Eskdalemuir Working Group Minutes – 19th February 2024

Welcome/Introductions

A Scottish Government official opened the meeting, and no apologies were noted for members. Group members welcomed a new representative for RenewableUK, completing a round of introductions setting out their individual backgrounds and roles in the working group.

Guidance Update

A Scottish Government representative provided a brief update on the guidance drafting process, supported by a member of the BVGA team providing support on this and wider EWG administrative tasks. BVGA have amalgamated draft versions and released a live version for further updates. Also created a tracker for comments and another for actions which is used by Scottish Government, BVGA and SR to monitor progress of the drafting process.

Group members were reminded that the deadline for consulting on the draft guidance is set as end of March, acknowledging that the last day of March falls on a Sunday and therefore would be the last working day possible (28 March 2024). To enable this, all members were asked to review and provide further comment on the draft document by the end of the week (23 February 2024).

The group discussed the purpose of sub-groups which had been set up to take place over the following two weeks, clarification provided that these sub-groups will seek to address specific outstanding comments within the draft where there is either conflict or actions to be agreed upon. Two sub-groups have been established, one will take place on 20 February and the other on 5 March. All comments remaining in the draft will be addressed w/c 4 March by Scottish Government.

The Scottish Government representative confirmed that the intention is to finalise a document for consultation by 15 March 2024 to ensure there is sufficient time to arrange the consultation. It was flagged that ensuring read across from this document and MOD's management approach document (details provided in MOD Update section below) will be a key priority over the next few weeks.

A point was raised around process flow charts. The Scottish Government representative noted they would reach out to the HOPS representative following the meeting for some information to aid the creation of these.

MOD Update

The MOD representative provided an update to group members on three key strands of work currently underway:

1. Baseline validation – MOD have procured external consultancy support to conduct this exercise, with MOD and its subject matter experts using the information provided to inform decisions moving forward. The aim of this initial stage is to establish what Seismic Ground Vibration (SGV) level has been

utilised and how this affects potential headroom. Difficult to estimate an accurate timeframe but MOD expect this is not likely to complete in Q1.

2. Proposed approach to SGV management – A draft approach is undergoing internal review within MOD and their legal team. MOD intend to share a version of this draft in the coming weeks to the Scottish Government and UK Government (DESNZ) representatives, before sharing to EWG members. It will be shared more widely shortly after that. Without prejudice and commitment, and without pre-empting the consultation on the proposed approach, MOD is proffering a 'first come, first served' approach treating applications the same.
3. Safeguarding tool development – MOD representative acknowledged recent conversations with Xi Engineering on MOD requirements for an updated tool and noted they are currently considering data sharing and software matters given MOD IT security. This is ongoing.

The MOD representative noted that there will be constraints on MOD availability in coming weeks due to participation in an ongoing public local inquiry and 1:1 engagement with various developers.

The group discussed the interlinked nature of the draft guidance document and the MOD's draft management approach, acknowledging that the two documents will need to ensure consistency and mitigate any risk of conflict. A representative for the SLG and the MOD representative raised concerns regarding outstanding issues between the MOD approach and the guidance and the timescale for publishing the guidance. As part of this discussion a Scottish Government representative clarified that the management approach falls within MOD's remit. A request was made of MOD to share the draft management approach in advance of the guidance document being consulted upon.

The group discussed the consultative nature of the guidance document allowing for sufficient opportunity to review and update in the event the MOD's draft management approach causes a shift. Nevertheless, an ask was made to consider the timescales for consulting on the guidance document and the Scottish Government representative agreed to take this point away and engage with relevant officials – with reference to the onshore wind sector deal commitments.

Xi Engineering Update

A presentation was delivered by the Xi Engineering representative, slides for which are included with these minutes.

The group discussed the suggested timeframes set out in the presentation and discussed which pieces of work should be considered highest priority, noting that the work package on removal of background noise is likely to be lower priority.

It was agreed by members that further discussion on how these work packages will be funded was needed and is likely to be a fundamental consideration in what will be progressed first. The AIFCL representative confirmed that AIFCL act as the contract managing organisation as well as contributing financially towards further work. AIFCL have a track record of dealing with complex contracting such as this.

The group will consider this as a key aspect of future EWG meetings with effect from April (i.e. once the draft guidance is out to consultation).

Actions List

- BVGA to set up meeting invite for 11 March, 14:00-16:00
- BVGA to amend time of sub-group 1 meeting and reach out to any invitees who have yet to respond.
- Scottish Government to contact HOPS representative re: flowcharts
- MOD, UK Government and Scottish Government to schedule follow-up meeting to discuss MOD draft management approach and other matters
- SLG representative to send comments to Scottish Government re: publication/consultation timescales for draft guidance document

Xi Engineering Consultants

Eskdalemuir SIL Analysis

Scenario 6,7,11 & 12 Visualisation

Report presented to: AIFCL & Scottish Renewables

07/02/2024
Document number: AIFCL-103-EKA-Scenario-Visualisaton-v9

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Document Summary

The implications of Scenarios 6, 7, 11 & 12 on wind farms in Eskdalemuir 'queue' (now referred to as 'list') after Scotston Bank Wind Farm is examined. The four scenarios are extracted from the twelve scenarios as detailed in AIFCL-101-WindFarmAssessment-v10 are assessed against three pipelines. Each scenario and pipeline was modelled in order of planning application submission date then S36 scoping date. The effect of the 10 km and 15 km exclusion zones, and 2.0 GW and 2.5 GW targeted SIL on installable capacity were examined. The implications of the 2.0 GW and 2.5 GW targeted SIL on likely mitigation required by wind farms in planning and S36 scoping were also investigated.

Action	Name	Date	Version	Amendment
Originator	Dr B. Marmo	26/01/2023	v1	Document Creation
Checked by	Dr MP Buckingham	29/1/2024	v2	Review
Checked by	Dr B. Marmo	30/1/2024	v3	Mitigation section
Review	Dr MP Buckingham	30/1/2023	V4	Review
Review	Dr M Chung	31/01/2024	v5	Review
Review	Dr B. Marmo	1/2/2024	v6	Technical Review
Review	R. Horton	1/2/2024	v7	Review
Review	Dr B. Marmo	1/2/2024	v8	Review for Release
Review	Dr MP Buckingham	7/2/2024	v9	Minor Edit for re-release

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1. Introduction

The Eskdalemuir Consultation Zone (ECZ) represents roughly 10% of the Scottish Landmass and presents an ideal opportunity to deliver towards the Onshore Wind Sector Deal (OWSD) ambition of 20GW by 2030. There is in excess of 2.9GW within the ECZ currently in the planning 'queue', either at planning application stage or Sections 36 Scoping stage.

The immediate choices made by the EWG will either deliver a minimum of 1GW towards the 20GW target or have the potential to provide nearer 5GW should the appropriate measures be taken to mitigation the impact of sites closer to the array.

The AIFCL commissioned 'Implications Report' (AIFCL-101-WindFarmAssessment-v10) presented the potential impact of each of the 12 exclusion Zone and SIL scenarios from the Phase 5 work (AIFCL-101-Phase5-Rev-v08.pdf) on proposed Wind Farm Sites within the Eskdalemuir Consultation zone.

These approaches are based on a five-phase scientific study conducted by Xi Engineering Consultants (Xi) on behalf of the Scottish Government. In order for the industry to better understand the implications of the approaches on sites already within the planning system and to future proof approaches the AIFCL have identified the need for further analysis of four Scenarios:

- 10 km exclusion zone and 2.0 GW SIL
- 10 km exclusion zone and 2.5 GW SIL
- 15 km exclusion zone and 2.0 GW SIL
- 15 km exclusion zone and 2.5 GW SIL

The effect of these scenarios has been modelled to determine the likely additional capacity that could be provided by wind farms in the Eskdalemuir consultation zone. The implications with respect to seismic mitigation of wind farms in planning and S36 scoping have also been assessed.

2. Background

The seismometer array at Eskdalemuir (EKA) has two arms, each of ten seismometers, and became operational on 19 May 1962. The array is operated by AWE Blacknest (AWE) and is part of the seismic network of the organisation set up to help verify compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT) which bans nuclear explosions.

Concerns were raised that vibrations from wind turbines might affect the ability of EKA to operate properly, and MoD were advised to set a maximum permissible seismic ground vibration budget limit within a 50km radius of the EKA station location in order to safeguard its effectiveness in accordance with the CTBT. Beyond 50km it was determined that the seismic ground vibration contribution from a wind turbine is negligible and developments beyond 50 km are not included in the budget calculations. The budget limit that was deemed to be acceptable from all wind turbines that might be built within 50km of the array was set at a threshold amplitude of 0.336nm.

Xi were commissioned by the Eskdalemuir Working Group (EWG) in 2013 to develop a robust physics-based approach to estimating the worst-case seismic ground vibration produced by wind turbines. Xi developed such an algorithm which is currently used by the MoD to calculate the worst-case cumulative effect of all wind turbines on EKA; see "Seismic Vibration produced by wind turbines in the Eskdalemuir region Release 2.0 of Substantial Research Project". It is this experience that makes Xi uniquely qualified to assess and deliver a solution to mitigate the seismic ground vibration risk from wind turbines within the Eskdalemuir statutory consultation zone. The Xi algorithm requires the distance to the array, rotor diameter and the hub height to estimate the seismic ground vibration.

Due to the limited public data available on seismic emissions from wind turbines, a conservative 'worst-case' approach was adopted. This worst-case turbine algorithm now used by the MoD to allocate budget is effectively two turbines combined to provide a significant safety factor. The budget algorithm is designed with safety factors such that it over-predicts the output of any single turbine.

Xi's work: "Seismic Vibration produced by wind turbines in the Eskdalemuir region Release 2.0 of Substantial Research Project" was reviewed by the MOD Subject matter expert (Dr D Bowers) who subsequently presented to the CTBTO and it was ultimately accepted by the Scottish Government. Adopting the new algorithm opened up over 1GW of onshore wind power within the 50km Eskdalemuir consultation zone compared to the MoD's earlier approach.

3. Method

Analysis of Pipelines

Xi Engineering Consultants were supplied with a pipeline analysis report by BVGA (doc ref 'List of Projects within the consultation Zone for Xi Engineering.xlsx'). Xi performed a line-by-line audit against this spreadsheet. Several differences were noted in this audit;

- The BVGA sheet included 77 sites opposed to the current Xi list of 131 sites.
- The majority of small single wind turbines were not captured within the BVGA spreadsheet which made up the majority of missing projects and therefore have a minimal impact on predicted seismic levels.
- As the exact centre of the EKA was unknown to BVGA, eleven sites were captured that were out with the EKA consultation zone.

Regarding proposed development within the region BVGA had the following anonymised data directly from developers.

Capacity (MW)	LPA
930	Dumfries & Galloway Council
520	South Ayrshire Council
150	Scottish Borders Council

Table 1 Data on predicted future development provided by BVGA

Unfortunately it is unknown as to where within each of the LPA's these proposed developments are and if they are in the consultation zone.

The source of BVGA data was the RUK Energy Pulse system. As RUK have provided Xi Engineering Consultants some additional functionality within the Energy Pulse system, Xi directly extracted all sites within the ECZ from the EnergyPulse System. Currently Energy Pulse has 63 sites registered in the EKA zone.

Based on this analysis, Xi reverted back to the original list, however, did capture data from Table 1 to inform future deployment analysis.

Budget Headroom

The seismic impact of all sites which did not receive an objection from the MoD on seismic level grounds was determined in the previous work reported in *AIFCL-101-WindFarmAssessment-v11.pdf*. The cumulative seismic impact of all wind farms in the list up to and including Scotston Bank is 0.20756 nm. This is significantly below the budget threshold of 0.336 nm. Given that the impact of additional farms sum in quadrature, the headroom is 0.26422 nm:

$$\sqrt{0.336^2 - 0.20756^2} = 0.26422 \qquad \text{(eq. 1)}$$

Calculation of Seismic Impact Limit Levels

A *Seismic Impact Limit* (SIL) for any given turbine is the maximum value permitted of the predicted seismic ground vibration amplitude at EKA generated by the given turbine (in nanometres) relative to its rated-power output (in megawatts) given by:

$$Seismic\ Impact\ Limit = \frac{Ampitude\ at\ EKA}{\sqrt{Power}} \qquad \text{(eq. 2)}$$

Equation 2 can be used to determine the level for the SIL that would guarantee that the consumption of the 0.26422 nm of budget headroom would result in at least an additional 1 GW, 1.25 GW, 1.5 GW, 2.0 GW or 2.5 GW of wind generating capacity (Table 2). This calculation is based on the worst-case assumption that every additional turbine would produce seismic ground vibration with amplitude equal to the SIL (see *AIFCL-101-WindFarmAssessment-v11.pdf* for further details on the SIL level).

A SIL levels of 0.00591 nm.MW$^{-0.5}$ would guarantee that the available headroom would result in at least 2.0 GW, and a SIL of 0.00528 nm.MW$^{-0.5}$ would guarantee at least 2.5 GW (Table 2).

Installable Capacity Target (GW)	SIL $nm.MW^{-0.5}$
1.0	0.00836
1.25	0.00747
1.5	0.00682
2.0	0.00592
2.5	0.00529

Table 2 Seismic Impact Level (SIL) that would guarantee given targets for installable wind energy capacity based on the consumption of the 0.26422 nm of budget headroom.

Modelling methodology

The derivation of the SIL levels to guarantee deployable capacity reported in *AIFCL-101-Phase5-Rev-v11.pdf* assumed the worst-case whereby all new turbines were built close to the EKA and produce seismic levels equal to the Seismic Impact Limit for the given turbine. This implies that turbines are either being installed at the exact distance at which they meet the SIL or (more likely) utilise turbines with low seismic emissions which could incorporate some form of seismic reduction technology e.g., isolation whereby they meet the SIL. This worst-case assumption is unlikely; more likely is that many wind farms will be built at further distances from EKA whereby their impact does not approach the Seismic Impact Limit.

To determine how a Seismic Impact Limit may affect the deployable capacity within the consultation zone, a simulation was constructed to sequentially place wind turbines from the proposed wind farms after Scotston Bank in the EKA list. The simulation stops if the budget threshold in reached. At that point the total deployable capacity is calculated.

In scenarios when all turbines in the budget list have been deployed without consuming all the available headroom, then the remaining headroom is assessed by randomly placing with farms until the budget threshold is reached (following the approach detailed in in *AIFCL-101-Phase5-Rev-v11.pdf*). The number of turbines with each wind farm was randomly assigned a number between 1 and 100. The size of each turbine in the wind farm was randomly assigned a capacity between 1 and 8 MW; and every turbine within any one wind farm had the same capacity. In each simulation, any wind turbines that exceeded the Seismic Impact Limit for its given rated power, the seismic output was limited to equal the Seismic Impact Limit (effectively assuming that the turbine would have sufficiently low seismic emissions to allow it to be built). For each simulation, the total installed capacity was calculated up to the point at which all of the 0.26422 nm of budget headroom was consumed. The simulation was integrated 10,000 times and the probability distribution of total additional deployable capacity assessed.

4. Results

Installable capacity

The installation capacity was modelled for three Eskdalemuir Development Pipelines:

1. All wind farms currently in planning
2. All wind farms in planning including those in S36 scoping
3. All wind farms in planning with S36 scoping with the exception of Faw Side. The exclusion of Faw Side in this analysis is based on the recent decision by Ministers to reject the planning application. It is understood that the developer of the site still has further legal options, however, a scenario that excludes Faw Side wind farm is presented for completeness.

The modelling of installable capacity follows that in AIFCL-101-WindFarmAssessment-v11, and each Eskdalemuir Pipeline has been completed for the following four scenarios:

- 10 km exclusion zone and 2.0 GW SIL (scenario 6)
- 10 km exclusion zone and 2.5 GW SIL (scenario 7)
- 15 km exclusion zone and 2.0 GW SIL (scenario 11)
- 15 km exclusion zone and 2.5 GW SIL (scenario 12)

The results from the installable capacity analysis are listed in Table 3. Of the twelve analyses only number 5 which included S36 Scoping Farms with a 10 km exclusion zone and 2.0 GW SIL consumed all available seismic headroom before the pipeline was completed; in this case the final turbine that could be built was the 33rd at Liddesdale (of 80). In all other analysis, the entire pipelines could be installed and to estimate total capacity wind farms were placed randomly.

Analysis	Scenario	Exclusion zone	SIL (nm·MW-0.5)	SIL Minimum Deployment (GW)	Potential Immediate Deployment (GW)	Additional capacity after immediate deployment (GW)	Total additional capacity (GW)			Last Farm	Last Turbine
						Median of simulations	Median of simulations	10th %tile of simulations	90th %tile of simulations		
All turbines in planning (excluding S36 Scoping)											
1	6	10 km	0.00592	2GW	2.48	1.27	3.75	3.12	4.7	n/a	n/a
2	7		0.00529	2.5GW	2.48	2.36	4.84	3.95	6	n/a	n/a
3	11	15 km	0.00592	2GW	1.82	3.12	4.94	3.26	7.09	n/a	n/a
4	12		0.00529	2.5GW	1.82	4.14	5.96	4.12	8.17	n/a	n/a
All turbines in planning and scoping											
5	6	10 km	0.00592	2GW	3.11	n/a	n/a	n/a	n/a	Liddesdale	33 (of 80)
6	7		0.00529	2.5GW	3.34	0.92	4.26	3.76	5.05	n/a	n/a
7	11	15 km	0.00592	2GW	2.50	2.8	5.3	3.86	7.16	n/a	n/a
8	12		0.00529	2.5GW	2.50	3.74	6.24	4.69	8.24	n/a	n/a
All turbines in planning and scoping with Faw Side excluded											
9	6	10 km	0.00592	2GW	3.03	0.8	3.83	3.35	4.61	n/a	n/a
10	7		0.00529	2.5GW	3.03	1.8	4.83	4.06	5.87	n/a	n/a
11	11	15 km	0.00592	2GW	**2.47**	**2.88**	5.35	3.91	7.28	n/a	n/a
12	12		0.00529	2.5GW	**2.47**	**3.81**	6.28	4.66	8.27	n/a	n/a

Table 3 Summary of deployable capacity based on the addition of turbines from the EKA list followed by the randomised addition of turbines. For scenarios when the budget threshold was reached before all turbines in the list have been deployed the last wind farm and last turbine before the threshold has been listed.

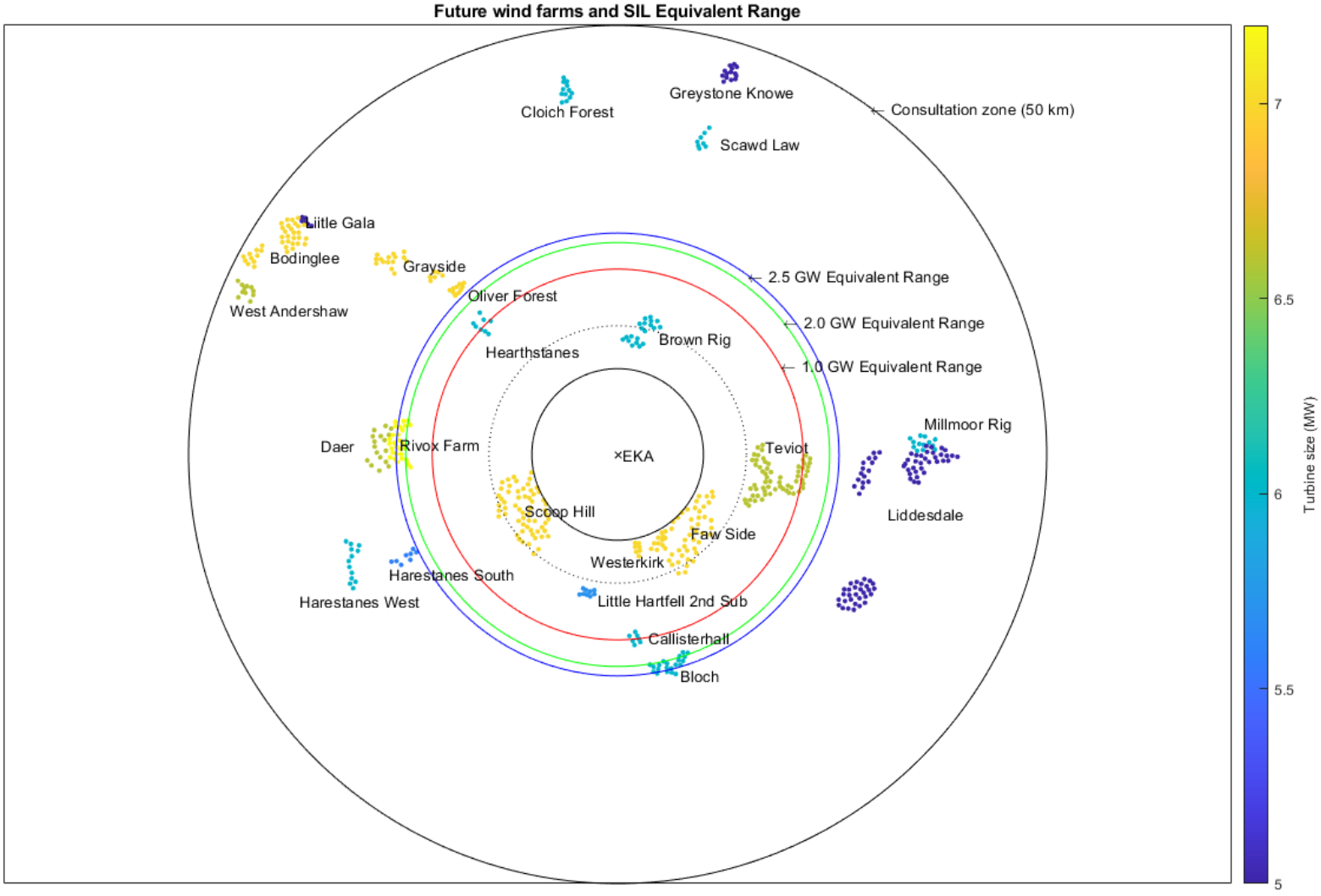


Figure 1 All turbines after Scotston Bank in the EKA list including those in S36 Scoping with the SIL Equivalent Range for 1.0 GW, 2.0 GW and 2.5 GW based on a 7.0 MW turbine

2.0 GW SIL compared to 2.5 GW SIL

The analysis reported in AIFCL-101-WindFarmAssessment-v11.pdf included Equivalent SIL Range for each SIL level. The Equivalent SIL Range is the distance at which a turbine of a given power would likely exceed the SIL and require some form of seismic mitigation. The range at which turbines would require mitigation to be installed increases with the SIL target capacity from 21.6 km for a SIL targeted at 1 GW to 25.8 km for a SIL targeted at 2.5 GW (based on a 7.0 MW wind turbine) (Table 4).

SIL Target Capacity	Seismic Impact Limit	Equivalent SIL Range for a Turbine with 7.0 MW rated power
GW	$nm.MW^{-0.5}$	km
1.0	0.00836	21.6
2.0	0.00592	24.7
2.5	0.00528	25.8

Table 4 The Equivalent SIL Range of 7.0 MW turbines are compared (scaled from the synthetic spectra derived from the measurement of GE turbines at Langhope Rig, see *AIFCL-101-WindFarmAssessment-v11.pdf*).

Figure 1 shows the position of all wind turbines in the EKA list after Scotston Bank including those in S36 Scoping. The map includes the Equivalent SIL Range for SIL values targeted at 2.0 and 2.5 GW. Increasing the SIL target from 2.0 to 2.5 GW may result in some turbines at Rivox Farm and Bloch requiring some form of mitigation to be installed without breaching the SIL.

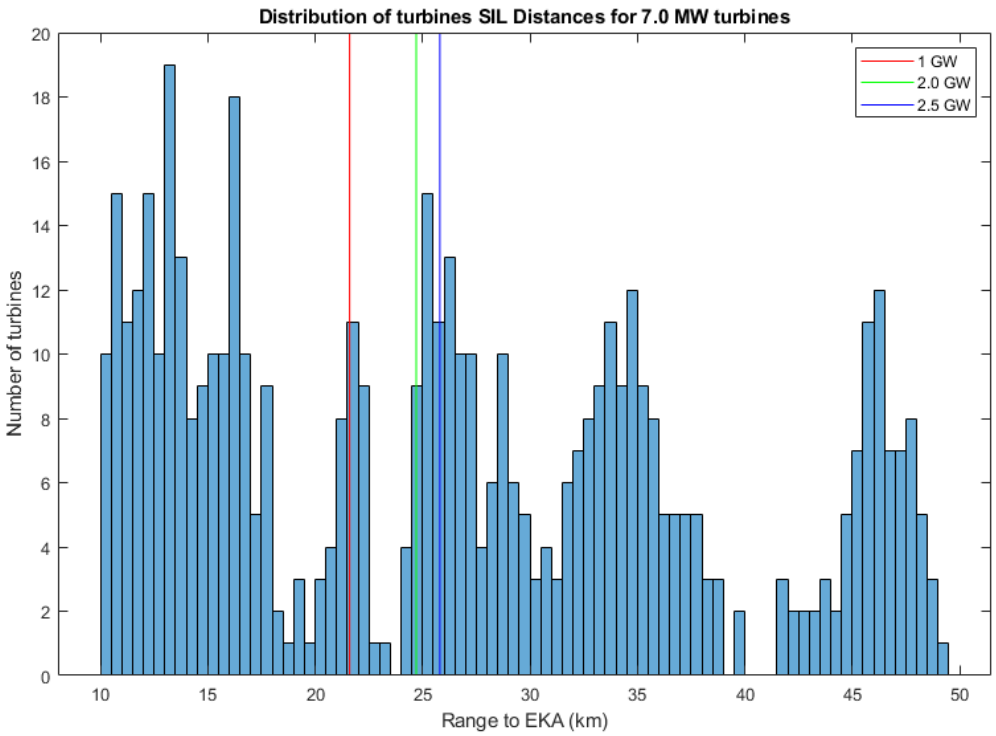


Figure 2 Histogram showing the range from EKA of all turbines in the EKA list after Scotston Bank list including those in S36 Scoping. The SIL Equivalent Range for 1.0 GW, 2.0 GW and 2.5 GW based on a 7.0 MW turbine are also shown.

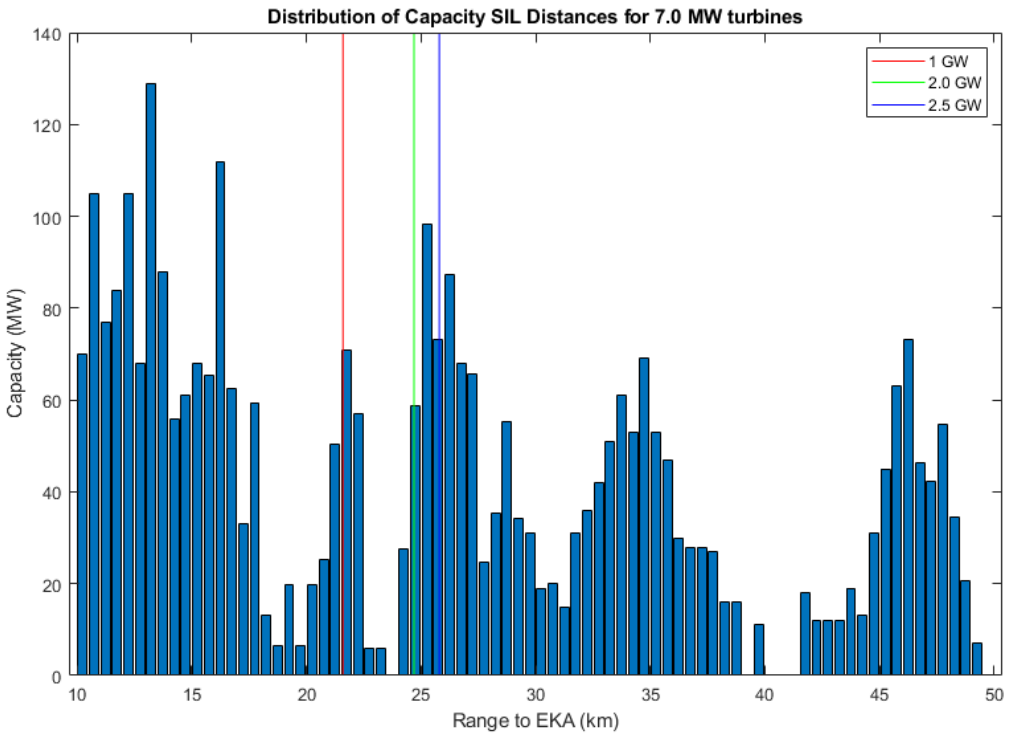


Figure 3 Bar chart showing the relationship between range from EKA and capacity with the range bin size 500 m. The data is for all turbines in the EKA list after Scotston Bank list including those in S36 Scoping. The SIL Equivalent Range for 1.0 GW, 2.0 GW and 2.5 GW based on a 7.0 MW turbine are also shown.

Mitigation levels

If proposed turbines produce seismic levels that exceed the SIL for the given turbine, then options include selection of a quieter turbine or mitigation of a turbine's seismic output. The level of mitigation required will vary with the make and model of turbine and their rated power. Figure 4 and Figure 5 show the amount of mitigation required to operate individual turbines with SIL targeted at 2.0 GW and 2.5 GW respectively. The values in Figure 4 and Figure 5 give an indication of the degree by which turbines would require to have their seismic level reduced mitigation (%). For instance, a mitigation level of 30% indicates that the given turbine would need to have the seismic impact reduced by 30%. The impact varies with distance from EKA, so the degree of mitigation also varies with distance (Figure 4 and Figure 5). The 20% intervals in Figure 4 and Figure 5 are for illustrative purposes only as the required mitigation will vary with makes and models of individual turbines and their rated power. The distances from EKA of the contours in Figure 4 and Figure 5 are listed in Table 5. Figure 6 and Figure 7 show histograms of the distribution of all proposed wind farms after Scotston Bank including those in S36 Scoping and the range the indicative mitigation contours for 2.0 GW and 2.5 GW targeted SIL respectively.

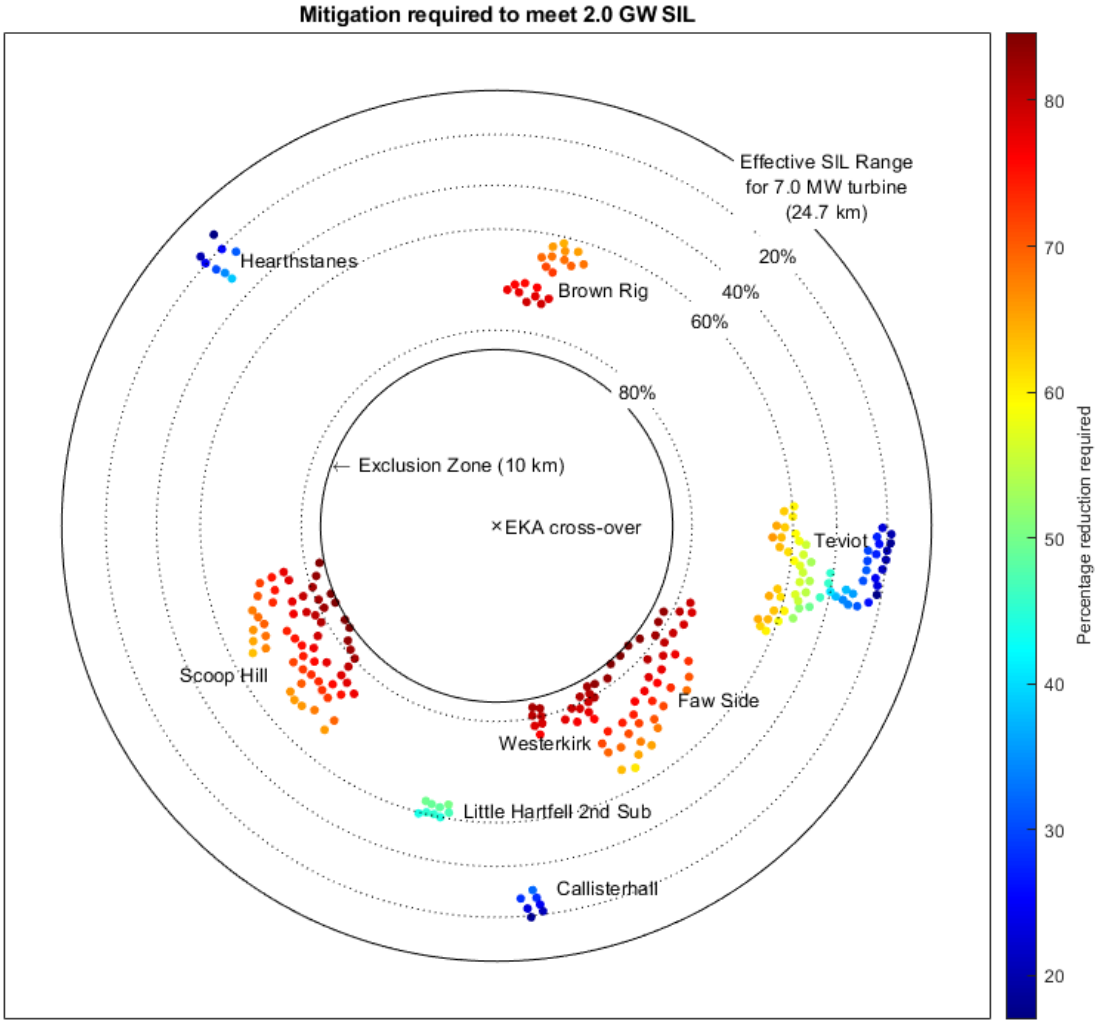


Figure 4 Levels of mitigation that may be required for individual turbines to operate within the SIL for targeted for 2.0 GW. The contours show mitigation levels at 20% intervals and for illustrative purposes only as the mitigation level will be dependent on the make and model of the turbine and its rated power.

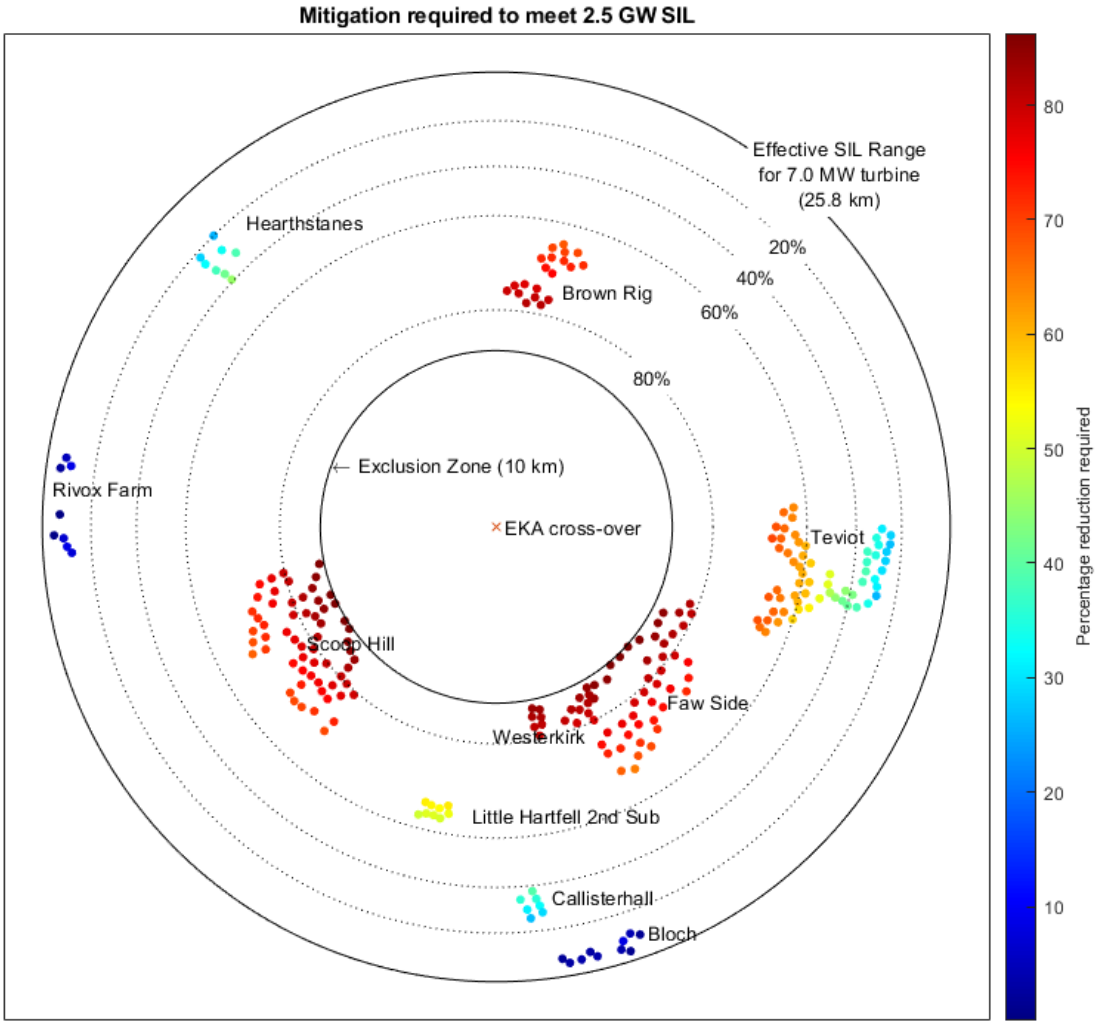


Figure 5 Levels of mitigation that may be required for individual turbines to operate within the SIL for targeted for 2.5 GW. The contours show mitigation levels at 20% intervals and for illustrative purposes only as the mitigation level will be dependent on the make and model of the turbine and its rated power.

	Indicative range to EKA (km)	
Mitigation required (%)	2.0 GW SIL	2.5 GW SIL
0 (Effective SIL Range)	24.7	25.8
20	22.2	23.0
40	19.3	20.5
60	16.8	17.7
80	11.1	12.3

Table 5 Distance from EKA of the indicative mitigation contours in Figure 4 and Figure 5. The contours are for illustrative purposes only as the mitigation level will be dependent on the make and model of the turbine and its rated power.

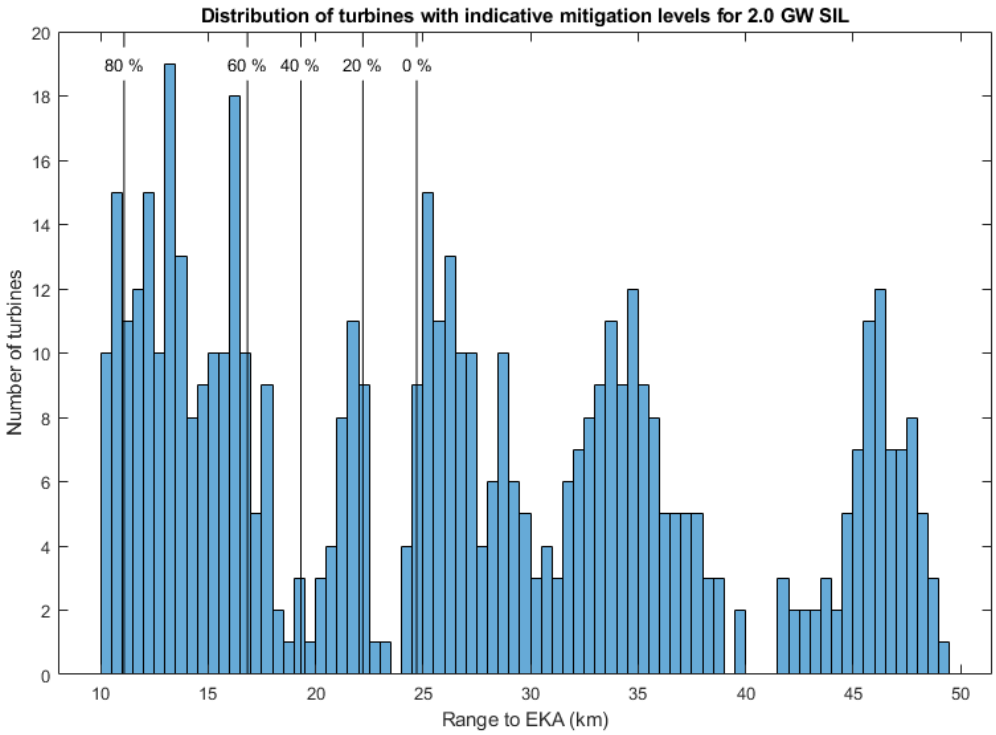


Figure 6 Histogram showing the range from EKA of all turbines in the EKA list after Scotston Bank list including those in S36 Scoping. Lines should indicative mitigation required for individual turbines to operate within the SIL for targeted for 2.0 GW. The lines showing mitigation levels are for illustrative purposes only as the mitigation level will be dependent on the make and model of the turbine and its rated power.

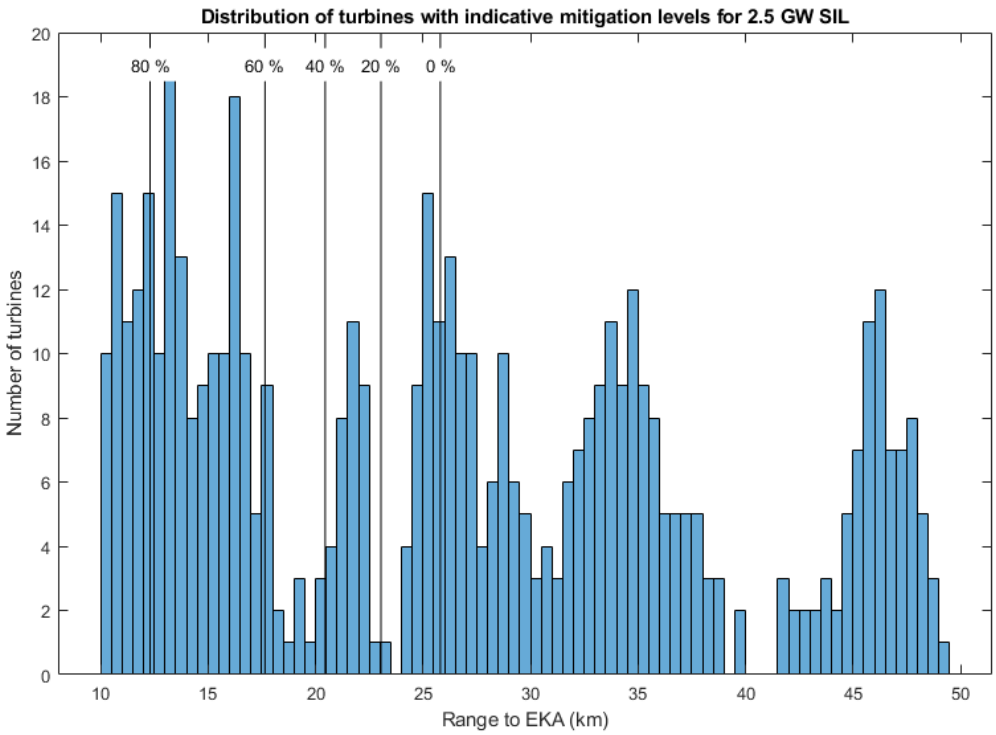


Figure 7 Histogram showing the range from EKA of all turbines in the EKA list after Scotston Bank list including those in S36 Scoping. Lines should indicative mitigation required for individual turbines to operate within the SIL for targeted for 2.5 GW. The lines showing mitigation levels are for illustrative purposes only as the mitigation level will be dependent on the make and model of the turbine and its rated power.

5. Discussion

Assumptions

The calculation of headroom in the budget was based on the same methodology and assumption set as used in AIFCL-Phase4-Rev-v9 and therefore follows the same conservative approach. Here, as in AIFCL-Phase4-Rev-v9, in cases where decisions regarding data handling and extrapolation were required, a conservative worst-case approach was taken that was consistent with previous work for the Eskdalemuir Working Group. Following this approach, in cases where the wind turbine manufacturer for a given wind farm was not known or EWT (EWT was not measured as part of Phase 4), the synthetic spectra for all wind turbines for the distance from EKA, hub height and rotor diameter were assessed, and the highest amplitude taken; again, following a worst-case approach.

The deployable capacity based on wind turbines in the list after Scotston Bank assumes that all sites receive planning consent and are installed.

Based on the recent Minister's decision on the Fawside wind farm and the close proximity to the array, a pipeline excluding Faw side Wind Farm was modelled. It is noted by the author that the developer still has the opportunity to legal action which could alter this decision.

Comparison of exclusion zone and SIL level

The deployable capacity was modelled for three Eskdalemuir Development Pipelines; all turbines in the planning system, all turbine in planning and S36 Scoping; and, all turbine in planning and S36 Scoping excluding Faw Side (Table 3). When all turbines with planning and scoping were assessed assuming a 10 km exclusion zone and a SIL targeted at 2.0 GW the headroom was exhausted before all turbines were built (last turbine was Liddesdale 33rd of 80 proposed). In all other scenarios there was sufficient capacity to build all proposed wind turbines (Table 3).

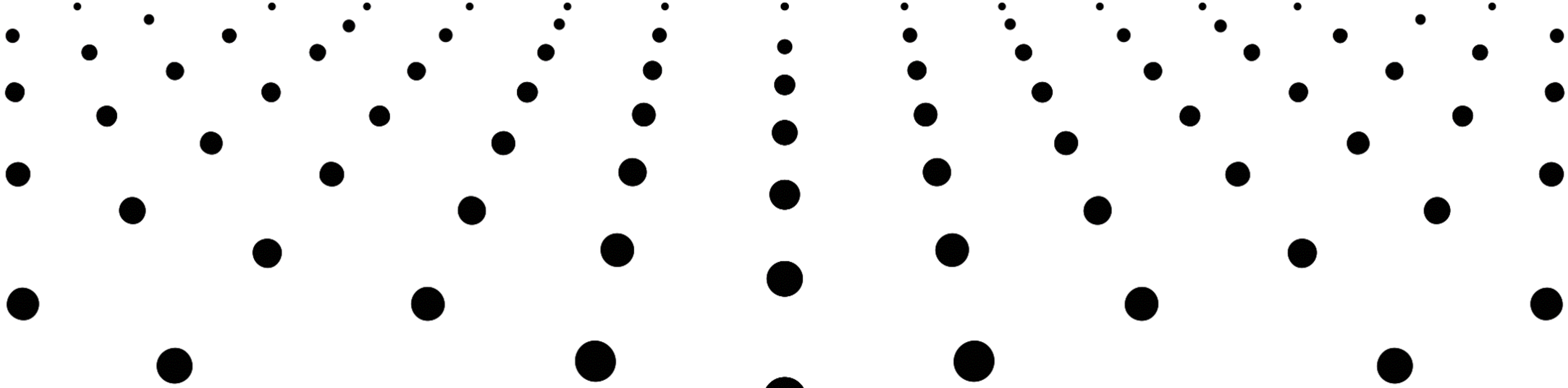
Increasing the SIL target from 2.0 to 2.5 GW increases the distance at which turbines may require mitigation from ~24.7 km to ~25.8 km. There are 28 turbines (of a total of 528 on the list after Scotston Bank) that lie in ranges between 24.7 and 25.8 km (Figure 1 and Figure 2) principally affecting Rivox Farm and Bloch. Increasing the SIL target from 2.0 to 2.5 GW also increases the amount of mitigation required by all turbines within respective Equivalent SIL Ranges (Figure 4 and Figure 5).

Xi Engineering Consultants

Xi Eskdalemuir update

19th Feb 2024

Prepared by Dr Mark-Paul Buckingham



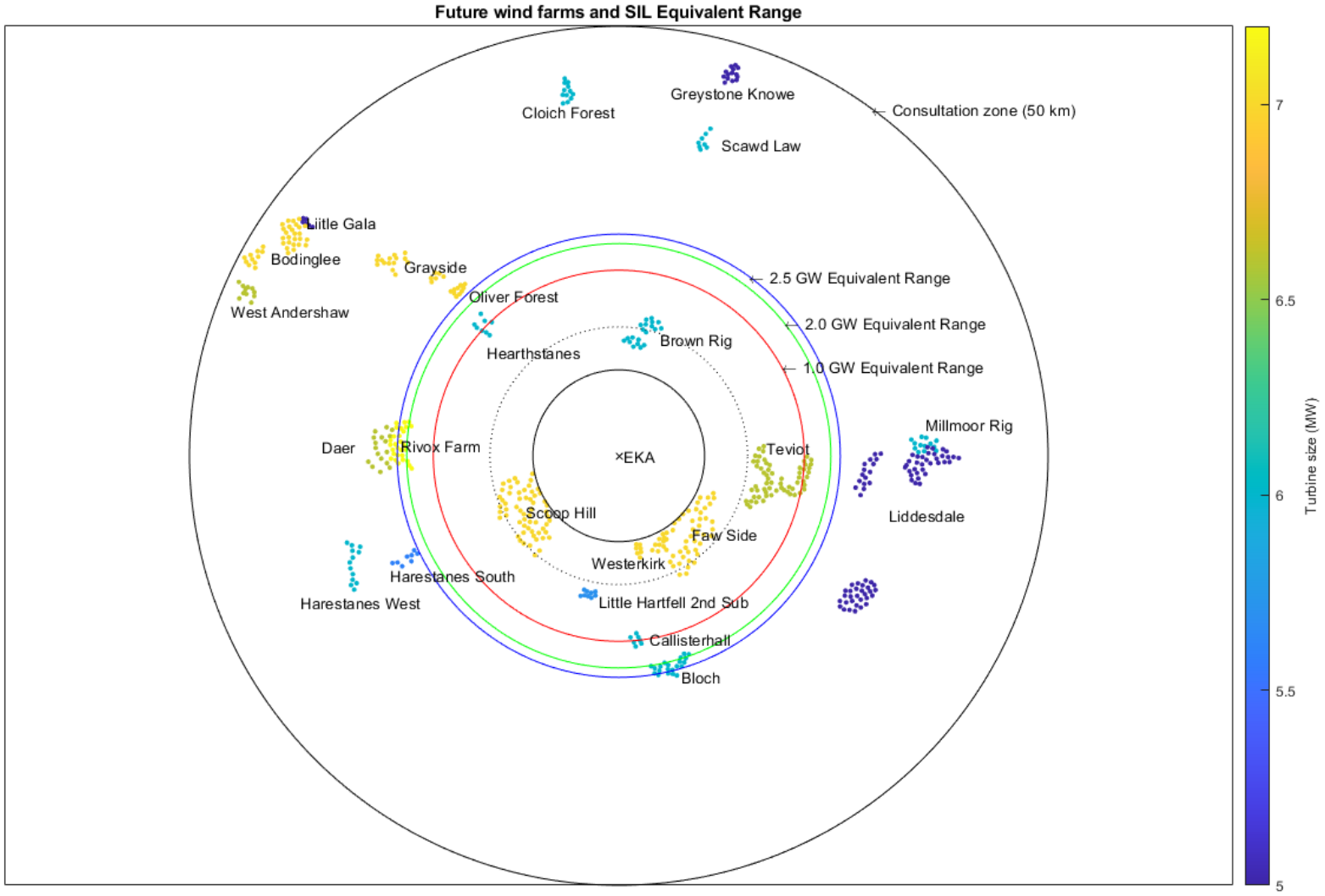
EKA Xi sit rep

1. Eskdalemuir SIL Analysis - Scenario 6,7,11 & 12 Visualisation Issued
    - Highlighted Energy Pulse and List discrepancies
    - Further analyses of distribution and SIL levels
    - Slight increase in potential deployment when S36 scoping included

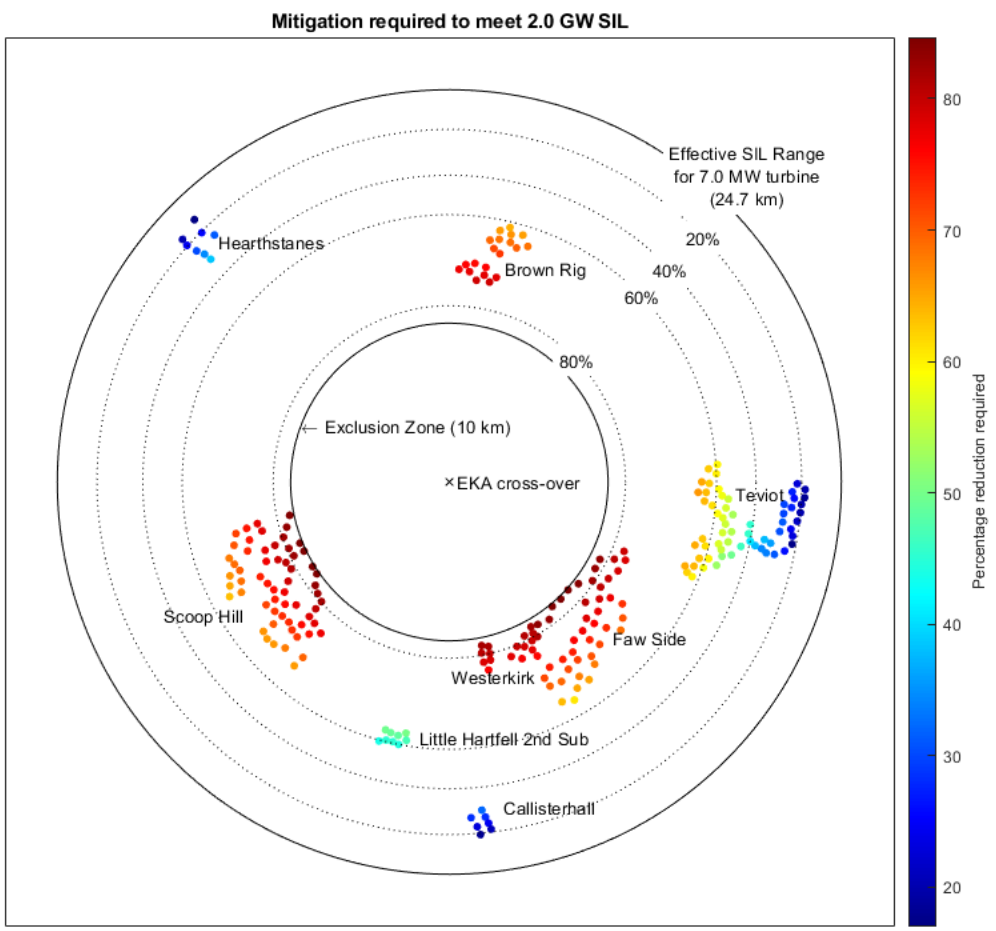
2. Six Technical Work packages defined and estimate issued

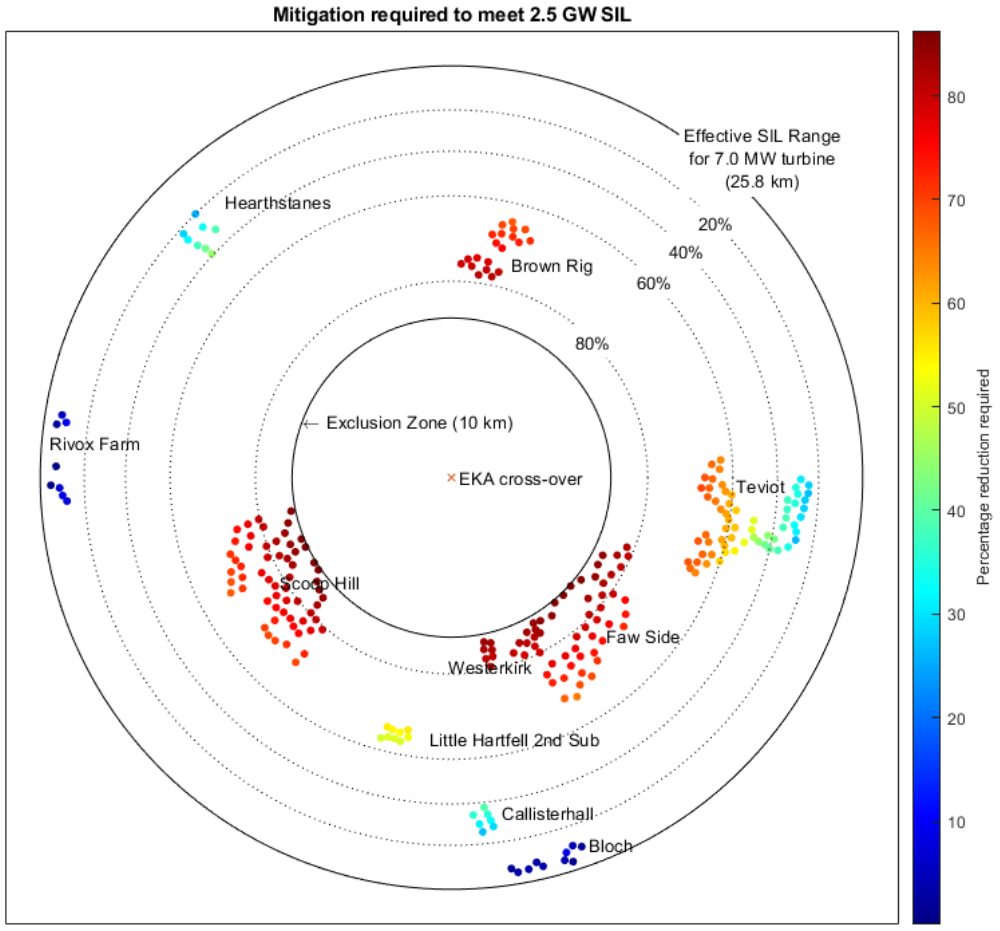
Analysis	Scenario	Exclusion zone	SIL (nm·MW-0.5)	SIL Minimum Deployment (GW)	Potential Immediate Deployment (GW)	Additional capacity after immediate deployment (GW)	Total additional capacity (GW)			Last Farm	Last Turbine
						Median of simulations	Median of simulations	10th %tile of simulations	90th %tile of simulations		
All turbines in planning (excluding S36 Scoping)											
1	6	10 km	0.00592	2GW	2.48	1.27	3.75	3.12	4.7	n/a	n/a
2	7		0.00529	2.5GW	2.48	2.36	4.84	3.95	6	n/a	n/a
3	11	15 km	0.00592	2GW	1.82	3.12	4.94	3.26	7.09	n/a	n/a
4	12		0.00529	2.5GW	1.82	4.14	5.96	4.12	8.17	n/a	n/a
All turbines in planning and scoping											
5	6	10 km	0.00592	2GW	3.11	n/a	n/a	n/a	n/a	Liddesdale	33 (of 80)
6	7		0.00529	2.5GW	3.34	0.92	4.26	3.76	5.05	n/a	n/a
7	11	15 km	0.00592	2GW	2.50	2.8	5.3	3.86	7.16	n/a	n/a
8	12		0.00529	2.5GW	2.50	3.74	6.24	4.69	8.24	n/a	n/a
All turbines in planning and scoping with Faw Side excluded											
9	6	10 km	0.00592	2GW	3.03	0.8	3.83	3.35	4.61	n/a	n/a
10	7		0.00529	2.5GW	3.03	1.8	4.83	4.06	5.87	n/a	n/a
11	11	15 km	0.00592	2GW	**2.47**	**2.88**	5.35	3.91	7.28	n/a	n/a
12	12		0.00529	2.5GW	**2.47**	**3.81**	6.28	4.66	8.27	n/a	n/a

Summary of deployable capacity based on the addition of turbines from the EKA list followed by the randomised addition of turbines. For scenarios when the budget threshold was reached before all turbines in the list have been deployed the last wind farm and last turbine before the threshold has been listed.



All turbines after Scotston Bank in the EKA list including those in S36 Scoping with the SIL Equivalent Range for 1.0 GW, 2.0 GW and 2.5 GW based on a 7.0 MW turbine





Levels of mitigation that may be required for individual turbines to operate within the SIL for targeted for 2.0 and 2.5 GW. The contours show mitigation levels at 20% intervals and for illustrative purposes only as the mitigation level will be dependent on the make and model of the turbine and its rated power

Analysis	Scenario	Exclusion zone	SIL (nm·MW-0.5)	SIL Minimum Deployment (GW)	Potential Immediate Deployment (GW)	Additional capacity after immediate deployment (GW)	Total additional capacity (GW)			Last Farm	Last Turbine
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Summary of deployable capacity based on the addition of turbines from the EKA list followed by the randomised addition of turbines. For scenarios when the budget threshold was reached before all turbines in the list have been deployed the last wind farm and last turbine before the threshold has been listed.

What is needed?

Policy Work

Draft, Consultation, Final – MoD policy

WP1: MOD management Tool

Design Phase

Implementation phase estimate

WP2: Open accesses tool

Design Phase

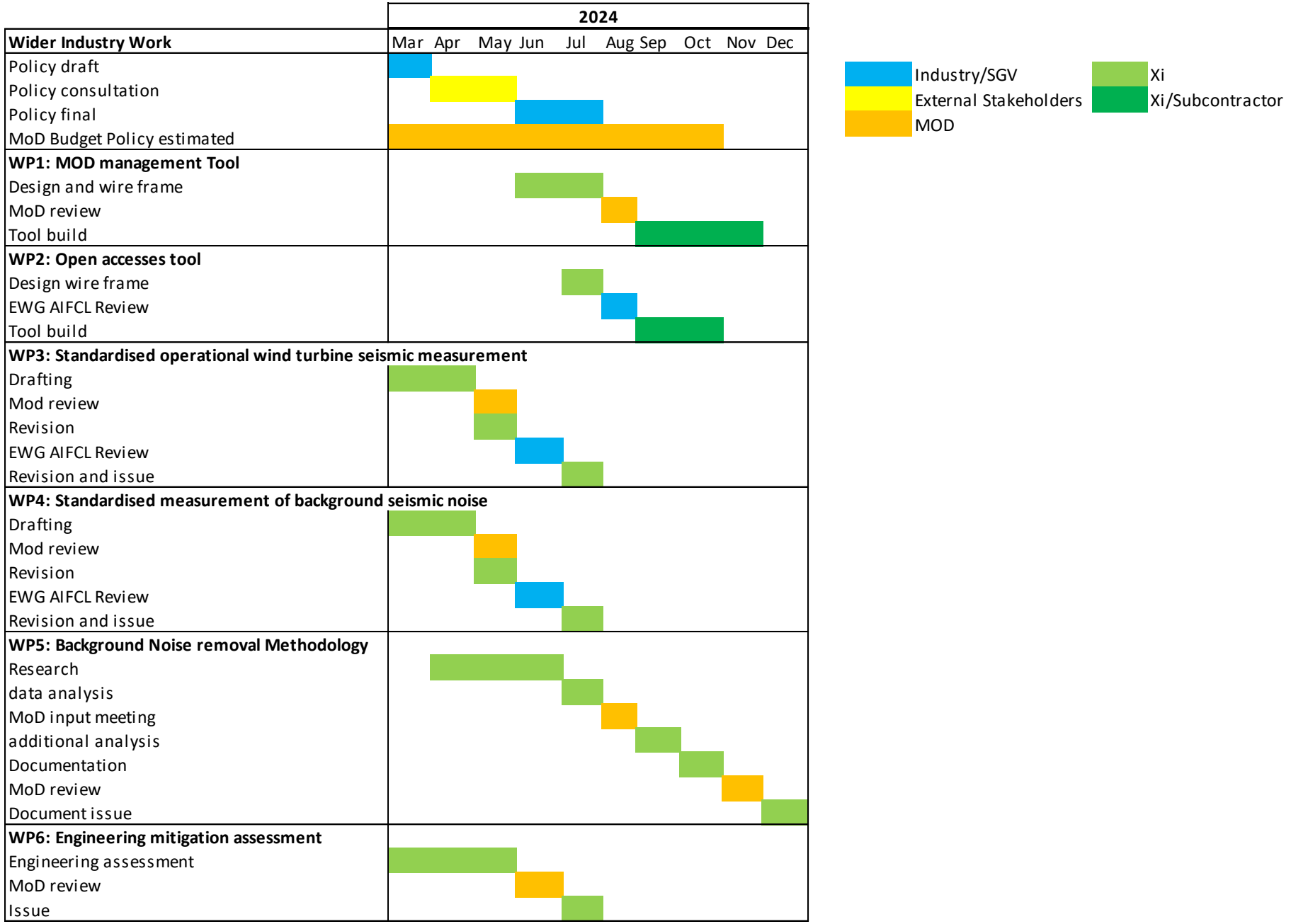
Implementation phase estimate

WP3: Standardised operational wind turbine seismic measurement

WP4: Standardised measurement of background seismic noise

WP5: Background Noise Removal Methodology

WP6: Engineering mitigation assessment


2024
Wider Industry Work
Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Policy draft
Policy consultation
Policy final
MoD Budget Policy estimated
WP1: MOD management Tool
Design and wire frame
MoD review
Tool build
WP2: Open accesses tool
Design wire frame
EWG AIFCL Review
Tool build
WP3: Standardised operational wind turbine seismic measurement
Drafting
Mod review
Revision
EWG AIFCL Review
Revision and issue
WP4: Standardised measurement of background seismic noise
Drafting
Mod review
Revision
EWG AIFCL Review
Revision and issue
WP5: Background Noise removal Methodology
Research
data analysis
MoD input meeting
additional analysis
Documentation
MoD review
Document issue
WP6: Engineering mitigation assessment
Engineering assessment
MoD review
Issue
Industry/SGV
External Stakeholders
MOD
Xi
Xi/Subcontractor

Work packages	Labour costs	Expenses	Total
WP1: MOD management Tool			
▪ Design Phase	£17,380	£0	£17,380
▪ Implementation phase estimate	£125,000	£25,000	£150,000
WP2: Open accesses tool			
▪ Design Phase	£11,578	£0	£11,578
▪ Implementation phase estimate	£65,000	£10,000	£75,000
WP3: Standardised operational wind turbine seismic measurement	£45,868	£0	£45,868
WP4: Standardised measurement of background seismic noise	£30,016	£0	£30,016
WP5: Background Noise Removal Methodology	£62,591	£2,998	£65,589
WP6: Engineering mitigation assessment	£73,262	£0	£73,262
Total	£430,695	£37,998	£468,693

Xi Engineering Consultants

COMSOL Certified Consultant

bsi. ISO 9001 Quality Management