8. Climate Change and Carbon Balance

8.1 Non-Technical Summary

8.1.1 The predicted future climatic baseline conditions are highly unlikely to affect the operation of the Revised Consented Development. The Revised Consented Development will have a positive effect on carbon savings, and a significant positive effect when considered cumulatively with UK-wide renewable energy deployment. No additional significant effects to those already identified within the EIA Report will occur as a result of climate change during the operational phase of the Revised Consented Development. The effects of the Revised Consented Development on climate change is not significant.

8.1.2 The Revised Consented Development will not significantly influence climate change and the Revised Consented Development would contribute to Government Objectives on renewable energy and would have a positive cumulative effect with regards to reduction in carbon emissions when considering the UK-wide electricity generation mix.

8.1.3 It is predicted that the carbon loss in developing the Revised Consented Development will be paid back in ~2.3 years (5.75% of the 40-year operational life) based upon the fossil fuel mix and the expected outcome. Even considering the maximum scenario, the Revised Consented Development would have achieved the carbon balance within ~4.0 years (10% of the 40-year operational life).

8.1.4 On the basis of potential annual CO2 savings of 124,053 tonnes/year (based on figure of 446g of CO2 savings per kWh and a site specific capacity factor of 36%), the Revised Consented Development could result in a total carbon saving of approximately 4,962,151 tonnes over its 40 year operational life and generate electricity to annually supply the equivalent of 81,977 average homes in Scotland. A comparison of the conclusions of the chapter with previous applications is provided in **Table 8.0**.

Table 8.0 Summary of Conclusions – Previous Applications

2012 ES (24 Turbine Layout)	2016 ES (24 Turbine Layout)	2017 Supplementary Information (21 Turbine Layout - Consented Development)	2021 Section 36C Application (21 Turbine Layout with amended access tracks – Revised Consented Development)
As the 2017 EIA Regulations introduced specific mention of 'climate change' amongst other topics, the effects on this topic were not specifically assessed in the 2012 ES. However the estimated payback period for the 2012	Similarly to the 2012 ES, the effects on climate change were not specifically assessed in the 2016 ES, however The estimated payback period for the 2016 Proposed Development was 2.9 years compared to grid-mix electricity generation (range 2.4 – 5.8 years). In	Similarly to the 2012 ES and 2016 ES the effects on climate change were not specifically assessed in the 2017 SI, however the carbon payback for the Consented Development was calculated to be 1.6 years for the expected outcome (fossil	The predicted future climatic baseline conditions are highly unlikely to affect the operation of the Revised Consented Development. No additional significant effects to those already identified within the EIA Report will occur as a

2012 ES (24 Turbine Layout)	2016 ES (24 Turbine Layout)	2017 Supplementary Information (21 Turbine Layout - Consented Development)	2021 Section 36C Application (21 Turbine Layout with amended access tracks – Revised Consented Development)
Proposed Development was calculated using the fossil fuel sourced grid as being 1.4 years for the expected outcome with a minimum of 1.1 years for the best case scenario and 4.6 years for the highly precautionary worst case scenario.	comparison to the fossil fuel mix and coal fired electricity generation the payback period of the wind farm was calculated to reduce to 1.8 years (range 1.5 – 3.6 years) and 1.3 years (range 1.0 – 2.5 years) respectively.	fuel mix). It was calculated his could be as low as 0.9 years for the best case scenario, but increased to 2.2 years for the worst case scenario	result of climate change during the operational phase of the Revised Consented Development. It is predicted that the carbon loss in developing the Revised Consented Development will be paid back in ~2.3 years based upon the fossil fuel mix and the expected outcome. Even considering the maximum scenario, the Revised Consented Development would have achieved the carbon balance within ~4.0 years.

8.2 Introduction

8.2.1 This chapter sets out renewable energy policy and guidance and evaluates the effects of the Revised Consented Development on climate change and carbon balance. Climate Change Impact Assessment (CCIA) is a requirement through the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017.

8.2.2 The following assessment areas are considered for the Revised Consented Development:

- The vulnerability of the Revised Consented Development to climate change;
- The influence of the Revised Consented Development on climate change; and
- A summary of effects on environmental receptors sensitive to climate change.

8.2.3 The vulnerability of the Revised Consented Development to climate change considers effects on the Development as a receptor. In contrast, the other two assessments consider effects on environmental receptors as a result of the Revised Consented Development.

8.2.4 This chapter is supported by the following Technical Appendices provided in **Volume 4** of this EIA Report:

- **Appendix 8.A Carbon Calculator - Justification for Values Used.**

8.3 Legislation, Policy and Guidance

8.3.1 This section provides an overview of legislation, policy, and guidance relevant to this chapter.

International Context

International Agreements and Obligations – The COP21 Paris Agreement

8.3.2 The Paris Agreement[i] was adopted on 12th December 2015 by 196 parties to the UN Framework Convention on Climate Change, creating a legally-binding, international agreement towards tacking climate change. The UK is one of the signatories and is legally bound to the Paris Agreement.

8.3.3 The Paris Agreement came into force on November 4th, 2016 having been ratified by at least 55% (the point which triggers ratification) of the 196 countries. The meeting in Paris was considered a make-or-break opportunity to secure an international agreement on the approach to tackling climate change, commitment to a longer-term goal or near zero emissions in the second half of the century and supporting the transition to a clean economy and low carbon security.

8.3.4 Governments agreed:

- A long-term goal of keeping the increase in global average temperature to well below 2 degrees Celsius above pre-industrial levels;
- To aim to limit the increase to 1.5 degrees Celsius since this would significantly reduce risks and the impacts of climate change;
- On the need for global emissions to peak as soon as possible, recognising that this will take longer for developing countries; and
- To undertake rapid reductions thereafter in accordance with the best scientific guidance available.

8.3.5 Countries are legally obliged to make new post-2030 commitments to reduce emissions every five years.

Special Report on Global Warming of 1.5°C (2018)

8.3.6 Contained within the Decision of the 21st Conference of Parties of the United Nations Framework Convention on Climate Change to adopt the Paris Agreement was an invitation for the Intergovernmental Panel on Climate Change (IPCC) '*…to provide a Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways'.*

8.3.7 The IPCC responded to this invitation through the preparation of the 'Special Report on the impacts of global warming of 1.5°C'[ii], which was published in October 2018. The report presents a study on the impacts and possible methods of keeping temperature from warming by more than 1.5°C. It points out the differences between allowing temperatures to rise towards 2°C above pre-industrial times, or keeping them nearer to 1.5°C.

8.3.8 The report finds that a rise by 1.5°C could be reached in as little as 11 years – and almost certainly within 20 years without major cuts in carbon dioxide (CO_2)

emissions) if global warming continues to increase at the current rate. To limit the temperature rise to 1.5°C, global net human-caused emissions of carbon dioxide (CO_2) would need to fall by about 45% from 2010 levels by 2030 in order to reach 'net-zero' around 2050. However, to achieve these emissions reductions, "rapid and far-reaching" transitions in land, energy, industry, buildings, transport, and cities and "unprecedented change" would be required.

8.3.9 The report estimates that renewables would be required to supply 70-85% of electricity by 2050 in 1.5°C pathways. Making this monumental shift in energy production would require substantial new investment in low-carbon technologies and energy efficiency.

UK Policy and Targets

The Fifth Carbon Budget (2016)

6.1.1 At the UK level, on 30 June 2016, the UK Government confirmed its intention to set the Fifth Carbon Budget[iii] to reduce UK greenhouse gas emissions relative to 1990 levels by 57% by 2028-32. This is in line with advice provided to the UK Government by the UK Committee on Climate Change. The Fifth Carbon Budget was officially set through The Carbon Budget Order 2016 which came into effect on 21 July 2016.

6.1.2 The UK has met its first Carbon Budget (23% reduction of UK greenhouse gas emissions between 2008-2012) and is on track to meet the 2nd Carbon Budget (29% reduction of UK greenhouse gas emissions between 2013-2017) and 3rd Carbon Budget (35% reduction of UK greenhouse gas emissions between 2018-2022). However, the UK is currently not on track to meet the 4th Carbon Budget (50% reduction of UK greenhouse gas emissions between 2023-2027).

The UK Clean Growth Strategy (2017)

6.1.1 In October 2017, the UK Government published the Clean Growth Strategy (CGS) 'Leading the Way to a Low Carbon Future'[iv]. The key message of the Strategy is that clean growth means growing our national income while cutting greenhouse gas emissions. The CGS sets out a comprehensive set of policies and proposals that aim to accelerate the pace of 'clean growth' i.e. deliver increased economic growth and decreased emissions. It states that *"in order to meet these objectives, the UK will need to nurture low carbon technologies, processes and systems that are as cheap as possible"*. The Strategy is considered to be *"at the heart of the UK's Industrial Strategy"*.

6.1.2 The Strategy draws on the UK's commitments under the Climate Change Act 2008, which commits the UK to reducing greenhouse gas emissions and the associated 'Carbon Budgets' relative to 1990 levels by at least 80% by 2050. It is reported that the UK outperformed the target emissions reduction of the first carbon budget (2008 to 2012) and is projected to outperform against the second and third budgets (covering 2013 to 2022). However, it is considered that in order to meet the fourth and fifth carbon budgets (covering the period 2023 to 2027 and 2028 to 2032) *"we will need to drive a significant acceleration in the pace of decarbonisation and in this strategy we have set out stretching domestic policies that keep us on track to meet our carbon budgets"*.

8.3.10 The Strategy references the 2015 Paris Agreement and states that *"the actions and investments that will be needed to meet the Paris commitments will ensure the shift to clean growth will be at the forefront of policy and economic decisions made by governments and businesses in the coming decades".*

The UK Industrial Strategy (2017)

8.3.11 The Industrial Strategy entitled 'Building a Britain fit for the future'[v] was published by the UK Government in November 2017. The overall aim of this Strategy is to create an economy that boosts productivity and earning power throughout the UK. The Strategy identifies four 'Grand Challenges' that are set to put the UK at the forefront of the industries of the future and one of these is 'Clean Growth', against which it is stated that the Government will *"maximise the advantages for UK industry from the global shift to clean growth"*.

8.3.12 Key policy areas relate to ideas, people, infrastructure, business environment and places. In discussing Clean Growth, the UK Industrial Strategy states *"we will maximise the advantages for UK industry from the global shift to clean growth – through leading the world in the development, manufacture and use of low carbon technologies, systems and services that cost less than high carbon alternatives".*

Scottish Climate Change and Energy Policy

8.3.13 The Scottish Government has devolved authority over matters relating to the implementation of energy policy and there have been a number of policy documents and legislation produced in recent years dealing with climate change and renewable energy. The documents summarised below are considered to set out the Scottish Government's commitment to reducing carbon emissions via the promotion and development of renewable energy and the contribution this can make to energy generation throughout Scotland.

Climate Change (Emissions Reduction Targets) (Scotland) Bill 2019

8.3.14 The Scottish Government introduced a new Climate Change (Emissions Reduction Targets) (Scotland) Bill to Parliament on 23rd May 2018. The Bill was subsequently passed in September 2019 and became an Act[vi].

8.3.15 The Bill raises the ambition of further reducing greenhouse gas emissions by amending the targets set out within the Climate Change (Scotland) Act 2009 and sets a legally binding net zero targets of all greenhouse gases by 2045. This target date is five years ahead of the current date set for the rest of the UK and aims to ensure Scotland contributes to the worldwide efforts to deliver on the Paris Agreement.

8.3.16 Setting a net-zero target by 2045 is an ambitious target and places Scotland at the forefront of efforts to combat climate change. Through this bill and other associated Government strategies and policies, the Scottish Government aim to provide certainty and credibility to businesses, industries and investors that are vital partners in Scotland's transition to a low carbon economy.

Climate Change Emergency

8.3.17 In April 2019 the Scottish Government declared a climate change emergency, which instigated a commitment to enforcing stronger climate change proposals and targets whilst delivering support to the transition to a low carbon economy. It is anticipated at this stage that this declaration will deliver revised approaches and shape future guidance for a range of policy decisions, affecting transport, oil and gas and renewable energy strategy.

The Planning (Scotland) Act 2019

8.3.18 As part of the planning reform, a Bill for an Act[vii] of the Scottish Parliament to make provision about how land is developed and used, was introduced by the Cabinet Secretary in December 2017. The Bill sets out a number of new provisions to be

adopted under the Town and Country Planning (Scotland) Act 1997. The Bill aspired to strengthen 'inclusive growth, housing and infrastructure delivery whilst empowering communities' and it is anticipated that Local Authorities will have more scope in the future for local planning to influence regional and national plans.

8.3.19 The Scottish Parliament passed the Scotland (Planning) Bill on 20th June 2019, and this received Royal Assent as the Planning (Scotland) Act 2019 on 25th July 2019. Work has commenced on developing the required secondary legislation to set out the detail of how the new provisions will work in practice. As part of this, the National Planning Framework is to be reviewed, and the new NPF (NPF4) is not expected to be adopted until later in 2020.

Scottish Government Climate Change Adaptation Programme 2019: Fifth Annual Progress Report

8.3.20 In May 2019 the Scottish Government published its fifth annual progress report[viii] on Scotland's Climate Change Adaptation Programme. This report provides the wider context for climate change adaptation throughout Scotland whilst setting out the progress towards implementing the objectives, proposals and policies set out in the statutory Adoption Programme.

8.3.21 The report indicates that alongside existing climate change issues we are experiencing there is a strong risk of future issues occurring as a result of climate change. The report does however indicate there are many opportunities to combat the effects of climate change, and the Scottish Government are committed to ensuring measures can be implemented to meet the net zero target in 2045.

8.3.22 This report sits alongside Scotland's second climate change adaptation programme, published in 2019.

Climate Ready Scotland: Climate Change Adaptation Programme 2019 – 2024

8.3.23 Published in September 2019 and following on from the first programme published in 2014, the Climate Change Adaptation Programme 2019 – 2024[ix] sets out a five-year programme to prepare Scotland for the challenges likely to be faced as our climate continues to change. The programme aims to ensure *'that Scotland is a place where its built and natural places, supporting systems, economy and societies are climate ready, adaptable and resilient to climate change.'*

8.3.24 The programme responds to the urgent requirement for action to cut emissions and the stronger net-zero target of 2045 and sets the goal of ending Scotland's contribution to climate change within a generation. Setting out an outcome-based approach derived from the UN sustainable goals and Scotland's National Performance Framework, the programme promotes collaboration between sectors to achieve climate change adaptation.

Low Carbon Scotland: Climate Change Plan – Third Report on Proposals and Policies 2018-2032

8.3.25 Published in September 2018 the Climate Change Plan – Third Report on Proposals and Policies[x] provides an overview of the Scottish Governments climate change plan between 2018 and 2032. The report includes up to date statistics on renewable energy generation, stating:

"In 2015, Scotland had reduced its emissions by 41% from the 1990 baseline, and in 2017 Scotland has generated 68.1% of its electricity requirements from renewables. Scotland's success in decarbonising electricity paves the way for

transformational change across all sectors of the economy and society, particularly as electricity will be increasingly important as a power source for heat and transport."

8.3.26 The Climate Change Plan anticipates that by 2032 Scotland will have reduced its emissions by 66% (relative to baseline) while growing the economy, increasing the wellbeing of the people of Scotland and enhancing the natural environment. Additionally, the plan anticipates that by 2032 Scotland's electricity system will be largely decarbonised and increasingly important as a power source for transport and heat.

Protecting Scotland's Future: The Government's Programme for Scotland 2019-2020

8.3.27 Published in September 2019, Protecting Scotland's Future: The Government's Programme for Scotland 2019-2020[xi] sets out these key actions and legislative programme for the next parliamentary year. One of the key focus areas for the programme is outlining the next steps for tackling climate change to meet the challenge posed by the climate emergency, and a range of actions are proposed to achieve this.

8.3.28 One of the notable actions within the programme is a target that by 2024 all new homes constructed must be heated via renewable sources or low carbon heat.

8.3.29 Continued investment in renewable energy projects is targeted and the Government are committed to accelerating the effort to use 100% renewable energy on the Scottish public estate. Furthermore, the programme states the importance of ensuring we generate sufficient levels of renewable energy to reach the target of net-zero greenhouse gas emissions by 2045.

Climate Change (Scotland) Act 2009

8.3.30 The Climate Change (Scotland) Act 2009[xii] provides a long-term framework to ensure a reduction in greenhouse gas emissions by 80% by 2050, with an interim milestone of 42% by 2020.

8.3.31 Whilst successive bills and legislation have increased the target to net zero emissions, as reported below, the Climate Change (Scotland) Act 2009 provides the wider context for Scotland's ambitious targets for the reduction of carbon emissions.

Scottish Energy Strategy

8.3.32 The Scottish Energy Strategy 2017: The Future of Energy in Scotland[xiii] outlines the vision for the future energy system in Scotland, up until 2050. Among the key priorities are the development of an integrated approach that considers both the use and supply of energy for heat, power and transport.

8.3.33 The Energy Strategy aims to strengthen the development of local energy projects, protect consumers and support Scotland's climate change ambitions.

Onshore Wind Policy Statement

8.3.34 In December 2017 the Scottish Government published its Onshore Wind Policy Statement[xiv] to sit alongside the Scottish Energy Strategy. The ministerial foreword by Paul Wheelhouse MSP highlights the *"vital"* role that onshore wind will continue to play in Scotland's future, *"helping to substantively decarbonise our electricity supplies, heat and transport systems, thereby boosting our economy and meeting local and national demand."* The ministerial foreword continues to highlight that this important role *"means we must support development in the right places, and increasingly – the extension and replacement of existing sites, where acceptable,*

with new and larger turbines, based on an appropriate, case by case assessment of their effects and impacts."

8.3.35 Specifically, in relation to the use of larger turbines, the policy statement makes the following points:

"In order for onshore wind to play its vital role in meeting Scotland's energy needs, and a material role in growing our economy, its contribution must continue to grow. Onshore wind generation will remain crucial in terms of our goals for a decarbonised energy system, helping to meet the greater demand from our heat and transport sectors, as well as making further progress towards the ambitious renewable targets which the Scottish Government has set.

This means that Scotland will continue to need more onshore wind development and capacity, in locations across our landscapes where it can be accommodated.

We know that new projects face a highly uncertain route to market. The arrangements which have enabled onshore wind to expand and to reduce its costs so successfully are no longer in place. Continued innovation and cost reduction, a supportive and well-resourced planning system, and continued advances in turbine and blade technology will help close the gap that currently exists – but not sufficiently, and not for all developments.

We acknowledge that onshore wind technology and equipment manufacturers in the market are moving towards larger and more powerful (i.e. higher capacity) turbines, and that these – by necessity – will mean taller towers and blade tip heights.

The technology shift towards larger turbines may present challenges when identifying landscapes with the capacity to accommodate larger scale development, as not all will be suitable. However, fewer but larger wind turbines may also present an opportunity for landscape improvement, as well as increasing the amount of electricity generated.

The Scottish Government acknowledges the way in which wind turbine technology and design is evolving, and fully supports the delivery of large wind turbines in landscapes judged to be capable of accommodating them without significant adverse impacts…"

8.3.36 The Onshore Wind Policy Statement clearly states the Scottish Government's policy and support towards onshore wind, whilst ensuring suitable protection is afforded to the environment and residential amenity. There is clear support for protecting and enhancing community benefits.

8.3.37 Within the Policy Statement onshore wind is recognised as a mature technology which is expected to remain at the centre of a clean, reliable and low carbon energy future. To facilitate the role of onshore wind in meeting Scotland's future energy needs, it is considered that the installed capacity needs to continue to grow in locations where it can be suitably accommodated throughout the country.

8.4 Assessment Methodology and Significance Criteria

8.4.1 Future climate projections are published by the Met Office through the UK Climate Projections website. The UK Climate Projections Report 2018 (UKCP18) provides an update to the Climate Change Projections Report 2009 (UKCP09)[xv] , which remains the official source of information on how the climate of the UK may change over this century.

8.4.2 While UKCP18 projections use different emissions scenarios from UKCP09, they were also run for the SRES A1B "medium" scenario to allow a direct comparison between the two.

8.4.3 For this assessment it is proposed that the medium emissions scenario (A1B) will be utilised as the future baseline. This scenario is based on a future of rapid economic growth and the rapid introduction of new, more efficient technologies with a balance of non-fossil fuel and fossil fuel intensive energy technologies. Projected climatic changes at the 50% probability level (central estimate) are also utilised in this CCIA assessment, unless otherwise indicated.

Vulnerability of the Revised Consented Development to Climate Change

8.4.4 This section of the CCIA identifies aspects of the Revised Consented Development which are potentially vulnerable to the effects of climate change. Where identified, these vulnerabilities can then be mitigated through embedded mitigation or the application of other measures.

Influence of the Revised Consented Development on Climate Change

8.4.5 This section of the CCIA seeks to quantify the effect of the Revised Consented Development on climate change. The methodology provides a balance of total carbon savings and carbon losses over the life of the Revised Consented Development. It estimates the carbon payback time for the Revised Consented Development based on the source of power being displaced (i.e., the time needed to generate carbon saving equivalent to the amount of carbon lost).

8.4.6 For this application, version 1.6.1 of the online calculator was used on 09/06/2021, with reference number UZS0-WUGX-1YDR.. See **Plate 8.1** for a screen shot of the online carbon calculator results page.

Payback Time and CO_2 emissions • UZS0-WUGX-1YDR v4

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	255,896	191,922	263,004
...grid-mix of electricity generation (t CO2 / yr)	70,533	52,899	72,492
...fossil fuel-mix of electricity generation (t CO2 / yr)	125,166	93,875	128,643
Energy output from windfarm over lifetime (MWh)	11,125,901	8,344,426	11,434,954

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	86,162	83,448	88,876
3. Losses due to backup	69,537	0	69,537
4. Lossess due to reduced carbon fixing potential	1,540	552	2,375
5. Losses from soil organic matter	40,408	17,811	80,161
6. Losses due to DOC & POC leaching	47	0	177
7. Losses due to felling forestry	117,275	99,684	136,169
Total losses of carbon dioxide	314,968	201,494	377,295

8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	0	0	0
8b. Change in emissions due to improvement of felled forestry	-21,572	0	-37,925
8c. Change in emissions due to restoration of peat from borrow pits	-319	0	-656
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	-21,891	0	-38,581

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	293,077	162,913	377,295
Carbon Payback Time			
...coal-fired electricity generation (years)	1.1	0.6	2.0
...grid-mix of electricity generation (years)	4.2	2.2	7.1
...fossil fuel-mix of electricity generation (years)	2.3	1.3	4.0
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	1.85	0.46	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	26.34	14.25	45.22

Plate 8.1 Screen shot of the carbon calculator results page

8.4.7 The Scottish Government's carbon calculator tool has been completed for the Revised Consented Development using the latest version of the calculator (C-CalcWebV1.6.1). The carbon assessment methodology used is consistent with that published by the Rural and Environment Research and Analysis Directorate of the Scottish Government entitled 'Calculating carbon savings from wind farms on Scottish peat lands – a new approach'. This publication sets out the approach and assumptions that should be used to estimate potential carbon losses and savings from wind farms on Scottish peatlands. The carbon balance assessment is included in this chapter.

8.4.8 The carbon calculator determines the carbon emission savings and the carbon payback of wind farms and explores the potential implications under different scenarios of developments and assumptions about the site i.e. expected, best case

and worse case scenarios. It provides the potential carbon savings and carbon costs associated with wind farms.

8.4.9 The calculation of the carbon balance of a proposed wind farm provides a mechanism by which the carbon costs of a wind farm development can be weighed against the carbon savings attributable to the wind farm during its lifetime. This calculation is summarised as the length of time (in years) it will take the carbon savings to amount to the carbon costs and is referred to as the 'payback period'. This information can then inform decision makers of the viability of a wind farm development in terms of overall carbon savings.

8.4.10 The data sources and assumptions used in the carbon balance assessment are detailed in **Appendix 8.A**.

Effects on Environmental Receptors Sensitive to Climate Change

8.4.11 This section of the CCIA identifies where climate change has the potential to significantly impact the findings of assessments undertaken and reported elsewhere in this EIA Report. Reference is made to the specific assessment chapters, where the sensitivity of receptors is discussed, and assessments are not repeated here.

Assessment Limitations

8.4.12 This climate change projections are based on global models for a range of greenhouse gas emissions scenarios and generally consider regional responses to climate change rather than local responses. Regional (e.g. Scotland wide) and national (e.g. UK wide) data has been used to inform the assessments of all climatic considerations. The lifetime of the Revised Consented Development is for a period of 40 years from date of commissioning. Future predictions for regional and national climatic changes are available for 2040-2099 which is towards the end of the projected lifespan of the Revised Consented Development.

Significance Criteria

8.4.13 The IEMA guidelines[xvi] for the CCIA state the following with regards to the assessment of significance:

''This guidance is not proposing changes to the significance criteria used in the EIA process. However, the susceptibility or resilience of the receptor to climate change must be considered as well as the value of the receptor.

Therefore, a high-value receptor that has very little resilience to changes in climatic conditions should be considered more likely to be significantly affected than a high-value receptor that is very resilient to changes in climatic conditions.

The uncertainty of the combined effect needs to be taken into account. If uncertainty about how a receptor will adapt to a changing climate is high, then it is recommended that a conservative threshold of significance is adopted within the evaluation.''

8.4.14 To determine whether effects are significant under the EIA Regulations, it is appropriate to consider the sensitivity (value and resilience) of the receptor and the magnitude of the impact, taking into account uncertainty. This is based on the professional judgement of the assessor and uses the matrix set out in **Table 8.1** below.

Table 8.1 Significance Evaluation Matrix

		Magnitude of Change			
		Very High	**High**	**Medium**	**Low**
Sensitivity/Importance/Value	**Very High**	Major (**significant**)	Major (**significant**)	Moderate (Probably significant)	Minor (Not significant)
	High	Major (**significant**)	Major (**significant**)	Moderate (Probably significant)	Minor (Not significant)
	Medium	Major (**significant**)	Major (**significant**)	Moderate (Probably significant)	Minor (Not significant)
	Low	Moderate (Probably significant)	Moderate (Probably significant)	Minor (Not significant)	Negligible (Not significant)

8.4.15 Effects assessed can be both beneficial (positive) and adverse (negative) as a result of the Revised Consented Development. Sensitivity of climate change receptors is inherently linked to the magnitude of change. Whilst receptors may be considered *"Very-high"* or *"high" value*, a medium magnitude of change for a low sensitivity receptor and a low magnitude of change for all classifications of receptor would result in any effects being considered not significant.

8.5 Scoping Responses and Consultation

8.5.1 Throughout the scoping exercise, and subsequently during the ongoing EIA process, relevant organisations were contacted with regards to the Revised Consented Development. **Table 8.2** outlines the consultation responses received in relation to climate change and carbon balance.

Table 8.2: Consultation Responses

Consultee	Issues Raised	Response	Where Addressed in This Chapter
The Highland Council	Alternatives: Such assessment should also highlight sustainable development attributes including for example assessment of carbon emissions / carbon savings.	Comments Noted	This chapter sets out the carbon emissions and savings from the Proposed Development.
The Highland Council	The EIAR needs to address all relevant climatic factors which can greatly influence the impact range of many of the preceding factors on account of seasonal changes affecting, rainfall, sunlight, prevailing wind direction etc. From this base data information on the expected impacts of any development can then be founded recognising likely impacts for each phases of development	Comments Noted	This chapter addresses all relevant climatic factors.

Consultee	Issues Raised	Response	Where Addressed in This Chapter
	including construction, operation, and decommissioning.		
The Highland Council	Carbon balance calculations should be undertaken and included within the EIAR with a summary of the results provided focussing on the carbon payback period for the wind farm.	Comments noted.	The carbon payback period for the wind farm is set out in this chapter.

8.6 Baseline

Climate Projections

8.6.1 The UK Climate Projection Report: The Climate of the UK and Recent Trends[xvii] provides observed climate data for UK Regions. **Table 8.3** below indicates the observed changes in climatic variables between 1961 and 2006 (reported at the 95% confidence level) for the North of Scotland where the Revised Consented Development is located.

Table 8.3: Observed Changes in Climate Variables for the North of Scotland (1961 – 2006)

Climate Variables	Annual Observed Change (1961 – 2006)
Daily mean temperature	+ 1.05 degrees Celsius (°C)
Daily maximum temperature	+ 1.18 °C
Daily minimum temperature	+ 0.97 °C
Change in days of air frost	- 24.6 days
Change in cooling degree days	+ 3.4 days
Change in heating degree days	- 11.5 days
Change (days) in days of rain > 1mm	+ 7.7 days
Percentage change in total precipitation	+ 23.0 %
Change in mean sea-level pressure (hectopascal (hPa))	- 0.6 hPa
Change in relative humidity	- 3.2 %

8.6.2 Findings from the UK climate projections headline findings[xviii]

Wind Speed

8.6.3 The UK Climate Projections Science Report: Probabilistic Projections of Wind Speed[xix] provides projections for summer and winter wind speeds for time periods 2040 - 2069 and 2070 - 2099. The lifetime of the Revised Consented Development is for a period of 40 years from date of commissioning and as such, the 2040 – 2069 period provides the closest projections to the operational phase and is used for the purpose of this assessment. For Scotland, projected summer wind speeds for 2040 – 2069, at the 50% probability level (under the medium emissions scenario), are slightly skewed towards a small reduction in wind speed, with changes predicted between – 0.2 m/s and 0 m/s which equates to around a reduction of 0.4 knots. This is a minimal

change compared with the typical magnitude of summer mean wind speeds for Scotland which is between 7 – 14 knots.

8.6.4 Projected winter wind speeds for 2040 – 2069 in Scotland at the 50% probability level (under the medium emissions scenario) are between – 0.2 m/s to 0.1 m/s which equates to roughly 0.4 knots and is a relatively small change compared to the mean observed winter wind speed value of between 10 - 24 knots over Scotland.

8.6.5 These projections are in line with the findings by Pryor and Barthelmie (2010)[xx] who concluded that in the near-term (i.e. until the 2050s) there will be no detectable significant change in the wind resource of northern Europe.

Precipitation

8.6.6 During the 2040 – 2069 period, the annual mean precipitation percentage change in North Scotland is predicted at -2%, derived from a predicted winter increase of 10% precipitation and a summer decrease of 12% (based on 50% probability level and medium emissions scenario, considered to be the central estimate).

Temperature

8.6.7 Based on predictions included in the UK Climate Projections Science Report, temperature changes are assessed for regional areas including the North of Scotland.

8.6.8 At 50% probability levels there is a change to the average daily mean temperature (ºC) of the winter (+2.5 ºC) and summer (+4ºC) by the 2080s in North Scotland, under the medium emissions scenario[xxi].

2018 UK Climate Projections

8.6.9 Using the latest science from the Met Office and around the world, the UK Climate Projections 2018 illustrate a range of future climate scenarios until 2100 – showing increasing summer temperatures, more extreme weather and rising sea levels are all on the horizon and urgent international action is needed.

8.6.10 The high emission scenario shows:

- Summer temperatures could be up to 5.4ºC hotter by 2070, while winters could be up to 4.2ºC warmer;
- The chance of a summer as hot as 2018 is around 50% by 2050;
- Sea levels in London could rise by up to 1.15 metres by 2100; and
- Average summer rainfall could decrease by up to 47 per cent by 2070, while there could be up to 35 per cent more precipitation in winter.

8.6.11 Sea levels are projected to rise over the 21st century and beyond under all emission scenarios – meaning we can expect to see an increase in both the frequency and magnitude of extreme water levels around the UK coastline.

2019 UK Climate Projections

8.6.12 In September 2019 updated findings[xxii] of UK climate projections were published. Headline findings include:

- The average temperature over the most recent decade (2009-2018) has been on average 0.3ºC warmer than the 1981-2010 average and 0.9ºC warmer than the 1961-1990 average. All the top ten warmest years for the UK, in the series from 1884, have occurred since 2002;

- The longest running instrumental record of temperature in the world, the Central England temperature dataset, shows that the most recent decade (2009-2018) was around 1°C warmer than the pre-industrial period (1850-1900). The 21st century so far, has been warmer than the previous three centuries.
- Winters in the UK for this most recent decade (2009-18) have been on average 5% wetter than 1981-2010 and 12% wetter than 1961-1990. Summers in the UK have also been wetter, by 11% and 13% respectively.
- Total rainfall from extreme wet days (days exceeding the 99th percentile of the 1961-1990 rainfall) increased by around 17% in the decade (2008-2017), for the UK overall. Changes are largest for Scotland.

Greenhouse Gas Emissions and Renewable Energy

8.6.13 Table 8.3 of the Digest of United Kingdom Energy Statistics (DUKES) 2018[xxiii] provides details of the sources used in generation of electricity throughout 2017 by major power producers. Of a total of 52.79 million tonnes of oil equivalent generated in 2017 within the UK, 27.9 million tonnes of oil equivalent were generated by natural gas, oil and coal, and 7.7 million tonnes of oil equivalent were generated from renewable resources. These numbers demonstrate that fuels which emit high levels of carbon emissions are currently generating the majority of electricity within the UK.

8.6.14 Updated DUKES figures[xxiv] from 2019 (the most recent available) show that Electricity generated from renewable sources in the UK in 2019 reached a record 37.1 per cent of total UK electricity generation, up from 33.1 per cent in 2018. This increase reflected a 6.5 per cent rise in renewable generation capacity to 47.2 GW.

8.6.15 Of a total of 48.76 million tonnes of oil equivalent generated in 2020 within the UK 36.32 million tonnes of oil equivalent were generated by natural gas, oil and coal, and 12.44 million tonnes of oil equivalent were generated from renewable resources. These numbers continue to demonstrate that fuels which emit high levels of carbon emissions are currently generating the majority of electricity within the UK.

8.6.16 As outlined in section 8.3, the Scottish Government has set ambitious targets for reductions in greenhouse gas emissions and renewable technologies generated the equivalent of 59.4% of Scotland's electricity requirements in 2015. This is compared to just over 10% in 2001 with the majority of this growth attributed to a substantial increase in onshore wind developments. With the continued development of onshore wind farms, in the planning and pre-construction phases, it is anticipated that onshore wind farms will continue to make a sizeable contribution to the energy generated from renewable energy technologies within Scotland.

8.7 Assessment of Potential Effects

Vulnerability of the Revised Consented Development to Climate Change

8.7.1 Wind turbines are designed to capture wind energy. Turbines are therefore built to withstand extreme climatic conditions and are purposefully located in exposed locations. However, wind energy developments could potentially be sensitive to significant changes in climatic variables, including atmospheric circulation and land cover changes as well as changes in the frequency of extreme events (e.g., storms), which could damage wind turbines or alter their efficiency.

8.7.2 In the near-term (i.e., 2040 – 2069) there will be no detectable significant change in the wind resources of northern Europe. As a result, these minor predicted changes in summer and winter wind speeds between 2040 and 2069 are highly unlikely to affect the operation of the Revised Consented Development. It is unlikely that the energy projections for the Revised Consented Development will be affected during its lifetime.

8.7.3 Due to its location, the Revised Consented Development is not prone to natural disasters. Whilst adverse weather conditions, most notably high windstorms, ice producing conditions and lightning strikes, do occur within Scotland, wind turbines are designed to withstand extreme weather conditions. Therefore, none of the identified climate change trends detailed in the baseline in **Section 8.6** above will affect the Revised Consented Development with the exception of increased windstorms. Due to the exposed nature of windfarm sites, wind turbines are designed to withstand extreme weather conditions. Brake mechanisms installed on turbines allow them to be operated only under specific wind speeds and, should severe windstorms be experienced, then the turbines would be shut down. Although an unlikely event for Scotland, the brake mechanism could also apply to a hurricane scenario.

8.7.4 Given the negligible magnitude of change from the Revised Consented Development and the low sensitivity of the Revised Consented Development as an environmental receptor, there are no significant effects predicted as a result of increased wind speeds during the operational phase of the Revised Consented Development.

Potential Contribution of the Revised Consented Development to Government Objectives

Energy Yield

8.7.5 The installed capacity of a wind turbine is a measure of its maximum rated output, which in the context of the Revised Consented Development is an estimated 88.2MW[xxv] (assuming 21 x 4.2MW machines). Calculations of the likely electricity generation of the turbines are dependent on the 'capacity factor', which involves an assessment of the actual output of the development against its installed capacity[xxvi].

5.1.3 On this basis, and with an estimated installed capacity of 88.2MW, the amount of electricity produced by the Revised Consented Development has been estimated to be 278,147MWh per year[1] based on a site-specific capacity factor of 36% derived from the use of larger turbine blades and with over two years of wind monitoring from the temporary anemometer mast installed at the Development Site (noting that this capacity factor is greater than the 5 years average Scottish capacity factor of 27% and UK capacity factor of 26.7%[xxvii]).

5.1.4 This 36% capacity factor has been used to calculate potential annual energy yield for the Revised Consented Development, shown in **Table 8.4** below.

Carbon Dioxide Savings & Electricity Generation

5.1.5 It is widely accepted that electricity produced from wind energy has a positive benefit with regard to reducing CO_2 emissions. However, there has been much debate about the actual level of emissions savings that might arise from a wind farm development. In estimating the actual saving it is important to consider the mix of alternative sources of electricity generation, for example, coal, oil, and gas powered. To

[1] Estimated electricity generation based on the rolling Scottish average capacity factor of 27% is 205,520 MWh.

represent this energy mix, Renewable UK recommend the use of a static figure of 446g of CO_2 saved for every kWh generated (Renewable UK, UKWED Figures explained, 2020). A figure of 446g of CO_2 savings per kWh has therefore been assumed for the purposes of this assessment, with savings of CO_2 estimated on the basis of a range of capacity factors.

6.1.6 The Department for Business, Energy, and Industrial Strategy (BEIS), formerly the Department for Energy and Climate Change (DECC) produces a range of statistics detailing electricity consumption across the UK. The average domestic consumption in Scotland, based on sales per household, was 3,393 kWh in 2019 (compared to a UK average figure of 3,578 kWh in 2019) (DECC Regional and Local authority electricity consumption statistics, 2005 to 2019[2]).

6.1.7 The electricity generated by the Revised Consented Development will enter the National Grid, and therefore cannot be tracked to the individual consumer. Therefore, it is relevant to consider electricity demand in the context of Scotland as a whole, rather than within the Revised Consented Development surroundings.

6.1.8 The potential electricity generation and 'Homes Equivalent' electricity generation (based on 3,393kWh annual domestic consumption in Scotland) are provided in **Table 8.4**. The potential CO_2 savings as a result of the Revised Consented Development generating electricity instead of conventional power stations, with an assumed 446g CO_2 per kWh generated, are also presented. Results are presented for both Scottish average and site-specific capacity factors.

Table 8.4 Potential CO_2 Savings and Electricity Generation

Capacity Factor (%)	Electricity Generation (MWh per year)[xxviii3]	Homes Equivalent (based on average consumption)[4]	Carbon dioxide savings (Tonnes of CO_2 per year) based on Renewable UK savings figure
27%	208,610	61,483	93,040
36%	278,147	81,977	124,054

Carbon Balance of the Revised Consented Development

Overview

8.7.6 The following sections outline the specific values for the carbon losses and carbon gains associated with the Revised Consented Development. For each input parameter (as outlined in **Appendix 8.A**), an expected minimum and maximum value is required to provide an expected minimum and maximum scenario for the carbon payback.

[2] https://www.gov.uk/government/statistics/sub-national-electricity-and-gas-consumption-summary-report-2019

[3] For example, using a 27% capacity factor, figures are derived as follows: 88.2MW × 8,760 hours/year × 0.27 (capacity factor) = 208,610MWh.

[4] This is calculated using the most recent statistics from BEIS showing that annual Scottish average domestic household consumption is 3,3931kWh.

8.7.7 For this application, version 1.6.1 of the online calculator was used on 09/06/2021, the reference number is not supplied in this document, but has been communicated separately to the ECU and relevant consultees.

8.7.8 A table containing the values for each scenario and the justification for the values used for the carbon balance calculations is in **Appendix 8.A.**

Carbon Losses

8.7.9 The manufacturing, construction, and installation (including concrete) of the wind turbines at the Revised Consented Development has an associated carbon cost. Using figures from the online calculator, the expected case carbon emission losses associated with the manufacture, construction and decommissioning of the twenty-one turbines of average 88.2MW installed capacity, is 86,162 tonnes CO_2 equivalent (t CO_2e), which equates to approximately 27.4% of total CO_2 losses.

8.7.10 The carbon payback model attributes carbon losses due to the requirement for extra capacity to back up wind power generation at times of peak demand. This is quantified as a percentage of total capacity, which was input as 5% for this case (the recommended figure within the model) and equates to 69,537 t CO_2e (i.e., approximately 22.1% of total carbon dioxide losses).

8.7.11 Carbon losses associated with CO_2 release from soil organic matter for the expected case amount to 40407.54 t CO_2e which equates to approximately 12.8% of total CO_2 losses. These losses result from peat removal and drainage effects following excavation for items of infrastructure, notably turbine foundations, hard standings and access tracks, as well as borrow pits. It is worth noting that this figure assumes 100% loss of CO_2 from removed/disturbed peat, as this is the default value within the carbon model and cannot be amended. In reality, losses are likely to be considerably less than this, as it is expected that the majority of the peat would be used in reinstating the Site (see **Appendix 13.C Peat Management Plan**).

8.7.12 The wind farm will require 222.11 ha of commercial forestry to be felled. Of this total, 148.92 ha will be restocked with timber and the remaining area (73.19 ha) will be improved ecologically (see carbon gains section below). Carbon losses associated with the felling of timber total 117,275 t CO_2e which equates to approximately 37.2% of total CO_2 losses.

8.7.13 Small carbon losses are generated by the reduction of carbon fixing potential, which occurs due to the loss of bog plants as a result of wind farm construction, together with dissolved organic carbon (DOC) and particulate organic carbon (POC) leaching, both of which are associated with gaseous losses from improved land. For the expected case, these total 1,540 t CO_2e, which equates to 0.5% of total carbon dioxide losses.

Carbon Gains

8.7.14 There are small carbon gains due to reinstatement of peat within borrow pits, improvement of felled forestry and removal of drainage from foundations and hardstanding. These total 1.85 t CO_2e. **Appendix 13.C** of the EIA Report (the Peat Management Plan) sets out how peat will be re-used for habitat reinstatement wherever practicable.

<u>Carbon Payback of the Revised Consented Development</u>

8.7.15 To calculate the carbon payback period, the online calculator uses three different fossil fuel displacement scenarios, which are updated automatically using data from the Digest of UK Energy Statistics (DUKES):

- Grid mix, the mix of electricity sources supplying the UK as a whole;
- Coal fired for coal fired electricity generation; and
- Fossil fuel mix for fossil fuel sourced electricity generation alone.

8.7.16 Nayak *et al* 2011[xxix] recommend using the fossil fuel sourced grid mix scenario as the most appropriate for calculating the carbon payback time (the counterfactual). Based on this scenario, the payback for the Revised Consented Development is predicted to be 2.3 years for the expected outcome.

8.7.17 The payback period could be as low as 1.3 years for the minimum scenario, but increases to 4.0 years for the maximum scenario for fossil fuel mix. The carbon payback for each scenario is shown in **Table 8.5** below.

Payback in years for each Scenario used in the Carbon Calculator

Table 8.5 Payback in Years for Each Scenario Used in the Carbon Calculator

Fuel source	Carbon payback time (years) Expected value	Carbon payback time (years) Minimum value	Carbon payback time (years) Maximum Value
Coal fired	1.1	0.6	2
Grid mix	4.2	2.2	7.1
Fossil fuel mix	2.3	1.3	4.0

Effects of Future Climate Change Scenario on Environmental Receptors Sensitive to Climate Change

8.7.18 The potential for environmental receptors to be impacted by the Revised Consented Development is assessed in other Chapters of this EIA Report.

8.7.19 As outlined above in the near-term (i.e. until the 2050s, based on 50% probability level and medium emissions scenario) there will be no significant change in the regional wind resource and therefore no noticeable change to the future baseline as a result of this parameter. Similarly, estimates of annual mean precipitation amounts show very little change everywhere at the 50% probability level.

8.7.20 Projected changes to the winter and summer seasonal mean temperature in North Scotland at the 50% probability levels are projected as +2.5% during winter and +4°C in summer by the 2080s (based on 50% probability level and medium emissions scenario). A summary of the effects of these changes on receptors are presented in **Table 8.6**.

Table 8.6: Climate Change Effects on Environmental Receptors

EIA Report Chapter	Receptor	Climate Change Effect	Effect on Receptor
11	Ecology – Habitats, Protected Species	Temperature – up to + 2.5°C in winter & +4°C in summer Precipitation - Slight decrease (-2%) overall with increased seasonal variation Negligible change in wind speeds	While a change in precipitation and temperature could affect the composition and growth rates of plant communities and invertebrates, and hence protected species and habitats, the uncertainties are high and it is not clear that the effect of the Revised Consented Development on those receptors would alter substantially as a result.
12	Ornithology	Temperature – up to + 2.5°C in winter & +4°C in summer Precipitation - Slight decrease (-2%) overall with increased seasonal variation Negligible change in wind speeds	A rise in temperature and increased seasonal variation in precipitation have the potential to impact on habitats which in turn may affect the behaviour of birds. As noted above uncertainties are high and the type and significance of effects identified from the Revised Consented Development are not anticipated to alter as a result.
13	Hydrology	Precipitation - slight decrease (-2%) overall with increased seasonal variation	Increased precipitation in winter has the potential to lead to increases in flooding, but uncertainties are high. With the robust embedded design elements such as watercourse buffers, and preparation of a CEMP etc. prior to the construction phase, it is not anticipated that there will be additional significant effects not already identified or mitigated.

8.7.21 As summarised in **Table 8.6**, this EIA Report has considered the effects of climate change on sensitive environmental receptors, based on the future climate change projections detailed in **Section 8.6** of the Chapter.

8.7.22 Given the relatively limited magnitude of change in climate parameters predicted over the period of the Revised Consented Development, negligible changes to the baseline for environmental receptors is anticipated during this period. This is incorporated into the assessments undertaken in other chapters of this EIA Report.

8.7.23 No significant effects will occur as a result of climate change during the operational phase of the Revised Consented Development.

8.8 Assessment of Cumulative Effects

8.8.1 The Scottish and UK Governments have set ambitious targets for reducing greenhouse gas emissions by 2050. The Revised Consented Development, in conjunction with other renewable energy developments, will contribute to Scotland

and the UK's aims to reduce carbon emissions and achieve its ambitious greenhouse gas emissions targets.

8.8.2 DUKES 2020[xxx] details the sources used in generation of electricity throughout 2019 by major power producers, with onshore wind having the highest share of renewable capacity and generation (at 31.7 per cent and 29 per cent respectively).

8.8.3 DUKES 2020 statistics[xxxi] show that renewable electricity represented 37.1% of total generation in 2019, up from 33.1% in 2018. Generation from onshore and offshore wind increased by 6.5 per cent and 20 per cent respectively to new records, both boosted by higher capacities, offsetting lower wind speeds. Installed electrical generating capacity of renewable sources rose by 6.5 per cent (2.9 GW), to 47.2 GW in 2019. Most of the increase was in wind capacity (2.3 GW). Taken together, onshore, and offshore wind represent just over half of renewable electrical capacity.

8.8.4 The Revised Consented Development will contribute up to 88.2MW further installed capacity. This is considered to be a significant, beneficial, cumulative environmental effect under the EIA Regulations and will contribute to the UK's legally binding emission reduction targets.

8.9 Mitigation Measures and Residual Effects

8.9.1 This Chapter identified that negative effects are of such limited and negligible nature that they are not significant and therefore no mitigation is required under the EIA Regulations or recommended as best practice.

8.9.2 Other mitigation measures will include the management of wind turbines to maintain operational efficiency during their lifetime. Maintenance plans for wind turbines would be developed to maximise turbine output and efficiency. Key performance indicators to monitor and track operational efficiency would be developed.

8.10 Summary

8.10.1 The predicted future climatic baseline conditions are highly unlikely to affect the operation of the Revised Consented Development. The Revised Consented Development will have a positive effect on carbon savings and a significant positive effect when considered cumulatively with UK-wide renewable energy deployment. No additional significant effects to those already identified within the EIA Report will occur as a result of climate change during the operational phase of the Revised Consented Development.

8.10.2 The Revised Consented Development will not significantly influence climate change but will have a positive cumulative effect with regards to a reduction in carbon emissions when considered with the UK-wide electricity generation mix. The effects of the Revised Consented Development on climate change are considered to be not significant.

8.10.3 It is predicted that the carbon loss in developing the Revised Consented Development will be paid back in ~2.3 years (5.7% of the 40-year operational life) based upon the fossil fuel mix and the expected outcome. Even considering the maximum scenario, the Revised Consented Development would have achieved the carbon balance within ~4.0 years (10.0% of the 40-year operational life).

8.10.4 On the basis of potential annual CO_2 savings of 124,054 tonnes/year (based on the figure of 446g of CO_2 savings per kWh and a site-specific capacity factor of 36%), the Revised Consented Development could result in a total carbon saving of

approximately 4,962,152 tonnes over its 40 year operational life, and generate electricity to annually supply the equivalent of 81,977 average homes in Scotland.

8.11 References

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[xxv] The installed capacity for the Consented Development presented in the 2016 ES was 72 MW.

[xxvi] The net capacity factor of a wind farm is the ratio of its actual energy output (after energy losses within the wind farm have been accounted for) over a defined period of time (typically a year) to its energy output, had it operated at maximum power output continuously, over the same period of time.

[xxvii] The capacity figure for the Revised Consented Development based on empirical data is substantially greater than the average Scottish and UK capacity factor of 27%, the long term average figure for Scotland and the UK published by Department of Energy and Climate Change (DECC), Energy Trends Section 6: Renewables (ET6.1 Renewable Electricity Capacity and Generation, March 2021. Capacity factor for UK- https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437811/et6_1.xls.

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