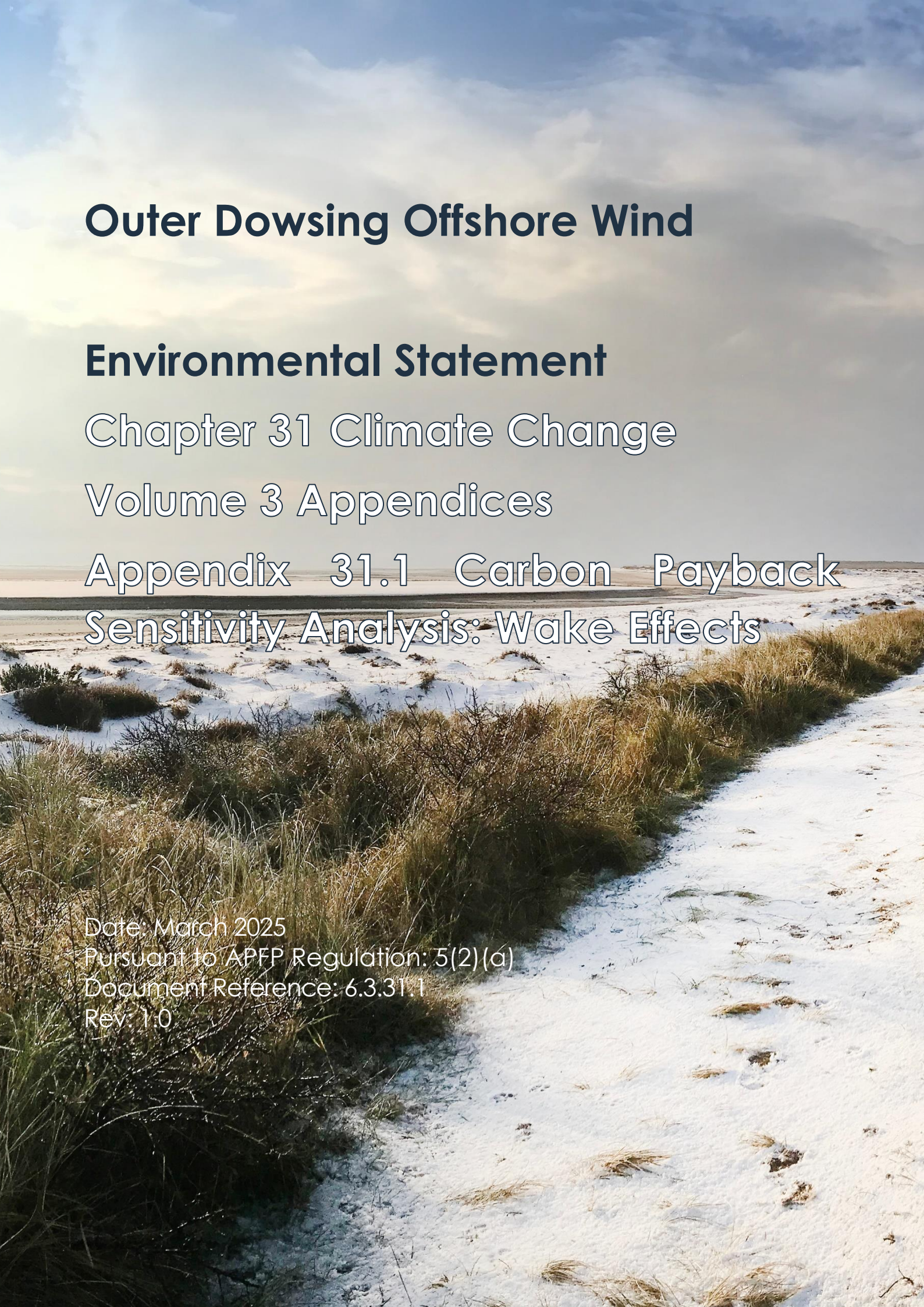

Outer Dowsing Offshore Wind

Environmental Statement

Chapter 31 Climate Change

Volume 3 Appendices

Appendix 31.1 Carbon Payback Sensitivity Analysis: Wake Effects

Date: March 2025
Pursuant to APFP Regulation: 5(2)(a)
Document Reference: 6.3.31.1
Rev: 1.0

Company:	**Outer Dowsing Offshore Wind**	Asset:	**Whole Asset**
Project:	**Whole Wind Farm**	Sub Project/Package:	Whole Asset
Document Title or Description:	Appendix 31.1 Carbon Payback Sensitivity Analysis: Wake Effects		
Internal Document Number:	PP1-ODOW-DEV-CS-REP-0282	3rd Party Doc No (If applicable):	N/A

Rev No.	**Date**	**Status / Reason for Issue**	**Author**	**Checked by**	**Reviewed by**	**Approved by**
1.0	March 2025	Deadline 5 ES Update	Outer Dowsing / SLR	Outer Dowsing	Shepherd & Wedderburn	Outer Dowsing

The content presented in this Appendix was included in the Applicant's Wake Loss Technical Note (REP4-114). This appendix has been created to include the information within the examination updates to the ES and to reflect where relevant clarifications to date in Examination.

Table of Contents

Table of Tables

Acronyms & Definitions

Abbreviations / Acronyms

Abbreviation / Acronym	Description
CO2eq	carbon dioxide equivalent
DCO	Development Consent Order
DUKES	Digest of UK Energy Statistics
EIA	Environmental Impact Assessment
ExA	Examining Authority
GWh	Gigawatt hours
IP	Interested Party
Lidar	Light Detection and Ranging
MtCO2eq	Million Tonnes of carbon dioxide equivalent
NPS	National Policy Statement
OWF	Offshore Wind Farm
SAR	Synthetic-aperture radar
TWh	Terrawatt hours
WIPAFF	WInd PArk Far Fields
WTG	Wint Turbine Generator

Terminology

Term	Definition
The Applicant	GT R4 Ltd. The Applicant making the application for a DCO. The Applicant is GT R4 Limited (a joint venture between Corio Generation (and its affiliates), Total Energies and Gulf Energy Development (GULF)), trading as Outer Dowsing Offshore Wind. The Project is being developed by Corio Generation, TotalEnergies and GULF.
AfL array area	The area of the seabed awarded to GT R4 Ltd. through an Agreement for Lease (AfL) for the development of an offshore wind farm, as part of The Crown Estate's Offshore Wind Leasing Round 4.
Array area	The area offshore within which the generating station (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling will be positioned.
Baseline	The status of the environment at the time of assessment without the development in place.
Cumulative effects	The combined effect of the Project acting additively with the effects of other developments, on the same single receptor/resource.
Cumulative impact	Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with the Project.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP).

Term	Definition
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the sensitivity of the receptor, in accordance with defined significance criteria.
EIA Directive	European Union 2011/92/EU (as amended by Directive 2014/52/EU).
EIA Regulations	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Regulations, including the publication of an Environmental Statement (ES).
Environmental Statement (ES)	The suite of documents that detail the processes and results of the EIA.
Mitigation	Mitigation measures are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.
Offshore Restricted Build Area (ORBA)	The area within the array area, where no wind turbine generator, offshore transformer substation or offshore accommodation platform shall be erected.
Outer Dowsing Offshore Wind (ODOW)	The Project.
Order Limits:	The area subject to the application for development consent, The limits shown on the works plans within which the Project may be carried out.
The Planning Inspectorate	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
The Project	Outer Dowsing Offshore Wind, an offshore wind generating station together with associated onshore and offshore infrastructure.
Wind turbine generator (WTG)	A structure comprising a tower, rotor with three blades connected at the hub, nacelle and ancillary electrical and other equipment which may include J-tube(s), transition piece, access and rest platforms, access ladders, boat access systems, corrosion protection systems, fenders and maintenance equipment, helicopter landing facilities and other associated equipment, fixed to a foundation.
WTG area	The area within the order limits where Wind Turbine Generators (WTG), offshore transformer substations and offshore accommodation platform can be located following the introduction of the Offshore Restricted Build Area (ORBA).

1 Introduction and Document Purpose

The purpose of this document is to quantify the possible consequences of “wake effects” on the carbon payback of the Project. The term “wake effects” refers to the impacts that one windfarm may have on others that are down-wind of it. Depending on proximity, the up-wind windfarm may reduce the amount of energy in the wind arriving at the down-wind windfarms, as well as making the wind flow more turbulent. Both these effects could result in reduced power output from the down-wind windfarms.

It has been suggested that wake effects caused by the Project have the potential to reduce the power output from existing downstream offshore wind farms. This could cause a reduction in the net power production, and therefore the carbon savings that the Project contributes to the UK.

To confirm the positive carbon impact of the Project, two net benefit assessments were completed to evaluate how a reduction in power output from other offshore wind farms would affect the carbon payback of the Project.

2 Possible Consequences of Wake Effects

Two net benefit assessments were conducted on the basis of highly conservative hypothetical scenarios where the wake effect of the Project results in either a 0.5% or 1% loss of energy production from a number of neighbouring OWFs. The total gross annual energy production figures (including existing wake loss before the Project is added) of these OWFs has been calculated using data from the Project wind measurement campaigns, and using data related to other OWFs from the MapStand database and 4c offshore wind.

The OWFs considered in this assessment, their total annual energy production figures, and 0.5% and 1% of these figures are shown in Table 2-1 (noting that from the above assessment (Section 4 Table 4-1) figures are, for most projects, substantially below the 0.5% and therefore the below values are hypothetical).

Table 2-1: Annual electricity production figures of the OWFs considered

Wind Farm	Gross production including wake (GWh/yr)	0.5% of the Gross production	1% of the Gross production
Race Bank	1,968	9.8	19.7
Dudgeon	1,468	7.3	14.7
Triton Knoll	3,287	16.4	32.9
Hornsea 1	5,695	28.5	57.0
Hornsea 2	5,819	29.1	58.2
Hornsea 3	14,078	70.4	140.8
Humber Gateway	954	4.8	9.5
Inner Dowsing	381	1.9	3.8
Lincs	1,181	5.9	11.8
Lynn	377	1.9	3.8
Sheringham Shoal	1,199	6.0	12.0
Westermost Rough	798	4.0	8.0
Hornsea 4	11,277	56.4	112.8
Sheringham Shoal Extension	1,620	8.1	16.2
Dudgeon Extension	2,178	10.9	21.8
Total	52,280	261.4	522.8

Table 2-2 shows how the 0.5% and 1% of annual electricity production figures for these OWFs compares with the predicted annual electricity production of the Project.

Table 2-2: Predicted annual electricity generation of the Project compared with 0.5% and 1% of the annual electricity generation for the OWFs considered

Project annual electricity generated (GWh/yr)	5332
0.5% of all electricity generated (GWh/yr) by neighbouring Wind Farms	261.4
1% of all electricity generated (GWh/yr) by	522.8
Ratio of the Project's annual electricity generation to 0.5% of that of its neighbouring Wind Farms	20.4
Ratio of the Project's annual electricity generation to 1.0% of that of its neighbouring Wind Farms	10.2

Table 2-2 shows that the predicted annual electricity generation of the Project is 20.4 times larger than 0.5% of the total annual electricity generation of the neighbouring OWFs considered, and 10.2 times larger than 1% of it. **Therefore, the first conclusion that can be drawn is that the building of the Project would still result in a significant net increase in renewable energy generation under these hypothetical scenarios.**

We have also analysed how the expected carbon pay-back times for the Project change under these two hypothetical scenarios. The following tables present this information.

Table 2-3 shows the expected electricity generation of the Project, and the amount of carbon dioxide equivalent (CO2eq) emissions it is expected to offset under normal circumstances. The calculations assume a load factor of 40.58%, based on a calculation by RenewableUK[1] that determined the average of the past five years of published data from the Digest of UK Energy Statistics (DUKES) from DESNZ. The two offset emissions numbers are based on the Project offsetting either a mix of all non-renewable energy sources, or just gas.

Table 2-3: Original Project electricity generation and offsetting figures

Total annual power generation (GWh)	5,332
Total power generation over 35 year lifetime (TWh)	186.6
35 years of counterfactual "all non-renewables CO2eq emissions" (MtCO2eq)	79.1
35 years of counterfactual Gas CO2eq emissions (MtCO2eq)	69.2

Table 2-4 shows the expected pay-back times, which were calculated from the electricity generation and offsetting figures presented above. The payback times are shown for two scenarios, where the foundation choice for the Project turbines is either a 50:50 combination of jacket/pile foundations and gravity based structures, or 100% jacket/pile foundations.

[1] RenewableUK, 2023, Wind Energy Statistics Explained UK Wind energy database (UKWED) | RenewableUK

Table 2-4: Original Project payback times under two foundation scenarios

	50:50 combination	100% Jacket/pile foundations
Lifetime emissions (MtCO2eq)	5.2	6.3
Total carbon savings for "all non renewables"(MtCO2eq)	73.8	72.8
Total carbon savings for gas (MtCO2eq)	64.0	62.9
Payback time for "all non-renewables" (years)	2.3	2.8
Payback time for gas (years)	2.6	3.2

2.1 Carbon Payback for 0.5% Wake Effect Scenario

For the first comparison, the total annual electricity generation of 0.5% of all the neighbouring OWFs (261.4GWh) has been subtracted from the expected Project total annual electricity generation, leaving the net additional electricity that the Project would generate after wake effects. This results in a new annual electricity generation figure of 5,071GWh for the purposes of pay-back times.

Table 2-5 shows this new electricity generation, and the amount of carbon dioxide equivalent emissions it is expected to offset under these circumstances.

Table 2-5: Project electricity generation and offsetting figures under the 0.5% wake effect hypothetical scenario

Total annual power generation (GWh)	5,071
Total power generation over 35 year lifetime (TWh)	177.5
35 years of counterfactual "all non-renewables CO2eq emissions" (MtCO2eq)	75.2
35 years of counterfactual Gas CO2eq emissions (MtCO2eq)	65.8

Table 2-6 shows how this reduced carbon dioxide equivalent offsetting translates to the pay-back times, both for the two foundation scenarios.

Table 2-6: Project payback times under two foundation scenarios and the 0.5% wake effect hypothetical scenario

	50:50 combination	100% Jacket/pile foundations
Lifetime emissions (MtCO2eq)	5.2	6.3
Total carbon savings for "all non renewables"(MtCO2eq)	70.0	68.9
Total carbon savings for gas (MtCO2eq)	60.6	59.5
Payback time for "all non-renewables" (years)	2.4	2.9
Payback time for gas (years)	2.8	3.3

2.2 Carbon Payback for 1% Wake Effect Scenario

For the second comparison, the same process was used, with the total annual electricity generation of 1% of all the neighbouring OWFs (522.8GWh) being subtracted from the expected Project total annual electricity generation, leaving the net additional electricity that the Project would generate after wake effects. This results in a new annual electricity generation figure of 4,809GWh for the purposes of pay-back times.

Table 2-7 shows this new electricity generation, and the amount of carbon dioxide equivalent emissions it is expected to offset under these circumstances.

Table 2-7: Project electricity generation and offsetting figures under the 1% wake effect hypothetical scenario

Total annual power generation (GWh)	4,809
Total power generation over 35 year lifetime (TWh)	168.3
35 years of counterfactual "all non-renewables CO2eq emissions" (MtCO2eq)	71.3
35 years of counterfactual Gas CO2eq emissions (MtCO2eq)	62.4

Finally, Table 2-8 shows how this reduced carbon dioxide equivalent offsetting translates to the pay-back times, both for the two foundation scenarios.

Table 2-8: Project payback times under two foundation scenarios and the 1% wake effect hypothetical scenario

	50:50 combination	100% Jacket/pile foundations
Lifetime emissions (MtCO2eq)	5.2	6.3
Total carbon savings for "all non renewables"(MtCO2eq)	71.3	65.0
Total carbon savings for gas (MtCO2eq)	62.4	56.1
Payback time for "all non-renewables" (years)	2.6	3.1
Payback time for gas (years)	2.9	3.5

Considering Table 2-3, Table 2-4, Table 2-5, Table 2-6, Table 2-7 and Table 2-8, **the second conclusion to be drawn from this hypothetical scenario is that the carbon pay-back times for the Project would increase from between 2.3 and 3.2 years (the original numbers) to between 2.4 and 3.3 years for the 0.5% wake effect scenario, and to between 2.7 and 3.5 years for the 1% wake effect scenario**. These changes are an increase from the original numbers of between 4% and 6% for the 0.5% wake effect scenario, and between 10% and 11% for the 1% wake effect scenario.

Overall, then, we see that, if the Wake Effects from the Project reduced electricity production from neighbouring OWFs by 0.5%, its carbon payback time would increase to 2.4-3.3 years, while if it reduced electricity production by 1%, its carbon payback time would increase to 2.7-3.5 years. These increases are not considered to be material for the purposes of EIA.