

FOR-206 Balgray Wind Farm – Eskdalemuir Seismic Impact Statement

Environmental Impact Assessment Submission

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Xi Engineering Consultants, CodeBase, Argyle House, 3 Lady Lawson Street, Edinburgh, EH3 9DR, United Kingdom.
T: +44 (0)131 290 2250, xiengineering.com, Company no. SC386913

1. Executive Summary

This Environmental Impact Assessment (EIA) outlines the seismic impact of the proposed Balgray Wind Farm on the Eskdalemuir Seismic Array. Located 19.5 km from the array, Balgray falls within the Ministry of Defence's (MOD) 50 km Consultation Zone. Safeguarding this site, critical to the UK's obligations under the Comprehensive Nuclear-Test-Ban Treaty (CTBT), requires that all developments adhere to a cumulative seismic vibration threshold of 0.336 nanometers (nm).

The authors of this document (Xi Engineering Consultants), are recognised UK experts in this domain and original co-authors of the MOD's 2014 seismic safeguarding algorithm. Xi has conducted a full technical analysis of Balgray's potential impacts using updated empirical methodologies, ensuring alignment with evolving policy and safeguarding criteria. Xi's modelling tools and methodologies continue to underpin the MOD safeguarding approach.

The seismic safeguarding approach for Balgray aligns with work conducted by the Scottish Government and reformed Eskdalemuir Working Group (EWG) since 2020. The output of the EWG work and national consultations has formed a revised approach to safeguarding the array going forward. This approach is recognised by the MOD, UK Government, Scottish Government, Renewable UK and Scottish Renewables as the clear proposed route forward to be adopted as formal policy. Balgray aligns to this policy and can be built without adversely affecting the EKA based on the following points:

- **Adoption of an empirical algorithm:** The original worst-case algorithm from 2014 is now recognised as over-conservative. The MOD's 2025 consultation confirms that "the current predictive model over-estimates the seismic ground vibration from existing wind farms... and that it is appropriate for a new predictive model to be developed" [1].
- **Application of a Seismic Impact Limit (SIL):** The Scottish Government has proposed SIL thresholds to fairly distribute the 0.336 nm limit. This approach is explicitly endorsed by the MOD, which stated in its 2025 consultation that it "agrees that it is appropriate for a new predictive model to be developed" and that "Seismic Impact Limits should be used to ensure individual turbines do not cause excessive impact" [1]. The UK Government's Onshore Wind Taskforce further confirms that adoption of the SIL framework is essential. According to its 2025 policy update:

"The Taskforce strongly supports the implementation of a queue-based Seismic Impact Limit (SIL) allocation model as the most effective way to unlock constrained capacity within the Eskdalemuir Consultation Zone, whilst preserving the operational integrity of the seismic array" [2].

- **Before-and-after monitoring methodology:** Both MOD and Scottish Government guidance now endorse pre- and post-installation seismic measurements to subtract background seismic noise not attributable to turbines. As stated in Eskdalemuir Working Group reports:

"It is an over-estimate to assume all measured vibration is from turbines, as it includes background noise. Measuring both before and after installation allows this background to be removed from calculations" [3].

- **Selection of low seismic emission turbines:** Scottish Government guidance encourages the use of turbine models with "*the lowest seismic impact*" [4][5]. This approach is backed by empirical studies showing 23–43% lower measured amplitudes than original worst-case estimates. The range shows that specific turbine choice can allow substantially lower impact within the ECZ. As noted in Xi Engineering reports [6] and endorsed in Renewable's 2025 briefing, turbine selection based on low seismic output is a critical mitigation strategy within the consultation zone [2].

Balgray has been designed to satisfy all four criteria and, under all proposed Seismic Impact Limit (SIL) ranges (1.0 GW to 2.5 GW), and across all SIL queue analysis scenarios, Balgray can be built out using a number of turbine models, adopting the standard before-and-after monitoring approach. These configurations remain well within both the absolute MOD threshold of 0.336 nm and the SIL framework.

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Matters relating to this document should be directed to:	
Xi Engineering Consultants	
Audrey Opdycke-Barnes	E: audrey@xiengineering.com
Futures Development Manager	T: +44 (0)131 290 2208
Dr Mark-Paul Buckingham	E: mp@xiengineering.com
Managing Director	T: +44 (0)131 290 2257
Fred. Olsen Renewables	
Julie Aitken	E: Julie.Aitken@fredolsen.com
Senior Project Manager	T: +44 (0)7887 922180

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2. Background and National Safeguarding Policy

The Eskdalemuir Seismic Array is a critical national defence asset and a core component of the UK's seismic monitoring infrastructure. It is a designated auxiliary station of the International Monitoring System (IMS) under the CTBT, operated by the MOD with the explicit goal of detecting covert nuclear tests worldwide.

To protect the array's detection sensitivity, the MOD applies a cumulative seismic noise limit of 0.336 nm for all wind developments within 50 km [5]. Within a 10 km inner exclusion zone, no turbines are permitted. The remainder of the consultation zone is managed through a cumulative noise budget, historically governed by an algorithm developed by Xi Engineering in 2014 [6].

That 2014 algorithm was intentionally conservative. It used limited empirical data and assumed worst-case turbine vibration characteristics, which led to the early theoretical exhaustion of the 0.336 nm seismic vibration budget. However, real-world measurement campaigns collected over the last decade across operational sites have consistently shown that actual turbine-induced seismic noise is substantially lower — in some cases, 23–43% lower — than the algorithm assumed [6].

This discrepancy has triggered a broad policy shift. The Scottish Government and MOD are currently consulting on technical and planning reforms, while the UK Government is progressing legislative changes to formalise these measures. This includes work to embed the Seismic Impact Limit (SIL) approach and associated safeguarding controls into national consenting legislation for onshore wind development.

The emerging policy includes:

- Empirical modelling methodologies.
- The Seismic Impact Limit (SIL) approach: assigning per-turbine seismic emission limits scaled by turbine capacity.
- Queue-based SIL budgeting to ensure fairness across the 50 km zone.
- Optimised deployment utilising before-and-after measurement protocols.

These measures are clearly reflected in the MOD's 2025 public consultation [1], the Scottish Renewables Eskdalemuir Roadmap [3], and endorsed in Renewable's 2025 policy update [2].

3. Assessment Approach and Results

Balgray Wind Farm comprises six turbines rated at 6.2 MW each. A comprehensive seismic assessment has been carried out by Xi Engineering, developed in accordance with methodologies emerging from the Scottish Government's Eskdalemuir Working Group (EWG), which the MOD recognises as the appropriate forum for evolving policy and technical direction in multiple published consultations. This confirms Balgray's compatibility with the emerging safeguarding regime. A summary of the approach is provided here to demonstrate the robustness of the work undertaken:

- **The MOD-accepted empirical modelling approach** developed by Xi [6][7].
- **Empirical real-world data** used in the Scottish Government Phase 4 study, combined with additional measurements of modern turbines gathered in the intervening period.
- **Alignment with the before-and-after monitoring protocol** recommended by EWG and supported by the MOD [3].
- **Enforcement of the SIL over the full range** assessed in government modelling, including the Phase 5 report.
- **A queue-based SIL modelling approach** accounting for proposed developments in the 50 km zone [7].

Results:

- Balgray's total contribution remains significantly below the 0.336 nm cumulative limit.
- Several turbine configurations fall within the full range of proposed SIL thresholds when adopting the standard before-and-after monitoring approach.
- **When included in SIL queue scenarios, Balgray's cumulative impact remains below the 0.336 nm MOD threshold.**

Contingency:

Should future vibration reductions be necessary — for example, due to unexpected future queue growth or revised SIL thresholds — Balgray retains technical scope to deploy known mitigation approaches such as:

- Control-based curtailment measures (similar to acoustic noise strategies).
- Installation of Tuned Mass Dampers (TMDs), commonly used on tall steel chimneys and some wind farms.

- Seismic foundation isolation, a proven technique for protecting sensitive infrastructure such as hospitals and power stations.

4. Policy and Planning Alignment

The Balgray approach to seismic vibration is not just technically robust — it has been explicitly designed to align with the evolving UK-wide policy environment. The following official positions and planning documents directly support the project’s methodology:

- **MOD (2025 Consultation):** Advocates for SIL adoption and a shift away from the original predictive model [1].
- **UK Government Onshore Wind Taskforce (2023–2025):** Supports queue-based SIL implementation and increased turbine-specific analysis to unlock constrained capacity [2].
- **Scottish Government – Draft Onshore Wind Policy Statement (2022):** Emphasises empirical modelling and safeguarding alignment [4].
- **Scottish Government – Onshore Wind Sector Deal (2023):** Encourages low-vibration turbine selection and commitments to national security safeguards [5].
- **Onshore Wind Taskforce – Industry Working Paper (2023–2024):** Promotes background subtraction, queue-based limits, and updated developer tools [4].
- **Scottish Renewables – Eskdalemuir Roadmap (2025):** Provides detailed implementation guidance for developers and consenting authorities [3].

Collectively, these policy instruments confirm that Balgray’s approach is not speculative — it directly reflects best-practice planning guidance and national security safeguarding under development across the UK. The development anticipates future monitoring obligations and **remains within the MOD’s agreed 0.336 nm cumulative vibration budget**, while aligning with the technical direction and consultation outcomes shaping future consenting requirements.

5. Conclusion

Balgray Wind Farm demonstrates that renewable energy development and national security safeguards can be successfully balanced through the use of empirical data, modern modelling techniques, and alignment with emerging policy.

The project:

- Aligns with the latest policy direction from the MOD, UK Government, and Scottish Government.
- Applies the Seismic Impact Limit (SIL) approach advocated across national consultations.
- Incorporates before-and-after seismic monitoring to isolate turbine-specific impact.
- Has been fully assessed by Xi Engineering Consultants, who performed all technical calculations using validated empirical data and SIL queue modelling.
- All supporting analysis has been completed and is available but has not been appended here to maintain clarity and avoid excessive technical detail in the Environmental Impact Assessment submission.
- Can be built without adversely affecting the Eskdalemuir array, remaining within the MOD's agreed 0.336 nm cumulative vibration budget, based on the adoption of the SIL approach combined with before-and-after monitoring. This gives Fred. Olsen Renewables the flexibility to select from several turbine models that will meet this requirement.
- Offers a technically sound, policy-aligned development model that sets a precedent for future wind energy consenting within the Eskdalemuir Consultation Zone.

6. References

- [1] Ministry of Defence – Consultation on Safeguarding the Eskdalemuir Seismological Array (2025): <https://www.gov.uk/government/consultations/eskdalemuir-seismic-safeguarding-consultation-2025>
- [2] Renewable UK – Policy Update on the Eskdalemuir Constraint (2025), on behalf of the UK Government Onshore Wind Taskforce:
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- [4] Scottish Government – Draft Onshore Wind Policy Statement (2022):
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- [6] Xi Engineering – SGV_204_Technical_Report_v12 (2022):
https://www.scottishrenewables.com/assets/000/003/471/SGV_204_Technical_Report_v12_original.pdf
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