalysis 5th Generation
ECMWF	European Centre for Medium-Range Weather Forecasts
EPSG	European Petroleum Survey Group Geodetic Parameter Database
FL	Floating Lidar
IEC	International Electrotechnical Commission
MM	Meteorological (Met.) Mast
MERRA	Modern-ERA Retrospective analysis for Research and Applications
MoMM	Mean of Monthly Means
CAPEX	Capital Expenditure
EIA	Environment Impact Assessment
O&M	Operation and Maintenance
P50	Exceedance probability: The probability of exceeding the reported P50 value for annual energy production is 50%
P90	Exceedance probability: The probability of exceeding the reported P90 value for annual energy production is 90%
PBE	Production Based Estimate
PC	Power Curve
PPA	Power Purchase Agreement
Q&A	Questions and Answers
SPV	Special Purpose Vehicle
SCADA	Supervisory Control and Data Acquisition
TI	Turbulence Intensity
TSA	Turbine Supply Agreement
WAsP	Wind Atlas Analysis and Application Program
WF	Wind Farm
WRF	Weather Research and Forecasting
WSBE	Wind Speed Based Estimate
WSM	Wind Sector Management
WTG	Wind Turbine Generator
WT	Wood Thilsted

EXECUTIVE SUMMARY

Ørsted (the "Client") has retained Wood Thilsted Partners Ltd (WT) to develop an independent wake impact assessment for their operational offshore wind farm assets in the Irish Sea. These assets are anticipated to be impacted by the proposed neighbouring wind farms, including Mona[1], Morgan[2] and Morecambe[3] (abbreviated as MoMoMo).

Apart from the individual impacts of the wakes of each of the wind farms given above, the cumulative impact caused by all three wind farms on the Client's assets will also be assessed. Along with the MoMoMo wind farms, WT has also considered the effect of existing neighbouring operational wind farms including Gwynt y Môr, Rhyl Flats, North Hoyle and Ormonde, and the future wind farm Awel y Môr.

A range of publicly available datasets has been utilized for the assessment of future wind farm parameters, including the development phase, possible turbine configurations, turbine type and hub height. Sources for this include the 4C Offshore Wind Market Intelligence [1], submissions to the National Infrastructure Planning Portal [3], along with correspondence with the Client [2]. It should be noted that due to the early stage of some of the projects, the information compiled for the future projects are not considered final, therefore the impacts will be subject to change – this report should be considered as being based on the best available information at the time of preparation.

The wind farms belonging to Ørsted, namely Barrow, Walney 1, Walney 2, Walney Extension 3 and 4, West of Duddon Sands, Burbo Bank and Burbo Bank Extension are situated in the wider Liverpool Bay area, close to the UK coastline of the Irish Sea, ranging from 20-30 km from the shore.

This report provides a summary of the data used along with the industry standard methodologies for deriving the impact of wakes between operational wind farms. The primary objective of the study is to estimate the comparative loss in energy for the Ørsted assets due to wakes caused by the addition of new wind farms, and not estimating the absolute values for energy production and wakes. A short description of wind farm wakes, their effects and methodologies for their modelling is also included in Section 1.2.

WT has assessed the effects of future wind farms by utilizing different scenarios. Table 1 below summarizes the main scenarios used and Table 2 summarizes the magnitudes of additional losses with respect to the baseline scenario.

[1] Mona Windfarm, https://www.morganandmona.com/en/ a joint venture of EnBW - BP
[2] Morgan Windfarm, https://morecambeandmorgan.com/morgan/ a joint venture of EnBW - BP
[3] Morecambe Windfarm, https://morecambeandmorgan.com/morecambe/en/ a joint venture of Cobra Instalaciones y Servicios, S.A. - Flotation Energy Limited

Table 1 External Wakes Scenarios

Scenario	Included Wind Farms	Comments / Assumptions
Baseline	Ørsted assets[1] + Neighbouring operational wind farms[2]	Existing operational conditions
Scenario 1	Baseline + proposed **Mona**[3] Wind Farm	Mona Wind Farm capacity will be up to 1500 MW, to start construction in 2026, and owned by a joint venture of EnBW - BP
Scenario 2	Baseline + proposed **Morgan**[3] Wind Farm with	Morgan Wind Farm capacity will be up to 1500 MW, to start construction in 2027, and owned by a joint venture of EnBW - BP
Scenario 3	Baseline + **Morecambe**[3] Wind Farm	Morecambe Wind Farm capacity will be up to 480 MW, to start construction in 2027/2028, and owned by a joint venture of Cobra - Flotation Energy
Scenario 4	Baseline + all **MoMoMo**[3] assets	-
Scenario 5	Scenario 4 + **Awel y Môr**[3]	Awel y Môr Wind Farm capacity will be approximately 576 MW and will be operational by 2030.

[1] Barrow, Walney 1, Walney 2, Walney Extension 3 and 4, West of Duddon Sands, Burbo Bank and Burbo Bank Extension

[2] Gwynt y Môr, Rhyl Flats, North Hoyle and Ormonde

[3] 15 MW capacity turbines (each), 150 m hub height and 236 m rotor diameter turbine

Based on these scenarios the additional wake loss in individual wind farms varies between **-0.20 %** and **-5.34 %** depending on the scenario and the existing Ørsted assets under consideration. Considering the total effect on all the existing Ørsted Irish Sea Portfolio, the effect varies between **-0.68 %** (considering if only Morecambe OWF is consented) to **-3.82 %** (considering if all future wind farms considered in this study are consented), depending on the scenario.

As such, if all the proposed development takes place, the cumulative impact on the Ørsted Irish Sea Portfolio is just under **-4 %**. Whilst this may only be following the total build out (with completion timelines post 2030), the impact on annual energy production (AEP) of individual future wind farms has been seen to be between **-0.68 %** and **-1.68 %** on the existing Ørsted Irish Sea Portfolio.

Considering the engineering wake model approaches used and distances between the Client assets and proposed neighbouring wind farms, WT considers the assessed additional wake loss numbers to be commensurate with WT's expectations. WT also finds the above results comparable with recent studies conducted by DNV and RWE [7] about cluster wakes and their effects on wind farm annual energy production, where values of -3.0% to -3.6% additional wake losses arising from neighbouring wind farms which are 5-30 km away from the projects under interest.

Subject to specific criteria on each wind farm site, including capacity factor, age of the wind farm, turbine type/size and the agreed electricity sale price, the financial and technical consequences of additional wake losses could be considerable. WT also notes that increased turbulence levels due to the added wake may increase the fatigue / structural loading and may cause additional downtime for the turbines, where electricity production is halted.

Due to uncertainty on the ultimate turbine selection, WT has also undertaken a series of sensitivity scenarios for the future wind farm assets, based on an assumption of 22.6 MW 276 m diameter wind turbines (instead of 15 MW 236 m rotor diameter turbines). The turbine types chosen for this analysis are based on the expected available turbine models in the delivery year. The results of this sensitivity test (shown in Table 5-2) suggest that the additional wake losses will typically be reduced with larger turbines.

Table 2 Summary of the results of the main scenarios, normalized to the baseline

Scenario	**Additional wake loss on each wind farm (%)**								
	Barrow	**Walney 1**	**Walney 2**	**Walney Extension 3**	**Walney Extension 4**	**West of Duddon Sands**	**Burbo Bank**	**Burbo Bank Extension**	**Total additional wake loss on all Ørsted Irish Sea assets**
Baseline	0	0	0	0	0	0	0	0	0
Scenario 1 - Addition of Mona OWF	-1.55%	-1.67%	-1.22%	-0.83%	-1.58%	-1.57%	-0.96%	-1.22%	-1.38%
Scenario 2 – Addition of Morgan OWF	-0.45%	-1.58%	-2.18%	-3.35%	-3.22%	-1.28%	-0.25%	-0.20%	-1.68%
Scenario 3 – Addition of Morecambe OWF	-1.37%	-0.53%	-0.32%	-0.40%	-0.56%	-1.01%	-0.46%	-0.45%	-0.68%
Scenario 4 – Cumulative addition of MoMoMo	-3.09%	-3.78%	-3.69%	-4.13%	-5.21%	-3.86%	-1.63%	-1.84%	-3.65%
Scenario 5 – Cumulative addition of MoMoMo and Awel y Môr	-3.36%	-3.84%	-3.73%	-4.16%	-5.34%	-3.97%	-2.16%	-2.45%	-3.82%

1. INTRODUCTION

1.1. Background to the study

Ørsted (the "Client") has retained Wood Thilsted Partners Ltd (WT) to complete an independent assessment of the possible additional external wake losses for their operational wind farms located in Irish Sea. The starting hypothesis is that these additional losses will be incurred from the proposed future neighbouring wind farms, including Morgan, Mona and Morecambe (abbreviated as MoMoMo) and Awel y Môr.

The Client's operational wind farms are considered to include:

- Barrow (90 MW, commissioned in 2006)
- Walney Phase 1 (183.6 MW, commissioned in 2011)
- Walney Phase 2(183.6 MW, commissioned in 2012)
- West of Duddon Sands (388.8 MW, commissioned in 2014)
- Walney Extension[4] (Walney Phases 3 & 4) (659 MW, commissioned in 2018)
- Burbo Bank (90 MW, commissioned in 2007)
- Burbo Bank Extension (256 MW, commissioned in 2017)

The Client is interested in the potential differences in annual energy production driven by the external wake effects from the proposed future MoMoMo wind farms. These future farms are at the stage of having their Development Consent Orders examined. Apart from the individual impacts of the wakes on each wind farm listed above, the Client has also requested the cumulative impact caused by all three wind farms on each of the Client's Irish Sea assets. It should be noted that due to the physical complexity of wind turbine wake phenomena (as explained in Section 1.2 below), the cumulative assessment will not be as high as the sum of impact of each individual wind farm added together. This is something expected, considering the complexity of flow and interaction & recovery processes of wakes downstream of a wind turbine. Therefore, in order to have a fairer view of the wake impacts, it is considered appropriate to assess their effects on both individual and cumulative basis, considering that these wind farms will be built in successive manner between the years 2026-2028, as given in Table 1.

[4] Walney Extension is a single asset from a legal and ownership perspective, however it is made up of two phases with different turbine technology and separate transmission infrastructures, namely Walney Extension 3 & Walney Extension 4. The energy modelling on these phases is performed individually.

The project area has a range of proposed and operational wind farms as noted in Figure 1-1. WT has modelled the existing operational wind farms including Gwynt y Môr, Rhyl Flats, North Hoyle and Ormonde. It should be noted that, apart from the Morgan, Mona & Morecambe wind farms given above, there are other future projects around the Client Irish Sea assets which are in earlier phases of their development, including Awel y Môr and Mooir Vannin. WT notes that Awel y Môr wind farm will also affect the energy production of Client Irish Sea assets when it becomes operational. Consequently, WT will include this wind farm in its wake estimations in Scenario 5. It should be noted that the Mooir Vannin wind farm is excluded from the assessment since it hasn't obtained consent at the time of writing, though would likely have an additional impact on the results of this assessment.

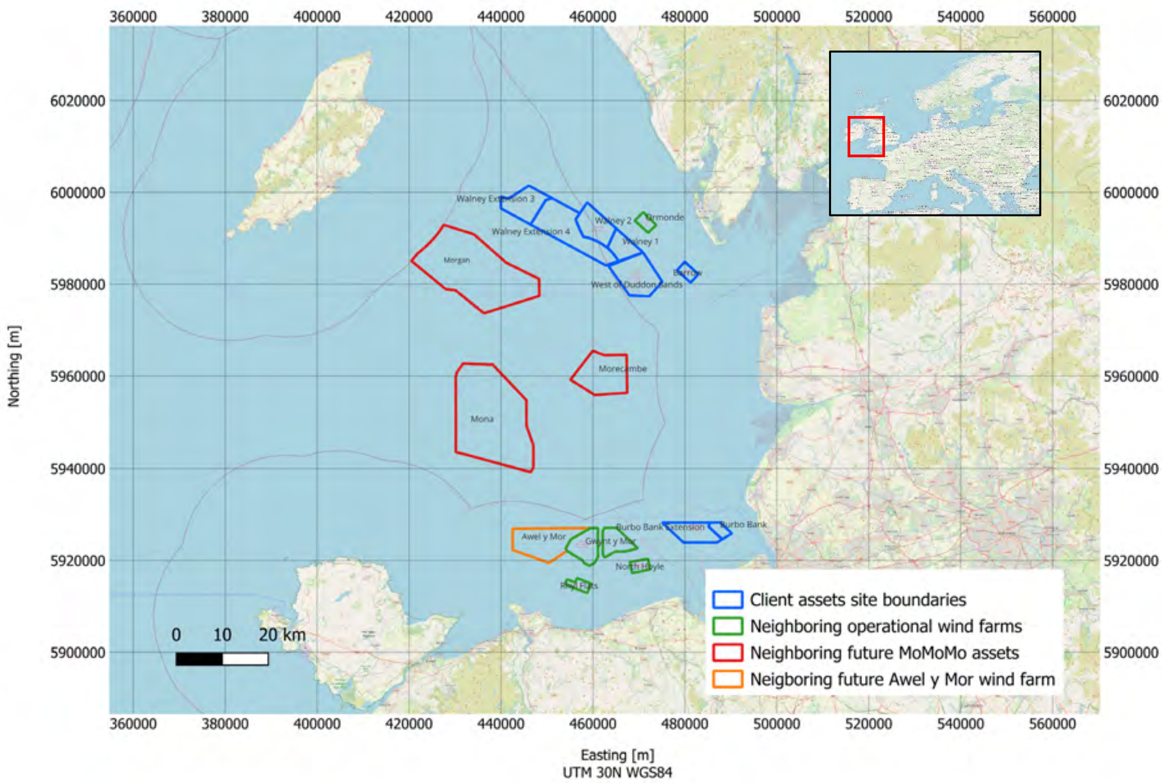

Figure 1-1 Location of the Client's operational Irish Sea Portfolio assets (shown as the site boundaries in blue). The existing wind farms (green site boundaries) and the future proposed wind farms (shown as orange and red boundaries).

By way of introduction, WT finds it appropriate to briefly explain the issue of wind farm wakes and industry methodologies to model them.

1.2. Wind Farm Wakes

Wind turbines generate electricity by extracting the useful kinetic energy within the wind. This energy conversion process leaves a slower-moving and highly chaotic, therefore less-useful wind downstream of the wind turbine. This downstream region is characterized by lower wind speeds and higher turbulence and is referred as the wind turbine wake. The turbulence in the wake is driven by tip vortices generated at the turbine blade tips and turbulent eddies just behind the turbine, which is a region with intense swirling motions of air. Wakes both affect the performance of the downstream turbines, and they also increase the mechanical stress in the turbines, reducing the useful life of the turbines.

As the flow propagates downstream, the highly chaotic state of the wake recovers gradually to the original airflow state, by mixing of the slower, turbulent air within the wake with the undisturbed air in the surroundings. This recovery is affected by factors such as the atmospheric turbulence, which is the natural turbulence of the background atmosphere; wind shear, which describes the change in wind speed with height; and the atmospheric stability, which is the resistivity of the atmosphere to the disturbances. The full recovery behind a single turbine usually requires distances such as 10-12 turbine rotor diameters. However, wake effects from entire wind farms have been shown to persist for much greater distances > 30km and potentially up to 100km downstream [7], potentially affecting wind farms located further away.

Modelling the effects associated with wakes and designing the wind farm turbine layouts in such a way to minimize these effects are essential in the realisation of wind farms. Industry best practices often apply constraints of 4-6 rotor diameters between the turbines in non-significant wind directions and 7-8 rotor diameters between the turbines in prevailing wind directions.

There are several methodologies in the industry for modelling the wakes, ranging from simple analytical / empirical models to more advanced CFD based models, which have trade-offs in terms of accuracy and computational cost. As covered in Section 5, WT's typical best practice is to use the WindFarmer: Analyst Eddy Viscosity with large wind farm correction model to estimate offshore wake and turbine interaction effects. This model has been validated by DNV in 2019, and results in lower errors across a number of operational offshore wind farms compared to other wake models [8], [9].

2. DESCRIPTION OF THE ASSESSED PROJECTS

2.1. Location of the client assets & data

The Client assets are situated in the wider Liverpool Bay area, close to the UK coastline of the Irish Sea, ranging from 20-30 km from the shore.

A map showing available wind climate locations at West of Walney (WOW) Extension FL, Shell Flats MM and Burbo Bank FL, as well as boundaries of existing Client assets are presented in Figure 2-1. Further information related to the wind climate files can be found in Section 3.

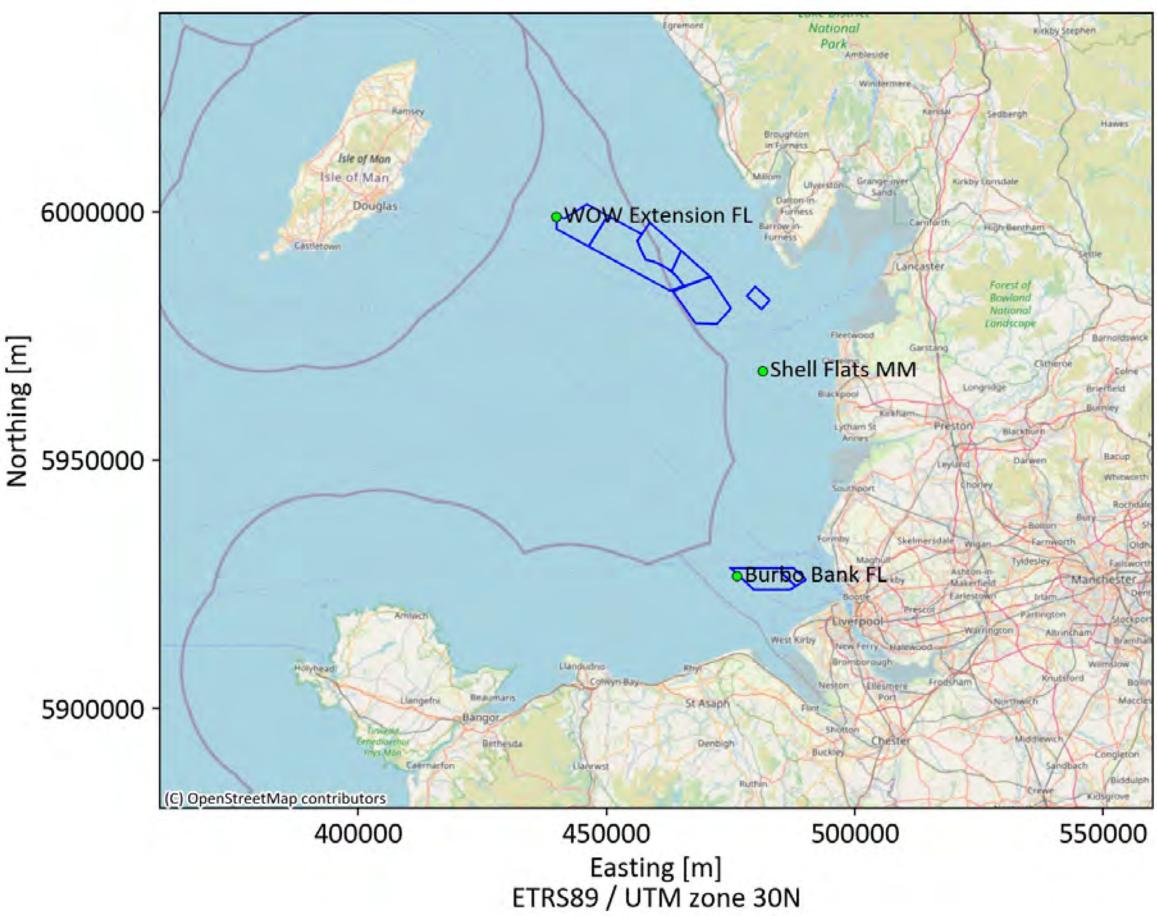

Figure 2-1 Map of the existing projects along with the available measured wind data locations used to derive wind climates

2.2. Turbine Layouts and Configurations

2.2.1. Power Curves

Turbine configurations for the Client assets and neighbouring and future wind farms, including the turbine model and associated wind farm, rated power, hub height, peak power coefficient, number of turbines and total installed capacity, are provided in Table 2-1. The information related to the Client assets and neighbouring operational wind farms were provided by the Client [2]. For the future MoMoMo assets and Awel y Môr, WT has made reasonable assumptions including designing layouts with a set of constraints as described in Section 2.2.2.

It should be noted that for the MoMoMo wind farms, WT has made reasonable assumptions for the turbine models including the parameters such as rotor diameter, hub height, and power and thrust curves considering the project timelines, current sector trends and best practices. The information compiled for the future projects are not certain at this stage, and the impacts will be subject to change; therefore, this report should be considered as being based on the best available information at the time of preparation.

The power curves of the turbine models for the Ørsted Irish Sea Portfolio assets and operational neighbouring assets have been provided by the Client [2]. WT has derived two turbine models to be used for the future farms, namely WT 15MW-236m and WT 22.6MW-276m. The characteristics and performance data of the turbines are presented in Appendix B. It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

WT has obtained historical pressure and temperature records from eight nearby meteorological stations within a maximum radial distance of 90 km and maximum elevation difference of 150 m from the site. Using standard lapse rate assumptions, WT has derived air density values between 1.221 kg/m^3 and 1.223 kg/m^3 at an elevation of 155 mMSL. Based on these data, WT has estimated the long-term air density at the site to be 1.222 kg/m^3 at an average elevation of 155 mMSL for all the wind farms.

The supplied power curves used in this analysis have been adjusted to the predicted site air density, in accordance with the recommendations of IEC [10]. This has been undertaken on an individual turbine basis.

2.2.2. Layouts

The layouts related to the Client assets and neighbouring operational wind farms were provided by the Client [2]. However, for the future wind farms, Mona, Morgan, Morecambe and Awel y Môr, WT has designed preliminary wind turbine layouts based on guidelines and constraints described in the project submissions available in the Planning Inspectorate Portal [3], and Development Consent Order (DCO) documents for Mona [4], Morgan [5] and Morecambe [6], which include a number of constraining parameters, including minimum and maximum number of turbines, maximum rotor diameter, maximum blade tip height and minimum tip clearance, and minimum distance between turbines.

Due to the preliminary nature of the future wind farms, WT did not consider additional constraints including foundation type or seabed properties such as depth and slope. WT would expect that micrositing or additional layout considerations would ultimately alter the results, however these are likely to be small compared to the changes due to turbine selection. As such, WT has designed two layouts for each MoMoMo site considering the WT 15MW-236m and WT 22.6MW-276m wind turbines, and one layout for the Awel y Môr site considering the WT 15MW-236m turbine. The allowable number of turbines for each of the MoMoMo sites has been obtained from the DCO documents [4], [5], [6] and applied to the above turbine models. Using WT 15MW-236m turbines, the resulting capacities for these sites are all within the upper limits stated in Table 1. However, for the sites with the WT 22.6MW-276m turbines, the minimum number of turbines results in site capacities that exceed the site capacity limits and are therefore not compliant with the DCO project descriptions. These layouts have been provided for completeness and to demonstrate the effect of using larger turbines.

Based on the derived wind climates (see Section 4), WT has estimated the prevailing wind direction at each site in order to define acceptable minimum turbine separation distances in the prevailing and non-prevailing wind directions, and to align the layout grid such that the wake impacts from a row of turbines on the rows behind them are minimised. Typical offshore wind farms currently under development maintain an average inter-turbine spacing of approximately 7-8 rotor diameters in prevailing wind directions, and 4-6 rotor diameters in non-prevailing wind directions.

Given the wind regimes at the wind climate locations, which can be seen in Appendix D-3, WT considers that inter-turbine spacings of 8 rotor diameters in the prevailing wind directions and 6 rotor diameters in the non-prevailing wind directions can be accommodated for the MoMoMo wind farms for most scenarios. The exceptions to this are the Morecambe and Awel y Môr sites when using 15 MW turbines, and in order to achieve the desired wind farm capacity, layouts using 7 and 5 rotor diameters have been applied in the prevailing and non-prevailing wind directions, respectively. As such, the minimum inter-turbine separation distances applied are considered to be consistent with those defined in the DCO project descriptions [4], [5], [6].

The grid coordinates of the turbines for all the wind farms under consideration are given in Appendix A.

Table 2-1 Turbine model parameters and turbine configurations.

Turbine	Associated wind farm	Rated power (MW)	Hub height (mMSL)	Number of turbines	Installed Capacity
Siemens Gamesa SWT-3.6-107	Burbo Bank	3.6	83.4	25	90
Vestas V164-8.0 MW	Burbo Bank Extension	8.0	108.0	32	256
Vestas V90-3.0MW	Barrow	3.0	75.0	30	90
Siemens Gamesa SWT-3.6-120	West of Duddon Sands	3.6	85.77	108	388.8
Siemens Gamesa SWT-3.6-107	Walney 1	3.6	78.4	51	183.6
Siemens Gamesa SWT-3.6-120	Walney 2	3.6	84.9	51	183.6
MHI Vestas V164-8.25MW	Walney Extension 3	8.3	112.3	40	330
Siemens Gamesa SG-7.0-154	Walney Extension 4	7.0	106.7	47	329
Senvion / Repower 5M	Ormonde (neighbouring)	5.0	90.0	30	150
Vestas V90-2.0MW	North Hoyle (neighbouring)	2.0	67.0	30	60
Siemens Gamesa SWT-3.6-107	Gwynt y Môr (neighbouring)	3.78	84.4	160	604.8
Siemens Gamesa SWT-3.6-107	Rhyl Flats (neighbouring)	3.78	80.0	25	94.5
WT 15MW-236m [1]	Mona (future)	15.0	150.0	96	1440
WT 15MW-236m [1]	Morgan (future)	15.0	150.0	96	1440
WT 15MW-236m [1]	Morecambe (future)	15.0	150.0	32	480
WT 22.6MW-276m [1]	Mona (future)	22.6	170.0	68	1536.8
WT 22.6MW-276m [1]	Morgan (future)	22.6	170.0	68	1536.8
WT 22.6MW-276m [1]	Morecambe (future)	22.6	170.0	22	497.2
WT 15MW-236m [1]	Awel y Môr (future)	15.0	150.0	39	585

1. A conceptual wind turbine with a power curve, thrust curve and rotational speed calculated by WT internal tools.

3. DESCRIPTION OF THE AVAILABLE WIND DATA

3.1. Wind Climate Files

The Client has provided the long-term corrected time series at the hub heights of all Ørsted assets from the following wind measurements in the vicinity of the sites [2] (denoted as "wind climates") as summarized in Table 3-1 below and shown in Figure 2-1.

Table 3-1 Wind climates summary.

Device	Provided long term time series heights		Period of time series	Location	
	Wind speed (m)	Wind direction (m)		Latitude	Longitude
WOW Extension Floating LiDAR (FL)	75.0, 78.4, 83.4, 84.9, 85.77, 106.7, 108.0, 112.3	108.0	01/01/1999 – 30/06/2023	54.13619°	-3.91969°
Shell Flats Met. Mast (MM)	75.0, 78.4, 83.4, 84.9, 85.77, 106.7, 108.0, 112.3	80.0	01/01/2002 – 30/06/2023	53.85979°	-3.28329°
Burbo Bank Floating LiDAR (FL)	75.0, 78.4, 83.4, 84.9, 85.77, 106.7, 108.0, 112.3	108.0, 76.0	01/01/1999 – 30/06/2023	53.48829°	-3.35809°

Further details of the individual wind climate files provided by the Client, including monthly data statistics at selected heights, can be found in Appendix C.

The WOW Extension FL system is located in the northern part of the Irish Sea, approximately 30 km east of the Isle of Man and 40 km west of UK shores, in the vicinity of Walney 1, Walney 2, Walney Extension and West of Duddon Sands Wind Farm project areas.

The Shell Flats MM is located in the eastern part of the Irish Sea, approximately 15 km west of the city of Blackpool and approximately 15 km south of Barrow Wind Farm project area.

The Burbo Bank FL system is located in the south-eastern part of the Irish Sea, approximately 20 km west of the city of Liverpool and in the close vicinity of Burbo Bank and Burbo Bank Extension Wind Farm project areas.

It should be noted that the Client has provided the wind climates in the form of long-term corrected time series from the measurement devices. Therefore, further details about the measurement devices including the device type, configuration, installation and maintenance records and raw wind data is not available to WT. WT has discussed the process followed by the Client while producing these wind climates and also conducted quality checks of this data, including comparisons of WT's assessment of publicly available data and Client-provided data for the Shell

Flats Met Mast, and have deemed this wind climate data acceptable as input for the wake assessment. Further details can be found in Section 4.

3.2. Reference Data

WT has used reference data in the form of wind speed maps for the derivation of horizontal wind speeds across the turbine locations. These include the New European Wind Atlas (NEWA) [11], Global Wind Atlas (GWA) [12] and Vortex proprietary data. Vortex data has been provided by the Client [2] and publicly available data including NEWA and GWA, have been obtained by WT.

WT has undertaken checks regarding the variation of wind speeds on those wind speed maps and compared the cross predictions of the wind climate files summarised in Section 3.1. Based on these checks WT has developed an approach for the prediction of the wind conditions at the turbine locations. Further information on the approach can be found in Section 4.3.1.

3.2.1. New European Wind Atlas (NEWA)

The New European Wind Atlas (NEWA) [11] uses the Weather Research and Forecasting (WRF) model, forced with ERA5 reanalysis data, to generate a regional map of wind speed variation across Europe and Turkey, including offshore.

Data are available at seven heights between 50 m and 500 m. Both mesoscale and microscale modelling has been performed, and WT has obtained data from the mesoscale model. The mesoscale data is based on a simulation period of 30 years and has a horizontal grid resolution of 3 km. WT used wind map data at a height of 100 mMSL for the horizontal wind speed variation. The wind map at 100 m can be seen in Figure 3-1 along with the site boundaries.

WT has further extracted timeseries data at a height of 100 mMSL, covering an approximately 13-year period from January 2005 to December 2018 from the nodes nearest to all the centroids of the wind farms listed in Table 2-1.

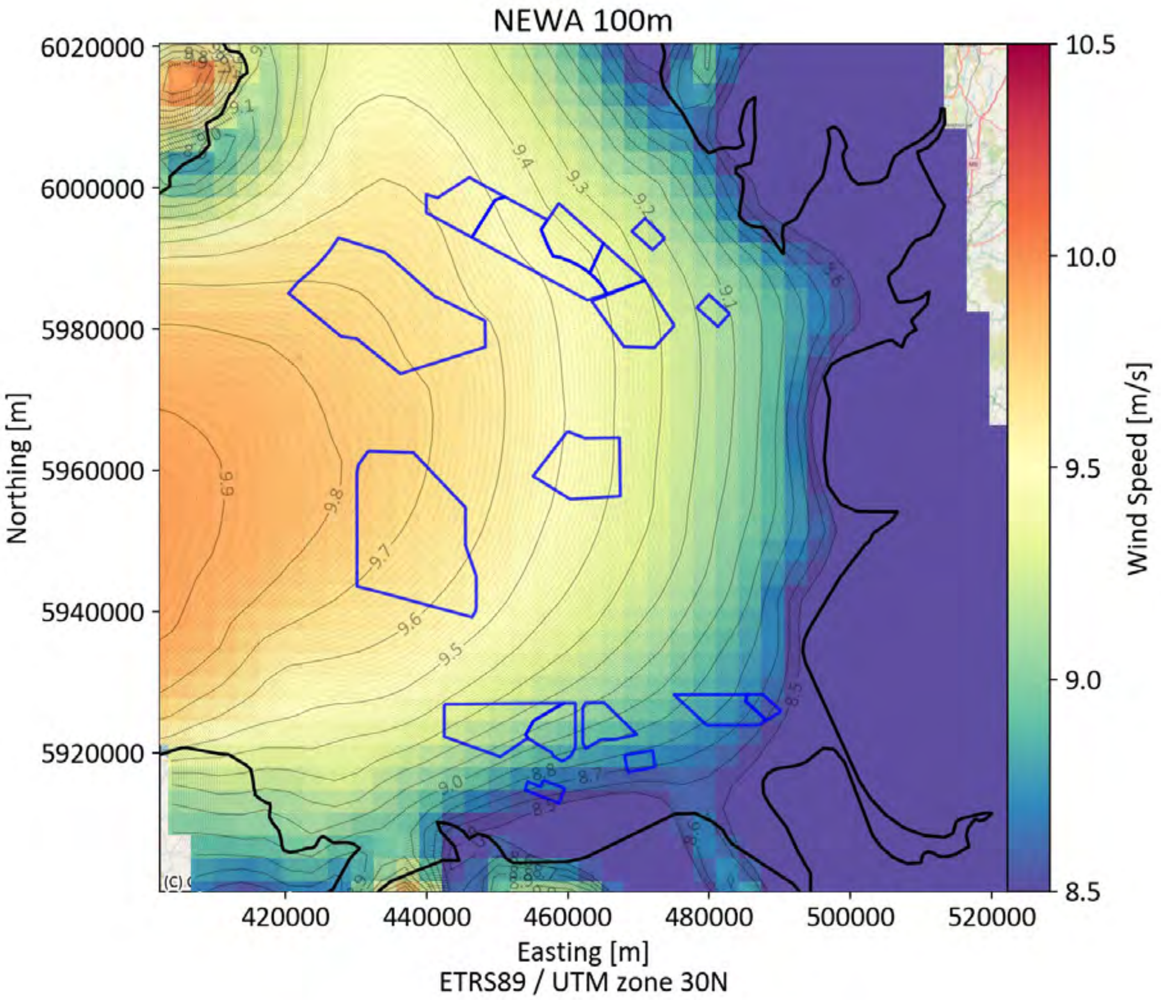

Figure 3-1 New European Wind Atlas (NEWA) 100 m wind map for the site area.

3.2.2. Global Wind Atlas (GWA)

The Global Wind Atlas (GWA) [12], uses the Weather Research and Forecasting (WRF) model forced with ERA5 reanalysis data to generate a global map of wind speed variation (including offshore). The model is based on a simulation period of 58 years (from 1961 to 2019).

Data are available at five heights between 10 m and 200 m at a horizontal grid resolution of 3 km that has then been downscaled to a horizontal resolution of 250 m using microscale modelling [12].

WT has obtained wind map data at a height of 100 mMSL to inform the horizontal wind speed variation across the site area. The wind map at 100 m can be seen in Figure 3-2 along with the site boundaries.

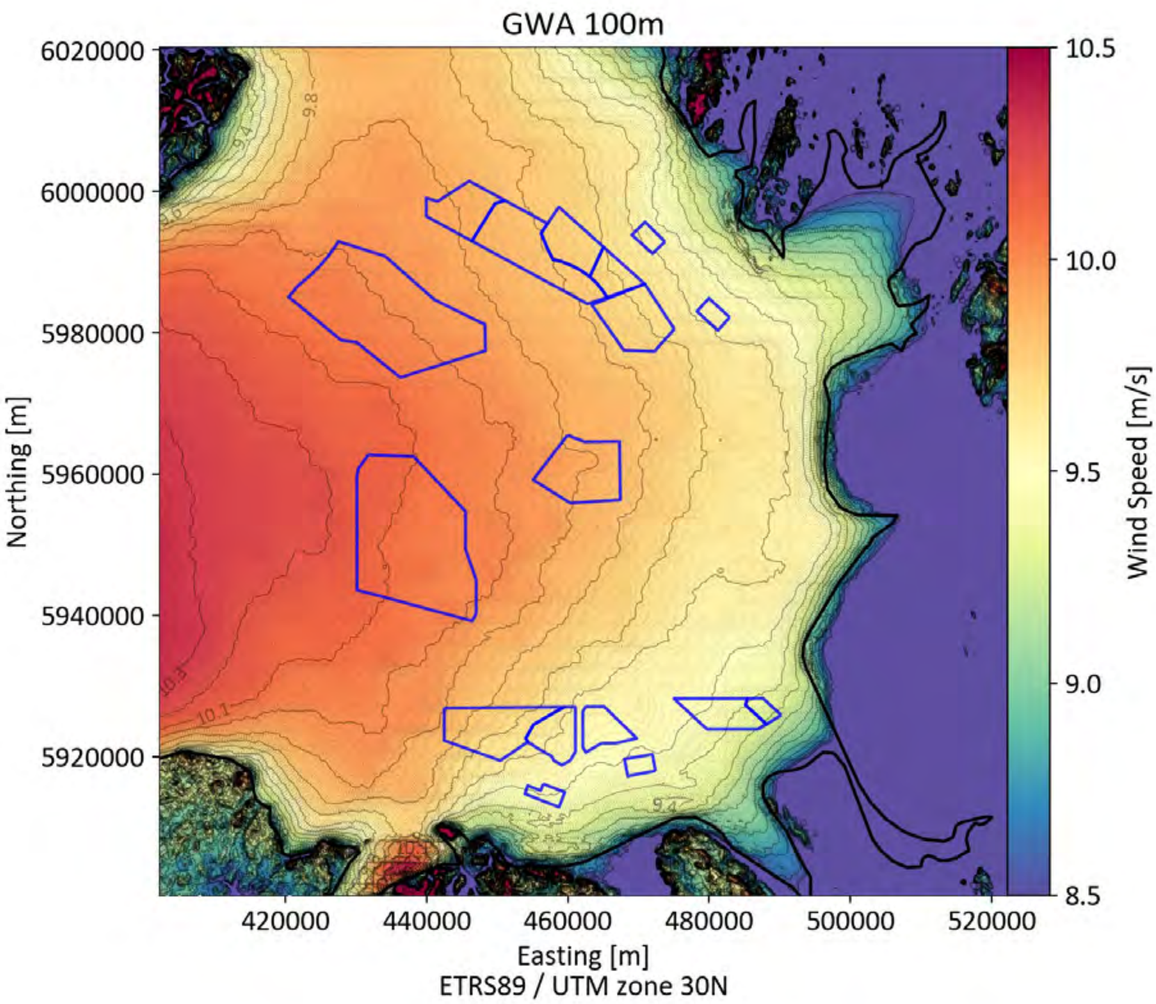

Figure 3-2 Global Wind Atlas (GWA) 100 m wind map for the site area.

3.2.3. Vortex Wind Map

To assess the horizontal wind speed variation across the sites, WT has further considered the Vortex MAP product, purchased on behalf of the Client from Vortex [13]. This has been provided at several heights ranging from 50 m to 200 m, and uses the Weather Research and Forecasting (WRF) model forced with ERA5 and downscaled to the site. The wind map at 100 m can be seen in Figure 3-3 along with the site boundaries.

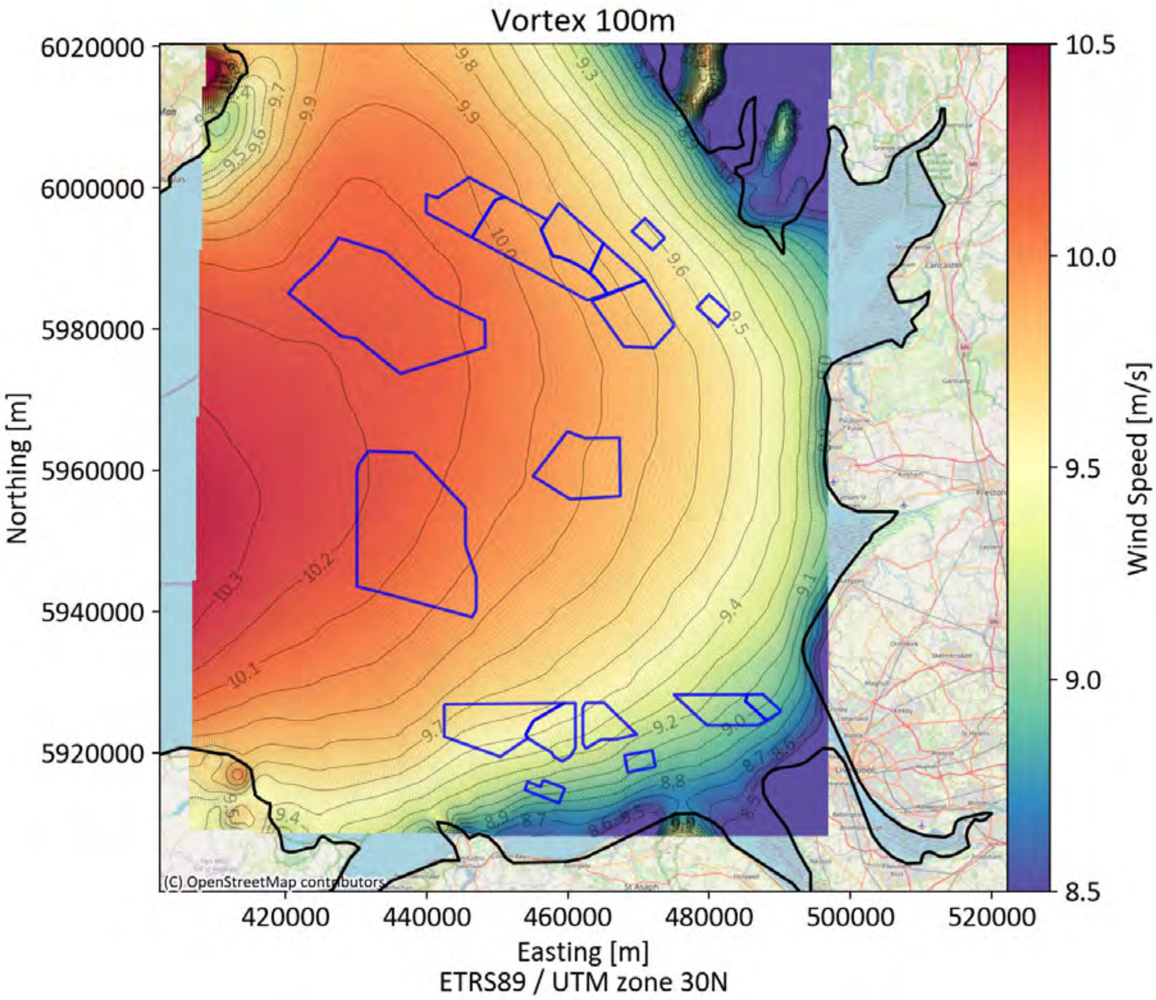

Figure 3-3 Vortex 100 m wind map for the site area.

4. LONG-TERM WIND REGIME AT THE SITE

4.1. Choice of primary source of wind climate files and wind maps

WT has evaluated the long-term wind climate files of Shell Flats MM, Burbo Bank FL system and WOW Extension FL system, which are summarized in Section 3.1, and using the wind maps summarized in Section 3.2 has developed an approach to predict the long term wind speeds at each wind turbine, which were used as inputs for the wake modelling runs.

WT has correlated the time series in wind climate files with each other and observed that there is generally good agreement among the wind climates at the three locations. The correlation results can be seen in Appendix D-1. WT has further compared the frequency distributions derived from each of the wind climate files to see if any differences in the wind roses across the sites are observed. The results of this comparison can be seen in Appendix D-3. It can be seen in these comparisons that while the Shell Flats MM and Burbo Bank FL system seem in good agreement, there is some difference between the Shell Flats MM and WOW Extension FL system, especially in the 210-, 270-, and 300-degree wind direction sectors, implying that there might be changes in the wind roses within the site, according to the differences between Shell Flats MM and WOW Extension FL system.

Furthermore, WT has checked the wind speed predictions of each wind map at the locations of the wind climate files, which can be seen in Table 4-4, and compared these predictions with the long-term mean wind speeds of the time series given in the wind climate files. WT has further cross-predicted the wind speeds at the wind climate locations using the speedups derived from each of the wind speed maps and evaluated the consistency of the wind climate files and performance of wind speed files. The results of this check can be seen in Table 4-5.

WT observed that there is good consistency among the wind climate files and the wind speed predictions of the wind maps. Due to its superior performance compared to Global Wind Atlas and Vortex, WT has decided to use the New European Wind Atlas map for the predictions of wind speeds at the turbine locations.

For specifying the wind climate files to be used in turbine location wind speed predictions, due to their proximity to the project areas and similar expected wind climate exposure, and in order to mitigate the possible effects of the change of wind rose across the site, WT has used the predictions of Burbo Bank FL system data for the southern wind farms (namely Burbo Bank, Burbo Bank Extension, Gwynt y Môr, Rhyl Flats, Mona, Awel y Môr and North Hoyle Wind Farms) and the predictions of WOW Extension FL system for the northern wind farms (namely Walney 1-2, Walney

Extension 3-4, West of Duddon Sands, Barrow, Morgan, Morecambe and Ormonde). This is considered the most robust and lowest uncertainty route to defining the wind regime over the wind farm sites. WT did not consider use of Shell Flats Met Mast as explained in Section 4.3.1. The approach discussed above is also summarized in Table 4-1.

Long term wind speed and direction frequency distributions of each wind climate file can be inspected in Appendix D-2.

Table 4-1 Summary of wind speed prediction route for the wind farms under consideration.

Wind farms	Wind climate file used for predicting wind climate at turbine locations	Reference wind map used
Walney 1-2, Walney Extension 3-4, West of Duddon Sands, Barrow, Morgan, Morecambe and Ormonde	WOW Extension FL system	New European Wind Atlas (NEWA)
N/A	Shell Flats MM	
Burbo Bank, Burbo Bank Extension, Gwynt y Môr, Rhyl Flats, Mona, Awel y Môr and North Hoyle	Burbo Bank FL system	

4.2. Long term hub height wind regime at the site

4.2.1. Derivation of long-term wind speed at the wind climate locations

As discussed in Section 3, since the wind climate files contain wind time series already adjusted according to the long-term wind speed and extrapolated to some of the hub heights of 75.0 m, 78.4 m, 83.4 m, 84.9 m, 85.77 m, 106.7 m, 108.0 m and 112.3 m, WT has directly used them in order to derive the wind speed and direction distributions for the other hub heights and derived the time series in all hub heights.

The variations in wind speed with height at the wind climate locations have been defined using the power law shear exponents which are calculated for each wind climate file and have been used to predict the wind resource at the proposed hub heights for the respective device.

The power law wind shear exponent is defined by Equation 1:

$$\frac{\overline{U}(z_1)}{\overline{U}(z_2)} = \left(\frac{z_1}{z_2}\right)^{\alpha} \qquad (1)$$

Where:

α is power law wind shear exponent (-)

$\overline{U}$ is the wind speed (m/s)

z is the height above ground level (m)

The shear exponents at the wind climate locations have been derived and used to extrapolate the long-term wind speeds at the respective wind climate files to all the hub heights. The estimated shear exponents are given in Table 4-2 while the long-term wind speeds at all the hub heights are provided in Table 4-3 with associated wind farm for each hub height.

We note that the estimated wind shear exponents are in line with WT's expectations for such offshore locations.

Table 4-2 Summary of the predicted wind shear exponents.

Wind Climate File	Predicted wind shear exponent from the time series
WOW Extension FL system	0.090
Shell Flats MM	0.093
Burbo Bank FL system	0.071

Table 4-3 Summary of the long-term hub height wind speeds

Hub Height in ascending order (m)	Associated wind farm	WOW Extension FL system (m/s)	Shell Flats MM (m/s)	Burbo Bank FL system (m/s)
67	North Hoyle (neighbouring)	9.5	9.0	8.9
75	Barrow	9.6	9.1	8.9
78.4	Walney 1	9.7	9.1	9.0
80	Rhyl Flats (neighbouring)	9.7	9.2	9.0
83.4	Burbo Bank	9.7	9.2	9.0
84.4	Gwynt y Môr (neighbouring)	9.7	9.2	9.0
84.9	Walney 2	9.7	9.2	9.0
85.77	West of Duddon Sands	9.7	9.2	9.0
90	Ormonde (neighbouring)	9.8	9.3	9.0
106.7	Walney Extension 4	9.9	9.4	9.1
108	Burbo Bank Extension	9.9	9.4	9.2
112.3	Walney Extension 3	10.0	9.4	9.2
150	MoMoMo cluster and Awel y Môr	10.2	9.7	9.4
170	MoMoMo cluster [1]	10.4	9.8	9.5

1- Considered for sensitivity scenarios, see Table 5-2

4.2.2. Derivation of the long-term hub height wind speed and direction frequency distribution

As indicated in Section 4.1, the primary measurement devices are specified as Burbo Bank FL system for the southern and WOW Extension FL system for the northern wind farms for the prediction of long-term wind speeds at the turbine locations, in order to take the possibility of the changes in the wind roses into account.

The measurement time series at the wind climate locations have been extrapolated to the turbine hub heights based on the estimated shear profile of the respective wind climate. The resulting hub height time series has been used to define the wind speed and direction frequency distributions.

The resulting time series has been used to derive the wind speed and direction frequency distribution at the wind climate locations using the following procedure to avoid the introduction of bias into the annual mean wind regime prediction from seasonally uneven data coverage:

- The mean wind speed and direction frequency distribution for each month was determined from the valid data recorded in that month over the period. The frequency distribution for each month considered to be representative of the long term for that month thereby assuming the valid data are representative of any missing data.
- The frequency distributions for each of the twelve months were averaged, weighted by the number of days in each month, to determine the long-term annual frequency distribution.

The resulting hub height wind rose and frequency distributions at the wind climate locations at 100 m height can be seen in Appendix D, where the wind rose shapes are considered as representative for the sites under consideration.

4.3. Wind regime across the site

4.3.1. Wind flow modelling

To assess the horizontal wind speed variation across the turbine locations at the sites, as explained in Section 3.2, WT has considered use of the Vortex MAP product, New European Wind Atlas and Global Wind Atlas, at 100 m height for reference.

Wind model validation

Given that wind climate files are available at three different locations across the wind farms, WT has undertaken a performance check utilizing all three-wind maps to understand the agreement. The results of this check are given in Table 4-4 below, including the percentage differences with the predicted long term hub height wind speeds in parentheses.

Table 4-4 Comparison of wind map wind speeds and long term wind speeds at 100 m height.

Wind Climate File	Wind speed derived on Vortex wind map [m/s]	Wind speed derived on GWA [m/s] [1]	Wind speed derived on NEWA [m/s] [1]	Predicted long term hub height wind speed [m/s] [1]
Burbo Bank FL SYSTEM	9.2 (1.5%)	9.5 (4.6%)	8.9 (-2.8%)	9.1
Shell Flats MM	9.6 (3.3%)	9.7 (3.6%)	9.1 (-2.4%)	9.3
WOW Extension FL SYSTEM	10.1 (2.0%)	9.9 (0.6%)	9.6 (-2.8%)	9.9

1- Values in the parentheses indicate the percentage difference between the wind speeds derived from the wind map and long-term hub height frequency distribution.

Whilst WT considers this exercise beneficial to inform the relative performance and agreement of wind maps and measurements, it is acknowledged that there are limitations and elevated uncertainty in performing this validation because of the nature of measurement devices as two are floating lidars and other one is a meteorological mast, in which the measurements may be affected by lattice structure of the mast at certain wind sectors, as well as the modelling inputs & methodology used in generation of the wind maps, which are summarized in Section 3.2.

Notwithstanding the uncertainties discussed above, it is considered that uncertainties in the wind regime across the site have a lower impact on the analysis conducted in Section 5 due to it being a delta on wake impact, which is not as sensitive to wind speed errors as a traditional energy yield analysis.

Whilst the measurements predict relatively similar wind speeds on all wind climate locations and they also indicate a similar variation in wind speed, WT considers the results of the validation to be inconclusive. Therefore, WT also conducted a cross-prediction check across the measurement devices and the results are given in Table 4-5, Table 4-6 and Table 4-7, which offers wind speed differences on the order of 0.5% between the predictions of NEWA and long-term hub height mean wind speed estimations.

Table 4-5 Wind speed cross-predictions at 100 m height for Vortex.

Predicted from wind climate file	Long term hub height mean wind speed at 100 m [m/s]	Predicted from Vortex MAPS at 100 m [m/s]		
		Burbo Bank FL	Shell Flats MM	WOW Extension FL
Burbo Bank FL	9.1		9.0 (-1.7%)	9.1 (-0.5%)
Shell Flats MM	9.3	9.5 (1.7%)		9.5 (1.2%)
WOW Extension FL	9.9	9.9 (0.5%)	9.7 (-1.2%)	

Table 4-6 Wind speed cross predictions at 100 m height for GWA.

Predicted from wind climate file	Long term hub height mean wind speed at 100 m [m/s]	Predicted from GWA at 100 m [m/s]		
		WOW Extension FL	**Shell Flats MM**	**Burbo Bank FL**
WOW Extension FL	9.1		9.2 (0.9%)	9.5 (4.0%)
Shell Flats MM	9.3	9.3 (-0.9%)		9.6 (3.0%)
Burbo Bank FL	9.9	9.5 (-3.8%)	9.6 (-2.9%)	

Table 4-7 Wind speed cross predictions at 100 m height for NEWA.

Predicted from wind climate file	Long term hub height mean wind speed at 100 m [m/s]	Predicted from NEWA at 100 m [m/s]		
		WOW Extension FL	**Shell Flats MM**	**Burbo Bank FL**
WOW Extension FL	9.1		9.1 (-0.4%)	9.1 (0.0%)
Shell Flats MM	9.3	9.4 (0.4%)		9.4 (0.4%)
Burbo Bank FL	9.9	9.9 (0.0%)	9.8 (-0.4%)	

Wind speed variation across the sites

As noted in Section 4.1, the WOW Extension FL and Burbo Bank FL have been chosen as the primary sources of data for the analysis and therefore have been used to initiate the wind flow model from which the wind speeds at the proposed turbine locations have been predicted.

The reasoning behind this selection was the slight change in the wind roses across those wind climate files so that WT found it more sensible to predict the northern wind farms from WOW Extension FL and southern wind farms from Burbo Bank FL. Also as given in Table 4-7 the cross-predictions between Burbo Bank and WOW Extension are also minimal. Also, as seen in Appendix D-4, the turbine location predictions of these two wind climates are very close to each other with a difference level of lower than 0.5%.

Due to its superior performance compared to Global Wind Atlas and Vortex as shown above, WT has decided to use the New European Wind Atlas map for the predictions of wind speeds at the turbine locations.

4.4. Turbulence Intensity

It is widely accepted in the wind industry that turbulence intensity measurements from Lidar devices (volume measurements) are not directly comparable to turbulence intensity measurements from meteorological masts using cup anemometers (point measurements), which is currently what the wind industry standards are based on.

In addition to the difference in turbulence intensity measurements from Lidars due to the volume to point measurement issue, floating Lidar systems have the added complication of motion impacting the measurements, which artificially increases the measured turbulence intensity.

Due to these reasons, and due to the fact that the standard deviation data is not included in the provided wind climate files, WT finds it appropriate to calculate the turbulence intensity from its own independent assessment of the publicly available Shell Flats Met Mast data.

WT has adjusted the turbulence profile measured at the Shell Flats MM to be representative of the expected long-term hub height wind speeds at the WOW Extension FL and Burbo Bank FL. As standard deviation is assumed constant, the turbulence intensity can be scaled from the Shell Flats MM location to the turbine locations using the ratio in long-term wind speed between the Shell Flats MM and the long-term wind speed of the site in question.

Figure 4-1 and Figure 4-2 show the assumed turbulence intensity profile at the WOW Extension FL and Burbo Bank FL respectively, derived at the turbine hub height of 112.3 m, which is considered as representative for the turbine locations at 112.3 m, along with profiles for IEC turbulence subclasses A, B and C [10].

Table 4-8 shows the tabulated ambient turbulence intensity profiles for the mentioned combinations of sites and hub heights. WT notes that the magnitude of derived turbulence intensity values is in line with WT's experience, considering the expected offshore wind conditions at sites around the UK, with similar hub height.

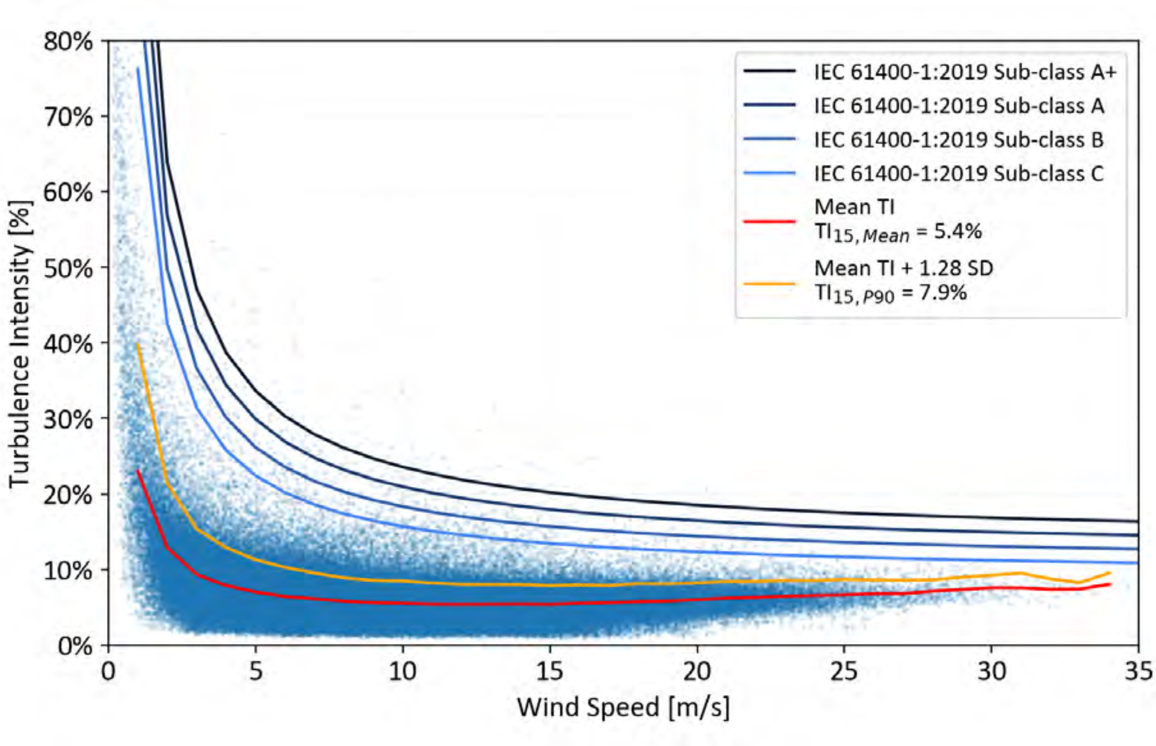

Figure 4-1 Ambient Turbulence Intensity profile assumed at the WOW Extension FL location at 112.3 m height, as derived from measurements made at the Shell Flats MM.

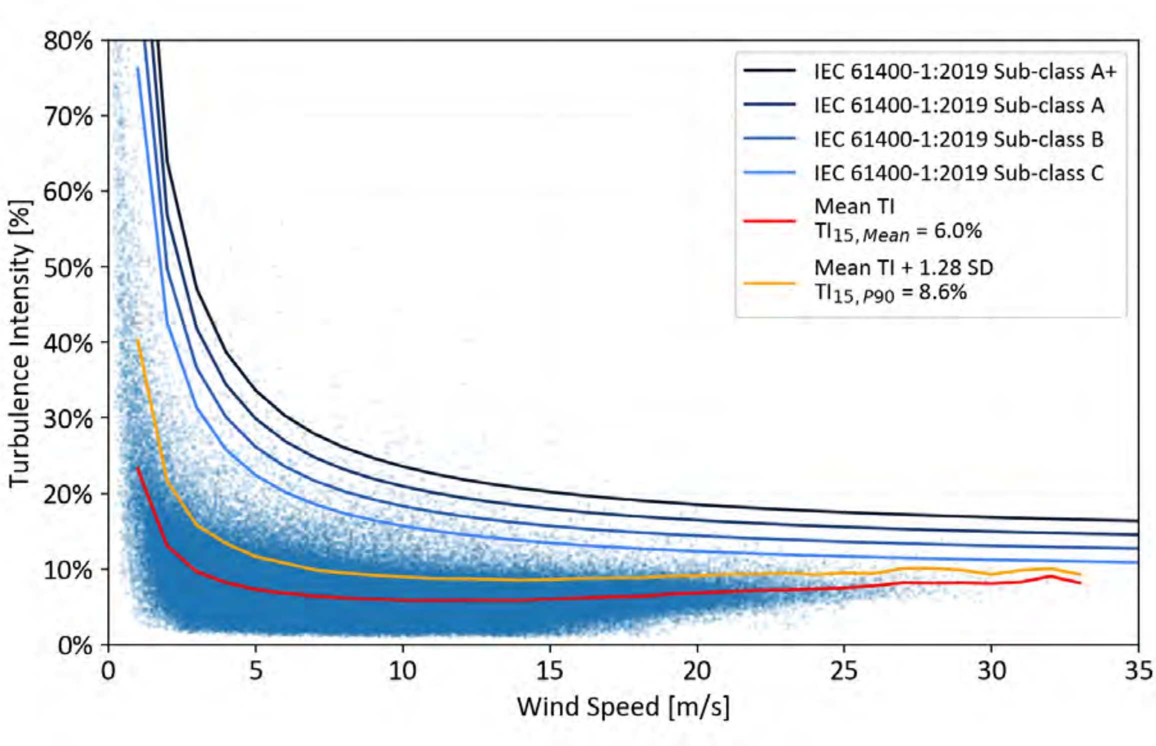

Figure 4-2 Ambient Turbulence Intensity profile assumed at the Burbo Bank FL location at 112.3 m height, as derived from measurements made at the Shell Flats MM.

Table 4-8 Ambient Turbulence Intensity profile assumed at Burbo Bank FL and WOW Extension FL at selected hub heights.

Wind speed bin centre (m/s)	Mean TI at WOW Extension FL at 75 mMSL hub height (%)	Mean TI at WOW Extension FL at 112.3 mMSL hub height (%)	Mean TI at WOW Extension FL at 150 mMSL hub height (%)	Mean TI at Burbo Bank FL at 75 mMSL hub height (%)	Mean TI at Burbo Bank FL at 112.3 mMSL hub height (%)	Mean TI at Burbo Bank FL at 150 mMSL hub height (%)
1	23.15%	23.03%	22.93%	23.32%	23.28%	23.16%
2	13.01%	12.93%	12.92%	13.19%	13.09%	13.08%
3	9.51%	9.38%	9.30%	9.77%	9.67%	9.59%
4	8.04%	7.90%	7.83%	8.35%	8.24%	8.16%
5	7.18%	7.06%	6.95%	7.43%	7.31%	7.25%
6	6.62%	6.46%	6.35%	6.97%	6.84%	6.73%
7	6.27%	6.15%	6.05%	6.57%	6.45%	6.36%
8	5.98%	5.84%	5.72%	6.31%	6.19%	6.10%
9	5.82%	5.62%	5.54%	6.19%	6.03%	5.93%
10	5.70%	5.54%	5.42%	6.07%	5.91%	5.81%
11	5.62%	5.44%	5.32%	6.05%	5.89%	5.77%
12	5.61%	5.41%	5.28%	6.10%	5.91%	5.77%
13	5.67%	5.43%	5.28%	6.05%	5.91%	5.81%
14	5.61%	5.45%	5.32%	6.12%	5.90%	5.75%
15	5.68%	5.41%	5.27%	6.28%	6.04%	5.89%
16	5.80%	5.54%	5.34%	6.43%	6.17%	5.98%
17	5.92%	5.62%	5.44%	6.55%	6.33%	6.17%
18	6.09%	5.77%	5.56%	6.79%	6.42%	6.24%
19	6.15%	5.85%	5.71%	7.00%	6.68%	6.47%
20	6.41%	6.03%	5.73%	7.12%	6.86%	6.68%
21	6.53%	6.24%	5.97%	7.35%	7.05%	6.79%
22	6.75%	6.34%	6.14%	7.39%	7.18%	6.99%
23	6.86%	6.51%	6.24%	7.52%	7.24%	7.06%
24	6.90%	6.60%	6.38%	7.66%	7.38%	7.07%
25	7.08%	6.67%	6.47%	8.04%	7.52%	7.28%
26	7.06%	6.83%	6.45%	8.24%	7.79%	7.56%
27	7.45%	6.84%	6.68%	8.43%	8.21%	7.83%
28	7.67%	7.17%	6.75%	8.68%	8.15%	8.04%
29	7.86%	7.38%	6.99%	8.24%	8.20%	8.15%
30	7.92%	7.61%	7.28%	8.53%	8.10%	7.88%
31	7.69%	7.60%	7.40%	9.34%	8.30%	7.98%
32	7.78%	7.41%	7.62%	8.41%	9.08%	8.83%
33	8.46%	7.44%	7.18%		8.17%	8.48%
34	8.50%	8.07%	7.30%	7.73%		7.30%
35	7.12%	8.26%	8.08%	8.54%	7.51%	
36		7.33%	7.67%	9.73%	8.30%	7.36%
37	7.17%		7.14%		9.46%	8.13%
38	7.92%	6.91%				9.27%
39	9.03%	7.64%	6.74%			
40		8.71%	7.44%			
41			8.48%			

5. METHODOLOGY & RESULTS OF THE WAKE ASSESSMENT

The Energy Yield and the subsequent impact of the wakes produced by the individual wind farms have been calculated using WindFarmer: Analyst software. Of concern in any Energy Yield study is the effect of wake and turbine interaction losses (including blockage effect) from inside the farm and from adjacent farm sites. WT's typical best practice is to use the WindFarmer: Analyst Eddy Viscosity with large wind farm correction model to estimate offshore wake and turbine interaction effects, as validated by DNV in 2019, which results in lower errors across a number of operational offshore wind farms compared to other wake models [8], [9].

As noted in Appendix E-4.1a, the blockage effects have also been calculated using the Blockage Effect Estimator Tool (BEET) implemented within WindFarmer: Analyst software, which is based on a validation study incorporating more than 50 CFD simulations. The wind farm blockage is defined as the slowing-down effect caused by the wind farm itself, as it presents an obstacle to the incoming wind flow. This effect is usually not estimated in many standard industry wake models. According to WT's estimates, the wind farm blockage based on the BEET is found to be around 1.3% for all the scenarios considered and this figure is also inherent in the wake effect estimations given in Table 5-4 and Table 5-5.

No specific sensitivity assessment of the available range of wake models has been undertaken as the intention is to provide an "industry standard" independent assessment.

A series of scenarios have been established to assess the relative impact of the build out of the proposed wind farms in this part of the Irish Sea. Table 5-1 and Table 5-2 below summarises the scenarios applied in this assessment.

The Baseline scenario represents the current situation of the project area, such that all existing assets from Ørsted with the full ownership details provided by Client [2], plus other existing assets are assessed, as listed in Table 5-3.

The MoMoMo wind farms were added in the order in which it is currently understood they will be constructed, such that Mona is going to begin construction in 2026 (Scenario 1), Morgan in 2027 (Scenario 2) and Morecambe in 2027/8 (Scenario 3) [1]. The impact from the entire MoMoMo cluster is also considered (Scenario 4), whilst the commissioning of Awel y Môr, which is planned for construction at a later stage, is considered in Scenario 5.

For Scenarios 1, 2 and 3 it is assumed that a 15 MW turbine with 236 m rotor diameter at a hub height of 150 m will be used for MoMoMo. This size turbine is typically being planned for other wind farms due for installation in the period. Some uncertainty remains over the selection of this turbine, therefore in order to estimate the impact of installing bigger turbines at the MoMoMo sites e.g. 22.6 MW capacity, 276 m rotor diameter and 170 m hub height, WT has considered Scenarios 1b, 2b and 3b as variations on the assessment.

No changes to the existing wind farms e.g. repowering/ extended maintenance or non-operational turbines were assumed.

The projected decrease in potential energy production due to additional wake and turbine interaction losses from each scenario on each of the Client assets are shown in Table 5-4 and Table 5-5.

The results of the turbine basis analysis are presented in Appendix D. A detailed definition of turbine interaction loss factors applied to all scenarios is included in Appendix E-4.

Table 5-1 External Wake Main Scenarios

Scenario	**Included Wind Farms**	**Comments / Assumptions**
Baseline	Ørsted assets[1] + Neighbouring operational wind farms[2.]	Existing operational conditions
Scenario 1	Baseline + proposed **Mona**[3] Wind Farm	Mona Wind Farm capacity will be up to 1500 MW, to start construction in 2026, and owned by a joint venture of EnBW - BP
Scenario 2	Baseline + proposed **Morgan**[3] Wind Farm with	Morgan Wind Farm capacity will be up to 1500 MW, to start construction in 2027, and owned by a joint venture of EnBW - BP
Scenario 3	Baseline + **Morecambe**[3] Wind Farm	Morecambe Wind Farm capacity will be up to 480 MW, to start construction in 2027/2028, and owned by a joint venture of Cobra - Flotation Energy
Scenario 4	Baseline + all **MoMoMo**[3] assets	-
Scenario 5	Scenario 4 + **Awel y Môr** [3]	Awel y Môr Wind Farm capacity will be approximately 576 MW

[1] Barrow, Walney 1, Walney 2, Walney Extension 3 and 4, West of Duddon Sands, Burbo Bank and Burbo Bank Extension

[2] Gwynt y Môr, Rhyl Flats, North Hoyle and Ormonde

[3.] 15 MW capacity turbines (each), 150 m hub height and 236 m rotor diameter turbine

Table 5-2 External Wake Sensitivity Scenarios

Scenario	Included Wind Farms	Comments / Assumptions
Scenario 1b	Baseline + **Mona** [4].	A sensitivity analysis on Scenario 1 using a bigger 22.6 MW turbine and a different layout
Scenario 2b	Baseline + **Morgan** [4]	A sensitivity analysis on Scenario 2 using a bigger 22.6 MW turbine and a different layout
Scenario 3b	Baseline + **Morecambe** [4]	A sensitivity analysis on Scenario 3 using a bigger 22.6 MW turbine and a different layout
[4]. 22.6 MW capacity turbines (each), 170 m hub height and 276 m rotor diameter turbine		

Table 5-3 Baseline scenario wind farms included.

Project Name	Ownership details [1]	Turbine	Farm Capacity
Barrow	100% Ørsted	V90 3MW (90m rotor diameter)	90MW
Walney Phase 1	50.10% Ørsted 25.10% Greencoat 24.80% OPW	SWT 3.6MW (107m rotor diameter)	183.6MW
Walney Phase 2	50.10% Ørsted 25.10% Greencoat 24.80% OPW	SWT 3.6MW (120m rotor diameter)	183.6MW
West of Duddon Sands	50% Ørsted 50% Scottish Power Renewable	SWT 3.6MW (120m rotor diameter)	389MW
Walney Extension (Walney Phases 3 & 4)	50% Ørsted 17.5% PKA 17.5% PFA 12.5% Octopus Energy Generation	W3: V164 8.0MW (164m rotor diameter) W4: SWT 7MW (154m rotor diameter)	659MW
Burbo Bank	100% Ørsted	SWT 3.6MW (107m rotor diameter)	90MW
Burbo Bank Extension	50% Ørsted 25% KIRKBI A/S 25% Greencoat	V164 8.0MW (164m rotor diameter)	256MW
Gwynt y Môr	RWE	SWT 3.6MW (107m rotor diameter)	576MW
Rhyl Flats	RWE	SWT 3.6MW (107m rotor diameter)	90MW
North Hoyle	Greencoast UK Wind PLC	V80 2.0MW (80m rotor diameter)	60MW
Ormonde	Vattenfall	SEN 5MW (126m rotor diameter)	150MW

1- The ownership details of Client operational offshore wind farm assets (Barrow, Walney Phase 1 & 2, West of Duddon Sands, Walney Extension, Burbo Bank and Burbo Bank Extension) were provided by the Client [2]. For the neighboring assets, publically available datasets were used [1].

It should be noted that the scope of work presented in this report has been focused on the potential difference in annual energy production due to wake impacts of each future wind farm scenario. As this is not a complete EPA study, WT did not undertake a comprehensive technical loss assessment, which is typically required in order to estimate a realistic annual energy production for any wind farm, and as such Table 5-4 presents the results as a percentage difference normalised to the baseline.

It should be noted that along with the increased wakes with the commissioning of the future wind farms, the turbine performance losses (including generic and site-specific power curve adjustments and hysteresis losses) may undergo changes with the different waked wind regime expected on the Client's operational wind farms, along with the possibility of increased fatigue. Assessment of these effects is not in the scope of this report. Nevertheless, these effects are considered of second order with relation to the wake impacts on annual energy production.

Table 5-4 Summary of the results of the main scenarios normalized to the baseline

Scenario	**Additional wake loss on each wind farm (%)**								
	Barrow	**Walney 1**	**Walney 2**	**Walney Extension 3**	**Walney Extension 4**	**West of Duddon Sands**	**Burbo Bank**	**Burbo Bank Extension**	**Total additional wake loss on all Ørsted Irish Sea assets**
Baseline	0	0	0	0	0	0	0	0	0
Scenario 1 - Addition of Mona OWF	-1.55%	-1.67%	-1.22%	-0.83%	-1.58%	-1.57%	-0.96%	-1.22%	-1.38%
Scenario 2 – Addition of Morgan OWF	-0.45%	-1.58%	-2.18%	-3.35%	-3.22%	-1.28%	-0.25%	-0.20%	-1.68%
Scenario 3 – Addition of Morecambe OWF	-1.37%	-0.53%	-0.32%	-0.40%	-0.56%	-1.01%	-0.46%	-0.45%	-0.68%
Scenario 4 – Cumulative addition of MoMoMo	-3.09%	-3.78%	-3.69%	-4.13%	-5.21%	-3.86%	-1.63%	-1.84%	-3.65%
Scenario 5 – Cumulative addition of MoMoMo and Awel y Môr	-3.36%	-3.84%	-3.73%	-4.16%	-5.34%	-3.97%	-2.16%	-2.45%	-3.82%

Table 5-5 Summary of the difference of results of the sensitivity scenarios and each main scenario

Scenario	Difference with respect to the main scenarios, for each wind farm (%)								
	Barrow	Walney 1	Walney 2	Walney Extension 3	Walney Extension 4	West of Duddon Sands	Burbo Bank	Burbo Bank Extension	Total additional wake loss on all Ørsted Irish Sea assets
Scenario 1b - Addition of Mona OWF	0.06%	0.14%	0.08%	0.04%	0.12%	0.13%	-0.11%	0.04%	0.09%
Scenario 2b – Addition of Morgan OWF	0.01%	0.20%	0.12%	0.29%	0.17%	0.05%	-0.11%	-0.14%	0.09%
Scenario 3b – Addition of Morecambe OWF	0.16%	0.05%	0.04%	0.04%	0.04%	0.16%	0.03%	0.01%	0.08%

6. CONCLUSIONS

A differential energy yield assessment approach has been undertaken using the industry standard WindFarmer:Analyst software, to provide an independent evaluation of the possible external wake losses for the existing Ørsted Irish Sea Portfolio assets located in the Irish Sea.

The following conclusions are noted:

1. Based on the approach detailed in this report, WT has conducted a series of wake model runs according to the selected scenarios given in Table 5-1 and compared the results with a baseline scenario whose details are provided in Table 5-3. Table 5-4 provides the additional wake effect results at all Ørsted assets for each of the future scenarios. It was assumed that there are no changes to the existing wind farms e.g. repowering/ extended maintenance or non-operational turbines.

2. Based on those results the additional wake loss in individual wind farms varies between **-0.20 %** and **-5.34 %** depending on the scenario and the Ørsted assets under consideration. Considering the total effect on all Ørsted assets, the effect varies between **-0.68 %** (considering only if Morecambe OWF is consented) to **-3.82 %** (considering if all future wind farms considered in this study are consented), depending on the scenario.

3. As such, if all of the proposed development takes place, the cumulative impact on the Ørsted Irish Sea Portfolio is just under **-4%**. Whilst this may only be following the total build out (with completion timelines post 2030), the impact on annual energy production (AEP) of individual future wind farms has been seen to be between **-0.68 %** and **-1.68 %** on the existing Ørsted Irish Sea Portfolio.

4. Morgan has the largest impact on the total additional wake loss of the Ørsted assets, particularly on the nearby Walney 2 and Walney Extension sites. Due to the south-westerly prevailing direction, it has less impact on the other sites in this northern cluster of Ørsted wind farms. Because of its more central location in the area, Mona has a large impact on all surrounding Ørsted assets, and Walney 1, Barrow, West of Duddon Sands, Burbo Bank and Burbo Bank Extension experience the highest added wake loss due to this site. Morecambe is the smallest of the sites and in a location that has less impact on Ørsted assets, with only West of Duddon Sands and Barrow experiencing additional losses of > 1 %. The inclusion of Awel y Môr sees a very small increase in additional wake loss, as it is situated a large distance from the majority of Ørsted assets. Its largest impact is on Burbo Bank and Burbo Bank Extension, which are located approximately 20 km to the east, which experience an additional ~0.5 % wake loss.

5. Considering the engineering wake model approaches used and distances between the Client assets and proposed neighbouring wind farms, WT considers the assessed additional wake loss numbers to be commensurate with WT's expectations. WT also finds the results comparable with a recent study conducted by DNV and RWE [7], where values of -3.0% to -3.6% additional wake losses arising from neighbouring wind farms with similar distances to the ones evaluated in this report, which are 5-30 km away from the projects under consideration. Subject to specific criteria on each wind farm site, including capacity factor, age of the wind farm, turbine type/size and the agreed electricity sale price, the financial and technical consequences of additional wake losses could be considerable. WT also notes that increased turbulence levels due to the added wake may increase the fatigue / structural loading and also may cause additional downtime for the turbines, where electricity production is halted.

6. WT has undertaken a sensitivity test based on the assumption of the potential for larger wind turbines to be installed for MoMoMo assets (instead of 15 MW 236 m rotor diameter turbines, WT assumed that 22.6 MW, 276 m rotor diameter turbines will be used). According to the results of this sensitivity test, WT found that the additional wake losses are reduced when using the larger turbine.

7. The wind farms in the vicinity of the Client assets are either operational or at an early stage of development. For the operational wind farms in the vicinity of Client assets, basic turbine and layout parameters are known to WT and summarized in Table 5-3, and as such modelling of these assets contains reduced uncertainty. For the wind farms at an early stage of development, there is currently limited information available about the turbine types, layouts and hub heights. For the prediction of current status of those future wind farms, including the development phase and possible turbine configurations, a range of publicly available datasets has been utilized including TGS Wind, 4C Offshore Wind Market Intelligence [1], and Development Consent Order documents for Mona [4], Morgan [5] and Morecambe [6]. As such, as some of the information compiled for the future projects is uncertain at this stage, the impacts will be subject to change – this report should be considered as being based on the best available information at the time of preparation.

8. It should also be noted that WT has utilized industry standard WindFarmer: Analyst Eddy Viscosity wake model with large wind farm and blockage correction.

7. REFERENCES

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APPENDIX A: WIND FARM SITE INFORMATION

Table A-1 Turbine coordinates (EPSG 25830) of Burbo Bank.

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
A12	487717.51	5925101.72	A13	556.9
A13	487307.29	5925478.39	A14	556.4
A14	486897.52	5925854.74	A13	556.4
A15	486487.67	5926231.28	A16	556.4
A16	486077.49	5926607.29	A15	556.4
A17	485667.52	5926984.01	A18	556.5
A18	485257.59	5927360.43	A17	556.5
B22	488355.08	5925493.73	B23	556.5
B23	487945.2	5925870.11	B22	556.5
B24	487535.26	5926246.73	B25	556.6
B25	487125.19	5926623.1	B26	556.5
B26	486715.35	5926999.6	B25	556.5
B27	486305.29	5927376.09	B28	556.7
B28	485895.15	5927752.46	B29	556.4
B29	485485.4	5928128.87	B28	556.4
C31	489402.82	5925509.24	C32	556.8
C32	488992.9	5925886.04	C33	556.3
C33	488583.14	5926262.26	C32	556.3
C34	488172.88	5926638.65	C33	556.8
C35	487762.75	5927015.19	C36	556.4
C36	487352.99	5927391.53	C35	556.4
C37	486942.69	5927768	C38	556.7
C38	486532.93	5928144.82	C37	556.7
D41	490040.21	5925901.64	D42	556.4
D42	489630.22	5926277.72	D41	556.4

Table A-2 Turbine coordinates (EPSG 25830) of Burbo Bank Extension.

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
A01	475278.1	5928124	A02	834.9
A02	475890.1	5927556	A01	834.9
B01	476577.6	5928125	A02	892.5
B02	476637.2	5926861	A02	1020.5
C01	477590.6	5928126	C02	962.8
C02	477645.9	5927165	C01	962.8
C03	477399.6	5926153	B02	1040.5
C04	478167.1	5925439	D04	1016.1
D01	478790.7	5928126	E01	959.0
D04	478911.3	5924748	C04	1016.1
E01	479749.7	5928128	D01	959.0

E03	479707	5926308	F02	1375.2
E05	479725.7	5923990	D04	1112.3
F01	480983.7	5928128	F02	954.3
F02	480751.8	5927203	F01	954.3
F04	480962.9	5925067	F05	1115.7
F05	481257.5	5923991	G05	1100.1
G01	482125.5	5928129	H01	1130.3
G02	482351.5	5927000	G03	993.2
G03	482090.1	5926042	G02	993.2
G05	482357.7	5923993	H05	1081.5
H01	483255.8	5928130	G01	1130.3
H04	483426.2	5925116	H05	1123.9
H05	483439.1	5923992	G05	1081.5
J01	484444.9	5928131	J02	1010.2
J02	484284.4	5927134	J01	1010.2
J03	484631.8	5926044	J02	1144.0
J05	484527.9	5923993	H05	1088.7
K04	485850	5924889	K05	918.1
K05	485627	5923998	K04	918.1
L05	486670.8	5923998	M05	931.3
M05	487526.3	5924366	L05	931.3

Table A-3 Turbine coordinates (EPSG 25830) of Barrow

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
A01	482336.5	5982596	A02	492.8
A02	481970.7	5982926	A03	492.1
A03	481605.8	5983256	A02	492.1
A04	481241.5	5983589	A05	493.6
A05	480875.2	5983920	A06	491.6
A06	480511.2	5984250	A05	491.6
A07	480145.1	5984581	A06	493.5
B01	482003.4	5981862	B02	493.0
B02	481638.9	5982193	B01	493.0
B03	481273.2	5982524	B04	492.7
B04	480908.1	5982855	B05	492.4
B05	480543.4	5983186	B04	492.4
B06	480178.3	5983517	B07	491.8
B07	479814.1	5983847	B06	491.8
B08	479448.2	5984178	B07	493.5
C01	481306.5	5981459	C02	492.7
C02	480941.4	5981790	C01	492.7
C03	480575.1	5982121	C04	492.3

C04	480211.2	5982453	C03	492.3
C05	479845	5982783	C06	492.0
C06	479481.1	5983114	C05	492.0
C07	479115.2	5983445	C06	493.3
D01	480972.9	5980725	D02	492.2
D02	480608.8	5981057	D01	492.2
D03	480243.8	5981388	D04	492.2
D04	479878.7	5981718	D03	492.2
D05	479513.6	5982051	D06	493.0
D06	479148	5982382	D07	492.3
D07	478783.1	5982712	D06	492.3
D08	478417.4	5983043	D07	493.2

Table A-4 Turbine coordinates (EPSG 25830) of West of Duddon Sands

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
A01	463706.01	5983670.73	B01	749.8
A02	464177.3	5983005.5	A03	650.2
A03	464552.77	5982474.68	A02	650.2
A04	464928.2	5981943.2	A05	649.8
A05	465303.5	5981412.69	A06	649.5
A06	465678.5	5980882.4	A05	649.5
A07	466053.4	5980351.2	A08	650.0
A08	466428.8	5979820.6	A07	650.0
A09	466803.85	5979289.4	A10	649.9
A10	467179.2	5978758.9	A11	649.6
A11	467554.6	5978228.8	A10	649.6
A12	467967.3	5977644.6	A11	715.3
B01	464408	5983934.2	A01	749.8
B02	464879.5	5983267.2	B03	651.0
B03	465255.8	5982736	B04	649.9
B04	465630.21	5982204.75	B03	649.9
B05	466006.5	5981673.66	B06	650.8
B06	466381.5	5981141.8	B07	650.1
B07	466756.9	5980611.1	B06	650.1
B08	467139.5	5980070.3	B09	650.8
B09	467515.2	5979538.9	B10	650.0
B10	467889.2	5979007.3	B09	650.0
B11	468265.8	5978476.1	B10	651.2
B12	468876.4	5977610.1	A12	909.8
C01	465110.86	5984198.3	D01	749.3
C02	465582.4	5983529.8	C03	651.5
C03	465958.97	5982998.18	C04	650.9

C04	466334.26	5982466.34	C03	650.9
C05	466710.03	5981934.71	C06	650.5
C06	467084.9	5981403.1	C05	650.5
C07	467460.41	5980870.8	C06	651.4
D01	465812.58	5984461.17	C01	749.3
D02	466286	5983791.53	D03	651.3
D03	466660.7	5983258.8	D02	651.3
D04	467036.72	5982726.93	D03	651.4
D05	467412.8	5982194.8	D06	650.9
D06	467788.8	5981663.5	D05	650.9
D13	470699.87	5977539.86	E13	851.9
E01	466736.2	5984808.8	F01	767.7
E02	467200.49	5984133.14	E03	649.4
E03	467567.38	5983597.26	E02	649.4
E08	469436.4	5980873.8	E09	642.0
E09	469776.96	5980329.58	E08	642.0
E10	470171.98	5979802.93	E11	650.2
E11	470539.9	5979266.8	E10	650.2
E12	470925.59	5978704.69	E11	681.7
E13	471337.02	5978105.31	E12	727.0
E14	471753.14	5977498.51	E13	735.8
F01	467455.2	5985078	E01	767.7
F02	467918.06	5984401.26	F03	650.3
F03	468284.25	5983863.86	F04	650.0
F04	468650.7	5983326.95	F03	650.0
F10	470885.3	5980051.7	F11	650.8
F11	471252.5	5979514.4	F10	650.8
F12	471632.3	5978958.5	F11	673.3
F13	472044.9	5978352.4	F14	717.1
F14	472449	5977760	F13	717.1
G01	468174.38	5985348.37	H01	767.9
G02	468635.79	5984668.71	G03	651.0
G03	469001.1	5984129.9	G04	649.7
G04	469366	5983592.3	G03	649.7
G11	471964.59	5979763.16	G12	666.9
G12	472339.2	5979211.4	G11	666.9
G13	472948.3	5978313.2	F14	745.2
H01	468893.2	5985618.6	G01	767.9
H02	469353.22	5984936.29	H03	650.5
H03	469717.37	5984397.28	H04	649.8
H04	470080.32	5983858.31	H03	649.8
H05	470444.49	5983318.84	H06	649.6

H06	470808.07	5982780.47	H05	649.6
H07	471172.9	5982241.1	H06	651.2
H10	472312.9	5980550.6	H11	650.5
H11	472677	5980011.5	H10	650.5
H12	473045.3	5979464.7	H11	659.3
H13	473448.8	5978867.3	H12	720.9
I01	469671	5985910.6	I02	822.1
I02	470121.67	5985223.01	I03	648.7
I03	470478.02	5984680.9	I02	648.7
I04	470834.28	5984138.54	I03	648.9
I05	471191.09	5983596.19	I04	649.2
I06	471547.4	5983053.5	I07	648.8
I07	471903.5	5982511.1	I06	648.8
I08	472315.2	5981884.6	I09	649.2
I09	472670.99	5981341.57	I10	648.7
I10	473027.6	5980799.7	I09	648.7
I11	473384.2	5980256.7	I10	649.6
I12	473938.7	5979412.4	H13	732.9
J01	470426.5	5986245	I01	826.2
J02	470824.13	5985484.66	J03	649.6
J03	471181.23	5984942.05	J04	649.3
J04	471538.11	5984399.62	J03	649.3
J05	471894.3	5983856.63	J04	649.4
J06	472251.1	5983313.8	J07	649.2
J07	472606.74	5982770.69	J06	649.2
J08	473025.5	5982133.8	J09	649.6
J09	473382.1	5981590.8	J08	649.6
J10	473738.4	5981047.4	J11	649.7
J11	474095.3	5980504.5	J12	642.7
J12	474447.9	5979967.1	J11	642.7
K02	471527.53	5985747.72	K03	650.0
K03	471883.93	5985204.15	K02	650.0
K04	472241.27	5984660.64	K05	649.7
K05	472597.66	5984117.39	K04	649.7
K06	472953.56	5983573.23	K07	649.9
K07	473310.7	5983030.2	K06	649.9
K08	473736.2	5982383	K09	650.6
K09	474092.14	5981838.44	K10	649.7
K10	474449.7	5981295.99	K09	649.7

Table A-5 Turbine coordinates (EPSG 25830) of Walney 1

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
A01	470699.9	5986944	A02	749.8
A02	470141.8	5987445	A01	749.8
A03	469582.7	5987945	A04	749.5
A04	469024.3	5988445	A03	749.5
A05	468465.8	5988946	A04	750.1
A06	467906.7	5989446	A07	749.8
A07	467348.5	5989947	A08	749.8
A08	466789.5	5990447	A07	749.8
A09	466230.8	5990948	A10	749.7
A10	465672.8	5991448	A09	749.7
A11	465113.8	5991948	A10	750.1
B01	469790.2	5986643	B02	750.1
B02	469231.2	5987143	B01	750.1
B03	468672.6	5987644	B04	749.7
B04	468113.9	5988144	B03	749.7
B05	467555.4	5988645	B06	749.7
B06	466996.9	5989145	B05	749.7
B07	466438.3	5989645	B06	749.7
B08	465879.1	5990146	B09	749.8
B09	465320.5	5990646	B08	749.8
B10	464761.8	5991147	B09	750.3
C01	468880.2	5986342	C02	750.1
C02	468321.2	5986842	C03	750.0
C03	467762.7	5987343	C04	750.0
C04	467204.1	5987843	C05	749.7
C05	466645.6	5988344	C04	749.7
C06	466086.3	5988844	C07	750.0
C07	465527.7	5989345	C08	749.5
C08	464969.3	5989845	C07	749.5
C09	464410.2	5990345	C08	750.5
D01	467970.2	5986041	D02	750.0
D02	467411.4	5986542	D01	750.0
D03	466852.4	5987042	D04	749.8
D04	466293.7	5987542	D03	749.8
D05	465735.3	5988043	D06	749.8
D06	465176.7	5988543	D05	749.8
D07	464617.9	5989044	D08	750.0
D08	464059.2	5989544	D07	750.0
E01	467059.9	5985740	E02	750.0

E02	466501.2	5986241	E01	750.0
E03	465942.4	5986741	E02	750.1
E04	465383.8	5987242	E05	749.8
E05	464825.2	5987742	E04	749.8
E06	464266.7	5988242	E05	749.9
E07	463707.7	5988743	E06	750.6
F01	466149.9	5985439	F02	750.4
F02	465591	5985940	F03	749.7
F03	465032.6	5986440	F04	749.7
F04	464474.2	5986941	F03	749.7
F05	463914.8	5987441	F06	749.5
F06	463356.7	5987941	F05	749.5

Table A-6 Turbine coordinates (EPSG 25830) of Walney 2

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
A12	464554.9	5992449	A13	775.1
A13	463977.5	5992966	A14	774.9
A14	463400.4	5993483	A13	774.9
A15	462823.1	5994000	A16	775.0
A16	462245.9	5994517	A15	775.0
A17	460514.1	5996068	A18	775.0
A18	459936.8	5996585	A19	775.0
A19	459359.5	5997102	A18	775.0
A20	458744.5	5997654	A19	825.8
B11	464203.5	5991647	B12	775.1
B12	463603.9	5992138	B13	774.9
B13	463004.6	5992630	B12	774.9
B14	462405	5993121	B13	775.1
B15	461730.2	5993673	B14	872.2
B16	459618	5995402	C15	751.8
B17	458973.8	5995930	B16	832.9
B18	458053.5	5996684	C16	826.5
C10	463206.9	5991275	C11	775.1
C11	462561.4	5991704	C12	774.9
C12	461916	5992133	C13	774.7
C13	461271	5992562	C12	774.7
C14	460625	5992991	C13	775.4
C15	459050.3	5994909	B16	751.8
C16	457625.9	5995977	B18	826.5
D09	463500.8	5990045	D10	806.4
D10	462850.3	5990521	D09	806.4
D11	462199.1	5990998	E10	791.6

D12	461496.8	5991396	D11	807.2
D13	460676.9	5991807	D14	917.2
D14	459857.2	5992219	D13	917.2
D15	458476.9	5994419	E15	738.7
D16	457842	5994874	D17	755.4
D17	457198.3	5995269	D16	755.4
E08	463149.4	5989243	E09	838.8
E09	462493.2	5989766	D10	835.4
E10	461815.8	5990305	D11	791.6
E11	461053.9	5990692	D12	831.6
E12	460161.7	5990870	E11	909.7
E13	459269.5	5991048	E12	909.7
E14	458377.2	5991225	F14	751.1
E15	457903.7	5993953	F15	738.7
E16	457264.4	5994378	D16	761.1
F07	462745.4	5988322	F08	837.7
F08	462056.1	5988798	F09	837.7
F09	461334.4	5989223	F08	837.7
F10	460584	5989596	F11	837.6
F11	459808.9	5989913	F10	837.6
F12	459012.8	5990174	F13	837.6
F13	458200.2	5990377	F14	743.4
F14	457691.3	5990919	F13	743.4
F15	457330.4	5993487	E15	738.7

Table A-7 Turbine coordinates (EPSG 25830) of Walney Extension 3

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
A01	440067.1	5996563	B02	1085.0
A02	441021.4	5996035	B03	1056.7
A03	442048.2	5995477	B04	1039.3
A04	443127.1	5994890	B05	963.5
A05	444382.1	5994678	B05	1090.5
B01	440066	5997837	B02	1025.5
B02	440907	5997250	B01	1025.5
B03	441885	5996644	A02	1056.7
B04	442871.8	5996111	A03	1039.3
B05	443786.9	5995592	A04	963.5
C01	440065.1	5998934	C02	970.6
C02	440983.2	5998619	C01	970.6
C03	441850.8	5997771	D01	992.0
C04	442895	5997204	D02	1067.2
C05	443951.8	5996670	D03	1053.0

C06	444727.4	5995939	C07	981.3
C07	445706.9	5995997	D05	919.6
D01	441982.6	5998754	E01	980.9
D02	443027	5998263	E01	1044.4
D03	444011.6	5997721	C05	1053.0
D04	445068.8	5997001	D05	1008.3
D05	446064.8	5996844	C07	919.6
E01	442807.9	5999284	D01	980.9
E02	444048.9	5998841	F01	1066.2
E03	445023.9	5998137	E04	1076.5
E04	446065.5	5997866	D05	1021.4
F01	443675.1	5999840	F02	957.8
F02	444614.3	6000028	F03	953.5
F03	445127.1	5999224	F02	953.5
F04	446145.8	5998946	F03	1055.9
F05	447162.9	5998497	G04	1086.5
G01	445219	6000830	H01	980.6
G02	445980	6000098	G01	1056.2
G03	446990	5999674	G02	1095.2
G04	448009.6	5999178	H04	1045.0
H01	446044	6001360	G01	980.6
H02	446962.2	6000861	H03	1044.4
H03	447880.2	6000363	H02	1044.4
H04	448797.9	5999864	H03	1044.8
H05	450634.1	5998867	H04	2089.1

Table A-8 Turbine coordinates (EPSG 25830) of Walney Extension 4

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
A06	450464.5	5991298	B07	979.3
A07	456212.2	5987782	A08	951.5
A08	457046.9	5987325	A07	951.5
A09	457895.8	5986863	A10	966.1
A10	458744.7	5986402	A11	966.0
A11	459593.7	5985941	A12	965.7
A12	460441.8	5985479	A11	965.7
A13	461290.9	5985018	A14	966.1
A14	462140	5984557	A13	966.1
B06	449554.8	5992656	C08	1097.8
B07	450624.9	5992264	A06	979.3
B08	451521.5	5991462	B09	913.1
B09	452402.2	5991703	B08	913.1
B10	456715.4	5988893	B11	1050.2

B11	457518.8	5988217	B12	984.4
B12	458485.8	5988032	B13	927.2
B13	459083.9	5987324	B12	927.2
B14	460185.6	5986719	A11	977.7
B15	461352	5986162	B16	1071.4
B16	462306.8	5985676	B17	1014.4
B17	463288.9	5985422	B16	1014.4
C08	449669.9	5993748	B06	1097.8
C09	451726	5992574	D08	1061.0
C10	453400.6	5992018	D09	969.6
C11	457223.5	5990002	C12	1000.9
C12	457900.7	5989265	C11	1000.9
C13	458951.2	5989176	C14	1033.6
C14	459928.7	5988840	C15	978.9
C15	460023.6	5987866	C16	957.4
C16	460850.8	5988348	C15	957.4
C17	461140.6	5987258	C18	928.0
C18	461884.6	5987813	C17	928.0
C19	462349.7	5986798	C18	1116.4
C20	463460.9	5986550	C21	1110.6
C21	464271.8	5985791	B17	1050.0
D06	449528.9	5994981	E05	1060.1
D07	450503.9	5994493	D06	1090.5
D08	452390.8	5993401	D09	1025.9
D09	453328.6	5992985	C10	969.6
E05	450303.7	5995705	D06	1060.1
E06	451374.8	5995175	D07	1105.9
E07	452412.8	5994619	E08	1129.8
E08	453409.6	5994087	D09	1104.9
F06	450154.6	5996788	G05	1086.6
F07	452336.6	5995763	E06	1127.5
G05	450323.5	5997861	F06	1086.6
H06	451551.8	5998369	G05	1329.2

Table A-9 Turbine coordinates (EPSG 25830) of neighbouring Rhyl Flats

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T221	454065	5914797	T225	460.1
T222	457049	5915828	T243	509.4
T223	457058	5913636	T244	437.2
T224	457651.3	5914502	T226	502.0
T225	454493.6	5914630	T227	456.7
T226	457182.8	5914682	T231	502.0

T227	454920	5914466	T225	456.7
T228	455348.6	5914299	T241	457.4
T229	455309.2	5915410	T232	500.9
T230	457999	5915460	T236	509.5
T231	456714.3	5914863	T226	502.0
T232	454842	5915591	T229	500.9
T233	455778.6	5915228	T229	503.6
T234	458474.1	5915276	T230	509.5
T235	454372.6	5915773	T232	503.6
T236	457524	5915644	T222	509.4
T237	459424.4	5914908	T234	1019.0
T238	459055.8	5913956	T242	501.1
T239	458119.8	5914320	T224	502.7
T240	456203.8	5913968	T245	458.5
T241	455775.1	5914134	T228	457.4
T242	458588.9	5914138	T238	501.1
T243	456574.1	5916012	T222	509.4
T244	457465.8	5913478	T223	437.2
T245	456631.5	5913803	T223	458.1

Table A-10 Turbine coordinates (EPSG 25830) of neighbouring North Hoyle

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T161	468727.9	5918058	T173	349.6
T162	470298.6	5918358	T171	349.6
T163	470822	5919884	T181	351.4
T164	471673.5	5919680	T175	342.6
T165	469513.3	5918209	T190	351.4
T166	471935.7	5918314	T178	349.6
T167	469382.6	5918896	T183	347.8
T168	470234.3	5918703	T169	348.0
T169	470167.7	5919044	T168	348.0
T170	471084.9	5918508	T179	349.6
T171	470364	5918014	T162	349.6
T172	471608.1	5920033	T164	358.7
T173	468793.2	5917714	T161	349.6
T174	468529.8	5919088	T186	348.0
T175	471740.2	5919344	T164	342.6
T176	470035.9	5919733	T187	349.8
T177	468661.5	5918401	T161	349.8
T178	471870.1	5918658	T166	349.6
T179	471019.5	5918852	T170	349.6
T180	471150.4	5918163	T170	351.4

T181	470887.4	5919539	T184	349.8
T182	469316.1	5919239	T189	349.4
T183	469447.9	5918554	T167	347.8
T184	470954	5919195	T179	349.6
T185	468465.6	5919434	T174	351.2
T186	468596.2	5918747	T174	348.0
T187	470102.4	5919390	T176	349.8
T188	471804.6	5919003	T175	347.6
T189	469251.9	5919582	T182	349.4
T190	469578.6	5917863	T165	351.4

Table A-11 Turbine coordinates (EPSG 25830) of neighbouring Ormonde

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T191	471393.6	5991898	T192	530.3
T192	470997.8	5992251	T191	530.3
T193	470602	5992606	T194	530.3
T194	470206.3	5992959	T193	530.3
T195	469810.6	5993314	T197	530.2
T196	472522.2	5991873	T220	532.5
T197	469415	5993667	T195	530.2
T198	471789.5	5991544	T191	531.6
T199	473213	5993264	T200	536.8
T200	472832.5	5993642	T199	536.8
T201	471309.1	5995155	T212	536.2
T202	473593.5	5992885	T199	536.8
T203	470959.8	5993322	T217	532.4
T204	470178.4	5994046	T206	532.4
T205	470936.1	5994416	T218	534.2
T206	470568.5	5993684	T204	532.4
T207	470929	5995534	T201	536.7
T208	472093.5	5993305	T216	534.3
T209	471321.9	5994044	T216	534.2
T210	472865.4	5992565	T219	534.3
T211	471741.4	5992597	T220	532.5
T212	471690.4	5994778	T201	536.2
T213	469787.2	5994408	T204	533.2
T214	472070.7	5994400	T212	536.7
T215	472451	5994021	T214	536.7
T216	471707.7	5993675	T209	534.2
T217	471350	5992959	T203	532.4
T218	470550.4	5994786	T205	534.2
T219	472479.4	5992934	T210	534.3

T220	472131.8	5992235	T211	532.5

Table A-12 Turbine coordinates (EPSG 25830) of neighbouring Gwynt y Môr

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T1	458372.5	5923891	T9	717.1
T2	454785.1	5922641	T160	689.9
T3	458377.2	5921405	T82	717.2
T4	460171.6	5922031	T38	717.2
T5	456583.4	5920779	T46	718.7
T6	460173.3	5920787	T72	717.3
T7	460176.2	5919542	T23	717.7
T8	459455.8	5920785	T80	717.2
T9	458015.1	5923270	T1	717.1
T10	469315	5922666	T69	718.4
T11	466440.5	5923903	T109	717.3
T12	456939.2	5922645	T41	717.2
T13	459449	5924516	T112	717.1
T14	460889	5922032	T4	717.4
T15	459090.7	5923894	T137	717.3
T16	458374.8	5922649	T39	717.3
T17	458738.2	5920784	T77	717.2
T18	458017.3	5922025	T22	717.2
T19	458733.3	5923271	T94	717.2
T20	463573.1	5921410	T151	717.4
T21	460168.8	5923273	T51	717.2
T22	457659.7	5921404	T18	717.2
T23	459458.4	5919541	T76	679.5
T24	462132.6	5923895	T99	717.7
T25	460527	5923897	T156	717.1
T26	455503.5	5922644	T87	717.2
T27	468236.7	5923285	T90	718.2
T28	462850.8	5923895	T68	717.4
T29	462134.9	5922651	T31	717.4
T30	458379.5	5920162	T82	717.5
T31	462495.2	5922030	T151	717.3
T32	460533.6	5920166	T6	717.5
T33	456578.5	5923266	T57	717.2
T34	455500.8	5923886	T84	717.1
T35	457296.8	5923269	T55	717.1
T36	457661.9	5920159	T93	717.5
T37	460892	5920788	T154	717.4
T38	460528.8	5922653	T4	717.2

T39	457657.6	5922648	T9	717.2
T40	467158.7	5923904	T90	716.8
T41	456581.5	5922023	T12	717.2
T42	467876.8	5923906	T141	717.3
T43	459808.8	5923896	T13	717.3
T44	462492.9	5923273	T70	717.4
T45	462855.6	5921408	T151	717.2
T46	457302	5920782	T22	717.2
T47	467878.4	5922662	T71	717.3
T48	455863	5922021	T91	716.4
T49	460167.1	5924517	T156	717.0
T50	456937.2	5923889	T55	717.1
T51	459811.6	5922651	T21	717.2
T52	466083.1	5923281	T56	717.1
T53	465364.8	5923279	T75	716.8
T54	465366.8	5922036	T79	716.8
T55	457654.3	5923890	T50	717.1
T56	466800.2	5923281	T52	717.1
T57	456220.8	5922644	T33	717.2
T58	466085.2	5922037	T83	714.3
T59	464288.8	5922654	T67	717.4
T60	462137.1	5921408	T31	717.8
T61	464646.6	5923277	T79	717.4
T62	463931	5922032	T59	717.7
T63	457298.8	5922024	T85	717.2
T64	455505.1	5921399	T48	717.2
T65	455145.6	5922020	T48	717.4
T66	463928.3	5923277	T92	716.8
T67	464649.5	5922034	T54	717.3
T68	463211.1	5923275	T96	716.8
T69	468596.7	5922663	T47	718.3
T70	462853.2	5922653	T96	717.3
T71	467161.1	5922660	T83	705.5
T72	459815.9	5920165	T6	717.3
T73	465722.4	5923901	T52	717.4
T74	458740.7	5919540	T76	679.0
T75	465724.4	5922659	T53	716.8
T76	459100.1	5918964	T74	679.0
T77	459095.7	5921406	T17	717.2
T78	464286	5923899	T92	717.1
T79	465007.2	5922657	T54	716.8
T80	459813.2	5921407	T8	717.2

T81	458735.8	5922028	T89	717.2
T82	458019.6	5920783	T3	717.2
T83	466799.4	5922054	T98	702.4
T84	455143	5923264	T34	717.1
T85	456941.1	5921403	T63	717.2
T86	462497.5	5920786	T45	717.8
T87	455861.3	5923265	T26	717.2
T88	456219	5923889	T134	717.1
T89	459093.2	5922650	T94	717.2
T90	467518.5	5923284	T40	716.8
T91	456223.7	5921402	T48	716.4
T92	463569	5923897	T66	716.8
T93	458021.9	5919539	T36	717.5
T94	459450.5	5923272	T89	717.2
T95	459098.3	5920163	T8	717.3
T96	463570.5	5922654	T68	716.8
T97	460887	5923275	T38	717.7
T98	466442.8	5922659	T83	702.4
T99	462490.6	5924517	T100	717.3
T100	462130.4	5925137	T99	717.3
T101	458728.5	5925759	T119	717.1
T102	463203.6	5927005	T131	717.2
T103	462128.2	5926382	T106	717.3
T104	460524.1	5925139	T49	717.1
T105	460522.3	5926384	T128	682.2
T106	462488.3	5925761	T103	717.3
T107	462485.9	5927004	T145	717.2
T108	460882.2	5925763	T105	717.3
T109	466079.8	5924523	T111	717.0
T110	459446.4	5925759	T112	717.3
T111	465362.9	5924523	T109	717.0
T112	459806.1	5925138	T13	717.1
T113	465720.3	5925145	T150	706.2
T114	466438.3	5925146	T126	716.7
T115	463208.6	5924519	T144	717.3
T116	459088.1	5925137	T137	717.1
T117	463921.3	5927007	T131	717.6
T118	465359.8	5925767	T147	673.4
T119	459085.6	5926381	T158	682.8
T120	464641.9	5925765	T139	717.3
T121	463566.4	5925141	T125	717.3
T122	458010.6	5925756	T135	717.3

T123	463924	5925763	T143	717.3
T124	459804.5	5926382	T133	682.2
T125	463206.1	5925761	T121	717.3
T126	466797.9	5924526	T114	716.7
T127	464999.4	5926387	T147	687.3
T128	460876.6	5926967	T105	682.2
T129	464644.8	5924521	T148	716.8
T130	460164.3	5925762	T124	717.3
T131	463563.8	5926385	T102	717.2
T132	464639	5927007	T127	717.2
T133	460158.9	5926965	T124	682.2
T134	456576.6	5924510	T88	717.1
T135	458370.1	5925136	T138	717.1
T136	463926.7	5924521	T121	717.3
T137	458730.9	5924515	T116	717.1
T138	458012.8	5924514	T135	717.1
T139	464281.6	5926385	T120	717.3
T140	455858.5	5924509	T88	717.9
T141	467515.9	5924526	T42	717.3
T142	457652.1	5925135	T122	717.6
T143	464284.4	5925143	T123	717.3
T144	462848.4	5925139	T115	717.3
T145	462846	5926383	T107	717.2
T146	465002.3	5925143	T111	717.3
T147	465685.9	5926356	T118	673.4
T148	465004.2	5923901	T129	716.8
T149	455140.4	5924507	T152	717.1
T150	466035.7	5925777	T118	676.0
T151	463212.5	5922030	T45	717.2
T152	454782.6	5923885	T149	717.1
T153	459453.1	5922030	T81	717.4
T154	460531.7	5921409	T37	717.4
T155	454424.7	5923262	T157	716.6
T156	460884	5924519	T49	717.0
T157	454067.8	5922641	T160	690.5
T158	459441.2	5926964	T119	682.8
T159	457294.7	5924511	T50	717.1
T160	454427.4	5922051	T2	689.9

Table A-13 Turbine coordinates (EPSG 25830) of future site Awel y Môr

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T01	442814.1	5923782	T03	1180.0

T02	443034.7	5926655	T04	1180.0
T03	443414.8	5922767	T01	1180.0
T04	443635.4	5925639	T02	1180.0
T05	444236.1	5924623	T04	1180.0
T06	444836.7	5923607	T08	1180.0
T07	445057.4	5926480	T09	1180.0
T08	445437.4	5922592	T06	1180.0
T09	445658	5925464	T11	1180.0
T10	446038.1	5921576	T08	1180.0
T11	446258.7	5924448	T09	1180.0
T12	446859.4	5923433	T14	1180.0
T13	447080	5926305	T15	1180.0
T14	447460	5922417	T12	1180.0
T15	447680.6	5925289	T17	1180.0
T16	448060.7	5921401	T14	1180.0
T17	448281.3	5924274	T15	1180.0
T18	448661.4	5920386	T16	1180.0
T19	448882	5923258	T21	1180.0
T20	449102.6	5926130	T22	1180.0
T21	449482.6	5922242	T19	1180.0
T22	449703.3	5925115	T24	1180.0
T23	450083.3	5921227	T21	1180.0
T24	450303.9	5924099	T22	1180.0
T25	450684	5920211	T23	1180.0
T26	450904.6	5923083	T28	1180.0
T27	451125.2	5925956	T29	1180.0
T28	451505.3	5922068	T30	1180.0
T29	451725.9	5924940	T31	1180.0
T30	452105.9	5921052	T28	1180.0
T31	452326.5	5923924	T32	1180.0
T32	452927.2	5922909	T31	1180.0
T33	453147.8	5925781	T35	1180.0
T34	453527.9	5921893	T32	1180.0
T35	453748.5	5924765	T33	1180.0
T36	454349.2	5923749	T35	1180.0
T37	454569.8	5926622	T38	1180.0
T38	455170.4	5925606	T37	1180.0
T39	456592.4	5926447	T38	1652.0

Table A-14 Turbine coordinates (EPSG 25830) of future site Mona for15 MW turbine

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T01	430490.8	5956153	T06	1416.0

T02	430661.2	5944738	T07	1416.0
T03	430674.3	5959552	T08	1416.0
T04	430844.7	5948137	T09	1416.0
T05	431028.1	5951535	T11	1416.0
T06	431211.6	5954934	T12	1416.0
T07	431382	5943519	T02	1416.0
T08	431395.1	5958333	T13	1416.0
T09	431565.5	5946918	T14	1416.0
T10	431578.6	5961731	T15	1416.0
T11	431748.9	5950317	T05	1416.0
T12	431932.4	5953715	T06	1416.0
T13	432115.9	5957114	T08	1416.0
T14	432286.3	5945699	T19	1416.0
T15	432299.4	5960513	T20	1416.0
T16	432469.8	5949098	T21	1416.0
T17	432653.2	5952496	T22	1416.0
T18	432836.7	5955895	T13	1416.0
T19	433007.1	5944480	T14	1416.0
T20	433020.2	5959294	T15	1416.0
T21	433190.6	5947879	T16	1416.0
T22	433374	5951278	T17	1416.0
T23	433557.5	5954676	T29	1416.0
T24	433727.9	5943261	T19	1416.0
T25	433741	5958075	T20	1416.0
T26	433911.4	5946660	T31	1416.0
T27	433924.5	5961474	T32	1416.0
T28	434094.8	5950059	T22	1416.0
T29	434278.3	5953457	T23	1416.0
T30	434461.8	5956856	T35	1416.0
T31	434632.2	5945441	T26	1416.0
T32	434645.3	5960255	T27	1416.0
T33	434815.6	5948840	T38	1416.0
T34	434999.1	5952239	T29	1416.0
T35	435182.6	5955637	T30	1416.0
T36	435353	5944222	T41	1416.0
T37	435366.1	5959036	T42	1416.0
T38	435536.4	5947621	T33	1416.0
T39	435719.9	5951020	T45	1416.0
T40	435903.4	5954419	T35	1416.0
T41	436073.8	5943004	T36	1416.0
T42	436086.9	5957817	T47	1416.0
T43	436257.2	5946402	T48	1416.0

T44	436270.3	5961216	T49	1416.0
T45	436440.7	5949801	T39	1416.0
T46	436624.2	5953200	T51	1416.0
T47	436807.7	5956598	T42	1416.0
T48	436978	5945184	T43	1416.0
T49	436991.1	5959997	T54	1416.0
T50	437161.5	5948582	T55	1416.0
T51	437345	5951981	T57	1416.0
T52	437528.5	5955380	T58	1416.0
T53	437698.8	5943965	T59	1416.0
T54	437711.9	5958778	T49	1416.0
T55	437882.3	5947363	T50	1416.0
T56	437895.4	5962177	T62	1416.0
T57	438065.8	5950762	T51	1416.0
T58	438249.3	5954161	T64	1416.0
T59	438419.6	5942746	T53	1416.0
T60	438432.7	5957560	T66	1416.0
T61	438603.1	5946145	T67	1416.0
T62	438616.2	5960958	T56	1416.0
T63	438786.6	5949543	T57	1416.0
T64	438970.1	5952942	T58	1416.0
T65	439140.5	5941527	T59	1416.0
T66	439153.6	5956341	T71	1416.0
T67	439323.9	5944926	T61	1416.0
T68	439337	5959739	T62	1416.0
T69	439507.4	5948325	T74	1416.0
T70	439690.9	5951723	T64	1416.0
T71	439874.4	5955122	T66	1416.0
T72	440044.7	5943707	T77	1416.0
T73	440057.8	5958521	T68	1416.0
T74	440228.2	5947106	T69	1416.0
T75	440411.7	5950504	T80	1416.0
T76	440595.2	5953903	T71	1416.0
T77	440765.5	5942488	T82	1416.0
T78	440778.6	5957302	T83	1416.0
T79	440949	5945887	T84	1416.0
T80	441132.5	5949286	T85	1416.0
T81	441316	5952684	T86	1416.0
T82	441486.3	5941269	T77	1416.0
T83	441499.4	5956083	T78	1416.0
T84	441669.8	5944668	T79	1416.0
T85	441853.3	5948067	T80	1416.0

T86	442036.8	5951465	T88	1416.0
T87	442220.2	5954864	T89	1416.0
T88	442757.6	5950247	T86	1416.0
T89	442941	5953645	T91	1416.0
T90	443478.4	5949028	T88	1416.0
T91	443661.8	5952427	T89	1416.0
T92	443845.3	5955825	T95	1416.0
T93	444199.2	5947809	T90	1416.0
T94	444382.6	5951208	T91	1416.0
T95	444566.1	5954606	T92	1416.0
T96	445103.4	5949989	T94	1416.0

Table A-15 Turbine coordinates (EPSG 25830) of future site Morecambe for 15 MW turbine

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T01	455727.3	5959456	T02	1416.0
T02	456855.2	5958600	T04	1416.0
T03	456868.8	5960960	T05	1416.0
T04	457983.1	5957744	T02	1416.0
T05	457996.7	5960104	T03	1416.0
T06	458010.3	5962464	T08	1416.0
T07	459124.6	5959248	T10	1416.0
T08	459138.2	5961608	T11	1416.0
T09	459151.8	5963968	T12	1416.0
T10	460252.5	5958392	T13	1416.0
T11	460266.1	5960752	T08	1416.0
T12	460279.7	5963112	T09	1416.0
T13	461380.4	5957536	T10	1416.0
T14	461394	5959896	T18	1416.0
T15	461407.6	5962256	T19	1416.0
T16	461421.2	5964616	T20	1416.0
T17	462508.3	5956680	T13	1416.0
T18	462521.8	5959040	T14	1416.0
T19	462535.4	5961400	T15	1416.0
T20	462549	5963759	T16	1416.0
T21	463649.7	5958183	T18	1416.0
T22	463663.3	5960543	T19	1416.0
T23	463676.9	5962903	T26	1416.0
T24	464777.6	5957327	T21	1416.0
T25	464791.2	5959687	T27	1416.0
T26	464804.8	5962047	T28	1416.0
T27	465919.1	5958831	T25	1416.0
T28	465932.7	5961191	T26	1416.0

T29	465946.3	5963551	T32	1416.0
T30	467047	5957975	T27	1416.0
T31	467060.6	5960335	T28	1416.0
T32	467074.2	5962695	T29	1416.0

Table A-16 Turbine coordinates (EPSG 25830) of future site Morgan for 15 MW turbine

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T01	421549.9	5985727	T02	1416.0
T02	422677.7	5984871	T01	1416.0
T03	423805.6	5984015	T05	1416.0
T04	423819.2	5986375	T06	1416.0
T05	424933.5	5983158	T08	1416.0
T06	424947.1	5985518	T04	1416.0
T07	424960.7	5987878	T10	1416.0
T08	426061.4	5982302	T05	1416.0
T09	426075.0	5984662	T13	1416.0
T10	426088.6	5987022	T14	1416.0
T11	426102.2	5989382	T15	1416.0
T12	427189.3	5981446	T17	1416.0
T13	427202.9	5983806	T18	1416.0
T14	427216.5	5986166	T10	1416.0
T15	427230.1	5988526	T11	1416.0
T16	427243.7	5990886	T21	1416.0
T17	428317.2	5980590	T12	1416.0
T18	428330.8	5982950	T13	1416.0
T19	428344.4	5985310	T25	1416.0
T20	428358.0	5987670	T26	1416.0
T21	428371.6	5990030	T27	1416.0
T22	428385.2	5992390	T28	1416.0
T23	429445.1	5979734	T29	1416.0
T24	429458.7	5982094	T30	1416.0
T25	429472.3	5984454	T19	1416.0
T26	429485.9	5986814	T32	1416.0
T27	429499.4	5989174	T21	1416.0
T28	429513.0	5991534	T22	1416.0
T29	430572.9	5978878	T35	1416.0
T30	430586.5	5981238	T24	1416.0
T31	430600.1	5983598	T25	1416.0
T32	430613.7	5985958	T26	1416.0
T33	430627.3	5988318	T39	1416.0
T34	430640.9	5990678	T40	1416.0
T35	431700.8	5978022	T29	1416.0

T36	431714.4	5980382	T30	1416.0
T37	431728.0	5982742	T43	1416.0
T38	431741.6	5985102	T44	1416.0
T39	431755.2	5987462	T33	1416.0
T40	431768.8	5989822	T46	1416.0
T41	432828.7	5977166	T47	1416.0
T42	432842.3	5979526	T48	1416.0
T43	432855.9	5981886	T37	1416.0
T44	432869.5	5984246	T38	1416.0
T45	432883.1	5986605	T39	1416.0
T46	432896.7	5988965	T40	1416.0
T47	433956.6	5976310	T54	1416.0
T48	433970.2	5978669	T42	1416.0
T49	433983.8	5981029	T43	1416.0
T50	433997.4	5983389	T44	1416.0
T51	434011.0	5985749	T58	1416.0
T52	434024.6	5988109	T59	1416.0
T53	434038.2	5990469	T46	1888.0
T54	435084.5	5975453	T47	1416.0
T55	435098.1	5977813	T48	1416.0
T56	435111.7	5980173	T62	1416.0
T57	435125.3	5982533	T63	1416.0
T58	435138.9	5984893	T64	1416.0
T59	435152.5	5987253	T65	1416.0
T60	436212.4	5974597	T54	1416.0
T61	436226.0	5976957	T66	1416.0
T62	436239.6	5979317	T56	1416.0
T63	436253.2	5981677	T68	1416.0
T64	436266.8	5984037	T58	1416.0
T65	436280.4	5986397	T59	1416.0
T66	437353.9	5976101	T61	1416.0
T67	437367.5	5978461	T62	1416.0
T68	437381.1	5980821	T63	1416.0
T69	437394.7	5983181	T74	1416.0
T70	437408.2	5985541	T75	1416.0
T71	438481.7	5975245	T66	1416.0
T72	438495.3	5977605	T76	1416.0
T73	438508.9	5979965	T77	1416.0
T74	438522.5	5982325	T78	1416.0
T75	438536.1	5984685	T79	1416.0
T76	439623.2	5976749	T72	1416.0
T77	439636.8	5979109	T81	1416.0

T78	439650.4	5981469	T74	1416.0
T79	439664.0	5983829	T75	1416.0
T80	440751.1	5975893	T76	1416.0
T81	440764.7	5978253	T77	1416.0
T82	440778.3	5980613	T85	1416.0
T83	440791.9	5982973	T86	1416.0
T84	441892.6	5977397	T87	1416.0
T85	441906.2	5979757	T88	1416.0
T86	441919.8	5982117	T83	1416.0
T87	443020.5	5976541	T84	1416.0
T88	443034.1	5978900	T85	1416.0
T89	443047.7	5981260	T91	1416.0
T90	444162.0	5978044	T92	1416.0
T91	444175.6	5980404	T93	1416.0
T92	445289.9	5977188	T90	1416.0
T93	445303.5	5979548	T91	1416.0
T94	445317.0	5981908	T91	1888.0
T95	446431.3	5978692	T96	1416.0
T96	447559.2	5977836	T95	1416.0

Table A-17 Turbine coordinates (EPSG 25830) of future site Mona for 22.6 MW turbine

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T01	430473	5957157	T05	1656.0
T02	430672.2	5943808	T11	2208.0
T03	430886.8	5947782	T07	1656.0
T04	431101.4	5951757	T08	1656.0
T05	431316	5955732	T01	1656.0
T06	431530.5	5959707	T10	1656.0
T07	431729.8	5946357	T11	1656.0
T08	431944.4	5950332	T04	1656.0
T09	432158.9	5954306	T14	1656.0
T10	432373.5	5958281	T06	1656.0
T11	432572.8	5944932	T07	1656.0
T12	432588.1	5962256	T17	1656.0
T13	432787.3	5948906	T18	1656.0
T14	433001.9	5952881	T09	1656.0
T15	433216.5	5956856	T20	1656.0
T16	433415.7	5943506	T11	1656.0
T17	433431	5960831	T12	1656.0
T18	433630.3	5947481	T22	1656.0
T19	433844.9	5951456	T23	1656.0
T20	434059.4	5955430	T24	1656.0

T21	434274	5959405	T25	1656.0
T22	434473.3	5946056	T18	1656.0
T23	434687.8	5950030	T19	1656.0
T24	434902.4	5954005	T20	1656.0
T25	435117	5957980	T21	1656.0
T26	435316.2	5944630	T31	1656.0
T27	435331.6	5961955	T32	1656.0
T28	435530.8	5948605	T33	1656.0
T29	435745.4	5952580	T24	1656.0
T30	435960	5956554	T25	1656.0
T31	436159.2	5943205	T26	1656.0
T32	436174.5	5960529	T27	1656.0
T33	436373.8	5947180	T37	1656.0
T34	436588.4	5951154	T38	1656.0
T35	436802.9	5955129	T30	1656.0
T36	437017.5	5959104	T40	1656.0
T37	437216.8	5945754	T41	1656.0
T38	437431.3	5949729	T34	1656.0
T39	437645.9	5953704	T44	1656.0
T40	437860.5	5957678	T36	1656.0
T41	438059.7	5944329	T46	1656.0
T42	438075.1	5961653	T47	1656.0
T43	438274.3	5948304	T48	1656.0
T44	438488.9	5952278	T49	1656.0
T45	438703.5	5956253	T50	1656.0
T46	438902.7	5942903	T41	1656.0
T47	438918	5960228	T42	1656.0
T48	439117.3	5946878	T43	1656.0
T49	439331.9	5950853	T44	1656.0
T50	439546.4	5954828	T45	1656.0
T51	439761	5958802	T47	1656.0
T52	439960.3	5945453	T48	1656.0
T53	440174.8	5949427	T57	1656.0
T54	440389.4	5953402	T50	1656.0
T55	440604	5957377	T51	1656.0
T56	440803.2	5944027	T52	1656.0
T57	441017.8	5948002	T60	1656.0
T58	441232.4	5951977	T61	1656.0
T59	441446.9	5955952	T62	1656.0
T60	441860.8	5946577	T57	1656.0
T61	442075.3	5950551	T63	1656.0
T62	442289.9	5954526	T64	1656.0

T63	442918.3	5949126	T61	1656.0
T64	443132.9	5953101	T62	1656.0
T65	443975.9	5951675	T67	1656.0
T66	444190.4	5955650	T68	1656.0
T67	444818.8	5950250	T65	1656.0
T68	445033.4	5954225	T66	1656.0

Table A-18 Turbine coordinates (EPSG 25830) of future site Morecambe for 22.6 MW turbine

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T01	455945	5959428	T02	1656
T02	457264	5958427	T01	1656
T03	457279.9	5961187	T05	1656
T04	458583.1	5957426	T02	1656
T05	458599	5960185	T03	1656
T06	458614.9	5962945	T08	1656
T07	459918	5959184	T10	1656
T08	459933.9	5961944	T11	1656
T09	459949.9	5964704	T12	1656
T10	461237.1	5958183	T07	1656
T11	461253	5960943	T08	1656
T12	461268.9	5963703	T09	1656
T13	462556.2	5957182	T10	1656
T14	462572.1	5959942	T16	1656
T15	462588	5962702	T17	1656
T16	463891.1	5958941	T14	1656
T17	463907	5961701	T15	1656
T18	465210.2	5957939	T16	1656
T19	465226.1	5960699	T17	1656
T20	465242	5963459	T22	1656
T21	466529.2	5956938	T18	1656
T22	466561	5962458	T20	1656

Table A-19 Turbine coordinates (EPSG 25830) of future site Morgan for 22.6 MW turbine

Turbine name	Easting [m]	Northing [m]	Closest turbine	Distance to closest turbine [m]
T01	421829.5	5986055	T02	1656.0
T02	423148.5	5985054	T01	1656.0
T03	424467.6	5984052	T05	1656.0
T04	424483.5	5986812	T06	1656.0
T05	425786.6	5983051	T03	1656.0
T06	425802.5	5985811	T09	1656.0
T07	425818.4	5988571	T10	1656.0
T08	427105.7	5982050	T12	1656.0

T09	427121.6	5984810	T13	1656.0
T10	427137.5	5987570	T07	1656.0
T11	427153.4	5990330	T15	1656.0
T12	428424.7	5981049	T08	1656.0
T13	428440.7	5983809	T09	1656.0
T14	428456.6	5986569	T19	1656.0
T15	428472.5	5989329	T11	1656.0
T16	428488.4	5992089	T21	1656.0
T17	429743.8	5980048	T22	1656.0
T18	429759.7	5982807	T23	1656.0
T19	429775.6	5985567	T24	1656.0
T20	429791.5	5988327	T25	1656.0
T21	429807.4	5991087	T26	1656.0
T22	431062.9	5979046	T17	1656.0
T23	431078.8	5981806	T18	1656.0
T24	431094.7	5984566	T19	1656.0
T25	431110.6	5987326	T20	1656.0
T26	431126.5	5990086	T21	1656.0
T27	432381.9	5978045	T22	1656.0
T28	432397.8	5980805	T33	1656.0
T29	432413.7	5983565	T34	1656.0
T30	432429.6	5986325	T35	1656.0
T31	432445.5	5989085	T36	1656.0
T32	433701.0	5977044	T37	1656.0
T33	433716.9	5979804	T28	1656.0
T34	433732.8	5982564	T29	1656.0
T35	433748.7	5985324	T30	1656.0
T36	433764.6	5988084	T31	1656.0
T37	435020.0	5976043	T32	1656.0
T38	435035.9	5978803	T33	1656.0
T39	435051.8	5981563	T44	1656.0
T40	435067.7	5984323	T45	1656.0
T41	435083.6	5987082	T46	1656.0
T42	436339.1	5975041	T37	1656.0
T43	436355.0	5977801	T47	1656.0
T44	436370.9	5980561	T39	1656.0
T45	436386.8	5983321	T49	1656.0
T46	436402.7	5986081	T41	1656.0
T47	437674.0	5976800	T43	1656.0
T48	437689.9	5979560	T52	1656.0
T49	437705.8	5982320	T45	1656.0
T50	437721.7	5985080	T46	1656.0

T51	438993.1	5975799	T47	1656.0
T52	439009.0	5978559	T55	1656.0
T53	439024.9	5981319	T49	1656.0
T54	439040.8	5984079	T57	1656.0
T55	440328.0	5977558	T52	1656.0
T56	440343.9	5980318	T59	1656.0
T57	440359.8	5983078	T54	1656.0
T58	441647.1	5976556	T55	1656.0
T59	441663.0	5979316	T61	1656.0
T60	441678.9	5982076	T62	1656.0
T61	442982.0	5978315	T59	1656.0
T62	442997.9	5981075	T60	1656.0
T63	444301.1	5977314	T61	1656.0
T64	444317.0	5980074	T65	1656.0
T65	445636.1	5979073	T64	1656.0
T66	445652.0	5981833	T68	1656.0
T67	446955.1	5978072	T65	1656.0
T68	446971.0	5980831	T66	1656.0

APPENDIX B: WIND TURBINE INFORMATION

Table B-1 Turbine data for the Siemens Gamesa SWT-3.6-107 at Burbo Bank

Manufacturer	Siemens Gamesa
Turbine	SWT-3.6-107
Power Control	Pitch
Rated power	3,600 kW
Diameter	107 m
Hub height	83.4 mMSL
Rotor speed	8.0 – 17.5 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	25.0 m/s
Restart ten-minute mean wind speed	20.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-

Source: [2]

Table B-2 Turbine data for the Vestas V164-8.0 MW at Burbo Bank Extension

Manufacturer	Vestas
Turbine	V164 – 8.0 MW
Power Control	Pitch
Rated power	8,300 kW
Diameter	164 m
Hub height	108 mMSL
Rotor speed	4.0 – 11.5 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	31.0 m/s
Restart ten-minute mean wind speed	26.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-

Source: [2]

Table B-3 Turbine data for the Vestas V90-3.0MW at Barrow

Manufacturer	Vestas
Turbine	V90 – 3.0 MW
Power Control	Pitch
Rated power	3,000 kW
Diameter	90 m
Hub height	75 mMSL
Rotor speed	8.0 – 21.0 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	25.0 m/s
Restart ten-minute mean wind speed	20.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-

Source: [2]

Table B-4 Turbine data for the Siemens Gamesa SWT-3.6-120 at West of Duddon Sands

Manufacturer	Siemens Gamesa
Turbine	SWT-3.6-120
Power Control	Pitch
Rated power	3,600 kW
Diameter	120 m
Hub height	85.77 mMSL
Rotor speed	4.0 – 11.5 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	25.0 m/s
Restart ten-minute mean wind speed	20.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-

Source: [2]

Table B-5 Turbine data for the Siemens Gamesa SWT-3.6-107 at Walney 1

Manufacturer	Siemens Gamesa
Turbine	SWT-3.6-107
Power Control	Pitch
Rated power	3,600 kW
Diameter	107 m
Hub height	78.4 mMSL
Rotor speed	8.0 – 17.5 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	32.0 m/s
Restart ten-minute mean wind speed	27.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-

Source: [2]

Table B-6 Turbine data for the Siemens Gamesa SWT-3.6-120 at Walney 2

Manufacturer	Siemens Gamesa
Turbine	SWT-3.6-120
Power Control	Pitch
Rated power	3,600 kW
Diameter	107 m
Hub height	84.9 mMSL
Rotor speed	6.0 – 11.5 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	32.0 m/s
Restart ten-minute mean wind speed	27.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-

Source: [2]

Table B-7 Turbine data for the MHI Vestas V164-8.25MW at Walney Extension 3

Manufacturer	MHI Vestas
Turbine	V164-8.25MW
Power Control	Pitch
Rated power	8,300 kW
Diameter	164 m
Hub height	112.3 mMSL
Rotor speed	4.0 – 11.5 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	31.0 m/s
Restart ten-minute mean wind speed	26.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-

Source: [2]

Table B-8 Turbine data for the Siemens Gamesa SG-7.0-154 at Walney Extension 4

Manufacturer	Siemens Gamesa
Turbine	SG 7.0-154
Power Control	Pitch
Rated power	7,000 kW
Diameter	154 m
Hub height	106.7 mMSL
Rotor speed	5.0 – 12.0 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	31.0 m/s
Restart ten-minute mean wind speed	26.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-

Source: [2]

Table B-9 Turbine data for the Senvion / Repower 5M at Ormonde

Manufacturer	Senvion / Repower
Turbine	5M
Power Control	Pitch
Rated power	5,000 kW
Diameter	126 m
Hub height	90 mMSL
Rotor speed	6.0 – 15.0 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	30.0 m/s
Restart ten-minute mean wind speed	25.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-

Source: [2]

Table B-10 Turbine data for the Vestas V90-2.0MW at North Hoyle

Manufacturer	Vestas
Turbine	V80 – 2.0 MW
Power Control	Pitch
Rated power	2,000 kW
Diameter	80 m
Hub height	67 mMSL
Rotor speed	8.0 – 24.0 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	25.0 m/s
Restart ten-minute mean wind speed	20.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-

Source: [2]

Table B-11 Turbine data for the Siemens Gamesa SWT-3.6-107 at Gwynt y Môr

Manufacturer	Siemens Gamesa
Turbine	SWT-3.6-107
Power Control	Pitch
Rated power	3,780 kW
Diameter	107 m
Hub height	84.4 mMSL
Rotor speed	8.0 – 17.5 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	32.0 m/s
Restart ten-minute mean wind speed	27.0 m/s (assumed)

* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-

Source: [2]

Table B-12 Turbine data for the Siemens Gamesa SWT-3.6-107 at Rhyl Flats

Manufacturer	Siemens Gamesa
Turbine	SWT-3.6-107
Power Control	Pitch
Rated power	3,780 kW
Diameter	107 m
Hub height	80.0 mMSL
Rotor speed	8.0 – 17.5 rpm (assumed)
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	*
Cut out ten-minute mean wind speed	32.0 m/s
Restart ten-minute mean wind speed	27.0 m/s (assumed)

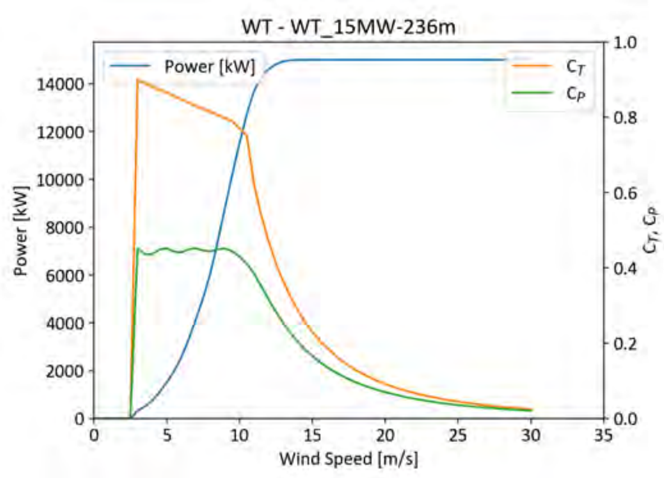
* It should be noted that the characteristics and performance data of the neighbouring operational wind farms are redacted for confidentiality reasons.

Wind Speed (m/s)	Power (kW) *	Thrust Coefficient (C_T) *
0	-	-
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-

Source: [2]

Table B-13 Turbine data for the conceptual WT 15MW-236m

Manufacturer	N/A
Turbine	N/A
Power Control	Pitch
Rated power	15,000kW
Diameter	236 m
Hub height	150.0 mMSL
Rotor speed	5.0 – 8.5 rpm
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	0.45
Cut out ten-minute mean wind speed	30.0 m/s
Restart ten-minute mean wind speed	25.0 m/s

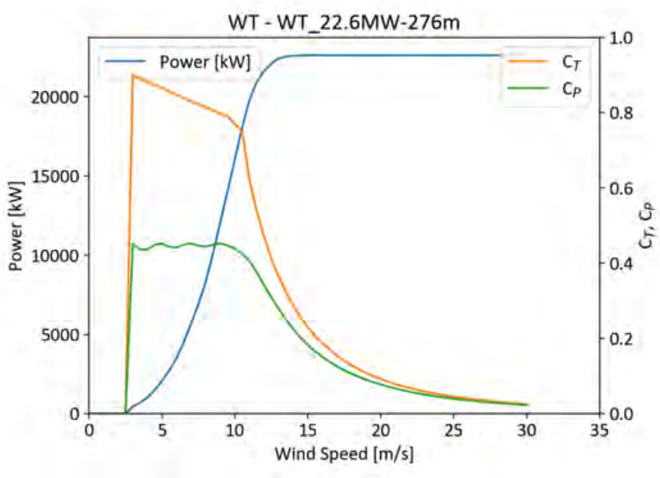


Wind Speed (m/s)	Power (kW)	Thrust Coefficient (C_T)
0	0	0
1	0	0
2	0	0
3	327	0.9
4	747	0.882
5	1514	0.865
6	2552	0.847
7	4154	0.83
8	6087	0.814
9	8818	0.798
10	11522	0.77
11	13710	0.62
12	14613	0.47
13	14934	0.364
14	14995	0.287
15	15000	0.23
16	15000	0.187
17	15000	0.154
18	15000	0.128
19	15000	0.108
20	15000	0.092
21	15000	0.078
22	15000	0.068
23	15000	0.059
24	15000	0.051
25	15000	0.045
26	15000	0.04
27	15000	0.035
28	15000	0.031
29	15000	0.028
30	15000	0.025

Source: -

Table B-13 Turbine data for the conceptual WT 22.6MW-276m

Manufacturer	N/A
Turbine	N/A
Power Control	Pitch
Rated power	22,600kW
Diameter	276 m
Hub height	170.0 mMSL
Rotor speed	3.0 – 6.5 rpm
Air Density	1.225 kg/m3
Turbulence intensity	Unknown
Peak C_p	0.45
Cut out ten-minute mean wind speed	30.0 m/s
Restart ten-minute mean wind speed	25.0 m/s



Wind Speed (m/s)	Power (kW)	Thrust Coefficient (C_T)
0	0	0
1	0	0
2	0	0
3	447	0.9
4	1022	0.882
5	2071	0.865
6	3491	0.847
7	5682	0.83
8	8326	0.814
9	12076	0.798
10	16051	0.77
11	19784	0.62
12	21623	0.47
13	22388	0.364
14	22568	0.287
15	22600	0.23
16	22600	0.187
17	22600	0.154
18	22600	0.128
19	22600	0.108
20	22600	0.092
21	22600	0.078
22	22600	0.068
23	22600	0.059
24	22600	0.051
25	22600	0.045
26	22600	0.04
27	22600	0.035
28	22600	0.031
29	22600	0.028
30	22600	0.025

Source: -

APPENDIX C: WIND DATA

C-1. WOW Extension FL

C-2. Shell Flats MM

C-3 Burbo Bank FL

C-1 WOW Extension FL

Table C-1 WOW Extension FL configuration.

Site name	Walney	Elevation (mMSL)	Eastings (m)	Northings (m)	Coordinate system	Datum	Zone
Device name	WOW Extension FL	0	439912.5	5999065.2	UTM	WGS 84	30N
Installation date	April 2014						

Table C-2 WOW Extension FL long-term wind climate data summary at 112 m.

Month	Monthly average mean wind speed (m/s)																								
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	12.5	11.6	10.3	13.3	12.5	12.2	15.1	9.8	14.9	13.6	11.5	9.9	9.5	12.7	11.7	12.8	14.3	12.7	10.5	12.9	9.8	12.3	9.8	10.5	11.9
Feb	12.6	14.1	9.9	14.8	11.8	10.8	10.9	9.6	10.0	12.1	9.1	7.1	12.2	10.9	10.3	15.0	10.5	11.7	12.3	11.0	11.7	16.0	12.9	14.7	10.9
Mar	10.8	9.8	9.9	10.9	9.9	11.3	10.6	10.7	11.6	12.5	11.0	9.2	7.2	9.0	10.1	11.1	11.3	8.7	10.3	10.7	11.8	11.0	11.1	9.7	10.6
Apr	9.9	8.4	9.3	9.4	9.7	9.9	10.8	9.6	8.3	9.0	8.5	7.7	9.2	9.2	11.2	9.0	8.2	8.9	8.6	9.3	9.9	8.4	6.9	8.4	8.3
May	9.4	7.2	7.4	10.6	10.5	6.8	9.6	9.4	8.6	8.6	10.8	7.0	12.4	7.5	10.7	8.2	10.4	9.1	8.4	7.2	7.6	9.0	8.3	9.6	7.7
Jun	7.3	8.5	8.6	10.4	8.4	9.6	8.2	7.1	7.7	9.0	7.2	6.8	8.1	8.9	7.9	7.4	8.9	6.5	10.5	6.9	9.0	9.0	8.0	8.1	7.7
Jul	-	6.6	7.9	7.4	9.2	7.6	7.9	7.5	8.5	9.6	9.3	9.6	6.8	7.9	6.2	7.1	9.7	8.8	8.2	6.4	8.8	8.9	5.4	8.1	
Aug	-	6.8	7.3	7.1	7.0	8.1	8.6	8.7	8.9	9.2	10.8	8.3	7.6	8.6	8.5	10.1	8.8	9.4	9.1	8.5	10.0	8.5	6.8	6.7	
Sep	-	9.0	10.2	6.2	7.2	11.6	10.3	9.8	9.8	9.0	8.9	10.2	11.7	10.7	9.8	6.6	8.4	10.3	9.7	10.7	9.4	9.4	7.1	9.5	
Oct	-	11.6	12.6	10.2	10.3	10.5	11.3	10.9	8.3	12.7	10.0	10.6	12.3	8.8	12.2	12.1	8.1	8.6	12.2	10.4	10.2	11.0	11.2	12.2	
Nov	-	12.1	10.0	11.6	11.7	10.1	10.6	13.0	10.9	11.2	13.4	11.1	12.9	10.6	10.0	10.5	13.5	9.2	10.5	12.7	10.5	11.9	10.6	12.3	
Dec	-	12.1	10.4	10.9	10.6	11.6	10.0	12.6	12.7	9.8	9.9	7.6	14.8	12.1	15.0	12.6	15.8	11.2	11.1	11.5	12.1	11.0	11.4	10.0	
MoMM	-	9.8	9.5	10.2	9.9	10.0	10.3	9.9	10.0	10.5	10.1	8.8	10.4	9.7	10.3	10.2	10.7	9.6	10.1	9.8	10.1	10.5	9.1	9.9	

C-2 Shell Flats MM

Table C-3 Shell Flats MM configuration.

Site name	Walney	Elevation (mMSL)	Eastings (m)	Northings (m)	Coordinate system	Datum	Zone
Device name	Shell Flats MM	0	481584.6	5967981.7	UTM	WGS 84	30N
Installation date	June 2013 *						

*Originally installed in 2005. Data from June 2013 onwards was utilized by the Client

Table C-4 Shell Flats MM long-term wind climate data summary at 112 m.

Month	Monthly average mean wind speed (m/s)																								
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	11.6	10.8	9.4	11.9	12.0	11.9	14.7	8.9	14.9	13.3	10.2	9.3	8.5	12.7	10.3	11.6	13.5	12.0	9.7	12.7	9.9	11.0	9.9	10.1	11.7
Feb	12.7	13.6	8.7	14.8	10.2	10.1	10.4	9.3	9.1	11.3	9.1	7.3	11.2	9.9	9.7	13.7	9.6	11.5	11.3	10.1	9.9	15.8	10.6	14.9	10.2
Mar	9.9	10.1	8.8	10.2	9.0	9.9	9.6	10.5	10.7	12.5	10.6	8.3	6.5	7.9	9.1	9.8	10.8	8.3	9.8	9.8	11.1	10.4	10.3	8.7	9.6
Apr	9.1	7.7	9.1	8.7	8.7	8.6	9.4	9.4	7.3	8.6	7.4	6.8	7.9	9.0	10.1	8.2	7.4	8.6	8.4	8.2	8.4	7.6	6.4	8.2	7.7
May	8.5	7.1	6.8	9.7	9.6	6.3	8.6	8.4	8.7	7.8	9.6	6.2	11.4	7.4	9.6	7.6	9.9	7.8	7.5	6.1	7.3	8.1	7.9	8.2	6.6
Jun	7.3	7.4	7.9	9.0	7.4	9.2	7.3	6.4	7.6	8.4	6.7	5.6	7.7	8.6	7.8	6.0	7.9	6.0	8.9	6.5	7.8	8.2	6.0	7.0	6.6
Jul	-	6.5	7.4	6.4	7.6	7.3	7.1	6.2	8.4	9.2	8.4	8.3	6.6	7.4	5.5	6.6	8.6	7.8	7.6	5.3	7.3	8.5	5.5	7.1	
Aug	-	6.5	6.6	6.3	6.4	7.4	8.0	8.7	8.1	8.3	8.8	8.2	7.3	7.4	7.6	9.7	7.3	8.8	7.7	7.4	9.0	8.2	6.8	6.2	
Sep	-	7.9	9.9	6.0	6.0	10.9	8.5	8.5	9.2	8.1	8.5	9.5	10.3	9.7	8.6	5.6	7.3	8.6	8.8	9.2	8.8	8.3	6.6	8.3	
Oct	-	11.0	11.1	9.7	10.0	9.9	9.6	10.0	7.1	11.6	9.2	9.3	11.5	8.7	11.2	10.5	7.4	7.6	11.5	9.3	9.1	10.3	9.8	10.4	
Nov	-	11.8	10.0	10.3	10.4	9.9	10.0	11.7	10.5	11.1	12.4	10.3	11.0	9.3	9.5	9.1	13.4	9.1	10.3	10.8	9.5	10.9	10.2	10.5	
Dec	-	11.2	10.3	10.1	9.8	11.0	9.5	11.7	11.9	8.9	9.4	7.4	14.9	11.4	13.1	12.7	13.8	10.0	10.8	10.7	11.2	9.9	10.6	9.0	
MoMM	-	9.3	8.8	9.4	8.9	9.4	9.4	9.1	9.5	9.9	9.2	8.0	9.6	9.1	9.4	9.2	9.8	8.8	9.3	8.8	9.1	9.7	8.4	9.0	

C-3 Burbo Bank FL

Table C-4 Burbo Bank FL configuration.

Site name	Walney	Elevation (mMSL)	Eastings (m)	Northings (m)	Coordinate system	Datum	Zone
Device name	Burbo Bank FL	0	476240.5	5926650.7	UTM	WGS 84	30N
Installation date	June 2013						

Table C-5 Burbo Bank FL long-term wind climate data summary at 112 m.

Month	Monthly average mean wind speed (m/s)																					
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	12.4	12.2	12.1	14.8	9.1	14.9	13.5	10.8	9.2	8.9	12.6	10.7	12.3	13.9	12.3	9.9	12.5	9.7	11.6	9.6	10.4	11.8
Feb	14.9	10.3	10.3	10.5	9.4	9.2	11.5	8.9	6.7	11.3	10.3	9.4	14.4	9.8	11.3	11.6	10.2	10.5	15.8	11.4	14.9	10.6
Mar	10.3	9.0	10.2	9.6	10.4	11.2	12.5	10.7	8.4	6.8	8.0	9.1	10.2	11.0	8.3	9.9	10.0	11.4	10.3	10.3	8.7	9.8
Apr	8.9	8.8	8.9	9.9	9.5	7.6	8.6	7.8	7.1	8.3	8.9	10.4	8.5	7.7	8.4	8.5	8.5	8.4	7.7	6.3	8.0	7.8
May	10.1	9.9	6.2	9.0	8.7	8.7	7.9	10.1	6.4	11.9	7.5	10.1	7.8	10.1	8.2	7.7	6.3	7.1	8.3	7.6	8.8	6.8
Jun	9.4	7.3	9.2	7.4	6.5	7.6	8.7	6.8	5.8	7.9	8.6	7.7	6.0	8.2	6.0	9.4	6.7	7.9	8.5	6.3	7.5	6.8
Jul	6.7	8.2	7.4	7.7	6.4	8.7	9.3	8.9	8.8	6.5	7.5	5.7	6.7	8.9	8.3	7.9	5.7	7.4	8.9	5.4	7.4	
Aug	6.5	6.3	7.4	8.2	8.6	8.3	8.9	9.6	8.2	7.4	7.8	8.2	9.8	8.1	9.0	8.5	8.0	9.6	8.3	6.9	6.4	
Sep	6.0	6.5	11.1	9.3	9.0	9.5	8.3	9.1	9.7	11.1	10.4	8.8	5.7	7.2	9.6	9.2	10.2	9.1	8.9	6.9	8.3	
Oct	9.7	9.8	10.2	10.2	10.3	7.5	12.1	9.5	9.8	12.0	8.8	11.6	11.5	7.5	7.9	12.1	9.9	9.5	10.8	11.1	11.2	
Nov	10.8	11.1	10.0	10.3	12.9	10.8	11.3	12.9	10.8	11.5	10.0	9.8	9.5	13.6	8.9	10.4	11.5	9.4	11.3	10.5	11.3	
Dec	10.1	10.0	11.3	9.6	12.3	12.2	9.1	9.6	7.5	14.9	11.5	14.2	12.4	14.9	10.6	10.9	11.1	11.6	10.2	10.8	9.5	
MoMM	9.6	9.1	9.5	9.7	9.4	9.7	10.1	9.6	8.2	9.9	9.3	9.6	9.6	10.1	9.1	9.6	9.2	9.3	10.0	8.6	9.3	

APPENDIX D: ANALYSIS RESULTS

D-1. Correlations across the wind climate files

D-2. Site long term wind regime

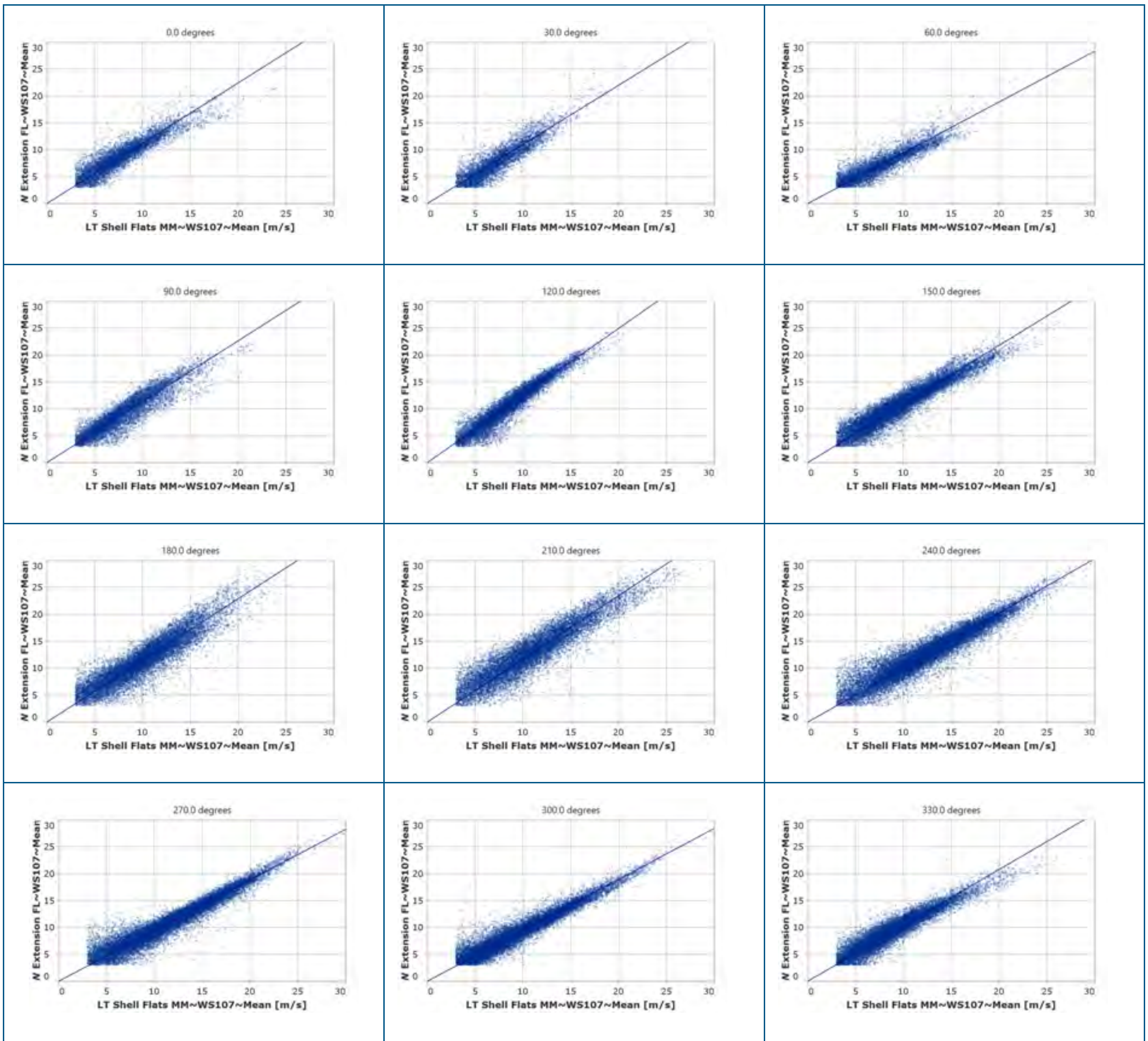
D-3 Long term frequency distribution comparisons

D-4. Plot of turbine predictions of each wind climate file

D-5. Turbine level wake results

D-1 Correlations across the wind climate files

Table D-1 Correlations between Shell Flats MM and WOW Extension FL



Directional correlation ratios		
Bin centres (degrees)	**Wind speed ratio**	**Number of records**
0.0	1.120	7809
30.0	1.098	6252
60.0	0.943	7039
90.0	1.131	8996
120.0	1.246	11556
150.0	1.089	16841
180.0	1.143	15202
210.0	1.172	15047
240.0	1.009	24073
270.0	0.941	23130
300.0	0.946	18950
330.0	1.037	15204
All directional	1.052	170099

Correlation of wind directions

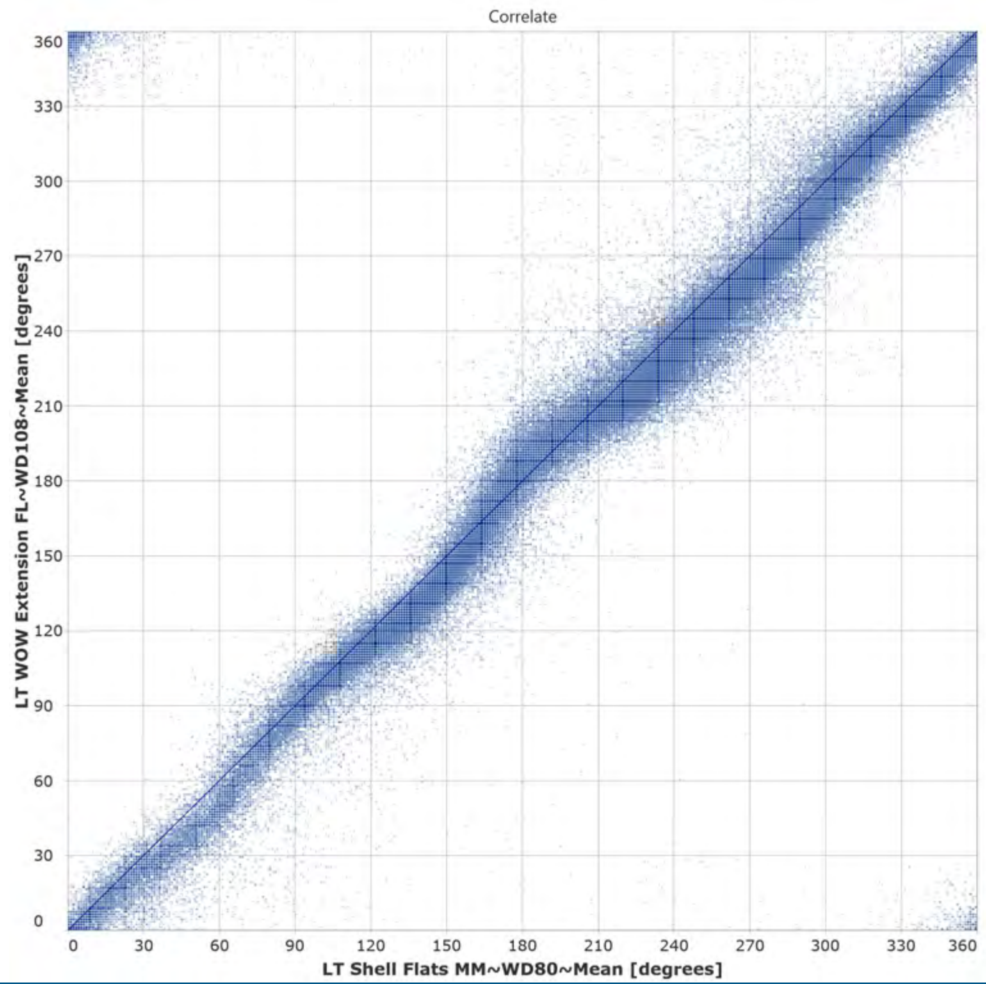
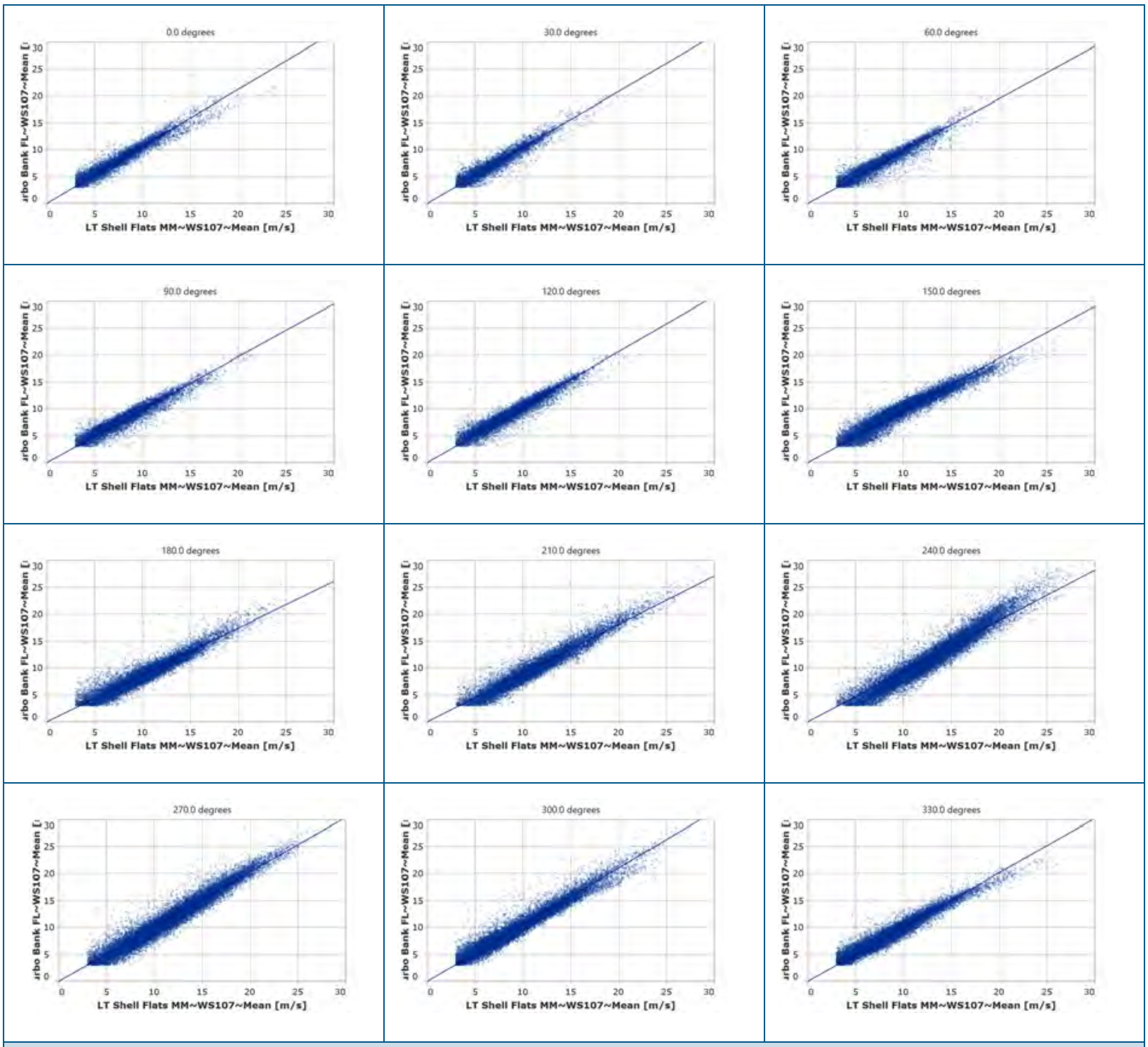
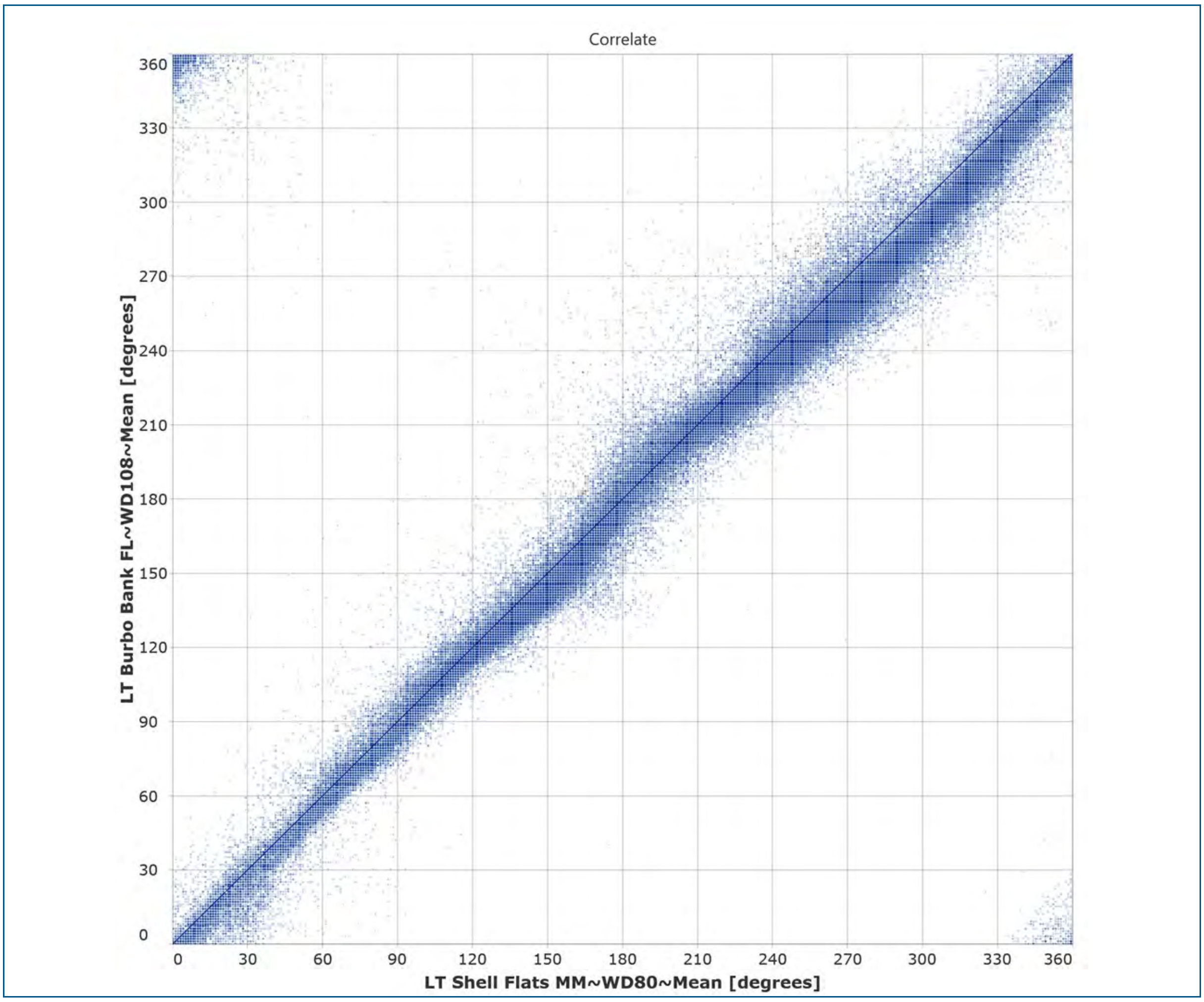


Table D-2 Correlations between Shell Flats MM and Burbo Bank FL



Directional correlation ratios		
Bin centres (degrees)	**Wind speed ratio**	**Number of records**
0.0	1.060	8151
30.0	1.042	6580
60.0	0.973	6957
90.0	0.983	8874
120.0	1.031	11438
150.0	0.968	16684
180.0	0.871	14654
210.0	0.904	14311
240.0	0.941	23413
270.0	1.013	22983
300.0	1.051	19270
330.0	1.006	15741
All directional	0.976	169056

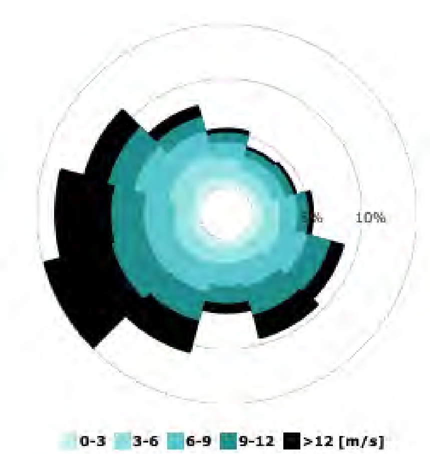
Correlation of wind directions

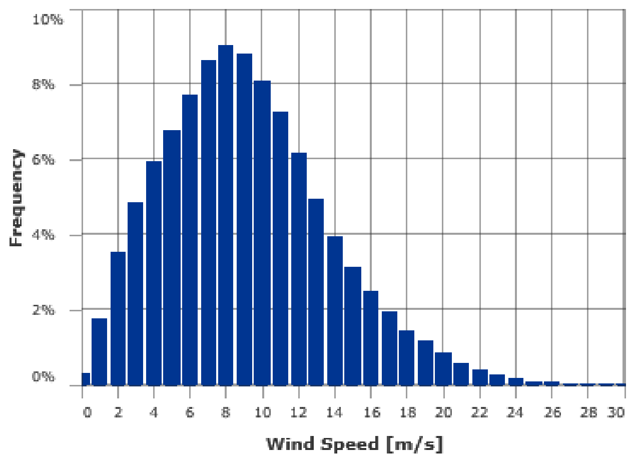

Correlate
LT Burbo Bank FL~WD108~Mean [degrees]
LT Shell Flats MM~WD80~Mean [degrees]
0
30
60
90
120
150
180
210
240
270
300
330
360

D-2 Site long-term wind regimes at 100 m height

Table D-3 Long-term wind regime for Burbo Bank FL at 100 m

Monthly mean wind speeds			
Month	Wind speed [m/s]	Valid wind speed data [years]	Valid direction data [years]
January	11.2	25.0	25.0
February	10.9	25.0	25.0
March	9.6	25.0	25.0
April	8.2	25.0	25.0
May	8.0	25.0	25.0
June	7.3	24.3	24.3
July	7.2	23.0	23.0
August	7.6	23.0	23.0
September	8.3	23.0	23.0
October	9.7	23.0	23.0
November	10.4	23.0	23.0
December	10.7	23.0	23.0
Annual	9.1		



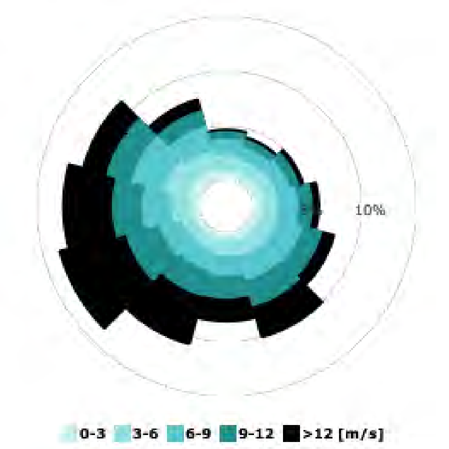


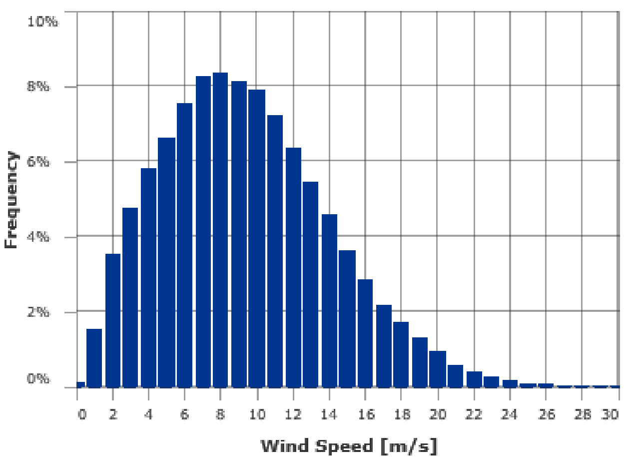
Wind Speed [m/s]	0	30	60	90	120	150	180	210	240	270	300	330	No Direction	Total [%]
0	0.01	0.01	0.01	0.03	0.02	0.01	0.02	0.04	0.06	0.02	0.03	0.03		0.28
1	0.10	0.09	0.11	0.18	0.14	0.12	0.15	0.20	0.20	0.12	0.15	0.15		1.73
2	0.32	0.26	0.26	0.32	0.32	0.22	0.27	0.33	0.33	0.25	0.29	0.37		3.54
3	0.50	0.35	0.35	0.42	0.43	0.33	0.33	0.37	0.42	0.31	0.46	0.56		4.82
4	0.62	0.41	0.35	0.48	0.52	0.41	0.40	0.48	0.44	0.47	0.64	0.74		5.95
5	0.58	0.41	0.36	0.52	0.60	0.52	0.47	0.53	0.53	0.57	0.85	0.81		6.75
6	0.55	0.42	0.42	0.57	0.77	0.59	0.58	0.60	0.67	0.73	0.98	0.81	+	7.69
7	0.51	0.41	0.49	0.57	0.89	0.73	0.65	0.77	0.80	0.93	1.11	0.74	+	8.61
8	0.51	0.36	0.44	0.54	0.87	0.84	0.70	0.95	0.96	1.04	1.13	0.68	+	9.03
9	0.42	0.30	0.37	0.43	0.93	0.94	0.68	1.01	1.05	1.07	1.01	0.60		8.80
10	0.34	0.25	0.28	0.39	0.80	0.96	0.59	0.96	1.14	0.98	0.89	0.49	+	8.06
11	0.24	0.22	0.23	0.30	0.67	0.88	0.53	0.89	1.10	1.00	0.75	0.43		7.23
12	0.22	0.14	0.18	0.22	0.51	0.78	0.39	0.73	1.07	0.92	0.64	0.34		6.15
13	0.13	0.10	0.11	0.16	0.38	0.59	0.25	0.57	1.00	0.79	0.56	0.28		4.93
14	0.08	0.05	0.06	0.08	0.25	0.48	0.16	0.50	0.92	0.70	0.45	0.19		3.91
15	0.05	0.03	0.02	0.07	0.19	0.29	0.12	0.39	0.81	0.64	0.34	0.16		3.11
16	0.03	0.02	0.02	0.04	0.13	0.22	0.09	0.33	0.70	0.56	0.22	0.12		2.49
17	0.02	0.02	0.01	0.02	0.05	0.17	0.06	0.26	0.56	0.51	0.16	0.08		1.92
18	0.02	0.01	0.01	0.01	0.02	0.09	0.04	0.20	0.48	0.42	0.12	0.04		1.45
19	0.01	0.01	+	0.01	0.02	0.04	0.02	0.17	0.42	0.38	0.06	0.03		1.16
20	0.01	0.01	+	0.01	0.01	0.01	0.01	0.10	0.34	0.25	0.05	0.02		0.82
21	+	+		+	+	0.01	0.01	0.07	0.26	0.17	0.04	0.01		0.59
22	+	+			+	+	+	0.05	0.18	0.12	0.02	0.01		0.38
23	+					+	+	0.03	0.13	0.09	0.01	+		0.26
24	+							0.02	0.06	0.06	+			0.14
25	+							0.01	0.04	0.03	+	+		0.09
26	+							0.01	0.03	0.01	+			0.05
27	+							+	0.02	0.01	+	+		0.03
28								+	0.01	0.01	+			0.02
29	+							+	+	+				0.01
30									+	+	+	+		0.01
30+														
Total [%]	5.28	3.85	4.09	5.36	8.52	9.23	6.54	10.58	14.75	13.15	10.96	7.70	+	100.00
Mean Speed	6.85	6.84	6.96	7.03	8.22	9.36	8.15	9.80	11.44	11.04	8.79	7.59	7.71	9.11

Note: '+' indicates a non-zero frequency <0.005%. Blank cell indicates zero frequency.

Table D-4 Long-term wind regime for Shell Flats MM at 100 m

Monthly mean wind speeds			
Month	Wind speed [m/s]	Valid wind speed data [years]	Valid direction data [years]
January	11.5	22.0	22.0
February	10.9	22.0	22.0
March	9.7	22.0	22.0
April	8.3	22.0	22.0
May	8.3	22.0	22.0
June	7.5	22.0	22.0
July	7.5	21.0	21.0
August	8.0	21.0	21.0
September	8.7	21.0	21.0
October	10.0	21.0	21.0
November	10.8	21.0	21.0
December	11.0	21.0	21.0
Annual	9.3		



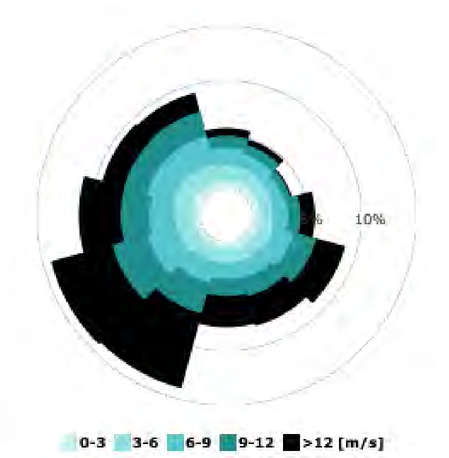


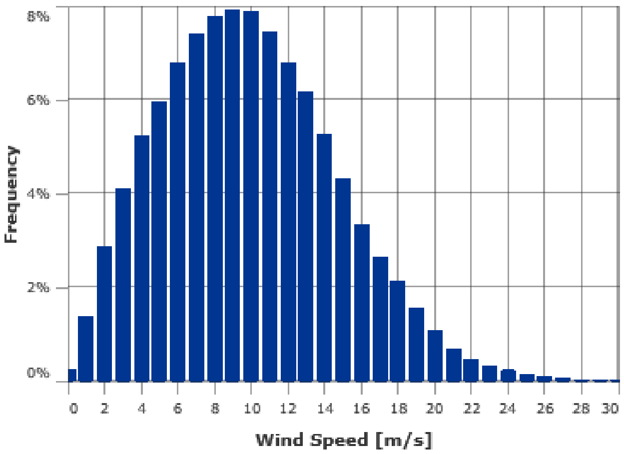
Wind Speed [m/s]	0	30	60	90	120	150	180	210	240	270	300	330	No Direction	Total [%]
0	0.01	0.02	0.01	+	+	0.01	0.01	+	+	0.01	0.01	0.01		0.10
1	0.15	0.14	0.16	0.12	0.10	0.10	0.09	0.10	0.07	0.11	0.18	0.18		1.51
2	0.34	0.24	0.32	0.32	0.26	0.26	0.27	0.24	0.20	0.30	0.42	0.39		3.54
3	0.41	0.33	0.41	0.34	0.38	0.36	0.35	0.31	0.30	0.42	0.64	0.51		4.76
4	0.47	0.40	0.43	0.46	0.45	0.49	0.41	0.35	0.39	0.55	0.80	0.58		5.78
5	0.52	0.47	0.50	0.53	0.59	0.56	0.46	0.43	0.43	0.67	0.83	0.65		6.63
6	0.55	0.46	0.49	0.63	0.75	0.67	0.57	0.49	0.50	0.76	0.96	0.70		7.53
7	0.50	0.46	0.49	0.66	0.82	0.75	0.62	0.55	0.63	0.86	1.06	0.83		8.24
8	0.44	0.39	0.44	0.60	0.82	0.77	0.62	0.61	0.80	0.99	1.06	0.79		8.33
9	0.35	0.29	0.38	0.57	0.80	0.83	0.68	0.75	0.92	0.90	0.95	0.69		8.11
10	0.27	0.29	0.32	0.47	0.72	0.89	0.75	0.82	1.06	0.90	0.83	0.56		7.88
11	0.21	0.21	0.28	0.42	0.56	0.78	0.69	0.85	1.12	0.93	0.73	0.44		7.21
12	0.14	0.15	0.22	0.31	0.43	0.73	0.59	0.82	1.09	0.92	0.61	0.35		6.35
13	0.07	0.10	0.17	0.19	0.35	0.67	0.50	0.79	1.03	0.79	0.53	0.26		5.44
14	0.03	0.05	0.08	0.13	0.25	0.55	0.44	0.70	0.98	0.71	0.44	0.21		4.56
15	0.02	0.03	0.05	0.07	0.19	0.45	0.31	0.58	0.86	0.62	0.31	0.15		3.63
16	0.01	0.02	0.04	0.06	0.12	0.33	0.23	0.47	0.72	0.51	0.23	0.11		2.84
17	0.02	0.01	0.02	0.04	0.05	0.22	0.14	0.43	0.57	0.42	0.14	0.08		2.14
18	0.01	0.01	+	0.02	0.03	0.18	0.11	0.35	0.50	0.31	0.11	0.06		1.70
19	+	0.01		0.01	0.02	0.14	0.07	0.26	0.38	0.27	0.09	0.03		1.28
20	+	+		0.01	0.01	0.06	0.04	0.21	0.30	0.18	0.06	0.03		0.92
21	+	+		0.01	0.01	0.04	0.03	0.13	0.18	0.11	0.04	0.02		0.57
22	+	+		+	+	0.02	0.02	0.10	0.11	0.07	0.02	0.01		0.37
23	+	+			+	0.01	0.01	0.08	0.06	0.06	0.01	0.01		0.24
24	+				+	0.01	+	0.05	0.04	0.03	0.01	0.01		0.15
25	+				+	+	+	0.03	0.03	0.01	+	+		0.08
26	+				+	+		0.02	0.01	+	0.01			0.05
27								0.01	0.01	+	+	+		0.02
28								0.01	+	+		+		0.01
29								+	+	+	+			0.01
30								+	+	+		+		0.01
30+														
Total [%]	4.53	4.06	4.81	5.96	7.70	9.89	8.02	10.56	13.30	12.43	11.09	7.65		100.00
Mean Speed	6.46	6.74	6.98	7.61	8.31	9.80	9.43	11.36	11.78	10.48	8.57	7.87	-	9.34

Note: '+' indicates a non-zero frequency <0.005%. Blank cell indicates zero frequency.

Table D-5 Long-term wind regime for WOW Extension FL at 100 m

Monthly mean wind speeds			
Month	Wind speed [m/s]	Valid wind speed data [years]	Valid direction data [years]
January	11.8	25.0	25.0
February	11.6	25.0	25.0
March	10.3	25.0	25.0
April	8.9	25.0	25.0
May	8.8	25.0	25.0
June	8.2	24.3	24.3
July	7.9	23.0	23.0
August	8.3	23.0	23.0
September	9.3	23.0	23.0
October	10.7	23.0	23.0
November	11.2	23.0	23.0
December	11.5	23.0	23.0
Annual	9.9		

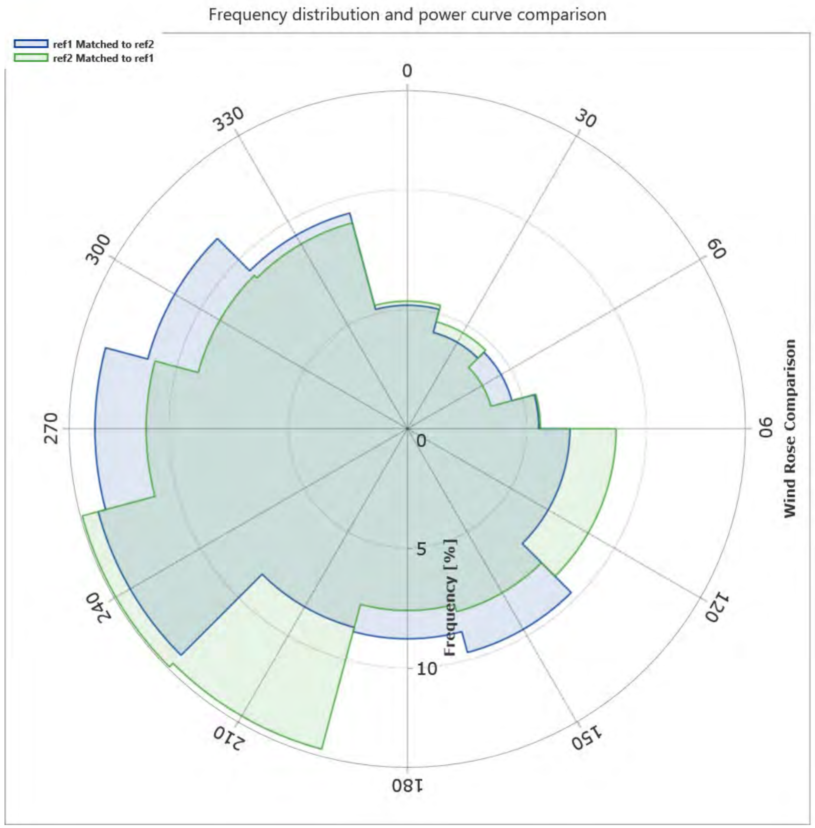




Wind Speed [m/s]	0	30	60	90	120	150	180	210	240	270	300	330	No Direction	Total [%]
0	0.01	0.02	+	0.01	0.03	0.01	0.02	0.01	+	0.02	0.07	0.03		0.23
1	0.10	0.16	0.11	0.10	0.12	0.10	0.11	0.09	0.05	0.11	0.18	0.12		1.36
2	0.22	0.27	0.26	0.20	0.23	0.24	0.22	0.22	0.18	0.25	0.28	0.27		2.85
3	0.37	0.39	0.35	0.30	0.33	0.30	0.31	0.31	0.33	0.34	0.41	0.36		4.08
4	0.46	0.43	0.44	0.37	0.38	0.41	0.37	0.38	0.48	0.50	0.50	0.52		5.22
5	0.53	0.48	0.40	0.41	0.48	0.40	0.47	0.46	0.61	0.52	0.60	0.61		5.96
6	0.57	0.44	0.42	0.45	0.52	0.47	0.45	0.52	0.75	0.64	0.77	0.76	+	6.78
7	0.56	0.44	0.39	0.48	0.59	0.53	0.46	0.60	0.83	0.77	0.85	0.88	+	7.38
8	0.53	0.41	0.31	0.45	0.71	0.54	0.53	0.72	1.01	0.82	0.84	0.91	+	7.78
9	0.48	0.38	0.30	0.44	0.74	0.55	0.54	0.79	1.08	0.85	0.86	0.88		7.90
10	0.41	0.33	0.26	0.42	0.72	0.61	0.51	0.98	1.13	0.88	0.77	0.87		7.89
11	0.32	0.25	0.19	0.35	0.72	0.58	0.52	1.00	1.16	0.95	0.69	0.69		7.43
12	0.25	0.20	0.11	0.35	0.62	0.56	0.52	1.09	1.11	0.80	0.58	0.59		6.78
13	0.19	0.16	0.06	0.30	0.58	0.53	0.49	1.08	0.99	0.79	0.50	0.49		6.15
14	0.14	0.10	0.02	0.24	0.48	0.50	0.46	1.01	0.91	0.68	0.41	0.32		5.26
15	0.08	0.06	0.01	0.21	0.39	0.45	0.38	0.85	0.79	0.56	0.29	0.26		4.32
16	0.06	0.04	+	0.14	0.30	0.34	0.30	0.73	0.67	0.41	0.18	0.16		3.34
17	0.05	0.02	+	0.10	0.23	0.24	0.25	0.64	0.53	0.31	0.13	0.10		2.62
18	0.03	0.02	+	0.07	0.16	0.18	0.19	0.58	0.46	0.24	0.11	0.07		2.12
19	0.02	0.01	+	0.05	0.12	0.13	0.15	0.46	0.34	0.15	0.07	0.03		1.53
20	0.01	0.01	+	0.02	0.08	0.07	0.11	0.34	0.23	0.11	0.05	0.03		1.07
21	0.01	0.01		0.01	0.04	0.04	0.08	0.24	0.13	0.07	0.03	0.02		0.67
22	+	+		+	0.02	0.02	0.05	0.21	0.07	0.05	0.01	0.01		0.45
23	+	+			0.01	0.01	0.04	0.14	0.05	0.03	0.01	+		0.30
24	+	+		+	0.01	+	0.03	0.11	0.03	0.02	+	+		0.22
25	+	+		+	+	+	0.02	0.06	0.02	0.01	+	+		0.12
26					+	+	0.01	0.04	0.02	+	+	+		0.08
27	+				+	+	0.01	0.02	0.01	+	+	+		0.05
28							+	0.02	+	+		+		0.03
29							+	+	+	+				0.01
30							+	+	+					0.01
30+														
Total [%]	5.42	4.66	3.61	5.48	8.60	7.82	7.61	13.73	13.98	10.89	9.19	9.02	+	100.00
Mean Speed	7.69	7.22	6.37	8.78	9.89	10.12	10.43	12.28	11.17	10.29	8.86	8.73	6.86	9.87

Note: '+' indicates a non-zero frequency <0.005%. Blank cell indicates zero frequency.

D-3 Long-term frequency distribution comparisons



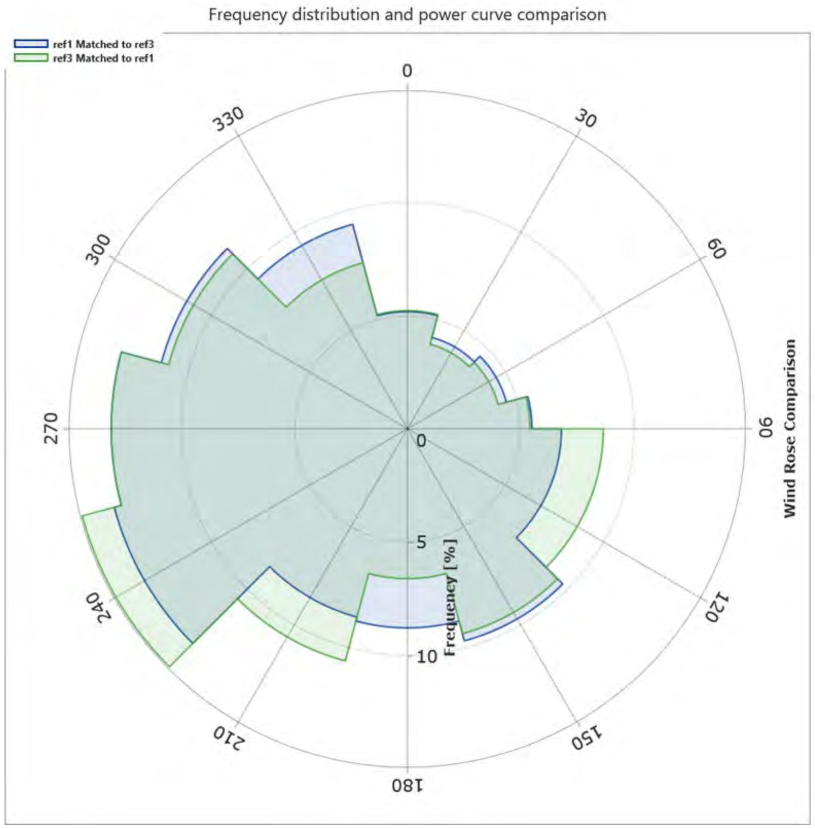


Figure D-1 Comparison of Shell Flats MM and WOW Extension FL (left) and Shell Flats MM and Burbo Bank FL long-term frequency distributions (right)

D-4 Plot of turbine predictions of each wind climate file

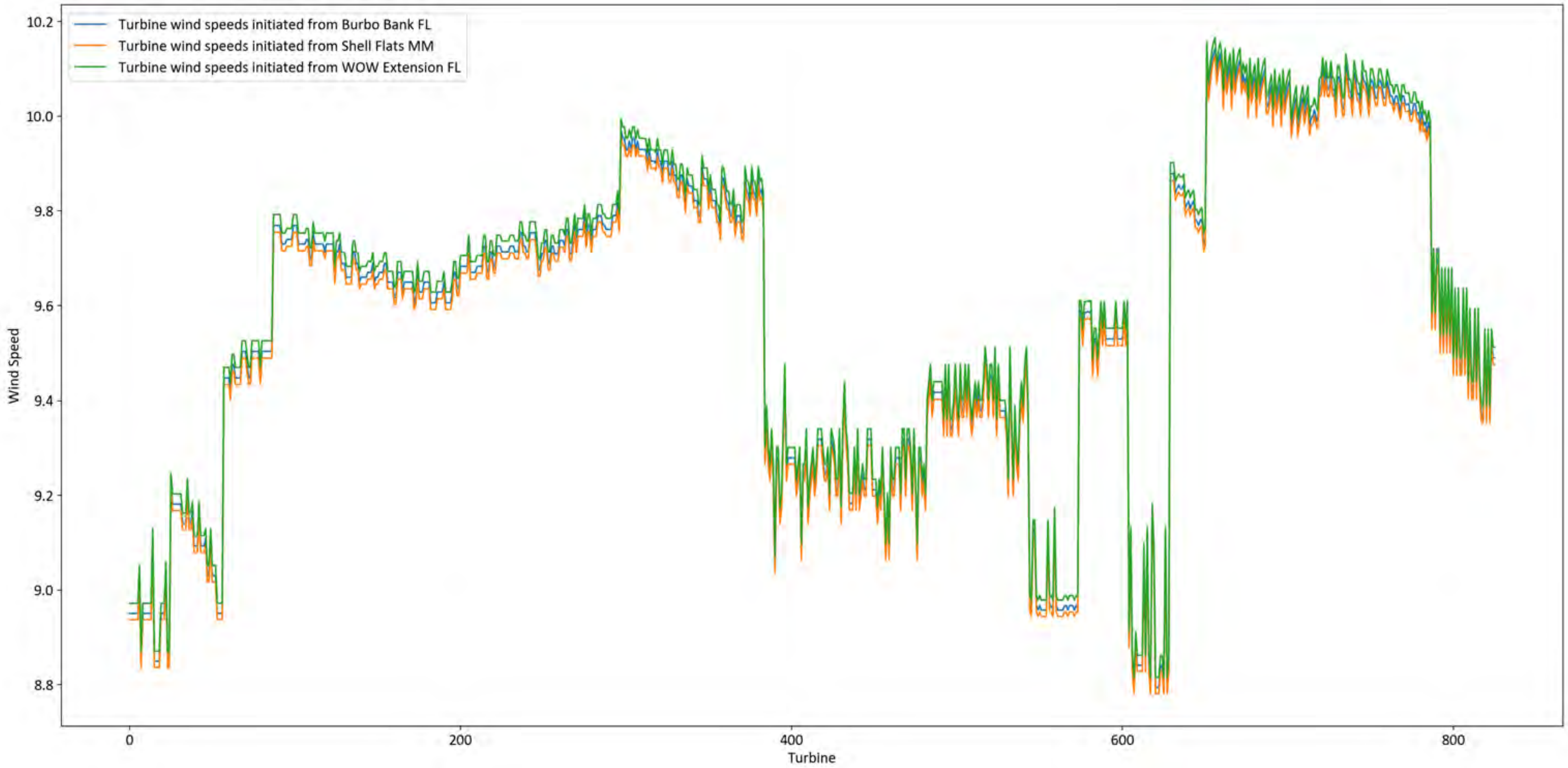


Figure D-2 Prediction of turbine wind speeds from each wind climate file using NEWA

D-5 Turbine level wake results

Table D-6 Turbine level wake results for Burbo Bank

Turbine name	Turbine model	Hub height [m]	Ambient mean wind speed [m/s]	Turbine interaction efficiency for baseline (%)	Compared to baseline for Scn1	Compared to baseline for Scn2	Compared to baseline for Scn3	Compared to baseline for Scn4	Compared to baseline for Scn5	Compared to baseline for Scn1b	Compared to baseline for Scn2b	Compared to baseline for Scn3b
A12	SG-3600-107-01o4	83.4	8.8	85.96%	-0.44%	-0.26%	-0.28%	-0.91%	-1.20%	-0.86%	-0.43%	-0.34%
A13	SG-3600-107-01o4	83.4	8.8	84.74%	-0.96%	-0.28%	-0.51%	-1.72%	-2.30%	-1.19%	-0.48%	-0.45%
A14	SG-3600-107-01o4	83.4	8.8	84.42%	-1.11%	-0.28%	-0.27%	-1.64%	-2.41%	-1.29%	-0.48%	-0.69%
A15	SG-3600-107-01o4	83.4	8.8	84.02%	-1.40%	-0.31%	-0.49%	-2.15%	-2.61%	-0.57%	-0.54%	-0.44%
A16	SG-3600-107-01o4	83.4	8.8	83.83%	-1.24%	-0.30%	-0.59%	-2.12%	-2.58%	-0.97%	-0.40%	-0.35%
A17	SG-3600-107-01o4	83.4	8.8	83.79%	-1.32%	-0.24%	-0.70%	-2.29%	-3.10%	-1.58%	-0.50%	-0.36%
A18	SG-3600-107-01o4	83.4	8.8	84.71%	-1.07%	-0.26%	-0.27%	-1.67%	-2.13%	-1.53%	-0.49%	-0.59%
B22	SG-3600-107-01o4	83.4	8.7	86.12%	-0.63%	-0.29%	-0.30%	-1.14%	-1.91%	-0.45%	-0.28%	-0.37%
B23	SG-3600-107-01o4	83.4	8.8	82.94%	-0.64%	-0.27%	-0.39%	-1.25%	-2.03%	-0.48%	-0.31%	-0.46%
B24	SG-3600-107-01o4	83.4	8.8	82.25%	-1.11%	-0.31%	-0.47%	-1.79%	-2.19%	-0.80%	-0.39%	-0.35%
B25	SG-3600-107-01o4	83.4	8.8	81.45%	-0.88%	-0.31%	-0.27%	-1.44%	-2.12%	-1.28%	-0.41%	-0.50%
B26	SG-3600-107-01o4	83.4	8.8	81.38%	-1.24%	-0.28%	-0.62%	-2.02%	-2.69%	-1.28%	-0.23%	-0.28%
B27	SG-3600-107-01o4	83.4	8.8	82.49%	-1.05%	-0.21%	-0.49%	-1.69%	-2.07%	-1.25%	-0.29%	-0.49%
B28	SG-3600-107-01o4	83.4	8.8	82.19%	-1.42%	-0.21%	-0.61%	-2.17%	-2.73%	-1.28%	-0.35%	-0.50%
B29	SG-3600-107-01o4	83.4	8.9	85.66%	-1.49%	-0.24%	-0.51%	-2.22%	-2.92%	-1.34%	-0.39%	-0.41%
C31	SG-3600-107-01o4	83.4	8.7	89.61%	-0.16%	-0.25%	-0.38%	-0.70%	-1.03%	-0.49%	-0.27%	-0.38%
C32	SG-3600-107-01o4	83.4	8.7	86.14%	-0.38%	-0.26%	-0.31%	-0.85%	-1.21%	-0.92%	-0.33%	-0.41%
C33	SG-3600-107-01o4	83.4	8.7	84.30%	-0.43%	-0.23%	-0.41%	-0.97%	-1.54%	-0.73%	-0.33%	-0.63%
C34	SG-3600-107-01o4	83.4	8.7	84.24%	-0.81%	-0.26%	-0.76%	-1.76%	-2.38%	-0.76%	-0.33%	-0.67%

C35	SG-3600-107-01o4	83.4	8.8	83.93%	-1.05%	-0.24%	-0.56%	-1.84%	-2.54%	-0.91%	-0.31%	-0.34%
C36	SG-3600-107-01o4	83.4	8.8	83.65%	-1.34%	-0.21%	-0.56%	-2.10%	-2.39%	-1.52%	-0.17%	-0.34%
C37	SG-3600-107-01o4	83.4	8.8	83.75%	-1.44%	-0.16%	-0.49%	-2.13%	-2.56%	-2.11%	-0.28%	-0.36%
C38	SG-3600-107-01o4	83.4	8.8	87.12%	-1.65%	-0.25%	-0.50%	-2.46%	-3.04%	-1.72%	-0.34%	-0.51%
D41	SG-3600-107-01o4	83.4	8.7	89.01%	-0.41%	-0.13%	-0.36%	-0.85%	-1.23%	-0.76%	-0.25%	-0.31%
D42	SG-3600-107-01o4	83.4	8.7	86.78%	-0.40%	-0.18%	-0.52%	-1.01%	-1.19%	-0.76%	-0.33%	-0.29%

Table D-7 Turbine level wake results for Burbo Bank Extension

Turbine name	Turbine model	Hub height [m]	Ambient mean wind speed [m/s]	Turbine interaction efficiency for baseline (%)	Compared to baseline for Scn1	Compared to baseline for Scn2	Compared to baseline for Scn3	Compared to baseline for Scn4	Compared to baseline for Scn5	Compared to baseline for Scn1b	Compared to baseline for Scn2b	Compared to baseline for Scn3b
A01	VES-8139-164-02ss	108	9.2	93.13%	-1.82%	-0.32%	-0.27%	-2.42%	-3.12%	-2.00%	-0.48%	-0.28%
A02	VES-8139-164-02ss	108	9.2	91.13%	-1.31%	-0.35%	-0.63%	-2.28%	-2.92%	-1.15%	-0.31%	-0.77%
B01	VES-8139-164-02ss	108	9.2	89.09%	-1.21%	-0.24%	-0.69%	-2.11%	-2.73%	-1.57%	-0.39%	-0.50%
B02	VES-8139-164-02ss	108	9.2	91.20%	-1.74%	-0.30%	-0.56%	-2.51%	-3.09%	-1.14%	-0.48%	-0.37%
C01	VES-8139-164-02ss	108	9.2	90.21%	-1.70%	-0.30%	-0.68%	-2.66%	-3.14%	-1.56%	-0.58%	-0.48%
C02	VES-8139-164-02ss	108	9.2	87.37%	-1.73%	-0.14%	-0.49%	-2.34%	-3.08%	-1.33%	-0.45%	-0.82%
C03	VES-8139-164-02ss	108	9.2	91.25%	-1.56%	-0.26%	-0.40%	-2.21%	-2.87%	-1.33%	-0.53%	-0.57%
C04	VES-8139-164-02ss	108	9.1	91.55%	-1.22%	-0.07%	-0.34%	-1.63%	-2.13%	-1.08%	-0.38%	-0.30%
D01	VES-8139-164-02ss	108	9.1	89.53%	-2.08%	-0.24%	-0.48%	-2.84%	-3.41%	-1.74%	-0.48%	-0.59%
D04	VES-8139-164-02ss	108	9.1	91.88%	-1.71%	-0.15%	-0.31%	-2.18%	-2.85%	-1.22%	-0.30%	-0.41%
E01	VES-8139-164-02ss	108	9.2	90.64%	-1.52%	-0.19%	-0.48%	-2.17%	-2.74%	-1.37%	-0.32%	-0.38%
E03	VES-8139-164-02ss	108	9.1	88.78%	-0.91%	-0.28%	-0.37%	-1.44%	-2.03%	-0.84%	-0.42%	-0.63%
E05	VES-8139-164-02ss	108	9.1	93.85%	-1.35%	-0.08%	-0.37%	-1.81%	-2.67%	-1.55%	-0.30%	-0.44%
F01	VES-8139-164-02ss	108	9.1	89.46%	-1.72%	-0.41%	-0.48%	-2.62%	-2.92%	-1.39%	-0.48%	-0.80%
F02	VES-8139-164-02ss	108	9.1	88.39%	-1.23%	-0.30%	-0.69%	-2.14%	-2.78%	-1.17%	-0.46%	-0.70%
F04	VES-8139-164-02ss	108	9.1	88.79%	-0.64%	-0.18%	-0.53%	-1.27%	-2.02%	-0.83%	-0.35%	-0.48%

F05	VES-8139-164-02ss	108	9.1	91.76%	-0.96%	-0.16%	-0.37%	-1.44%	-2.04%	-0.87%	-0.14%	-0.37%
G01	VES-8139-164-02ss	108	9.1	89.92%	-1.36%	-0.26%	-0.48%	-2.09%	-2.81%	-1.56%	-0.46%	-0.18%
G02	VES-8139-164-02ss	108	9.1	87.33%	-1.33%	-0.23%	-0.39%	-1.89%	-2.59%	-1.35%	-0.38%	-0.71%
G03	VES-8139-164-02ss	108	9.1	88.61%	-1.05%	-0.21%	-0.37%	-1.63%	-2.27%	-1.19%	-0.39%	-0.42%
G05	VES-8139-164-02ss	108	9.1	91.45%	-0.73%	-0.14%	-0.34%	-1.17%	-1.77%	-0.49%	-0.27%	-0.35%
H01	VES-8139-164-02ss	108	9.1	89.77%	-1.51%	-0.33%	-0.58%	-2.35%	-3.00%	-1.39%	-0.49%	-0.59%
H04	VES-8139-164-02ss	108	9.0	88.15%	-0.77%	-0.07%	-0.39%	-1.20%	-1.78%	-1.04%	-0.14%	-0.34%
H05	VES-8139-164-02ss	108	9.0	91.67%	-0.95%	-0.06%	-0.39%	-1.40%	-1.93%	-0.80%	-0.18%	-0.09%
J01	VES-8139-164-02ss	108	9.1	89.71%	-1.14%	-0.23%	-0.69%	-2.04%	-2.44%	-1.58%	-0.50%	-0.38%
J02	VES-8139-164-02ss	108	9.0	87.05%	-1.29%	-0.30%	-0.37%	-1.83%	-2.16%	-1.41%	-0.17%	-0.27%
J03	VES-8139-164-02ss	108	9.0	88.17%	-0.83%	-0.19%	-0.57%	-1.50%	-2.15%	-0.78%	-0.32%	-0.41%
J05	VES-8139-164-02ss	108	9.0	91.60%	-0.92%	-0.03%	-0.31%	-1.26%	-1.64%	-1.01%	-0.13%	-0.11%
K04	VES-8139-164-02ss	108	8.9	87.62%	-0.71%	-0.08%	-0.30%	-1.08%	-1.87%	-0.44%	-0.06%	-0.47%
K05	VES-8139-164-02ss	108	8.9	91.39%	-0.54%	-0.11%	-0.54%	-1.13%	-1.66%	-0.86%	-0.24%	-0.39%
L05	VES-8139-164-02ss	108	8.9	91.37%	-0.63%	-0.05%	-0.35%	-1.02%	-1.56%	-0.59%	-0.01%	-0.34%
M05	VES-8139-164-02ss	108	8.9	90.63%	-0.94%	-0.12%	-0.32%	-1.36%	-2.11%	-1.05%	-0.20%	-0.21%

Table D-8 Turbine level wake results for Barrow

Turbine name	Turbine model	Hub height [m]	Ambient mean wind speed [m/s]	Turbine interaction efficiency for baseline (%)	Compared to baseline for Scn1	Compared to baseline for Scn2	Compared to baseline for Scn3	Compared to baseline for Scn4	Compared to baseline for Scn5	Compared to baseline for Scn1b	Compared to baseline for Scn2b	Compared to baseline for Scn3b
A01	VES-3000-090-01	75	9.1	87.82%	-1.61%	-0.48%	-0.92%	-2.80%	-3.02%	-1.67%	-0.60%	-1.07%
A02	VES-3000-090-01	75	9.1	85.91%	-1.67%	-0.57%	-0.97%	-3.04%	-3.35%	-1.28%	-0.60%	-1.20%
A03	VES-3000-090-01	75	9.1	85.20%	-1.95%	-0.23%	-1.21%	-3.00%	-3.11%	-1.90%	-0.25%	-0.98%
A04	VES-3000-090-01	75	9.1	84.60%	-1.34%	-0.19%	-0.98%	-2.51%	-2.81%	-1.38%	-0.26%	-0.97%
A05	VES-3000-090-01	75	9.1	84.09%	-1.00%	-0.51%	-1.11%	-2.44%	-2.73%	-0.96%	-0.47%	-1.38%
A06	VES-3000-090-01	75	9.2	84.47%	-1.05%	-0.41%	-1.33%	-2.36%	-2.50%	-0.82%	-0.29%	-1.07%

A07	VES-3000-090-01	75	9.2	85.70%	-1.02%	-0.21%	-1.40%	-2.41%	-2.79%	-0.91%	-0.25%	-0.88%
B01	VES-3000-090-01	75	9.1	88.25%	-2.26%	-0.22%	-1.78%	-3.47%	-3.91%	-1.60%	-0.41%	-1.43%
B02	VES-3000-090-01	75	9.1	84.64%	-1.44%	-0.26%	-1.89%	-3.34%	-3.64%	-1.29%	-0.27%	-1.18%
B03	VES-3000-090-01	75	9.1	84.37%	-1.77%	-0.46%	-1.88%	-3.33%	-3.54%	-1.39%	-0.24%	-1.62%
B04	VES-3000-090-01	75	9.1	83.77%	-1.48%	-0.53%	-1.12%	-3.11%	-3.47%	-2.13%	-0.67%	-1.35%
B05	VES-3000-090-01	75	9.2	83.51%	-1.14%	-0.70%	-1.82%	-3.47%	-3.74%	-1.65%	-0.79%	-1.68%
B06	VES-3000-090-01	75	9.2	83.55%	-0.98%	-0.25%	-1.38%	-2.60%	-2.76%	-1.23%	-0.26%	-0.60%
B07	VES-3000-090-01	75	9.2	83.75%	-0.87%	-0.54%	-0.85%	-2.27%	-2.66%	-1.33%	-0.51%	-1.00%
B08	VES-3000-090-01	75	9.2	85.04%	-0.93%	-0.34%	-1.35%	-2.28%	-2.44%	-0.96%	-0.37%	-0.92%
C01	VES-3000-090-01	75	9.1	86.81%	-2.23%	-0.62%	-1.53%	-3.85%	-4.09%	-1.37%	-0.62%	-1.80%
C02	VES-3000-090-01	75	9.1	85.31%	-2.36%	-0.59%	-1.82%	-3.97%	-4.22%	-2.01%	-0.63%	-1.83%
C03	VES-3000-090-01	75	9.2	84.33%	-2.05%	-0.27%	-0.96%	-3.23%	-3.60%	-1.98%	-0.41%	-1.29%
C04	VES-3000-090-01	75	9.2	83.74%	-1.92%	-0.51%	-1.52%	-3.36%	-3.55%	-1.82%	-0.24%	-1.75%
C05	VES-3000-090-01	75	9.2	83.70%	-1.59%	-0.49%	-1.49%	-3.32%	-3.48%	-1.34%	-0.46%	-1.25%
C06	VES-3000-090-01	75	9.2	83.65%	-1.01%	-0.44%	-1.23%	-2.35%	-2.65%	-1.27%	-0.59%	-1.23%
C07	VES-3000-090-01	75	9.2	84.70%	-1.47%	-0.45%	-1.71%	-3.59%	-3.70%	-1.43%	-0.66%	-0.98%
D01	VES-3000-090-01	75	9.1	90.47%	-1.63%	-0.65%	-1.52%	-3.56%	-3.94%	-2.44%	-0.58%	-1.01%
D02	VES-3000-090-01	75	9.2	88.15%	-2.02%	-0.57%	-1.53%	-4.05%	-4.26%	-1.50%	-0.44%	-1.32%
D03	VES-3000-090-01	75	9.2	87.41%	-2.12%	-0.30%	-1.01%	-3.11%	-3.59%	-1.64%	-0.20%	-1.30%
D04	VES-3000-090-01	75	9.2	87.37%	-2.09%	-0.50%	-1.54%	-3.54%	-3.75%	-2.02%	-0.38%	-1.32%
D05	VES-3000-090-01	75	9.2	87.16%	-1.62%	-0.53%	-1.51%	-3.34%	-3.72%	-2.14%	-0.51%	-1.03%
D06	VES-3000-090-01	75	9.2	87.27%	-1.75%	-0.76%	-1.26%	-3.73%	-3.98%	-0.94%	-0.32%	-1.28%
D07	VES-3000-090-01	75	9.2	86.50%	-1.28%	-0.59%	-1.25%	-3.11%	-3.33%	-1.49%	-0.48%	-0.75%
D08	VES-3000-090-01	75	9.2	86.98%	-0.61%	-0.36%	-1.25%	-2.19%	-2.33%	-0.66%	-0.49%	-1.00%

Table D-9 Turbine level wake results for West of Duddon Sands

Turbine name	Turbine model	Hub height [m]	Ambient mean wind speed [m/s]	Turbine interaction efficiency for baseline (%)	Compared to baseline for Scn1	Compared to baseline for Scn2	Compared to baseline for Scn3	Compared to baseline for Scn4	Compared to baseline for Scn5	Compared to baseline for Scn1b	Compared to baseline for Scn2b	Compared to baseline for Scn3b
A01	SIE-3600-120-39	85.77	9.6	89.61%	-2.31%	-2.20%	-0.53%	-5.04%	-5.34%	-1.90%	-2.32%	-0.97%
A02	SIE-3600-120-39	85.77	9.6	88.36%	-2.11%	-2.58%	-0.82%	-5.51%	-5.84%	-2.36%	-2.16%	-0.63%
A03	SIE-3600-120-39	85.77	9.6	88.16%	-2.00%	-1.50%	-1.06%	-4.57%	-4.61%	-1.29%	-2.16%	-0.74%
A04	SIE-3600-120-39	85.77	9.6	88.17%	-2.52%	-2.25%	-0.98%	-5.75%	-5.87%	-1.86%	-1.82%	-0.98%
A05	SIE-3600-120-39	85.77	9.6	88.76%	-2.16%	-2.21%	-0.76%	-5.12%	-5.26%	-1.97%	-2.42%	-1.15%
A06	SIE-3600-120-39	85.77	9.5	88.62%	-2.19%	-2.09%	-0.98%	-5.26%	-5.63%	-1.86%	-1.80%	-0.52%
A07	SIE-3600-120-39	85.77	9.5	88.81%	-2.21%	-2.10%	-1.47%	-5.77%	-5.92%	-1.84%	-1.82%	-1.44%
A08	SIE-3600-120-39	85.77	9.5	88.92%	-1.52%	-1.62%	-1.73%	-4.87%	-4.87%	-1.48%	-2.09%	-1.26%
A09	SIE-3600-120-39	85.77	9.5	89.59%	-1.48%	-2.03%	-0.86%	-4.37%	-4.55%	-1.51%	-1.93%	-1.17%
A10	SIE-3600-120-39	85.77	9.5	89.99%	-1.88%	-2.05%	-1.31%	-5.24%	-5.72%	-1.27%	-1.75%	-1.58%
A11	SIE-3600-120-39	85.77	9.5	90.38%	-1.10%	-1.96%	-1.24%	-4.31%	-4.64%	-1.68%	-2.03%	-1.18%
A12	SIE-3600-120-39	85.77	9.5	92.18%	-1.85%	-1.63%	-1.70%	-5.18%	-5.32%	-2.01%	-1.81%	-1.40%
B01	SIE-3600-120-39	85.77	9.6	85.55%	-2.25%	-2.18%	-0.94%	-5.37%	-5.45%	-1.83%	-1.60%	-0.69%
B02	SIE-3600-120-39	85.77	9.6	84.04%	-1.83%	-2.34%	-0.70%	-4.87%	-5.07%	-2.22%	-1.81%	-0.26%
B03	SIE-3600-120-39	85.77	9.6	83.44%	-2.52%	-1.85%	-1.14%	-5.51%	-5.62%	-2.25%	-2.23%	-1.20%
B04	SIE-3600-120-39	85.77	9.5	83.68%	-1.88%	-2.20%	-0.78%	-4.86%	-4.94%	-1.93%	-2.16%	-1.07%
B05	SIE-3600-120-39	85.77	9.5	83.67%	-2.33%	-1.70%	-0.79%	-4.82%	-5.14%	-1.72%	-1.97%	-0.62%
B06	SIE-3600-120-39	85.77	9.5	84.32%	-2.27%	-2.23%	-1.00%	-5.49%	-5.58%	-1.56%	-2.14%	-1.02%
B07	SIE-3600-120-39	85.77	9.5	85.17%	-2.10%	-1.98%	-1.48%	-5.56%	-5.62%	-1.69%	-2.05%	-1.14%
B08	SIE-3600-120-39	85.77	9.5	85.25%	-2.09%	-1.85%	-1.26%	-5.19%	-5.21%	-1.89%	-1.76%	-0.66%
B09	SIE-3600-120-39	85.77	9.5	85.77%	-1.70%	-1.95%	-1.19%	-4.85%	-4.95%	-2.10%	-1.89%	-1.31%

B10	SIE-3600-120-39	85.77	9.5	86.28%	-2.05%	-1.83%	-0.98%	-4.86%	-5.15%	-1.89%	-1.38%	-1.10%
B11	SIE-3600-120-39	85.77	9.5	87.72%	-1.86%	-1.82%	-1.68%	-5.35%	-5.57%	-1.70%	-1.87%	-1.11%
B12	SIE-3600-120-39	85.77	9.5	91.53%	-1.26%	-1.64%	-1.30%	-4.36%	-4.93%	-1.71%	-1.34%	-0.96%
C01	SIE-3600-120-39	85.77	9.5	83.89%	-1.80%	-1.94%	-0.45%	-4.19%	-4.30%	-1.71%	-2.07%	-0.25%
C02	SIE-3600-120-39	85.77	9.5	82.31%	-1.65%	-1.71%	-0.74%	-4.11%	-4.30%	-1.80%	-2.29%	-0.51%
C03	SIE-3600-120-39	85.77	9.5	81.58%	-2.57%	-1.52%	-0.67%	-4.76%	-4.84%	-1.99%	-1.52%	-0.97%
C04	SIE-3600-120-39	85.77	9.5	81.76%	-1.58%	-1.92%	-0.50%	-3.99%	-4.26%	-1.47%	-1.70%	-0.38%
C05	SIE-3600-120-39	85.77	9.5	81.89%	-2.47%	-1.94%	-0.63%	-5.03%	-5.35%	-1.97%	-1.84%	-0.37%
C06	SIE-3600-120-39	85.77	9.5	82.29%	-1.93%	-1.82%	-0.72%	-4.47%	-4.77%	-2.18%	-1.42%	-1.12%
C07	SIE-3600-120-39	85.77	9.5	83.83%	-2.72%	-1.70%	-1.22%	-5.65%	-5.64%	-2.13%	-1.48%	-0.81%
D01	SIE-3600-120-39	85.77	9.5	84.23%	-1.72%	-1.77%	-0.71%	-4.20%	-4.25%	-1.54%	-1.40%	-0.44%
D02	SIE-3600-120-39	85.77	9.5	81.00%	-1.57%	-1.78%	-0.75%	-4.10%	-4.12%	-1.62%	-1.18%	-0.91%
D03	SIE-3600-120-39	85.77	9.5	81.08%	-1.43%	-1.87%	-0.46%	-3.76%	-3.90%	-2.12%	-1.51%	-0.46%
D04	SIE-3600-120-39	85.77	9.5	81.37%	-1.66%	-1.53%	-0.84%	-4.04%	-4.24%	-1.62%	-1.30%	-0.24%
D05	SIE-3600-120-39	85.77	9.5	81.97%	-1.69%	-1.22%	-0.65%	-3.57%	-3.70%	-1.64%	-1.70%	-1.11%
D06	SIE-3600-120-39	85.77	9.5	82.89%	-0.92%	-1.80%	-1.22%	-3.95%	-3.95%	-1.08%	-1.68%	-0.78%
D13	SIE-3600-120-39	85.77	9.4	91.53%	-2.11%	-1.52%	-1.70%	-5.32%	-5.43%	-1.74%	-1.32%	-1.41%
E01	SIE-3600-120-39	85.77	9.5	82.63%	-1.74%	-1.62%	-0.67%	-4.02%	-4.12%	-1.57%	-1.66%	-0.50%
E02	SIE-3600-120-39	85.77	9.5	81.05%	-1.61%	-1.69%	-0.66%	-3.95%	-3.95%	-1.28%	-1.51%	-0.75%
E03	SIE-3600-120-39	85.77	9.5	82.22%	-1.45%	-1.42%	-0.67%	-3.54%	-3.62%	-1.87%	-0.92%	-0.44%
E08	SIE-3600-120-39	85.77	9.5	85.45%	-1.34%	-1.07%	-1.22%	-3.63%	-3.63%	-1.58%	-1.20%	-1.37%
E09	SIE-3600-120-39	85.77	9.5	85.06%	-2.12%	-1.20%	-1.53%	-4.85%	-5.01%	-1.53%	-0.98%	-1.56%
E10	SIE-3600-120-39	85.77	9.5	85.95%	-1.53%	-1.30%	-1.22%	-4.05%	-4.34%	-1.55%	-1.02%	-0.79%
E11	SIE-3600-120-39	85.77	9.4	86.72%	-2.29%	-1.24%	-1.77%	-5.29%	-5.42%	-1.90%	-1.14%	-1.64%
E12	SIE-3600-120-39	85.77	9.4	87.40%	-1.62%	-0.90%	-1.85%	-4.34%	-4.33%	-1.55%	-1.18%	-1.07%
E13	SIE-3600-120-39	85.77	9.4	88.00%	-2.42%	-1.19%	-1.79%	-5.40%	-5.44%	-1.76%	-1.47%	-0.92%
E14	SIE-3600-120-39	85.77	9.4	90.71%	-1.34%	-1.33%	-1.09%	-3.90%	-4.16%	-1.95%	-1.21%	-1.01%
F01	SIE-3600-120-39	85.77	9.5	81.35%	-1.62%	-1.13%	-0.50%	-3.25%	-3.33%	-0.92%	-1.41%	-0.83%

F02	SIE-3600-120-39	85.77	9.5	80.37%	-1.53%	-1.32%	-0.56%	-3.42%	-3.43%	-1.45%	-1.27%	-0.46%
F03	SIE-3600-120-39	85.77	9.5	80.70%	-1.24%	-1.32%	-0.34%	-2.90%	-2.99%	-1.12%	-0.97%	-0.53%
F04	SIE-3600-120-39	85.77	9.5	82.42%	-1.56%	-1.08%	-0.43%	-3.07%	-3.15%	-1.25%	-0.92%	-0.82%
F10	SIE-3600-120-39	85.77	9.4	83.76%	-1.58%	-1.00%	-1.47%	-4.05%	-4.37%	-1.57%	-1.17%	-1.42%
F11	SIE-3600-120-39	85.77	9.4	83.56%	-2.47%	-1.46%	-1.67%	-5.43%	-5.53%	-1.87%	-0.99%	-1.32%
F12	SIE-3600-120-39	85.77	9.4	84.48%	-1.66%	-1.02%	-1.54%	-4.22%	-4.34%	-2.37%	-0.74%	-0.68%
F13	SIE-3600-120-39	85.77	9.4	85.55%	-2.23%	-1.28%	-1.47%	-4.80%	-4.93%	-1.54%	-0.83%	-1.00%
F14	SIE-3600-120-39	85.77	9.4	89.09%	-1.45%	-1.15%	-1.58%	-4.32%	-4.43%	-2.31%	-0.90%	-1.43%
G01	SIE-3600-120-39	85.77	9.5	80.38%	-1.08%	-1.36%	-0.51%	-2.95%	-2.95%	-1.13%	-1.16%	-0.65%
G02	SIE-3600-120-39	85.77	9.5	79.43%	-1.40%	-1.15%	-0.48%	-3.02%	-3.07%	-1.38%	-1.01%	-0.46%
G03	SIE-3600-120-39	85.77	9.5	79.72%	-1.08%	-0.77%	-0.40%	-2.25%	-2.28%	-1.25%	-0.70%	-0.73%
G04	SIE-3600-120-39	85.77	9.5	81.22%	-1.39%	-0.92%	-1.05%	-3.36%	-3.44%	-0.77%	-1.02%	-0.93%
G11	SIE-3600-120-39	85.77	9.4	83.64%	-1.79%	-0.88%	-1.20%	-3.87%	-3.94%	-1.42%	-1.01%	-0.71%
G12	SIE-3600-120-39	85.77	9.4	84.67%	-1.68%	-0.75%	-1.50%	-3.94%	-3.97%	-1.59%	-1.06%	-1.06%
G13	SIE-3600-120-39	85.77	9.4	87.31%	-1.14%	-0.86%	-1.89%	-3.96%	-4.14%	-1.89%	-0.88%	-1.52%
H01	SIE-3600-120-39	85.77	9.5	79.90%	-1.20%	-0.99%	-0.74%	-2.93%	-2.93%	-0.59%	-1.14%	-0.44%
H02	SIE-3600-120-39	85.77	9.5	79.64%	-1.26%	-0.98%	-0.98%	-3.22%	-3.25%	-0.95%	-1.14%	-0.76%
H03	SIE-3600-120-39	85.77	9.5	79.46%	-1.12%	-1.16%	-1.12%	-3.40%	-3.47%	-1.13%	-1.00%	-1.11%
H04	SIE-3600-120-39	85.77	9.5	80.62%	-1.50%	-0.50%	-0.86%	-2.86%	-2.92%	-1.43%	-0.90%	-0.77%
H05	SIE-3600-120-39	85.77	9.5	82.08%	-1.21%	-0.78%	-0.87%	-2.85%	-2.95%	-1.00%	-0.55%	-0.62%
H06	SIE-3600-120-39	85.77	9.4	82.24%	-1.51%	-0.69%	-0.96%	-3.16%	-3.15%	-0.80%	-0.67%	-1.04%
H07	SIE-3600-120-39	85.77	9.4	83.67%	-0.93%	-0.99%	-0.77%	-2.69%	-2.85%	-1.27%	-0.75%	-0.75%
H10	SIE-3600-120-39	85.77	9.4	83.96%	-1.72%	-1.20%	-1.22%	-4.07%	-4.09%	-1.12%	-0.93%	-0.93%
H11	SIE-3600-120-39	85.77	9.4	83.09%	-1.48%	-1.04%	-1.63%	-4.15%	-4.16%	-1.65%	-1.07%	-0.70%
H12	SIE-3600-120-39	85.77	9.4	84.47%	-1.45%	-1.04%	-0.98%	-3.36%	-3.47%	-1.43%	-0.68%	-0.92%
H13	SIE-3600-120-39	85.77	9.4	87.39%	-1.39%	-0.93%	-1.51%	-3.77%	-3.89%	-1.31%	-1.09%	-1.13%
I01	SIE-3600-120-39	85.77	9.5	80.80%	-0.88%	-0.80%	-0.48%	-2.16%	-2.16%	-0.75%	-1.27%	-0.63%
I02	SIE-3600-120-39	85.77	9.5	79.95%	-0.94%	-0.87%	-0.91%	-2.72%	-2.86%	-1.10%	-0.82%	-0.50%

I03	SIE-3600-120-39	85.77	9.5	79.54%	-1.13%	-0.73%	-1.03%	-2.88%	-2.87%	-0.96%	-1.00%	-1.00%
I04	SIE-3600-120-39	85.77	9.4	80.13%	-1.07%	-0.66%	-1.06%	-2.79%	-2.86%	-1.10%	-0.84%	-0.51%
I05	SIE-3600-120-39	85.77	9.4	79.62%	-1.22%	-0.61%	-0.83%	-2.66%	-2.77%	-0.94%	-0.72%	-0.85%
I06	SIE-3600-120-39	85.77	9.4	79.99%	-1.57%	-0.80%	-0.91%	-3.29%	-3.37%	-1.08%	-0.68%	-1.26%
I07	SIE-3600-120-39	85.77	9.4	82.09%	-1.39%	-0.66%	-1.08%	-3.13%	-3.12%	-1.23%	-0.92%	-0.97%
I08	SIE-3600-120-39	85.77	9.4	83.14%	-1.78%	-0.89%	-0.87%	-3.54%	-3.71%	-0.83%	-0.77%	-0.69%
I09	SIE-3600-120-39	85.77	9.4	83.27%	-1.33%	-1.25%	-1.13%	-3.62%	-3.62%	-1.42%	-1.08%	-0.85%
I10	SIE-3600-120-39	85.77	9.4	82.40%	-1.67%	-0.84%	-1.01%	-3.53%	-3.64%	-0.76%	-0.81%	-0.37%
I11	SIE-3600-120-39	85.77	9.4	83.28%	-1.45%	-0.70%	-0.90%	-3.05%	-3.07%	-1.71%	-0.82%	-1.06%
I12	SIE-3600-120-39	85.77	9.4	86.89%	-1.46%	-0.77%	-1.93%	-4.16%	-4.16%	-0.78%	-0.84%	-1.17%
J01	SIE-3600-120-39	85.77	9.5	81.70%	-0.87%	-0.64%	-0.48%	-1.99%	-2.01%	-0.72%	-1.17%	-0.43%
J02	SIE-3600-120-39	85.77	9.4	80.32%	-0.83%	-0.84%	-0.86%	-2.53%	-2.53%	-0.78%	-0.51%	-0.59%
J03	SIE-3600-120-39	85.77	9.4	80.06%	-1.05%	-0.69%	-0.75%	-2.49%	-2.70%	-0.65%	-0.68%	-0.42%
J04	SIE-3600-120-39	85.77	9.4	80.03%	-0.86%	-0.46%	-0.69%	-2.01%	-2.05%	-1.00%	-0.76%	-0.60%
J05	SIE-3600-120-39	85.77	9.4	80.27%	-0.95%	-0.99%	-0.80%	-2.73%	-2.76%	-0.96%	-0.84%	-1.03%
J06	SIE-3600-120-39	85.77	9.4	80.88%	-0.89%	-0.70%	-1.33%	-2.92%	-2.90%	-1.53%	-0.58%	-0.78%
J07	SIE-3600-120-39	85.77	9.4	81.45%	-1.25%	-0.88%	-0.91%	-3.04%	-3.10%	-0.86%	-0.80%	-0.52%
J08	SIE-3600-120-39	85.77	9.4	81.65%	-0.75%	-0.78%	-0.66%	-2.20%	-2.29%	-0.89%	-0.72%	-0.89%
J09	SIE-3600-120-39	85.77	9.4	81.94%	-1.14%	-0.64%	-0.80%	-2.57%	-2.58%	-1.12%	-0.76%	-0.49%
J10	SIE-3600-120-39	85.77	9.4	82.89%	-1.10%	-0.98%	-1.01%	-3.08%	-3.07%	-0.55%	-0.97%	-0.80%
J11	SIE-3600-120-39	85.77	9.4	83.74%	-1.38%	-0.75%	-0.82%	-2.75%	-2.96%	-1.91%	-0.67%	-0.81%
J12	SIE-3600-120-39	85.77	9.4	87.39%	-1.81%	-0.49%	-1.27%	-3.56%	-3.66%	-0.76%	-0.51%	-0.83%
K02	SIE-3600-120-39	85.77	9.4	83.16%	-0.80%	-0.98%	-0.97%	-2.75%	-2.77%	-0.56%	-0.80%	-0.70%
K03	SIE-3600-120-39	85.77	9.4	81.73%	-0.92%	-0.49%	-0.58%	-1.99%	-2.07%	-0.83%	-0.62%	-0.43%
K04	SIE-3600-120-39	85.77	9.4	82.00%	-0.66%	-0.57%	-0.70%	-1.93%	-1.96%	-0.67%	-0.32%	-0.63%
K05	SIE-3600-120-39	85.77	9.4	82.87%	-1.17%	-0.63%	-1.14%	-2.95%	-2.94%	-0.67%	-0.65%	-0.41%
K06	SIE-3600-120-39	85.77	9.4	82.77%	-0.87%	-0.48%	-0.93%	-2.28%	-2.40%	-1.48%	-0.52%	-0.59%
K07	SIE-3600-120-39	85.77	9.4	84.12%	-1.29%	-0.63%	-0.80%	-2.73%	-2.75%	-0.87%	-0.67%	-1.08%

K08	SIE-3600-120-39	85.77	9.4	83.73%	-1.32%	-0.63%	-0.51%	-2.41%	-2.53%	-1.65%	-0.64%	-0.65%
K09	SIE-3600-120-39	85.77	9.4	83.34%	-1.01%	-0.75%	-0.59%	-2.35%	-2.35%	-0.91%	-0.74%	-0.43%
K10	SIE-3600-120-39	85.77	9.4	85.28%	-1.19%	-1.35%	-0.90%	-3.43%	-3.72%	-0.81%	-0.94%	-0.65%

Table D-10 Turbine level wake results for Walney 1

Turbine name	Turbine model	Hub height [m]	Ambient mean wind speed [m/s]	Turbine interaction efficiency for baseline (%)	Compared to baseline for Scn1	Compared to baseline for Scn2	Compared to baseline for Scn3	Compared to baseline for Scn4	Compared to baseline for Scn5	Compared to baseline for Scn1b	Compared to baseline for Scn2b	Compared to baseline for Scn3b
A01	SIE-3600-107-36	78.4	9.3	81.44%	-1.00%	-1.25%	-0.57%	-2.82%	-2.82%	-0.63%	-0.88%	-0.64%
A02	SIE-3600-107-36	78.4	9.4	80.90%	-0.91%	-1.01%	-0.66%	-2.58%	-2.58%	-1.09%	-1.37%	-0.56%
A03	SIE-3600-107-36	78.4	9.4	81.41%	-0.71%	-1.26%	-0.41%	-2.38%	-2.38%	-0.72%	-0.93%	-0.43%
A04	SIE-3600-107-36	78.4	9.3	80.77%	-1.25%	-1.05%	-0.43%	-2.73%	-2.82%	-1.24%	-1.27%	-0.30%
A05	SIE-3600-107-36	78.4	9.3	81.47%	-1.34%	-1.13%	-0.43%	-2.90%	-2.90%	-1.06%	-1.06%	-0.44%
A06	SIE-3600-107-36	78.4	9.4	81.33%	-0.81%	-1.54%	-0.59%	-2.94%	-2.94%	-0.79%	-1.40%	-0.31%
A07	SIE-3600-107-36	78.4	9.4	81.27%	-1.21%	-0.95%	-0.24%	-2.40%	-2.47%	-1.16%	-0.71%	-0.45%
A08	SIE-3600-107-36	78.4	9.4	81.67%	-1.59%	-1.66%	-0.27%	-3.52%	-3.59%	-1.17%	-1.64%	-0.43%
A09	SIE-3600-107-36	78.4	9.4	82.67%	-1.42%	-1.38%	-0.49%	-3.29%	-3.29%	-1.04%	-1.57%	-0.68%
A10	SIE-3600-107-36	78.4	9.4	82.14%	-1.23%	-1.13%	-0.42%	-2.77%	-2.88%	-1.27%	-1.13%	-0.44%
A11	SIE-3600-107-36	78.4	9.4	82.37%	-1.49%	-0.93%	-0.46%	-2.87%	-2.94%	-1.37%	-1.07%	-0.25%
B01	SIE-3600-107-36	78.4	9.4	79.25%	-1.50%	-1.71%	-0.87%	-4.08%	-4.08%	-0.88%	-1.27%	-0.83%
B02	SIE-3600-107-36	78.4	9.4	79.31%	-1.27%	-1.33%	-0.42%	-3.02%	-3.01%	-1.04%	-1.69%	-0.22%
B03	SIE-3600-107-36	78.4	9.4	79.10%	-1.16%	-1.26%	-0.37%	-2.80%	-2.79%	-0.69%	-1.05%	-0.23%
B04	SIE-3600-107-36	78.4	9.4	79.52%	-1.86%	-1.70%	-0.55%	-4.11%	-4.11%	-1.83%	-1.41%	-0.66%
B05	SIE-3600-107-36	78.4	9.4	78.86%	-1.58%	-0.59%	-0.60%	-2.77%	-2.77%	-1.31%	-0.97%	-0.27%
B06	SIE-3600-107-36	78.4	9.4	78.73%	-2.03%	-1.46%	-0.23%	-3.73%	-3.79%	-2.13%	-1.13%	-0.38%
B07	SIE-3600-107-36	78.4	9.4	78.74%	-1.65%	-0.70%	-0.43%	-2.78%	-2.86%	-0.98%	-0.96%	-0.50%
B08	SIE-3600-107-36	78.4	9.4	79.21%	-1.34%	-1.49%	-0.75%	-3.59%	-3.67%	-1.18%	-1.39%	-0.56%

B09	SIE-3600-107-36	78.4	9.4	79.63%	-1.76%	-1.52%	-0.43%	-3.71%	-3.75%	-1.63%	-0.95%	-0.21%
B10	SIE-3600-107-36	78.4	9.4	80.10%	-1.17%	-2.07%	-0.74%	-3.97%	-4.03%	-1.81%	-1.81%	-0.10%
C01	SIE-3600-107-36	78.4	9.4	77.98%	-1.20%	-2.14%	-0.43%	-3.77%	-3.77%	-1.24%	-1.32%	-0.48%
C02	SIE-3600-107-36	78.4	9.4	78.22%	-1.59%	-1.49%	-0.91%	-3.99%	-3.98%	-1.63%	-1.17%	-0.65%
C03	SIE-3600-107-36	78.4	9.4	78.38%	-1.56%	-1.17%	-0.52%	-3.25%	-3.25%	-2.01%	-1.08%	-0.57%
C04	SIE-3600-107-36	78.4	9.4	78.24%	-2.02%	-1.10%	-0.44%	-3.56%	-3.55%	-1.36%	-0.79%	-0.14%
C05	SIE-3600-107-36	78.4	9.4	78.74%	-1.45%	-0.94%	-0.60%	-2.98%	-2.98%	-1.60%	-1.10%	-0.66%
C06	SIE-3600-107-36	78.4	9.4	77.75%	-2.14%	-1.13%	-0.09%	-3.36%	-3.37%	-1.61%	-0.97%	-0.51%
C07	SIE-3600-107-36	78.4	9.4	78.76%	-1.63%	-1.58%	-0.33%	-3.54%	-3.60%	-1.44%	-1.56%	-0.27%
C08	SIE-3600-107-36	78.4	9.4	79.15%	-1.75%	-2.06%	-0.33%	-4.14%	-4.28%	-1.45%	-0.87%	-0.53%
C09	SIE-3600-107-36	78.4	9.4	79.33%	-1.51%	-1.66%	-0.26%	-3.43%	-3.50%	-1.71%	-1.65%	-0.48%
D01	SIE-3600-107-36	78.4	9.4	76.99%	-1.53%	-1.97%	-0.50%	-4.00%	-4.00%	-1.89%	-1.61%	-0.50%
D02	SIE-3600-107-36	78.4	9.4	78.70%	-1.61%	-1.28%	-0.62%	-3.51%	-3.51%	-1.22%	-1.60%	-0.24%
D03	SIE-3600-107-36	78.4	9.4	78.28%	-1.97%	-1.98%	-0.66%	-4.61%	-4.69%	-2.30%	-1.49%	-0.33%
D04	SIE-3600-107-36	78.4	9.4	79.76%	-2.19%	-1.62%	-0.48%	-4.29%	-4.30%	-2.31%	-1.45%	-0.23%
D05	SIE-3600-107-36	78.4	9.4	78.18%	-1.77%	-1.42%	-0.47%	-3.67%	-3.76%	-1.59%	-1.55%	-0.57%
D06	SIE-3600-107-36	78.4	9.4	78.47%	-1.69%	-2.16%	-0.58%	-4.43%	-4.56%	-1.56%	-1.98%	-0.72%
D07	SIE-3600-107-36	78.4	9.4	78.92%	-1.59%	-1.76%	-0.52%	-3.86%	-4.04%	-1.44%	-1.62%	-0.39%
D08	SIE-3600-107-36	78.4	9.4	78.71%	-1.64%	-1.95%	-0.58%	-4.17%	-4.34%	-1.84%	-1.89%	-0.40%
E01	SIE-3600-107-36	78.4	9.4	79.11%	-1.92%	-2.07%	-0.42%	-4.41%	-4.44%	-1.77%	-1.39%	-0.41%
E02	SIE-3600-107-36	78.4	9.4	79.44%	-1.82%	-1.70%	-0.40%	-3.92%	-3.91%	-1.28%	-1.46%	-0.40%
E03	SIE-3600-107-36	78.4	9.4	79.80%	-2.99%	-2.03%	-0.38%	-5.40%	-5.59%	-2.77%	-1.56%	-0.58%
E04	SIE-3600-107-36	78.4	9.5	79.40%	-1.77%	-1.77%	-0.77%	-4.32%	-4.31%	-1.93%	-1.50%	-0.59%
E05	SIE-3600-107-36	78.4	9.5	79.20%	-1.85%	-1.86%	-0.51%	-4.22%	-4.29%	-1.92%	-1.58%	-0.84%
E06	SIE-3600-107-36	78.4	9.4	79.17%	-2.17%	-2.38%	-0.81%	-5.35%	-5.57%	-1.54%	-1.28%	-0.72%
E07	SIE-3600-107-36	78.4	9.4	79.64%	-2.05%	-1.76%	-0.70%	-4.51%	-4.65%	-1.46%	-1.75%	-0.57%
F01	SIE-3600-107-36	78.4	9.4	80.64%	-2.38%	-2.71%	-0.56%	-5.65%	-5.70%	-1.96%	-2.34%	-0.40%
F02	SIE-3600-107-36	78.4	9.4	81.84%	-2.37%	-1.64%	-0.73%	-4.74%	-4.84%	-2.44%	-1.52%	-0.65%

F03	SIE-3600-107-36	78.4	9.5	80.87%	-2.77%	-2.51%	-0.63%	-5.91%	-6.07%	-2.37%	-1.75%	-0.31%
F04	SIE-3600-107-36	78.4	9.5	80.15%	-1.62%	-2.21%	-0.56%	-4.40%	-4.61%	-2.15%	-1.72%	-0.59%
F05	SIE-3600-107-36	78.4	9.5	79.66%	-2.46%	-1.49%	-0.97%	-4.92%	-5.03%	-1.99%	-1.48%	-1.30%
F06	SIE-3600-107-36	78.4	9.5	80.62%	-2.09%	-1.87%	-0.67%	-4.64%	-4.82%	-1.70%	-1.52%	-0.46%

Table D-11 Turbine level wake results for Walney 2

Turbine name	Turbine model	Hub height [m]	Ambient mean wind speed [m/s]	Turbine interaction efficiency for baseline (%)	Compared to baseline for Scn1	Compared to baseline for Scn2	Compared to baseline for Scn3	Compared to baseline for Scn4	Compared to baseline for Scn5	Compared to baseline for Scn1b	Compared to baseline for Scn2b	Compared to baseline for Scn3b
A12	SIE-3600-120-14	84.9	9.5	84.65%	-1.20%	-1.03%	-0.17%	-2.40%	-2.48%	-0.96%	-0.75%	-0.36%
A13	SIE-3600-120-14	84.9	9.5	84.74%	-1.12%	-1.56%	-0.45%	-3.12%	-3.12%	-0.81%	-1.19%	-0.33%
A14	SIE-3600-120-14	84.9	9.5	85.81%	-1.19%	-1.55%	-0.20%	-2.93%	-2.96%	-0.66%	-1.53%	-0.16%
A15	SIE-3600-120-14	84.9	9.5	85.56%	-0.97%	-1.85%	-0.15%	-2.97%	-2.97%	-0.48%	-1.42%	-0.14%
A16	SIE-3600-120-14	84.9	9.5	88.24%	-0.73%	-2.22%	-0.19%	-3.14%	-3.14%	-0.44%	-2.48%	-0.22%
A17	SIE-3600-120-14	84.9	9.5	88.81%	-1.18%	-1.77%	-0.08%	-3.00%	-3.02%	-0.86%	-1.72%	-0.02%
A18	SIE-3600-120-14	84.9	9.5	88.13%	-1.37%	-2.42%	-0.18%	-3.97%	-4.00%	-1.35%	-2.05%	-0.39%
A19	SIE-3600-120-14	84.9	9.5	88.13%	-0.90%	-1.51%	-0.22%	-2.64%	-2.66%	-1.24%	-1.65%	-0.02%
A20	SIE-3600-120-14	84.9	9.5	90.73%	-1.17%	-2.95%	-0.09%	-4.03%	-4.05%	-1.15%	-1.96%	-0.33%
B11	SIE-3600-120-14	84.9	9.5	82.41%	-1.42%	-1.37%	-0.23%	-3.02%	-3.05%	-1.21%	-1.68%	-0.31%
B12	SIE-3600-120-14	84.9	9.5	82.78%	-1.03%	-1.71%	-0.43%	-3.17%	-3.22%	-1.42%	-1.57%	-0.07%
B13	SIE-3600-120-14	84.9	9.5	82.85%	-0.76%	-1.72%	-0.16%	-2.63%	-2.63%	-0.88%	-1.53%	-0.15%
B14	SIE-3600-120-14	84.9	9.5	84.15%	-1.30%	-1.72%	-0.25%	-3.26%	-3.28%	-1.32%	-1.84%	-0.09%
B15	SIE-3600-120-14	84.9	9.5	86.43%	-0.87%	-2.97%	-0.27%	-4.11%	-4.14%	-0.60%	-2.18%	-0.23%
B16	SIE-3600-120-14	84.9	9.5	87.32%	-1.34%	-2.71%	-0.12%	-4.15%	-4.22%	-1.35%	-2.40%	-0.26%
B17	SIE-3600-120-14	84.9	9.5	87.41%	-1.06%	-2.27%	-0.21%	-3.22%	-3.29%	-1.40%	-2.05%	-0.25%
B18	SIE-3600-120-14	84.9	9.5	89.88%	-0.87%	-1.34%	-0.35%	-2.30%	-2.30%	-0.95%	-2.34%	-0.11%
C10	SIE-3600-120-14	84.9	9.5	82.27%	-1.21%	-1.43%	-0.38%	-3.02%	-3.06%	-1.10%	-0.95%	-0.28%

C11	SIE-3600-120-14	84.9	9.5	82.04%	-1.25%	-1.83%	-0.56%	-3.65%	-3.75%	-1.01%	-1.56%	-0.27%
C12	SIE-3600-120-14	84.9	9.5	83.02%	-1.37%	-1.79%	-0.21%	-3.37%	-3.46%	-1.35%	-2.07%	-0.31%
C13	SIE-3600-120-14	84.9	9.5	83.64%	-0.92%	-2.43%	-0.46%	-3.81%	-3.81%	-1.16%	-1.87%	-0.12%
C14	SIE-3600-120-14	84.9	9.5	85.64%	-0.87%	-2.79%	-0.07%	-3.72%	-3.72%	-0.89%	-3.16%	-0.20%
C15	SIE-3600-120-14	84.9	9.5	87.71%	-1.35%	-2.67%	-0.47%	-4.48%	-4.50%	-1.14%	-2.68%	-0.03%
C16	SIE-3600-120-14	84.9	9.5	88.24%	-1.20%	-2.12%	-0.28%	-3.39%	-3.41%	-1.14%	-2.12%	-0.23%
D09	SIE-3600-120-14	84.9	9.5	81.27%	-1.51%	-1.41%	-0.40%	-3.32%	-3.35%	-1.00%	-1.53%	-0.53%
D10	SIE-3600-120-14	84.9	9.5	81.70%	-1.22%	-2.20%	-0.38%	-3.80%	-3.87%	-0.83%	-1.42%	-0.39%
D11	SIE-3600-120-14	84.9	9.5	81.90%	-1.29%	-1.93%	-0.33%	-3.54%	-3.54%	-0.88%	-1.78%	-0.20%
D12	SIE-3600-120-14	84.9	9.5	82.37%	-1.21%	-2.06%	-0.61%	-3.87%	-3.87%	-0.99%	-1.28%	-0.48%
D13	SIE-3600-120-14	84.9	9.5	84.17%	-1.09%	-2.49%	-0.17%	-3.75%	-3.81%	-1.11%	-2.12%	-0.20%
D14	SIE-3600-120-14	84.9	9.6	86.23%	-0.93%	-2.41%	-0.17%	-3.50%	-3.65%	-1.01%	-2.67%	-0.07%
D15	SIE-3600-120-14	84.9	9.5	86.94%	-1.20%	-2.37%	-0.08%	-3.63%	-3.65%	-1.34%	-2.48%	-0.14%
D16	SIE-3600-120-14	84.9	9.5	85.80%	-1.37%	-2.91%	-0.32%	-4.56%	-4.60%	-1.04%	-2.55%	-0.14%
D17	SIE-3600-120-14	84.9	9.5	89.49%	-0.96%	-2.18%	-0.12%	-3.20%	-3.33%	-1.65%	-1.86%	-0.30%
E08	SIE-3600-120-14	84.9	9.5	80.84%	-1.32%	-1.83%	-0.41%	-3.56%	-3.63%	-1.07%	-1.14%	-0.62%
E09	SIE-3600-120-14	84.9	9.5	82.03%	-1.50%	-1.90%	-0.56%	-3.96%	-4.03%	-1.39%	-1.57%	-0.53%
E10	SIE-3600-120-14	84.9	9.5	81.69%	-1.10%	-1.73%	-0.36%	-3.19%	-3.23%	-1.29%	-1.46%	-0.42%
E11	SIE-3600-120-14	84.9	9.5	82.56%	-1.31%	-1.78%	-0.26%	-3.36%	-3.42%	-1.10%	-1.61%	-0.22%
E12	SIE-3600-120-14	84.9	9.6	83.42%	-1.07%	-3.00%	-0.84%	-4.91%	-4.90%	-1.06%	-2.28%	-0.21%
E13	SIE-3600-120-14	84.9	9.6	83.76%	-1.04%	-2.61%	-0.54%	-4.19%	-4.22%	-0.83%	-2.58%	-0.43%
E14	SIE-3600-120-14	84.9	9.6	86.17%	-0.77%	-3.00%	-0.27%	-4.03%	-4.08%	-0.90%	-3.21%	-0.29%
E15	SIE-3600-120-14	84.9	9.5	86.62%	-1.15%	-2.65%	-0.40%	-4.16%	-4.16%	-0.99%	-2.93%	-0.15%
E16	SIE-3600-120-14	84.9	9.5	88.64%	-1.49%	-3.03%	-0.17%	-4.66%	-4.70%	-1.35%	-2.43%	-0.16%
F07	SIE-3600-120-14	84.9	9.5	82.97%	-1.16%	-1.66%	-0.64%	-3.46%	-3.46%	-1.53%	-1.71%	-0.49%
F08	SIE-3600-120-14	84.9	9.5	82.76%	-1.67%	-1.51%	-0.47%	-3.64%	-3.64%	-1.66%	-1.56%	-0.56%
F09	SIE-3600-120-14	84.9	9.5	83.04%	-1.33%	-2.01%	-0.57%	-3.91%	-3.98%	-1.48%	-1.85%	-0.49%
F10	SIE-3600-120-14	84.9	9.5	82.97%	-1.31%	-2.00%	-0.40%	-3.71%	-3.82%	-1.40%	-1.63%	-0.48%

F11	SIE-3600-120-14	84.9	9.6	83.24%	-1.04%	-2.31%	-0.34%	-3.69%	-3.78%	-1.62%	-2.95%	-0.32%
F12	SIE-3600-120-14	84.9	9.6	84.07%	-2.02%	-2.58%	-0.62%	-5.23%	-5.30%	-1.41%	-2.71%	-0.46%
F13	SIE-3600-120-14	84.9	9.6	85.50%	-1.74%	-3.40%	-0.45%	-5.44%	-5.51%	-1.58%	-3.89%	-0.51%
F14	SIE-3600-120-14	84.9	9.6	88.44%	-2.00%	-2.62%	-0.31%	-4.92%	-4.95%	-1.18%	-3.23%	-0.45%
F15	SIE-3600-120-14	84.9	9.5	90.07%	-1.82%	-3.31%	-0.25%	-5.33%	-5.33%	-1.49%	-3.18%	-0.25%

Table D-12 Turbine level wake results for Walney Extension 3

Turbine name	Turbine model	Hub height [m]	Ambient mean wind speed [m/s]	Turbine interaction efficiency for baseline (%)	Compared to baseline for Scn1	Compared to baseline for Scn2	Compared to baseline for Scn3	Compared to baseline for Scn4	Compared to baseline for Scn5	Compared to baseline for Scn1b	Compared to baseline for Scn2b	Compared to baseline for Scn3b
A01	VES-8320-164-02iF	112.3	10.0	94.77%	-0.75%	-3.92%	-0.42%	-4.72%	-4.76%	-0.84%	-4.46%	-0.51%
A02	VES-8320-164-02iF	112.3	10.0	92.85%	-0.68%	-4.65%	-0.62%	-5.52%	-5.52%	-0.69%	-4.52%	-0.53%
A03	VES-8320-164-02iF	112.3	10.0	92.56%	-1.01%	-4.85%	-0.43%	-5.84%	-5.84%	-0.84%	-4.46%	-0.44%
A04	VES-8320-164-02iF	112.3	10.0	92.43%	-0.90%	-4.42%	-0.72%	-5.97%	-5.96%	-1.08%	-4.30%	-0.63%
A05	VES-8320-164-02iF	112.3	10.0	91.73%	-1.01%	-4.82%	-0.44%	-5.97%	-6.04%	-1.17%	-4.06%	-0.35%
B01	VES-8320-164-02iF	112.3	10.0	93.45%	-0.59%	-4.41%	-0.30%	-4.92%	-4.92%	-0.82%	-3.39%	-0.31%
B02	VES-8320-164-02iF	112.3	10.0	90.34%	-0.53%	-3.67%	-0.17%	-3.99%	-4.01%	-0.92%	-3.80%	-0.28%
B03	VES-8320-164-02iF	112.3	10.0	89.46%	-0.87%	-4.38%	-0.35%	-5.17%	-5.16%	-0.87%	-4.00%	-0.18%
B04	VES-8320-164-02iF	112.3	10.0	88.51%	-1.04%	-4.47%	-0.44%	-5.57%	-5.57%	-0.96%	-3.63%	-0.25%
B05	VES-8320-164-02iF	112.3	10.0	89.41%	-1.18%	-5.18%	-0.42%	-5.98%	-6.05%	-0.79%	-4.28%	-0.36%
C01	VES-8320-164-02iF	112.3	10.0	93.72%	-0.80%	-3.37%	-0.38%	-4.00%	-4.00%	-0.72%	-3.43%	-0.43%
C02	VES-8320-164-02iF	112.3	10.0	90.72%	-0.74%	-3.45%	-0.24%	-4.08%	-4.10%	-0.57%	-2.91%	-0.24%
C03	VES-8320-164-02iF	112.3	10.0	89.34%	-0.73%	-4.10%	-0.58%	-5.03%	-5.03%	-0.78%	-3.60%	-0.25%
C04	VES-8320-164-02iF	112.3	10.0	87.89%	-1.09%	-4.01%	-0.52%	-4.81%	-4.81%	-0.61%	-3.70%	-0.28%
C05	VES-8320-164-02iF	112.3	10.0	86.59%	-0.87%	-3.72%	-0.66%	-4.60%	-4.60%	-0.70%	-3.07%	-0.56%
C06	VES-8320-164-02iF	112.3	10.0	87.33%	-0.87%	-4.34%	-0.57%	-5.41%	-5.49%	-1.18%	-4.24%	-0.47%
C07	VES-8320-164-02iF	112.3	9.9	88.71%	-0.86%	-4.10%	-0.55%	-4.98%	-5.05%	-0.96%	-3.66%	-0.56%

D01	VES-8320-164-02iF	112.3	10.0	89.94%	-0.54%	-3.20%	-0.22%	-3.59%	-3.61%	-0.69%	-3.21%	-0.36%
D02	VES-8320-164-02iF	112.3	9.9	87.87%	-0.81%	-3.97%	-0.43%	-4.68%	-4.68%	-0.68%	-3.37%	-0.27%
D03	VES-8320-164-02iF	112.3	9.9	86.65%	-0.58%	-3.38%	-0.39%	-4.09%	-4.09%	-0.49%	-2.79%	-0.35%
D04	VES-8320-164-02iF	112.3	9.9	87.09%	-1.17%	-2.73%	-0.66%	-4.15%	-4.22%	-1.12%	-3.84%	-0.63%
D05	VES-8320-164-02iF	112.3	9.9	87.03%	-1.20%	-3.49%	-0.47%	-4.35%	-4.43%	-0.98%	-3.62%	-0.58%
E01	VES-8320-164-02iF	112.3	10.0	88.70%	-0.80%	-2.70%	-0.45%	-3.52%	-3.53%	-0.68%	-2.43%	-0.25%
E02	VES-8320-164-02iF	112.3	9.9	86.98%	-0.49%	-2.85%	-0.28%	-3.22%	-3.24%	-0.71%	-2.60%	-0.48%
E03	VES-8320-164-02iF	112.3	9.9	85.56%	-0.62%	-3.22%	-0.64%	-4.09%	-4.12%	-0.77%	-2.60%	-0.23%
E04	VES-8320-164-02iF	112.3	9.9	86.93%	-1.17%	-2.87%	-0.66%	-4.15%	-4.26%	-0.87%	-2.77%	-0.47%
F01	VES-8320-164-02iF	112.3	9.9	89.01%	-0.78%	-2.06%	-0.31%	-2.79%	-2.79%	-0.45%	-1.89%	-0.34%
F02	VES-8320-164-02iF	112.3	9.9	88.10%	-0.59%	-2.14%	-0.24%	-2.78%	-2.79%	-0.68%	-1.69%	-0.36%
F03	VES-8320-164-02iF	112.3	9.9	86.12%	-0.51%	-2.48%	-0.32%	-3.03%	-3.07%	-0.44%	-2.25%	-0.33%
F04	VES-8320-164-02iF	112.3	9.9	86.16%	-0.97%	-2.70%	-0.56%	-3.51%	-3.61%	-0.65%	-1.73%	-0.56%
F05	VES-8320-164-02iF	112.3	9.9	87.35%	-1.04%	-3.42%	-0.44%	-4.15%	-4.22%	-1.30%	-2.47%	-0.36%
G01	VES-8320-164-02iF	112.3	9.9	89.24%	-0.51%	-1.92%	-0.12%	-2.24%	-2.25%	-0.38%	-1.80%	-0.30%
G02	VES-8320-164-02iF	112.3	9.9	87.37%	-0.80%	-2.49%	-0.43%	-3.38%	-3.40%	-0.89%	-2.11%	-0.35%
G03	VES-8320-164-02iF	112.3	9.9	86.14%	-1.03%	-2.65%	-0.17%	-3.10%	-3.17%	-0.78%	-1.88%	-0.17%
G04	VES-8320-164-02iF	112.3	9.9	88.12%	-0.95%	-2.97%	-0.27%	-4.03%	-4.13%	-0.79%	-2.39%	-0.13%
H01	VES-8320-164-02iF	112.3	9.9	90.27%	-0.71%	-1.67%	-0.12%	-2.00%	-2.06%	-0.52%	-1.65%	-0.24%
H02	VES-8320-164-02iF	112.3	9.9	88.55%	-0.84%	-2.02%	-0.29%	-2.70%	-2.75%	-0.45%	-2.02%	-0.26%
H03	VES-8320-164-02iF	112.3	9.9	88.03%	-0.89%	-2.15%	-0.17%	-2.63%	-2.68%	-0.79%	-2.43%	-0.22%
H04	VES-8320-164-02iF	112.3	9.9	89.57%	-0.92%	-2.18%	-0.17%	-3.03%	-3.10%	-0.94%	-2.14%	-0.14%
H05	VES-8320-164-02iF	112.3	9.8	89.95%	-0.86%	-2.31%	-0.20%	-3.09%	-3.11%	-1.14%	-2.39%	-0.15%

Table D-13 Turbine level wake results for Walney Extension 4

Turbine name	Turbine model	Hub height [m]	Ambient mean wind speed [m/s]	Turbine interaction efficiency for baseline (%)	Compared to baseline for Scn1	Compared to baseline for Scn2	Compared to baseline for Scn3	Compared to baseline for Scn4	Compared to baseline for Scn5	Compared to baseline for Scn1b	Compared to baseline for Scn2b	Compared to baseline for Scn3b
A06	SIE-7000-154-13	106.7	9.8	92.84%	-1.49%	-4.38%	-0.65%	-6.02%	-6.17%	-0.71%	-3.84%	-0.56%
A07	SIE-7000-154-13	106.7	9.8	92.45%	-1.89%	-3.81%	-0.64%	-6.31%	-6.46%	-1.28%	-2.80%	-0.56%
A08	SIE-7000-154-13	106.7	9.8	91.43%	-1.76%	-3.10%	-0.64%	-5.49%	-5.64%	-1.80%	-3.68%	-0.55%
A09	SIE-7000-154-13	106.7	9.8	90.73%	-1.95%	-2.93%	-0.65%	-5.53%	-5.65%	-1.32%	-2.87%	-0.75%
A10	SIE-7000-154-13	106.7	9.8	90.11%	-1.35%	-3.54%	-0.84%	-5.73%	-5.84%	-1.48%	-3.46%	-0.77%
A11	SIE-7000-154-13	106.7	9.8	90.16%	-1.65%	-3.25%	-0.85%	-5.74%	-5.92%	-1.86%	-2.46%	-0.58%
A12	SIE-7000-154-13	106.7	9.8	90.58%	-1.65%	-2.81%	-0.67%	-5.13%	-5.37%	-1.86%	-2.36%	-0.67%
A13	SIE-7000-154-13	106.7	9.8	89.73%	-1.69%	-2.50%	-0.85%	-5.04%	-5.27%	-1.73%	-2.34%	-0.51%
A14	SIE-7000-154-13	106.7	9.8	90.71%	-1.87%	-2.51%	-0.67%	-5.04%	-5.16%	-1.72%	-2.55%	-0.68%
B06	SIE-7000-154-13	106.7	9.9	92.32%	-1.26%	-4.44%	-0.48%	-5.72%	-5.97%	-0.64%	-3.86%	-0.44%
B07	SIE-7000-154-13	106.7	9.8	90.95%	-1.36%	-4.08%	-0.65%	-5.92%	-6.05%	-1.42%	-3.99%	-0.45%
B08	SIE-7000-154-13	106.7	9.8	90.73%	-1.69%	-4.43%	-0.37%	-6.27%	-6.40%	-1.87%	-3.11%	-0.85%
B09	SIE-7000-154-13	106.7	9.8	90.30%	-1.46%	-4.43%	-0.56%	-6.24%	-6.41%	-1.45%	-3.94%	-0.66%
B10	SIE-7000-154-13	106.7	9.8	90.12%	-1.25%	-3.93%	-0.48%	-5.77%	-5.87%	-1.24%	-3.56%	-0.28%
B11	SIE-7000-154-13	106.7	9.8	88.61%	-1.72%	-3.57%	-0.30%	-5.57%	-5.71%	-1.90%	-3.93%	-0.49%
B12	SIE-7000-154-13	106.7	9.8	86.13%	-1.57%	-2.86%	-0.48%	-4.90%	-5.04%	-1.74%	-2.83%	-0.44%
B13	SIE-7000-154-13	106.7	9.8	86.45%	-2.03%	-2.88%	-0.54%	-5.45%	-5.63%	-1.60%	-2.55%	-0.66%
B14	SIE-7000-154-13	106.7	9.8	86.61%	-2.29%	-3.04%	-0.54%	-5.87%	-6.12%	-1.65%	-2.61%	-0.60%
B15	SIE-7000-154-13	106.7	9.8	86.63%	-2.14%	-2.30%	-0.54%	-4.97%	-5.03%	-1.79%	-2.57%	-0.55%
B16	SIE-7000-154-13	106.7	9.8	86.66%	-2.14%	-2.40%	-0.51%	-5.05%	-5.23%	-2.31%	-2.33%	-0.58%
B17	SIE-7000-154-13	106.7	9.7	86.75%	-2.06%	-2.21%	-0.69%	-4.96%	-5.16%	-1.83%	-1.65%	-0.71%
C08	SIE-7000-154-13	106.7	9.8	91.00%	-1.12%	-4.94%	-0.55%	-6.14%	-6.33%	-1.58%	-4.22%	-0.36%
C09	SIE-7000-154-13	106.7	9.8	88.81%	-1.39%	-3.61%	-0.85%	-5.64%	-5.75%	-1.72%	-4.39%	-0.56%

C10	SIE-7000-154-13	106.7	9.8	90.19%	-1.54%	-3.71%	-0.83%	-6.02%	-6.11%	-1.29%	-4.28%	-0.56%
C11	SIE-7000-154-13	106.7	9.8	89.93%	-1.62%	-3.67%	-0.43%	-5.69%	-5.81%	-1.46%	-3.51%	-0.43%
C12	SIE-7000-154-13	106.7	9.8	87.72%	-1.88%	-3.63%	-0.59%	-6.09%	-6.24%	-1.68%	-3.66%	-0.55%
C13	SIE-7000-154-13	106.7	9.8	85.37%	-2.09%	-2.56%	-0.61%	-5.26%	-5.34%	-1.66%	-2.71%	-0.60%
C14	SIE-7000-154-13	106.7	9.8	85.69%	-1.43%	-2.50%	-0.45%	-4.38%	-4.50%	-1.59%	-2.65%	-0.34%
C15	SIE-7000-154-13	106.7	9.8	85.88%	-1.49%	-2.40%	-0.38%	-4.27%	-4.45%	-2.05%	-2.10%	-0.51%
C16	SIE-7000-154-13	106.7	9.7	84.17%	-1.54%	-2.30%	-0.54%	-4.39%	-4.39%	-1.71%	-2.13%	-0.56%
C17	SIE-7000-154-13	106.7	9.8	84.58%	-1.89%	-1.95%	-0.44%	-4.28%	-4.42%	-1.88%	-1.69%	-0.49%
C18	SIE-7000-154-13	106.7	9.8	84.80%	-1.91%	-1.82%	-0.50%	-4.23%	-4.26%	-1.55%	-1.61%	-0.49%
C19	SIE-7000-154-13	106.7	9.8	84.79%	-1.50%	-2.08%	-0.62%	-4.19%	-4.33%	-1.67%	-1.67%	-0.62%
C20	SIE-7000-154-13	106.7	9.7	85.00%	-2.19%	-1.84%	-0.71%	-4.74%	-4.88%	-1.60%	-1.52%	-0.37%
C21	SIE-7000-154-13	106.7	9.7	85.14%	-2.61%	-1.30%	-0.60%	-4.51%	-4.69%	-1.28%	-1.82%	-0.78%
D06	SIE-7000-154-13	106.7	9.8	90.42%	-1.28%	-3.66%	-0.49%	-4.93%	-5.05%	-0.88%	-3.99%	-0.34%
D07	SIE-7000-154-13	106.7	9.8	89.65%	-1.37%	-4.25%	-0.43%	-5.60%	-5.78%	-1.00%	-4.08%	-0.28%
D08	SIE-7000-154-13	106.7	9.8	88.43%	-1.29%	-3.83%	-0.55%	-5.43%	-5.59%	-1.57%	-3.52%	-0.45%
D09	SIE-7000-154-13	106.7	9.8	88.41%	-1.41%	-3.23%	-0.45%	-4.92%	-5.01%	-1.59%	-3.52%	-0.53%
E05	SIE-7000-154-13	106.7	9.8	88.62%	-0.90%	-3.65%	-0.36%	-4.66%	-4.74%	-1.02%	-4.06%	-0.25%
E06	SIE-7000-154-13	106.7	9.8	88.62%	-1.22%	-4.00%	-0.53%	-5.49%	-5.52%	-0.83%	-3.46%	-0.25%
E07	SIE-7000-154-13	106.7	9.8	88.36%	-1.00%	-3.72%	-0.47%	-4.98%	-5.07%	-0.58%	-3.44%	-0.52%
E08	SIE-7000-154-13	106.7	9.8	89.11%	-1.66%	-3.20%	-0.63%	-4.83%	-4.96%	-1.43%	-3.22%	-0.53%
F06	SIE-7000-154-13	106.7	9.8	90.50%	-0.94%	-3.92%	-0.38%	-4.54%	-4.58%	-0.69%	-3.37%	-0.26%
F07	SIE-7000-154-13	106.7	9.8	89.10%	-1.07%	-3.29%	-0.39%	-4.47%	-4.56%	-1.31%	-2.76%	-0.47%
G05	SIE-7000-154-13	106.7	9.8	90.55%	-0.91%	-3.68%	-0.40%	-4.62%	-4.62%	-0.92%	-3.08%	-0.30%
H06	SIE-7000-154-13	106.7	9.8	89.45%	-0.77%	-2.47%	-0.36%	-3.44%	-3.46%	-0.83%	-2.95%	-0.31%

APPENDIX E: ANALYSIS METHODOLOGY

E-1 Wind data analysis process overview

The analysis of the wind data involved several steps, which are summarised below:

1. The processed and long-term corrected wind speed data from the wind climate locations are processed and evaluated for an estimation of long-term wind speeds extrapolated to hub height using power law wind shear exponent.
2. Long-term hub-height wind speed and direction frequency distribution estimates at each wind climate location are derived from the measured and synthesized data.
3. The wind regime at the turbine locations is assessed using wind flow models and WT experience and judgment.

E-2 Hub-height wind speed and direction distributions

E-2.1 Shear power law

The boundary layer power law shear exponents at the measurement locations are derived from the available measurement heights. The power law relates the ratio of measured wind speeds, $\boldsymbol{U_1/U_2}$, to the ratio of the measurement heights, $\boldsymbol{z_1/z_2}$, using the wind shear exponent, $\boldsymbol{\alpha}$, as follows:

$$\frac{\overline{U}(z_1)}{\overline{U}(z_2)} = \left(\frac{z_1}{z_2}\right)^{\alpha}$$

where

α is power law wind shear exponent
$\overline{U}$ is the wind speed
z is the height above mean sea level

The boundary-layer power law shear exponent was derived for each measurement location using the ratios of measured concurrent wind speed data recorded at multiple measurement heights.

E-2.2 Directional shear method

The relationship between two or more heights at a measurement location is established for each of twelve 30° direction sectors, using the technique described in Section E-4.1. These relationships are used to derive the boundary-layer power law shear exponent in each of the twelve direction sectors, which are then used to extrapolate data recorded at the primary measurement height to the target hub height, on a directional basis.

The annual average wind speed frequency and direction distributions at measurement height are determined from the site period wind speed data using the mean of monthly means approach described in Section E-4.4. The resulting distributions in each direction sector are then scaled to the predicted long-term hub height wind speed(s).

E-2.3 Time series method

The boundary-layer power law shear exponent is derived between two measurement heights for each 10 minutes, or hourly, time step. A time series of wind speed at the target hub height is calculated by extrapolating the upper measurement height using the instantaneous boundary-layer power law shear exponent. The Mean of Monthly Means procedure is used to avoid the introduction of bias into the annual wind regime prediction from seasonally uneven data coverage at each mast as discussed in Section E-4.4.

E-2.4 Annual shear method

The relationship between two, or more, heights at a measurement location is established using the concurrent mean of monthly means technique described in Section E-4.4. These relationships are used to derive the boundary-layer power law shear exponent, which is then used to extrapolate data recorded at the upper measurement height to the target hub height.

E-3 Wind flow modelling (offshore)

To calculate the variation of mean wind speed over the site, several techniques are considered:

- For offshore projects, any site-specific downscaled mesoscale map obtained for the site will be considered.
- In addition to the above, any publicly available wind maps (global, regional, national) covering the vicinity of the project is considered.

Unless coastal effects are anticipated, speed-up factors between the proposed turbine locations and wind climate locations are derived on an all-directional basis from the different techniques outlined above and compared. Depending on the results of the comparison, and the quality of the validation if multiple measurement locations are available, the most robust technique for predicting the wind speed variation across the site will be identified. This may be an ensemble approach consisting of results from multiple models.

To determine the long-term mean wind speed at any location, the speed-up factor for each location is applied to the long-term wind speed previously derived for the measurement location.

The following sub-sections describe each of the modelling approaches in further detail.

E-3.1 Global Wind Atlas

The Global Wind Atlas is a combined mesoscale and microscale wind flow model which has been run to produce results for the entire global land mass and coastal areas with a focus on the needs of wind resource and energy assessment. Model outputs are available at elevations of 10, 50, 100, 150 and 200 m above ground/sea at a downscaled horizontal grid spacing of 250 m. Further details of the model can be found at https://globalwindatlas.info/about/introduction.

E-3.2 New European Wind Atlas

The New European Wind Atlas (NEWA) uses the Weather Research and Forecasting (WRF) model, forced with ERA5 reanalysis data, to generate a regional map of wind speed variation across Europe and Turkey, including offshore.

Data are available at seven heights between 50 m and 500 m. Both mesoscale and microscale modelling has been performed. The mesoscale data is based on a simulation period of 30 years and has a horizontal grid resolution of 3 km. Further details of the model can be found at www.neweuropeanwindatlas.eu.

E-4 Gross energy output / assessment of wakes

The gross energy production is the energy production of the wind farm obtained by calculating the predicted free stream hub height wind speed distribution at each turbine location and the manufacturer-supplied turbine power curve.

In defining the gross energy output, it is assumed that there are no wake interactions between the turbines and no energy loss factors are applied. The Energy Yield and the subsequent impact of the wakes produced by the individual wind farms have been calculated using WindFarmer Analyst computational model. It includes adjustments to the power curve to account for differences between the predicted long-term annual turbine location air density and the air density to which the power curve is referenced.

Of concern in any Energy Yield study is the effect of wake and turbine interaction losses (including blockage effect) from inside the farm and from adjacent farm sites. WT's typical best practice is to use the WindFarmer: Analyst Eddy Viscosity with large wind farm correction model to estimate offshore wake and turbine interaction effects, as validated by DNV in 2019, which results in lower errors across a number of operational offshore wind farms compared to other wake models.

E-4.1 Turbine interaction effect calculations

Wind turbines extract energy from the wind and downstream from each turbine there is a momentum deficit with respect to free stream conditions, which is equal to the thrust force on the machine, referred to as the wake, where the wind speed is reduced. As the flow proceeds downstream there is a spreading of the wake and the wake recovers towards free stream conditions. Turbulent momentum transfer is important in this process.

The wake effect loss is the aggregated influence on the energy production of the wind farm which results from the changes in wind speed caused by the impact of the turbines on each other. WT uses the WindFarmer: Analyst software – Eddy Viscosity model and implements the Large Wind Farm correction for offshore projects. This software has been developed by DNV and validated using measurements on both full-scale machines and on wind-tunnel models.

The model is employed in a scheme which, taking each wind speed and direction in turn calculates the power production of the wind farm. The important parameters used in this process are:

- array layout
- upstream mean wind speed
- ambient turbulence
- wind turbine thrust characteristic
- wind turbine power characteristic
- rotor speed
- speed-up factors from site wind flow calculations

Any wind speed variations across the site due to coastal or mesoscale effects are accounted for in the model using the speed-up factors calculated by an appropriate wind flow model as described above. The array model is used to calculate the wind speed in the turbine wakes, assuming the terrain is flat, and the wind speed is adjusted by the speed-up factor when the wake reaches a downstream turbine.

E-4.1a Internal wake and blockage effects

This is the effect that the wind turbines within the wind farm being considered have on each other. In addition, the wind farm itself presents an obstacle to the incoming wind flow, which is not accounted for in many standard industry wake models and causes a slow-down effect referred to as wind farm blockage. This effect has also been calculated using the Blockage Effect Estimator Tool (BEET) within WindFarmer:Analyst which is based on more than 50 CFD simulations.

E-4.1b Wake effect external

This is the effect that the wind turbines from neighbouring wind farms (if any) have on the wind farm being considered. These are calculated in the same way as internal wake effects.

E-4.1c Future wake effect

Where future wind farms are to be constructed in the vicinity of the project under consideration, the wake effect of these may be estimated and taken into account if sufficient information is available.