



Wind Power North Two Limited

Balblair Wind Farm

Environmental Impact Assessment Report (Volume 2)

Chapter 11 – Climate Change (Carbon Balance)

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11 CLIMATE CHANGE (CARBON BALANCE)

11.1 Introduction

11.1.1 Wind turbines and battery energy storage systems (BESS) provide an important mechanism for the reduction of carbon dioxide (CO₂), and other greenhouse gas (GHG) emissions into the atmosphere by reducing the consumption of fossil fuel generated mains electricity. However, during their manufacture, construction and decommissioning, wind farms can themselves result in GHG emissions, particularly in such instances as where natural carbon stores, such as peat, are present and potentially impacted by the development.

11.1.2 For this reason, this chapter provides an estimation of:

- the GHG emissions associated with the manufacture, construction, and decommissioning of the proposed Development;
- the contribution which the proposed Development would make towards the reduction of emissions, which would otherwise be produced by fossil fuel power generation.

11.1.3 Taken together, these two elements indicate the whole-life “carbon balance” of the proposed Development, together with an understanding of the “emissions payback” period. Once emissions resulting from the manufacture, construction and decommissioning of the proposed Development have been “paid back” (offset) by the wind farm, all subsequent wind-generated electricity would displace a similar amount of conventionally generated electricity, thereby contributing to an overall GHG reduction.

11.1.4 Although often colloquially termed “carbon balance”, the assessment includes all GHGs, not just carbon dioxide. The results are presented in tonnes of carbon dioxide equivalent (tCO₂e), where equivalence means having the same warming effect as CO₂ over 100 years.

11.2 Relevant legislation, planning policy and guidance

11.2.1 Planning and energy policy, including national and local policy objectives and requirements of legislation in relation to climate change, are summarised in **Chapter 5: Planning Policy and Legislation** of the EIA Report. Both national and local policy recognise that planning should consider the contributions a proposed Development makes towards achieving the climate change targets. Guidance and legislation relating specifically to carbon and GHG emissions are listed below.

Legislation

11.2.2 Relevant legislation and guidance documents have been reviewed and taken into account as part of this assessment. Of particular relevance are:

- The 2015 Paris Agreement;
- The Electricity Works (Environmental Impact Assessment) (Scotland) (Regulations 2017 (as amended) (EIA Regulations); and
- The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 and the legally binding net zero target for 2045 and interim targets for 2030 and 2040.

Planning policy

- 11.2.3 The following national policy documents are most relevant to this factor:
- National Planning Framework 4 (NPF4);
 - The Scottish Energy Strategy (December 2017);
 - The Scottish Government's declaration of a Climate Emergency (April 2019);
 - The Scottish Climate Change Plan Update (December 2020);
 - The Scottish Government's 'Programme for Government' (September 2022);
 - The Onshore Wind Policy Statement (December 2022);
 - The Draft Energy Strategy and Just Transition Plan (January 2023);
 - The Future of Energy in Scotland: Energy Strategy (2017);
 - Scottish Planning Policy (2014); and
 - Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017.
- 11.2.4 The Highland Council Net Zero Strategy (2023) is the only relevant local policy to this chapter. This outlines the Council's approach to reaching net zero targets by 2045, and addressing the climate change emergency. This includes the "Future Highland" programme delivering 'energy solutions' including increasing wind renewable energy generation.
- 11.2.5 Furthermore, the Highland-Wide Local Development Plan (HwLDP) was adopted in April 2012 and is generally supportive of renewable energy development. Supplementary Guidance is also available in the form of The Onshore Wind Energy Supplementary Guidance (SG) which was adopted in November 2016. Together these set out the spatial framework and planning policies for the whole of the Highland Council area (outwith National Parks).

Guidance

- 11.2.6 Recognisance has been taken of the following best practice guidelines / guidance etc:
- Institute of Environmental Management and Assessment (IEMA) Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance (2022).
 - Good Practice During Wind Farm Construction, NatureScot et al. (2019)
 - The SNH, now NatureScot, 'Good Practice During Wind Farm Construction' guidance recognises that one of the key aims of wind farm development is to reduce carbon emissions. However, wind farm developments, through the materials used, during the construction processes employed and the potential emissions from disturbed soils and habitats, do result in carbon emissions.
 - The guidance recognises that, in some circumstances, the carbon payback of wind farm developments could be significantly affected by the construction methods used and the degree of restoration of the site. The guidance, therefore, seeks to ensure that good practice is adopted to reduce the carbon emissions associated with wind farm development.

11.3 Consultation undertaken

11.3.1 Throughout the consultation process, climate change was not raised as a topic by the consultees.

11.4 Approach to Assessment

Scope of Assessment

11.4.1 The scope of this assessment has been established through an ongoing scoping process. Further information can be found in **Chapter 4: EIA Approach and Methodology**.

11.4.2 This section provides an update to the scope of the assessment and re-iterates/updates the evidence base for scoping out matters following further iterative assessment.

Receptors/matters scoped out of further assessment

11.4.3 **Table 11-1** presents the receptors/matters that are scoped out of further assessment, together with appropriate justification. Where a change has occurred since EIA scoping, this is clearly stated and justified.

Table 11-1: Receptor/matters scoped out of further assessment

Receptor/matter	Phase	Justification	Change since EIA Scoping?
Climate Change Risk	Construction, Operation & Decommissioning	UKCP18 projections suggest that climate change will lead to hotter drier summers, warmer wetter winters, increased likelihood of extreme weather events (e.g., heat waves, high rainfall events) and sea-level rise. Due to the embedded resilience of wind turbines to high heat and wind speeds, and the distance of the Site from coastline; these factors are not expected to significantly impact on the construction, operation, or decommissioning of the proposed Development. Flooding is not expected to have any significant impact on the project, due both to the embedded resilience of wind turbines and the lack of recorded historical flooding within the site boundary.	No. The Scoping Opinion agreed that this receptor/matter should be scoped out of further assessment.

Receptors/matters scoped into further assessment

11.4.4 presents the receptors/matters that are scoped into further assessment, together with appropriate justification. Where a change has occurred since EIA scoping, this is clearly stated and justified.

Table 11-2: Receptor/matters scoped into further assessment

Receptor/matter	Phase	Justification	Change since EIA Scoping?
GHG emissions	Construction	Embodied carbon of wind turbines and any ancillary developments can potentially be significant. It is important to include construction-related emissions when considering the overall lifecycle emissions of the proposed Development, to determine an accurate 'carbon-payback' time of the scheme.	No. The Scoping Opinion agreed that this receptor/matter should be scoped in to further assessment.
GHG emissions	Operation	Aligned with IEMA guidance, a project that causes GHG emissions to be avoided has a beneficial effect that is significant.	No. The Scoping Opinion agreed that this receptor/matter should be scoped in to further assessment.
GHG emissions	Decommissioning	The decommissioning process is likely to result in GHG emissions, particularly from the removal or renewal of turbines. It is important to include all emissions when considering the overall lifecycle emissions of the proposed Development, to determine an accurate 'carbon-payback' time of the scheme.	No. The Scoping Opinion agreed that this receptor/matter should be scoped in to further assessment.

Baseline Methodology

11.4.5 All baseline surveys and data collection were carried out by the respective discipline teams, primarily the teams responsible for collecting data relating to peat disturbance and the felling of forestry.

Assessment Methodology

- 11.4.6 Whilst the proposed Development is expected to deliver GHG savings over its lifetime, it could also cause GHG emissions through:
- disturbance of peatland; and
 - lifecycle emissions from turbines, the battery energy storage system (BESS), and other infrastructure.
- 11.4.7 The GHG assessment of the proposed Development has been undertaken using version 2.14.1 of the Scottish Government's Carbon Assessment Tool, which is the standard way of assessing GHG emissions and savings from renewable energy developments comprising wind turbine technology and BESS. The latest online version of the Scottish Government Carbon Calculator Tool (V1.8.1) was unavailable during the course of this assessment while undergoing maintenance and a server upgrade. Version 2.14.1 of the Calculator was provided as an Excel spreadsheet calculator by the Energy Consents Unit as a suitable alternative.
- 11.4.8 A detailed explanation of the Scottish Government's Carbon Assessment Tool methodology is found within **Technical Appendix 11.1**. In brief, the calculator uses project-specific data from the construction of the proposed Development (**Chapter 2: The Proposed Development**) and the receiving environment (**Chapter 8: Ecology to Chapter 13: Noise**), particularly with regards to peat disturbance. This allows GHG emissions and avoidance to be quantified across the project lifecycle stages (construction, operation, and decommissioning/site restoration). Specific information concerning the embodied emissions of materials, which would account for turbine manufacture and delivery, is assumed directly through the Carbon Calculator.
- 11.4.9 Calculations are provided for minimum, maximum and expected scenarios, whereby the minimum scenario assumes the lowest energy output and the lowest carbon losses from the proposed Development, and the maximum assumes highest energy output and highest carbon losses. The expected scenario is based on eight turbines with an anticipated total installed capacity of 36 MW and capacity factor of 35.6%, as well as a BESS of 120 MWh.
- 11.4.10 The Scottish Government's Carbon Assessment Tool includes embodied emissions from wind turbines and their foundations, but not for BESS or Solar PV. As such, a supplementary life cycle analysis (LCA) of the BESS and Solar PV has been conducted and integrated within the calculator outputs. Overall, LCA studies on BESS have found that the manufacturing stage has the greatest impact in terms of embodied GHG emissions. Lithium-ion batteries are the most common choice of battery technology, with several examples of Lithium-ion BESS supporting renewable energy developments in the UK. A study undertaken by Romare and Dahllöf (2017) indicates that the cradle to grave emissions of a lithium-ion battery is in the region of 150-200 kg CO₂e/kWh. Although this assessment was undertaken for batteries for light-duty vehicles, Lait and Walker (2022) suggest that there is a near-linear scale of GHG emissions when battery size increases.
- 11.4.11 The GHG emissions and savings are combined to establish the overall (net) GHG effect of the proposed Development, as well as its carbon payback period.

Significance

- 11.4.12 Given the international urgency of climate change, the sensitivity of the receptor (i.e., the global climate) to fluctuations in GHG emissions is considered 'Very High'. Thus, the level of the significance of effects is determined by the magnitude of change and timing of GHG emissions and the likelihood of avoiding severe climate change. As this proposed Development would contribute to the avoidance of GHG emissions in the short term, it would be beneficial towards the Scottish Government's 2030 renewable energy targets.
- 11.4.13 Aligned with IEMA's Guidance to Assessing GHG Significance (2022), any project that causes GHG to be avoided, or removed from the atmosphere, has a beneficial effect that is always significant. In such a scenario, the project substantially exceeds the national net zero requirements and is thus aligned with the goal of the Paris Agreement to limit temperature rise to well below 2°C, aiming for 1.5°C. The Scottish Government's legally binding net zero targets are also aligned with the Paris Agreement. **Table 11-3** presents the significance criteria used for the assessment.

Table 11-3: IEMA's Guidance to Assessing GHG Significance (2022) Framework for assessment of significant effects

Significance	Level	Criteria
Significant	Major adverse	Project adopts a business-as-usual approach, not compatible with the national Net Zero trajectory, or aligned with the goals of the Paris Agreement (i.e., a science-based 1.5°C trajectory). GHG impacts are not mitigated or reduced in line with local or national policy for projects of this type.
	Moderate adverse	Project's GHG impacts are partially mitigated, and may partially meet up-to-date policy; however emissions are still not compatible with the national Net Zero trajectory, or aligned with the goals of the Paris Agreement.
Not significant	Minor adverse	Project may have residual emissions, but the project is compatible with the goals of the Paris Agreement, complying with up-to-date policy and good practice.
	Negligible	Project has minimal residual emissions and goes substantially beyond the goals of the Paris Agreement, complying with up-to-date policy and best practice.
Significant	Beneficial	Project causes GHG emissions to be avoided or removed from the atmosphere, substantially exceeding the goals of the Paris Agreement with a positive climate impact.

Difficulties and Uncertainties

- 11.4.14 To ensure transparency within the EIA process, the following difficulties and uncertainties have been identified:

The accuracy of a GHG assessment depends on the quality of the data provided. Primary data should always be used where available. Where it is not possible to collect this data, in view of the fact that this assessment represents a forecast of emissions and some information may not yet be known, secondary data (such as estimates, extrapolations, benchmarks and proxy data) has been used. Assessments based largely on secondary data should only be viewed as an estimate of GHG emissions impact, and actual emissions may vary significantly.

- 11.4.15 The presence of BESS necessitated manual modification to the outputs of the Scottish Government Carbon Assessment Tool to account for the associated embodied emissions. These have been clearly marked within the **Technical Appendix 11.1**.
- 11.4.16 The inputs to the Scottish Government Carbon Assessment Tool were obtained from the relevant topic specialists. Any uncertainties concerning the data used within the calculations (**Technical Appendix 11.1**), will have been expanded upon in their respective chapter.
- 11.4.17 Any further assumptions and limitations will relate to the data collection process carried out by the discipline teams, which will be expanded upon in the respective chapter.

11.5 Existing environment

- 11.5.1 The baseline conditions describe the conditions of a business-as-usual scenario whereby the proposed Development is not undertaken. The baseline comprises existing carbon stock and sources of GHG emissions within the Site boundary of the existing activities on-site.
- 11.5.2 The Estate is located 2km to the north-west of Bonar Bridge in the Highland Council Area. All of the Estate is in private ownership, consisting of active crofts, common grazing, rough grazing, and moorlands. Initial phase 1 peat survey work has identified some pockets of deep peat across the Site. Multiple areas of forestry have been identified across the Site. There is a 0.1% chance of flooding within the Site boundary.
- 11.5.3 The forests adjoined to the north-west and south of the Estate are owned by Forestry and Land Scotland, whilst to the east of the Estate lies various crofts and scattered residential properties. The lands immediately north of the Site are subject of a current application for a wind farm.
- 11.5.4 The total perimeter of the Estate falls under Highland Council's jurisdiction, who set the opportunities that arise from renewable energy generation as a key area of focus in their 2045 Net Zero strategy (2023). The Highland Council also sets out interim targets to be aligned with the Scottish Government's corresponding strategy, such as reducing GHG emissions by at least 75% by 2030, and by least 90% by 2040.

Peat

- 11.5.5 The National Soil map of Scotland has been consulted to assist the high-level understanding of the carbon-rich soils within the Site. The area is predominantly made up of peaty gleys, with dystrophic blanket peat. There are two other significant areas; one

which is mainly made up of brown soils extending directly north of Loch Caroy, and one which is mainly made up of peat along the eastern side of Aketil Burn.

- 11.5.6 Peat depth and peat condition surveys were undertaken in June, August and November 2022 for areas of proposed infrastructure. The peat depth surveys and reconnaissance survey confirm that peat cover across the site is very extensive, with the majority of the site having peat that is between 0.5 – 1.5 m deep. For further information on the peatland habitat within the site, consult **Chapter 9: Geology, Hydrogeology, Hydrology and Peat**.

Forestry

- 11.5.7 There is no significant forestry areas within the Application Site, although small areas of tree cover can be found along watercourses.

11.6 Embedded mitigation

Design Considerations

- 11.6.1 Peat disturbance has been considered during the design process, which has sought to avoid areas of deep peat. The site design process is described in **Chapter 2** whilst specific details relating to peat depth are included in **Chapter 9**.

11.7 Predicted effects

- 11.7.1 The results of the carbon balance assessment carried out for the proposed Development are presented below for each project stage. The project-specific input and output data is contained within **Technical Appendix 11.1**, alongside the detailed methodology of the calculator.

Construction and Decommissioning Phase

- 11.7.2 **Table 11-4** presents the results of the GHG balance assessment for the manufacture, construction, and decommissioning stages of the proposed Development. The lack of significant forestry on site results in negligible predicted GHG emissions from forestry felling. Total projected emissions are 67,025 tCO₂e.

Table 11-4: Predicted GHG emissions from wind farm manufacture, construction and decommissioning

Source of GHG Emissions/Savings	GHG Emissions (tCO ₂ e)	% of Total Emissions
Losses due to turbine life (e.g. manufacture, construction, decommissioning)	31,671	47%
Losses due to backup	0	0%
Losses due to reduced carbon fixing potential	266	0%
Losses from soil organic matter	10,893	16%

Source of GHG Emissions/Savings	GHG Emissions (tCO ₂ e)	% of Total Emissions
Losses due to DOC & POC leaching	195	0%
Losses due to felling forestry	0	0%
Losses due to embodied emission of BESS	24,000	36%
Total	67,025	100%

*The losses due to the embodied emissions of BESS are not an output of the carbon calculator, and have been integrated into the calculations based upon an assumed 120 MWh capacity BESS

11.7.3 Any post-decommissioning site restoration and enhancement work, such as blocking drainage ditches to promote re-wetting, would be aligned with the outline Biodiversity Enhancement Management Plan (see **Technical Appendix 8.6**). Such activities can incur GHG savings by promoting growth of peat or other natural carbon stores.

11.7.4 **Table 11-5** shows the total CO₂ gains due to site improvement during post-decommissioning (tCO₂e).

Table 11-5: Total CO₂ Gains Due to Improvement of the Site (tCO₂e)

Improvement	GHG Emissions (tCO ₂ e)	% of total
Change in emissions due to improvement of degraded bogs	- 36,566	99
Change in emissions due to improvement of felled forestry	0	0
Change in emissions due to restoration of peat from borrow pits	0	0
Change in emissions due to removal of drainage from foundations and hardstanding	- 6	< 1
Total change in emissions due to improvements	- 36,573	100

11.7.5 Taking into account the predicted GHG emissions from wind turbine manufacture, construction and decommissioning alongside those savings from the improvement of the site, the total net GHG emissions from the proposed Development are expected to be 30,452 tCO₂e (**Table 11-6**).

Table 11-6: Total net GHG emissions from the proposed Development

	GHG savings (tCO ₂ e)	GHG emissions (tCO ₂ e)
Predicted GHG emissions from wind turbine manufacture, construction and decommissioning	-	67,025
Total CO ₂ gains/savings due to improvement of the Site	36,573	-
Total net GHG emissions from wind farm manufacture, construction, decommissioning and improvement of site		30,452

Operational Phase

11.7.6 The operational stage of the proposed Development (30 years) has the greatest potential for GHG savings. At this stage, GHG emissions from construction activities would have ceased and operation of the turbines would generate zero-carbon electricity for the remainder of their lifespan. **Table 11-7** presents projected annual emissions savings as measured against the grid-mix and fossil fuel-mix of electricity.

Table 11-7: Annual Emissions Savings Against Fossil Fuel & Grid Electricity Generation Mix

GHG savings*	GHG savings (tCO ₂ e)		
	Expected value	Minimum value	Maximum value
Grid mix electricity generation			
GHG savings per year	28,469	25,622	31,316
Lifetime GHG savings*	854,069	768,662	939,476
Fossil fuel mix electricity generation			
GHG savings per year	50,521	45,469	55,573
Lifetime GHG savings*	1,515,620	1,364,058	1,667,182
*Operational GHG savings based over a lifetime of 30 years			

Emissions Payback Period

11.7.7 The emissions payback time can be calculated by dividing the total expected emissions caused by the proposed Development for the manufacture, construction and decommissioning stages (67,025 tCO₂e: **Table 11-4**) by expected annual savings from operation (28,469 or 50,521 tCO₂e: **Table 11-7**). This gives an emissions payback time against a representative grid mix (electricity from the National Grid; this could be sourced from fossil fuels, renewable energy, nuclear, etc), and against a fossil-fuel mix electricity

generation (electricity that is sourced through the combustion of fossil fuels alone) as presented in Table 11-8.

Table 11-8: Carbon Payback Period of the proposed Development

	Carbon payback time (years)		
	Expected value	Minimum value	Maximum value
Grid mix electricity generation	1.1	- 2.0	8.2
Fossil fuel mix electricity generation	0.6	- 1.1	4.6

Net GHG Effect

11.7.8 Given the proposed Development’s projected operational life of 30 years, its total GHG savings are expected to be 823,617 tCO₂e against grid mix electricity generation, inclusive of construction, operation and decommissioning emissions; and 1,485,168 tCO₂e against fossil fuel mix electricity generation.

11.8 Additional mitigation

11.8.1 It has been assumed that all activities during construction, operation and decommissioning would be conducted in accordance with good practice guidance.

11.8.2 Relevant guidance includes:

- Good Practice During Wind Farm Construction, NatureScot et al. (2019); and
- Life Extension and Decommissioning of Onshore Windfarms, SEPA (2016).

11.8.3 Further, it is assumed that mitigation outlined in the Schedule of Commitments (**Chapter 14: Other Issues**) would be implemented to reduce environmental impacts, including GHG emissions, and improve effectiveness of restoration works.

11.8.4 As no adverse effects are predicted, no additional mitigation measures are proposed.

11.9 Cumulative effects

11.9.1 GHG emissions are inherently cumulative, as all emissions have the same impact on the same ultimate receptor (i.e. the global climate). Most developments result in the release of GHGs, and consequently have the potential to result in a cumulative effect. Conversely, renewable energy developments such as this have a net beneficial effect, in that they cause the reduction of GHG emissions.

11.9.2 As the receptor is not geographically constrained it is not appropriate to undertake a conventional cumulative effects assessment.

11.10 Summary of effects

- 11.10.1 GHG emissions will arise from the manufacture, construction and decommissioning activities, including the loss of peat and forestry, from the construction of turbines and associated infrastructure.
- 11.10.2 These emissions are projected to be offset 0.6 years (~7 months) after the proposed Development becomes operational against a fossil fuel mix of electricity, or 1.1 years (~13 months) against a grid-mix of electricity. The proposed Development is predicted to deliver total emissions savings of 1,485,168 tCO₂e over its 30-year operational lifetime, against a fossil fuel mix electricity generation, and 823,617 tCO₂e against grid mix electricity generation.
- 11.10.3 The overall impact is considered to represent a **Significant and Beneficial effect**, and contribute to long-term climate change mitigation. Consequently, the proposed Development contributes towards Scotland's emissions reduction targets as set out in the Climate Change (Emissions Reductions Targets) (Scotland) Act 2019, together with its renewable energy obligations as set out in the Scottish Climate Change Plan.

Table 11-9: Summary of effects

Potential impact	Pre-mitigation		Mitigation	Residual	
	Effect	Significance		Effect	Significance
Proposed Development Whole Lifecycle					
GHG Emissions	The proposed Development is anticipated to result in GHG Savings of 823,617 tCO ₂ e against a grid-mix electricity generation over its 30-year lifespan, and 1,485,168 tCO ₂ e against a fossil fuel mix electricity generation. This equates to a payback time of 1.1 years against a grid-mix electricity generation, and 0.6 years against a fossil fuel mix electricity generation.	Significant and Beneficial	As no adverse effects are predicted, no additional mitigation measures are proposed outside of adherence to best practice and the measures covered in Chapter 15: Schedule of Environmental Commitments	The proposed Development is anticipated to result in GHG Savings of 823,617 tCO ₂ e against a grid-mix electricity generation over its 30-year lifespan, and 1,485,168 tCO ₂ e against a fossil fuel mix electricity generation. This equates to a payback time of 1.1 years against a grid-mix electricity generation, and 0.6 years against a fossil fuel mix electricity generation.	Significant and Beneficial

11.11 References

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