ENVIRONMENTAL STATEMENT: 6.1 CHAPTER 13: GREENHOUSE GASES

DECARBONISATION

Cory Decarbonisation Project

PINS Reference: EN010128

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Revision A

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations (2009) - Regulation 5(2)(a)

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13. GREENHOUSE GASES

13.1. INTRODUCTION

13.1.1. This chapter reports the assessment of the likely significant effects of the Proposed Scheme on greenhouse gases (GHG) during construction and operation, and describes:

- relevant policy, legislation and guidance;
- consultation undertaken to date;
- the methodology for assessment;
- potential effects of the construction phase; and
- potential effects of the operation phase.

13.2. POLICY, LEGISLATION, AND GUIDANCE

13.2.1. The policy, legislation, and guidance relevant to the assessment of GHG for the Proposed Scheme is detailed in **Table 13-1**.

Table 13-1: GHG Summary of Key Policy, Legislation and Guidance

Policy, Legislation or Guidance	Description
Policy	
Overarching National Policy Statement (NPS) for Energy EN-1 2024[1]	This Overarching National Policy Statement for Energy (EN-1) is part of a suite of NPS designated by the Secretary of State of DESNZ in January 2024. This document has a specific section (3.5) on "*The need for new nationally significant carbon capture and storage infrastructure*". Paragraphs 3.5.1-3.5.7 set out the need for CCS infrastructure over the coming decades. Section 5.3 sets out how Applicants should carry out their assessments and the factors that the Secretary of State should take into account in decision making in respect of greenhouse gases. It also requires the Applicant to produce a Greenhouse Gas Reduction Strategy. The Applicant has not produced a dedicated strategy document in this regard, but its measures to reduce greenhouse gas emissions during the construction phase are set out in the **Outline CoCP (Document Reference 7.4)**. The **Planning Statement (Document Reference 5.2)** explains how carbon emissions have been accounted for in the Proposed Scheme development process to date.

Policy, Legislation or Guidance	Description
National Planning Policy Framework (NPPF) 2023[2]	The NPPF sets out the Government's planning policies for England and how these should be applied, with the following paragraphs relating to GHG: Section 11, Paragraph 124 of the NPPF notes that planning policies and decision should "*recognise that some undeveloped land can perform many functions, such as…carbon storage or food production*". Section 14, Paragraph 157 of the NPPF provides that *"The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure*". Paragraph 159 provides that "*New development should be planned for in ways that: … b) can help to reduce greenhouse gas emissions, such as through its location, orientation and design*". Paragraph 163 provides that "*When determining planning applications for renewable and low carbon development, local planning authorities should: a) not require applicants to demonstrate the overall need for renewable or low carbon energy…; and b) approve the application if its impacts are (or can be made) acceptable*". Whilst paragraph 5 of the NPPF confirms the framework does not contain specific policies for nationally significant infrastructure projects, it is identified that the policies contained in the NPPF may include other matters that are relevant. Accordingly, the Secretary of State may determine that the policies of the NPPF in relation to climate change, in addition to those contained in local planning policy, discussed below, are relevant to their determination of the Application for development consent for the Proposed Scheme.
The London Plan 2021[3]	The Spatial Development Strategy for Greater London setting out a framework for how London will develop over the next 20-25 years and the Mayor's vision for Good Growth. Policy SI2 of the London Plan is the key policy relevant to GHG emissions:

Policy, Legislation or Guidance	Description
	"Major development should be net zero-carbon. This means reducing greenhouse gas emissions in operation and minimising both annual and peak energy demand in accordance with the following energy hierarchy: *1) be lean: use less energy and manage demand during operation* *2) be clean: exploit local energy resources (such as secondary heat) and supply energy efficiently and cleanly* *3) be green: maximise opportunities for renewable energy by producing, storing and using renewable energy on-site* *4) be seen: monitor, verify and report on energy performance".* Paragraph 9.2.11 states: "*Operational carbon emissions will make up a declining proportion of a development's whole life-cycle carbon emissions as operational carbon targets become more stringent. To fully capture a development's carbon impact, a whole life-cycle approach is needed to capture its unregulated emissions (i.e., those associated with cooking and small appliances), its embodied emissions (i.e. those associated with raw material extraction, manufacture and transport of building materials and construction) and emissions associated with maintenance, repair and replacement as well as dismantling, demolition and eventual material disposal)".*
The Bexley Local Plan 2023[4]	The Local Plan, adopted on 26 April 2023, positively plans for sustainable development across the Borough, including measures to adapt to and mitigate the effects of climate change. It is essential to the delivery of the Council's other key plans and strategies, including the Bexley Plan, the Growth Strategy and the Connected Communities Strategy. Policy SP14: Mitigating and Adapting to Climate Change, states that the council *"will actively pursue the delivery of sustainable development by:* • *Supporting developments that achieve zero-carbon and demonstrate a commitment to drive down greenhouse gas emissions to net zero;* • *Supporting new and enhanced green infrastructure, including greening of development sites such as living roofs, and the contribution green infrastructure can make to managing flood risk and surface water, and to the mitigation of the urban heat island effect".*

Policy, Legislation or Guidance	Description
	The non-strategic development management policy for climate mitigation is Policy DP30, which states: *"Major development proposals must meet London Plan requirements and calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions".*
The Bexley Climate Change Statement and Action Plan 2022 to 2026[5]	This action plan works alongside Bexley's existing plans and strategies, setting out the climate priorities and ambitions for the years ahead. Part 2 of the action plan focuses on the actions that would "*Influence others to reduce emissions that are not within our direct control*". Under Commitment 5 – Empower our residents, businesses and partners to make positive changes, it is committed to "*Work with Cory Riverside Energy to encourage the use of the heat produced at the Belvedere Riverside Resource Recovery Ltd in a local district heating initiative or by a local business*."
London Environment Strategy 2018[6]	The London Environment Strategy seeks to ensure that London will become a "*zero carbon city by 2050*" by setting out policies and proposals in seven policy areas to address environmental challenges, including the transition to a low carbon circular economy. The Mayor wants to ensure "*London's businesses and workers are supported to be able to compete effectively in, and benefit from, this growing global market"*. The Strategy also outlines the carbon budgets for London from 2018 to 2032, which represents an ambitious pathway to put London on track to achieving zero emissions by 2050.
Powering up Britain 2023[7]	In 2021, the UK Government published the Build Back Greener Net Zero Strategy[8] which set out the UK's plans for meeting net zero emissions by 2050, and the carbon budgets. The strategy was ruled unlawful by the High Court in July 2021, because it was deemed not to meet the legal obligations under the Climate Change Act, as there was not enough detail provided on how the target would be met. 'Powering up Britain' was published in 2023, providing more detail on how carbon budgets will be achieved on a policy-by-policy basis, and presenting the Government's intentions to enhance the country's energy security and deliver the UK's net zero commitments.

Policy, Legislation or Guidance	Description
	Powering Up Britain includes: • Net Zero Growth Plan[9] • Energy Security Plan[10] • Government's response to the Independent Review of Net Zero (the Skidmore Review)[11] • Government's response to the Climate Change Committee's 2022 progress report[12] • Carbon Budget Delivery Plan[13] Powering up Britain 2023[7] includes an ambition to deliver four carbon capture, usage and storage (CCUS) clusters, capturing 20-30 $MtCO_2$/year across the economy, including 6 $MtCO_2$/year of industrial emissions, per year by 2030.
Intergovernmental Panel on Climate Change (IPCC) Special Report – Global Warming of 1.5 ºC 2018[14]	The IPCC has confirmed the need for global carbon emissions to follow a pathway that will prevent global warming exceeding 1.5 ºC. In its global emission pathways, the IPCC outlines the role of carbon capture and storage and how it can contribute to negative emissions, driving reductions in the energy sector. The IPCC's Synthesis Report for the Sixth Assessment (Summary for Policymakers) Report states that: *"All global modelled pathways that limit warming to 1.5°C with no or limited overshoot, and those that limit warming to 2°C involve rapid and deep and, in most cases, immediate greenhouse gas emissions reductions in all sectors this decade".* The report further highlights the need for CO_2 removal to stay within the bounds of 1.5°C warming trajectory.
Climate Change Committee (CCC): The Sixth Carbon Budget The UK's path to Net Zero 2020[15]	As part of the CCC's recommendation for the UK's Sixth Carbon Budget (which will run from 2033 to 2037), CCS is highlighted as a key mechanism to achieve the 'Balanced Pathway' to Net Zero for the UK. In particular, the report states that while natural removals of CO_2 are vitally important in achieving Net Zero, the CCC assessment shows that it is unlikely that Net Zero could be achieved cost-effectively without a significant contribution from 'engineered' removals of CO_2, for example through the use of CCS.
Carbon Budget Delivery Plan[16] and Carbon Budget 6	The Carbon Budget Delivery Plan details how the UK Government intends to meet Carbon Budgets 4 to 6 (to 2037), through the proposals and policies set out in the Net Zero Strategy and sets out projections of the anticipated

<table>
<tr><th>Policy, Legislation or Guidance</th><th>Description</th></tr>
<tr><td></td><td>residual emissions (where quantified) to 2037 with those proposals and policies in place.
The Plan also projects the expected performance against the Carbon Budgets and shows that for CB6 (965 $MtCO_2e$) there is expected to be an overshoot of 32 $MtCO_2e$ currently.
Sector Relevant Residual Emissions projections for each Carbon Budget (CB) are presented in the Plan, as summarised below in Table 13-2.

Table 13-2: Sector Relevant Residual Emissions for each Carbon Budget (CB)
<table>
<tr><th>Sector</th><th>CB4 5-yr: 2023-2027 (average pa)</th><th>CB5 5-yr: 2028-2032 (average pa)</th><th>CB6 5-yr: 2033-2037 (average pa)</th></tr>
<tr><td>Power</td><td>143 (29)</td><td>63 (13)</td><td>42 (8)</td></tr>
<tr><td>Greenhouse Gas Removals</td><td>0 (0)</td><td>-32 (-6)</td><td>-117 (-23)</td></tr>
</table></td></tr>
<tr><td>Net Zero Strategy: Build Back Greener[17]</td><td>The Strategy sets out the policies to decarbonise all sectors to meet the UK’s net zero target by 2050. Point 8 of the Strategy is a commitment to investing in Carbon Capture, Usage and Storage (CCUS) through a £1 billion CCUS Fund, with an aim is to use CCUS technology to capture and store 20-30 $MtCO_2$ per year by 2030.</td></tr>
<tr><td>The Clean Growth Strategy 2017[18]</td><td>One of the key policies under the UK’s Clean Growth Strategy is ‘Improving Business and Industry Efficiency’ of which a key area is to deploy CCS at scale in the UK.
This has been further supported by the UK Policy Paper: Carbon capture, usage and storage net zero investment roadmap[19]. This strategy outlines the joint government and industry commitments to the deployment of CCUS in the UK and sets out the approach to delivering 4 CCUS low carbon industrial clusters, capturing 20-30 MtCO2 per year across the economy by 2030 to help meet the UK’s 2050 net zero target.</td></tr>
<tr><td>South East Inshore Marine Plan 2021[20]</td><td>The South East Inshore Marine Plan area stretches from Felixstowe in Suffolk to west of Dover in Kent and incorporates the River Thames. It will help to enhance and protect the marine environment and achieve sustainable</td></tr>
</table>

Policy, Legislation or Guidance	Description
	economic growth while respecting local communities both within and adjacent to the marine plan area. Policy SE-AIR-1 states that "*Proposals must assess their direct and indirect impacts upon local air quality and emissions of greenhouse gases."* In addition, Policy SE-AIR-1 advises that "*Proposals that are likely to result in increased air pollution or increased emissions of greenhouse gases must demonstrate that they will, in order of preference:* *a) avoid* *b) minimise* *c) mitigate* *air pollution and/or greenhouse gas emissions in line with current national and local air quality objectives and legal requirements."*
Legislation	
United Nations Framework Convention on Climate Change 1992[21]	The UK is a member of the United Nations Framework Convention on Climate Change (UNFCCC) which drives international action on climate change. The UK has pledged to reduce Emissions under the 'Paris Agreement' in 2015, as a part of a joint pledge by members of the EU. This provides an overarching commitment by the UK.
The Climate Change Act 2008[22] **and the Climate Change Act 2008 (2050 Target Amendment) Order 2019.**	The Climate Change Act established a legal requirement for an 80% reduction in the GHG Emissions of the UK economy by 2050, in comparison to the 1990 baseline. In addition, in 2019 the UK Government updated this commitment to net zero emissions by 2050 through the Climate Change Act 2008 (2050 Target Amendment) Order 2019. The Climate Change Act also created the Committee on Climate Change, with responsibility for setting 5 year carbon budgets covering successive periods of Emissions reduction to 2050.
Guidance	
National Planning Practice Guidance 2021[23]	Explains the processes and tools that can be used through the planning system in England. The guidance highlights the importance of and advises how to identify suitable climate change mitigation and adaptation measures in the planning process. This would require the implementation of appropriate measures by the local planning authorities.

Policy, Legislation or Guidance	Description
PAS 2080:2023[24]	PAS 2080:2023 is a standard for managing carbon in building and infrastructure. It looks at the whole value chain and aims to reduce carbon and cost through intelligent design, construction and use.
GHG Protocol[25]	The GHG Protocol establishes comprehensive global standardised frameworks to measure and manage GHG emissions from private and public sector operations, value chains and mitigation actions.
IFC Environmental, Health, and Safety Guidelines for Thermal Power Plants 2017[26]	The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). The GIIP can be applied to similar infrastructure including carbon capture and storage.
IPCC Guidelines for National Greenhouse Gas Inventories 2006[27]	The 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was adopted and accepted during the 49th Session of the IPCC in 2019. It was prepared by the Task Force on National Greenhouse Gas Inventories (TFI) in accordance with the decision taken at the 44th Session of IPCC in Bangkok, Thailand, in 2016.
IEMA Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance 2022[28]	The requirement to consider this topic has resulted from the 2014 amendment to the EIA Directive. The aim of this Guidance is to assist practitioners with addressing GHG emissions assessment and mitigation in statutory and non-statutory EIA. The guidance sets out how to: • identify the GHG emissions baseline in terms of GHG current and future emissions; • identify key contributing GHG sources and establish the scope and methodology of the assessment; • assess the impact of potential GHG emissions and evaluate their significance; and • consider mitigation in accordance with the hierarchy for managing project related GHG emissions (avoid, reduce, substitute, and compensate).
Royal Institution of Chartered Surveyors (RICS) Whole Life Carbon Assessment for the Built	This RICS professional statement addresses the need for technical details of numerous aspects influencing whole life carbon calculations for built projects. It is intended to standardise whole life carbon assessment for built projects, including (but not limited to):

Policy, Legislation or Guidance	Description
Environment 2017[29]	• providing a consistent and transparent whole life carbon assessment implementation plan and reporting structure for built projects in line with BS EN 15978:2011 (Sustainability of construction works)[30]; • enabling coherence in the outputs of whole life carbon assessments to improve the comparability and usability of results; and • increasing the reliability of whole life carbon assessment by providing a solid source of reference for the industry.
Infrastructure Carbon Review 2013[31]	In 2013, the UK government published the Infrastructure Carbon Review aiming to *"release the value of lower carbon solutions and to make carbon reduction part of the DNA of infrastructure in the UK".* Major infrastructure owners, operators and developers across the communication, energy, transport, waste and water sectors were invited to endorse it, become signatories to, and make commitments under the Review. The Review provided increased emphasis on 'capital carbon' (GHG emissions associated with raw materials, activities and transport for construction, repairs, replacement, refurbishment and de-construction of infrastructure) while acknowledging that 'operational carbon' (associated with energy consumption for the operation and use of infrastructure) will continue to dominate overall emission to 2050 and beyond. The Infrastructure Carbon Review highlighted the importance of assessing GHG Emissions early in the lifecycle of an infrastructure scheme when there is the greatest carbon reduction potential. The assessment presented in this chapter provides an assessment of the Proposed Scheme early in its lifecycle. The Review also led to the publication of a Publicly Available Specification (PAS) on infrastructure carbon management; PAS2080:2016 (revised in 2023)[24].

13.3. CONSULTATION AND ENGAGEMENT

13.3.1. No consultation or engagement has been undertaken to specifically inform the GHG assessment presented in this chapter and no future engagement is required.

13.3.2. **Table 13-3** provides a summary of comments provided as part of the statutory consultation process and an appropriate response.

13.3.3. **Appendix 4-2: Scoping Opinion Responses (Volume 3)** provides a summary of the Planning Inspectorate and consultee comments on the EIA Scoping Opinion[32] and the Applicant's responses.

Table 13-3: Summary of the Statutory Consultation Comments in relation to Greenhouse Gases

Statutory Consultee	Response
London Borough of Bexley	
"It will be important to understand the whole-life cycle of greenhouse gasses associated with the project, not just the built structure, but also the processes involved in its operation. The amount of greenhouse gasses including carbon dioxide resulting from the processes associated with the operation of the carbon capture facility should be clearly set out, including emissions from sourcing of materials and chemicals to be used in the capturing of carbon, and emissions associated in transportation of captured carbon to its end destination."	The construction and operation phases of the Proposed Scheme have been considered in relation to the PAS 2080:2023[24] lifecycle stages. The assessment methodology presented in **Section 13.4** of this chapter sets out the emission sources covered for the calculation of GHG emissions in construction and operation phases. For the operation phase this includes, but is not limited to, the use of materials in the carbon capture process and the transport of captured carbon to its end destination. The GHG emissions calculated for the construction and operation phases of the Proposed Scheme are presented in **Section 13.8** of this chapter.
Environment Agency	
"We are supportive of achieving net zero and of achieving that for Riverside."	No response required.
Peabody Trust and Tilfen Land Limited	
"Peabody has no comments regarding net zero at this stage but is generally supportive of Cory's target to reach net zero by 2040."	No response required.
Dartford Borough Council	
"The scheme is aimed at reducing CO_2 emissions and this is of course welcomed but the impacts of achieving this CO_2 reduction should be fully considered and this should include all construction impacts including air quality impacts arising as a result of construction traffic." *"To conclude, the scheme is aimed at reducing CO_2 emissions and this is welcomed but the impacts of achieving this CO_2 reduction*	The assessment presented within this chapter has calculated the GHG emissions associated with the transport of materials to the Site during the construction phase, results are presented in **Table 13-8**. Impacts to air quality during the construction phase have been considered in **Chapter 5: Air Quality (Volume 1)**.

Statutory Consultee	Response
should be fully considered and this must include all construction impacts including air quality from construction traffic. Without this, the net benefits of the scheme are unknown."	

13.4. ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

13.4.1. The GHG assessment of the Proposed Scheme has been undertaken in line with the legislation, policy and guidance described in **Section 13.2**.

13.4.2. As set out in **Chapter 2: Site and Proposed Scheme Description (Volume 1)**, two options for the construction programme of the Proposed Scheme are being considered. The estimated construction period is approximately 60 months (five years) for Option 1 and approximately 42 months (three and half years) for Option 2. For the purposes of apportioning emissions to CB within this assessment, only Option 1 has been considered as this is considered to be representative of the worst case for GHG emissions for the construction phase in terms of the duration and phased development.

13.4.3. As set out in **Chapter 2: Site and Proposed Scheme Description (Volume 1)**, two options for the design of the Carbon Capture Facility are being considered. One option is for individual lines to be connected to the exhaust stacks for Riverside 1 and Riverside 2, with two individual Stack(s) for the Carbon Capture Facility. A second option is for the two lines from Riverside 1 and Riverside 2 to be combined into a single Stack at the Carbon Capture Facility. For the purposes of this assessment, the embodied carbon associated with construction of two individual lines with two individual Stack(s) is representative of the worst case scenario.

13.4.4. As set out in **Chapter 2: Site and Proposed Scheme Description (Volume 1)**, the choice between demolition or retention of the Belvedere Power Station Jetty (disused) is being considered. This assessment includes demolition of the Belvedere Power Station Jetty (disused) as this is considered to present the worst case scenario for greenhouse gases. This is because increased construction plant and materials would be required should the Belvedere Power Station Jetty (disused) be demolished. There would also be increased emissions associated with transport and end-use of the demolition waste. If the Belvedere Power Station Jetty (disused) is retained (with modifications) there would be a slight improvement in the assessment of impacts and effects reported within this chapter.

POTENTIAL SIGNIFICANT EFFECTS

13.4.5. Construction and operation phases of the Proposed Scheme have the potential for significant effects; consequently, each phase has been considered in relation to the PAS 2080:2023[24] lifecycle stages.

13.4.6. As set out in the EIA Scoping Report[24] and PEIR[33], the following effects are considered to be material and therefore have been included in this assessment.

- Construction:
  - Product stage (raw material supply (A1), transport of raw materials to suppliers (A2) and manufacture (A3));
  - Transport of materials to site (A4);
  - Plant and equipment use during construction (A5);

  - Transport of waste (A5);
  - Disposal of waste (A5); and
  - Land use, land use change and forestry (A5).
- Operation:
  - Operation (B1);
  - Maintenance, repair, replacement, refurbishment (B2-5);
  - Operational energy use (B6);
  - Operational water use (B7);
  - Land use, land use change and forestry (B8);
  - Process consumables used for the operation of the Proposed Scheme (B8); and
  - End-user emissions (B9/D) (Transport).

MATTERS SCOPED OUT

13.4.7. The following effects are considered unlikely to be material, or no longer arise as part of the Proposed Scheme and therefore have not been included in this assessment:

- End-User Emissions (B9/D) (Storage), as described in the EIA Scoping Report[34] the final storage of captured CO_2 and the development of proposed storage locations offshore are outside the scope of this assessment as this would be covered under separate planning considerations and jurisdiction. Geological storage of CO_2 is an established practice, which due to the timescales involved has been modelled to examine its effectiveness for long term storage of CO_2. The IPCC Special Report on Carbon Dioxide Capture and Storage[35] identifies that retention of CO_2 in managed geological reservoirs is likely to exceed 99% over 1,000 years, with the vast majority of CO_2 gradually becoming immobilised. It is assumed that the CO_2 captured by the Proposed Scheme would be stored in an appropriately designed, managed and regulated geological site. It is considered that the storage of CO_2 captured by the Proposed Scheme is not likely to be significant and therefore has been scoped out of the main assessment; however, for contextual purposes information on GHG emissions associated with options for transport and geological storage of CO_2 captured by the Proposed Scheme is provided at the end of **Section 13.8**;
- End-user Emissions (B9/D);
- Decommissioning Process (C1); and
- Transport and Disposal of End of Life Materials (C2-4).

BASELINE DATA COLLECTION

13.4.8. In the baseline, without the Proposed Scheme, GHG emissions occur constantly and widely as a result of human and natural activity. This includes emissions related to energy consumption (fuel and power), industrial processes, land use and land use change. **Table 13-4** to **Table 13-6** below show the contextual baseline for local and national emissions. The GHG assessment only considers instances in which the Proposed Scheme results in additional or avoided emissions in comparison to the baseline scenario and its assumed evolution. The baseline therefore focuses on those emissions sources subject to change between the baseline and the Proposed Scheme.

13.4.9. At the time of writing, construction works for Riverside 2 are being undertaken; however, it is anticipated that Riverside 2 will be operational by 2026, the start of construction for the Proposed Scheme. Therefore, the baseline and future baseline for the Proposed Scheme considers both Riverside 1 and Riverside 2 in operation.

ASSESSMENT METHODOLOGY

13.4.10. The assessment approach considers the likely magnitude of additional or avoided GHG emissions in comparison to the baseline, without the Proposed Scheme. It considers emissions throughout the in-scope lifecycle stages and sub-stages (in line with PAS 2080:2023[24]) of the Proposed Scheme. The associated emissions have been calculated through the collection of available data/information on the scale of GHG emitting activities (e.g. tonnes of concrete, litres of fuel, kWh of electricity) and GHG capturing activities for the baseline scenario and for the Proposed Scheme. Where available, primary raw data has been used in calculations, where this information is not available proxies or industry benchmarks have been used to estimate emissions. In each case this covers the Proposed Scheme lifecycle (minimum design life of 50 years, as described in **Chapter 2: Site and Proposed Scheme Description (Volume 1)**).

13.4.11. Calculation of the GHG emissions has been made by applying a suitable emissions factor of tonnes of CO_2 equivalent (tCO_2e) or tonnes of CO_2 (tCO_2) per unit of emissions generating activity. The sources of activity and emissions data, alongside the methodology are outlined in the rest of **Section 13.14** below.

13.4.12. The assumptions that have informed the assessment, such as distances for transporting raw materials, are presented in **Section 13.13**.

13.4.13. A summary of calculated emissions results for the baseline and the Proposed Scheme are summarised in **Section 13.7.4**.

13.4.14. The IEMA guidance[28] identifies that GHG emissions are not geographically limited, so impacts from emissions are not restricted to a specific location or physical boundary (as may be the case for other environmental impacts, such as noise, air quality or flooding) but impact the atmosphere at a global level. Avoided or emitted GHG emissions make a cumulative contribution to the global atmosphere and impact on climate change (beneficial or adverse). Therefore, in accordance with the IEMA

guidance, consideration of cumulative GHG emissions is inherent in the assessment and the cumulative impact of GHG emissions for the Proposed Scheme have been assessed against the contextual scale of relevant UK carbon budgets (**Section 13.7.4**). This approach has been supported by the recent judicial finding on the approach to cumulative assessment of GHGs in EIA (Case No: CA-2023-01482[36]), which considered that the only meaningful comparator with respect to the cumulative effects of carbon emissions from a Proposed Scheme is national carbon budgets. Additionally, given the location of the Proposed Scheme and the GLA's policy commitments, an assessment has been made against London carbon budgets even though is not necessary.

Construction Phase

13.4.15. The quantification of construction emissions was calculated from a preliminary Bill of Quantities (BoQ) produced in October 2023. The quantification process covered the following emission sources with reference to PAS 2080:2023[24]:

- Product stage (raw material supply (A1), transport of raw materials to suppliers (A2) and manufacture (A3);
- Transportation of materials to site (A4);
- Plant use onsite during construction (A5);
- Transportation of construction waste away from site (A5);
- Disposal of waste (A5); and
- Land use, land use change and forestry (A5).

13.4.16. The CO_2 quantification has been undertaken using best practice carbon management methods, professional judgement, and guidance including, but not limited to, the GHG Protocol[25] and PAS 2080:2023[24].

13.4.17. The carbon quantification involved reviewing the preliminary BoQ and utilising Inventory of Carbon and Energy (ICE)[37] and other industry recognised carbon reporting tools (such as the National Highways Tool[38] to supplement any gaps for materials not available from the ICE), to use the most accurate densities and emission factors as practicable.

A1-A3 – Product Stage (manufacture and transport of raw materials to suppliers)

13.4.18. Emissions 'embodied' within the construction materials are calculated as follows:

- Quantity of material (t) X Emissions factor (tCO_2e/t) = Emissions (tCO_2e).

13.4.19. However, for some construction materials emissions factors are only available on a mass or volume basis. Where only dimensions are available, volumes may need to be calculated; or where mass is required, volumes have been converted to mass using densities.

13.4.20. The quantity of materials for the Proposed Scheme was taken from the preliminary BoQ.

A4 and A5 – Transport of Materials to Site and Transport of Waste

13.4.21. Transportation of construction materials to the Site and waste off the Site are calculated as follows (based on default transport distances in RICS guidance[29] and relevant factors for vehicle emissions BEIS GHG reporting factors[39]):

- Quantity of material/waste (t) X Distance (km) X Emissions factor (tCO_2e/t.km) = Emissions (tCO_2e).

13.4.22. However, some construction materials emissions factors are only available on a volume basis. Where only dimensions are available, volumes have been calculated; or where mass is required, volumes have been converted to mass using densities.

A5 - Plant and Equipment Use

13.4.23. Due to the unavailability and uncertainty of plant and equipment usage for construction at the time of writing, an estimate of GHG emissions was calculated using the Royal Institute of Chartered Surveyors[29] assumption. This assumption is based on the estimated construction cost (adjusted for inflation) of the Proposed Scheme:

- Construction cost (£) X RICS Assumption (1400 $kgCO_2e$/£100k of construction cost) (tCO_2/£) = Emissions (tCO_2e)

A5 – Disposal of Waste

13.4.24. Quantities of construction waste reported in **Chapter 16: Materials and Waste (Volume 1)** have been used to determine emissions associated with the management of waste generated during the construction phase. Emissions arising from the waste management are calculated as follows:

- Quantity of waste material (t) X Emissions factor (tCO_2e/t) = Emissions (tCO_2e)

A5 – Land use, Land Use Change and Forestry (LULUCF)

13.4.25. The construction phase GHG emissions from LULUCF comprise of those released as a result of the change in land use from the baseline scenario during the construction phase. This considers loss of carbon storage from permanent and temporary loss of habitat and changes to carbon storage through reinstatement and improvement to habitat.

13.4.26. In order to estimate the carbon storage and the change over time from the different habitats, the habitat type and the hectares of individual habitats has been considered (aligning to the habitat types reported in **Chapter 7: Terrestrial Biodiversity (Volume 1)** along with appropriate values (tonnes of carbon per hectare (tC per ha)) for carbon storage and flux using a habitat carbon calculator. The calculator uses literature from the Natural England Carbon Storage and Sequestration by Habitat[40] and the Woodland Carbon Code Calculator[41].

13.4.27. The construction phase emissions from LULUCF are reported as the difference between construction of the Proposed Scheme and the baseline scenario.

Operation Phase

13.4.28. The quantification of operational emissions covers the following emission sources with reference to PAS 2080:2023[24] lifecycle stages:

- Operation (B1);
- Maintenance, repair, replacement and refurbishment (B2-5);
- Operational energy use (B6);
- Operational water use (B7);
- Land use, land use change and forestry (B8);
- Process consumables used for the Proposed Scheme (B8); and
- End-user emissions (B9/D) (Transport).

B1 – Operation

13.4.29. Operational data on emissions have been calculated based on maximum consented annual waste tonnages for Riverside 1 (850,000 tonnes) and Riverside 2 (805,920 tonnes). The Proposed Scheme will capture a minimum of 95% of CO_2 emissions from Riverside 1 and 95% of CO_2 emissions from Riverside 2 (once operational). The following calculation has been used to estimate the CO_2 captured by the Proposed Scheme:

- Quantity of annual consented waste for Riverside 1 and Riverside 2 (t) X Emissions factor (tCO_2/t) X % of CO_2 captured = Emissions captured (tCO_2).

13.4.30. Operational emissions have also identified the residual GHG emissions from Riverside 1 and Riverside 2 not captured by the Proposed Scheme, including comprising emissions of CO_2 and nitrous oxide (N_2O) that would be released to the atmosphere. As indicated in IPCC guidance regarding emissions from waste incineration, it can be assumed that under the oxidative combustion prevailing in waste incineration in municipal waste incinerators, methane (CH_4) is not present in the waste gas and consequently is not emitted to the atmosphere[42]. The N_2O emissions have been estimated based on operational information provided by the Applicant for Riverside 1 for 2022 and 2023 and the associated global warming potential (GWP) for N_2O[43]. Residual emissions have been calculated as follows:

- CO_2: Quantity of annual consented waste for Riverside 1 and Riverside 2 (t) X Emissions factor (tCO_2/t) X % of CO_2 not captured = Residual CO_2 emissions (tCO_2).
- Nitrous Oxide: Quantity of annual consented waste for Riverside 1 and Riverside 2 (t) X Average N_2O emissions for processed waste (tN_2O/t of waste) X GWP for nitrous oxide (tCO_2e/tN_2O) = Residual N_2O emissions (tCO_2e).

13.4.31. Operational data on the use of refrigerants in the Proposed Scheme is limited; however, it has been identified that the refrigerant used is likely to be propane (although ammonia is also being considered as refrigerant option at this stage), and there will be emissions associated with the leakage of propane to atmosphere (assuming a leakage rate for refrigerant of 3.8% per year for non-domestic

applications[44]) and 'embodied' emissions associated with the recharge of refrigerant in the Liquification Plant. The emissions associated with the use of propane as a refrigerant is calculated as follows:

- Quantity of propane leakage/recharge (t) X Emissions factor (tCO_2e/t) = Emissions (tCO_2e).

B2-B5 – Maintenance (B2), Repair (B3), Replacement (B4) and Refurbishment (B5)

13.4.32. With the exception of operational wastes (categorised in this assessment under B2 – Maintenance), quantitative data is not available at the current design stage. The following approaches have been used to evaluate emissions associated with the operational categories B2-B5.

B2 – Maintenance

13.4.33. Key sources of emissions expected to arise from maintenance of the Proposed Scheme are those relating to the transport and disposal of waste generated from routine operation. Quantities for operational waste reported in **Chapter 16: Materials and Waste (Volume 1)** have been used to determine emissions associated with the management of waste generated during the operation phase. Operational waste also includes materials arising from maintenance dredging of the riverbed. Emissions arising from waste management (including transport and disposal) are calculated as follows:

- Quantity of waste material (t) X Emissions factor (tCO_2e/t) = Emissions (tCO_2e); and
- Quantity of waste (t) X Distance (km) X Emissions factor ($tCO_2e/t.km$) = Emissions (tCO_2e).

B3 – Repair

13.4.34. Most elements of the Proposed Scheme have been designed to be maintained rather than repaired, with the need for repair being unforeseen, and as such repair emissions have been assumed to be zero.

B4 – Replacement and B5 – Refurbishment

13.4.35. Quantitative data is not available at the current design stage regarding replacement and refurbishment aspects of the Proposed Scheme. To address the gap in information available at this stage of the design for emissions arising from replacement and refurbishment activities a factor has been applied to the emissions determined for the embodied carbon during the construction phase (A1-A3). This is based on a study of whole life carbon for different building types by RIBA[45], identifying the relationship between operational carbon emissions (including, but not limited to replacement and refurbishment aspects) and embodied carbon emissions. This is potentially an overestimate as it may encompass emissions other than those directly related to replacement and refurbishment. Emissions estimated for replacement and refurbishment for the Proposed Scheme are calculated as follows:

- Total estimated embodied carbon for Proposed Scheme during construction (tCO_2e) X % factor for operational emissions = Emissions (tCO_2e).

B6 – Operational Energy Use

13.4.36. The electricity required for the Proposed Scheme is expected to be sourced from Riverside 1 and/or Riverside 2 and the Back-pressure Steam Turbines installed as part of the Proposed Scheme. Emissions for any electricity supplied to the Proposed Scheme by Riverside 1 and/or Riverside 2 are accounted for under B1 – Operation, so to avoid double-counting are not included here. However, there may be a limited demand for electricity from the grid at certain times, estimated to be no more than 2% of the total power demand for the Proposed Scheme. Emissions associated with the potential for operational electricity supplied from the grid are based on 2% of the indicative power demand for the Proposed Scheme and forecast emissions factors for UK grid average electricity supply. An average annual emissions factor for UK grid average electricity supply has been determined covering the operation phase of the Proposed Scheme (2031 to 2080), based on BEIS forecasts of UK grid average emissions factors (Consumption-based, Industrial)[46].

13.4.37. Emissions estimated for the use of electricity sourced from the UK grid has been calculated as follows:

- Proposed Scheme power demand (MWh) X Estimated grid electricity supply (%) X Average of UK grid electricity emissions factor for 2031-2080 (tCO_2e/MWh) = Emissions (tCO_2e).

13.4.38. As described in **Chapter 2: Site and Proposed Scheme Description (Volume 1)** backup power in the form of diesel generators will be available. Emissions resulting from the use of backup power diesel generators onsite are calculated as follows:

- Amount of diesel fuel (l) X Emissions factor (tCO_2e/l) = Emissions (tCO_2e).

B7 – Operational Water Use

13.4.39. Emissions resulting from the water consumption is calculated as follows:

- Amount of water (l) X Emissions factor (tCO_2e/l) = Emissions (tCO_2e).

B8 – Land use, Land Use Change and Forestry (LULUCF)

13.4.40. This assessment has been carried out in conjunction with A5 – Land use, Land Use Change and Forestry using the same methodology and data.

13.4.41. For the Proposed Scheme, this relates to habitats that are reinstated, retained or improved. The operation phase emissions from LULUCF are reported as the difference between the Proposed Scheme scenario and the future baseline scenario, covering the operational lifespan of the Proposed Scheme.

B8 – Process Consumables used for the Operation of the Proposed Scheme

13.4.42. Various consumables will be used in the operation of the Proposed Scheme. Indicative quantities for the process consumables listed below have been identified:

- amine-based solvent;

- sulphuric acid;
- sodium bisulphite;
- sodium hypochlorite;
- citric acid;
- anti Foam agent;
- sodium hydroxide;
- dessicants; and
- activated carbon.

13.4.43. Emissions factors for these consumables were primarily sourced from the Ecoinvent database[47], supplemented by literature review for any items not identified in the database. Emissions 'embodied' within the process consumables were calculated as follows:

- Quantity of process consumables (t) X Emissions factor (tCO_2e/t) = Emissions (tCO_2e).

B9/D – End-user Emissions (Transport)

13.4.44. Emissions associated with the transportation of the captured LCO_2 offsite to its end use (permanent storage) is calculated as follows:

- Amount of LCO_2 (tonnes) X Distance (km) X Emissions factor ($tCO_2e/t.km$) = Emissions (tCO_2e).

13.4.45. Information on the location of the transported captured LCO_2 is presented in **Chapter 2: Site and Proposed Scheme Description (Volume 1)**.

SIGNIFICANCE CRITERIA

13.4.46. Any magnitude of emitted or avoided GHG emissions makes a cumulative contribution to climate change (adverse or beneficial respectively).

13.4.47. Significance of GHG impacts is assessed in line with IEMA Guidance[28]: a development's emissions should be based on its net impact over its lifetime, which may be beneficial, adverse or negligible. The evaluation of significance should not just focus on GHG emissions, or the magnitude of those emissions, but whether the Proposed Scheme contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050.

13.4.48. The following terms have been used to define the significance of the effects identified as set out in IEMA Guidance[28]:

- **Major Adverse (Significant):** the GHG impacts are not mitigated or are only compliant with do-minimum standards set through regulation, and do not provide further reductions required by existing local and national policy nor make a meaningful contribution to the UK's trajectory towards net zero.
- **Moderate Adverse (Significant):** the GHG impacts are partially mitigated and may partially meet the applicable existing and emerging policy requirements but

would not fully contribute to decarbonisation in line with local and national policy goals, falling short of fully contributing to the UK's trajectory towards net zero.

- **Minor Adverse (Not Significant):** the GHG impacts are fully consistent with applicable existing and emerging policy requirements and good practice design standards; they are fully in line with measures necessary to achieve the UK's trajectory towards net zero.
- **Negligible (Not Significant):** the GHG impacts are reduced through measures that go well beyond existing and emerging policy and design standards for projects of this type, such that radical decarbonisation or net zero is achieved well before 2050.
- **Beneficial (Significant):** the net GHG impacts are below zero, causing a reduction in atmospheric GHG concentration, whether directly or indirectly, compared to the without-project baseline, substantially exceeding net zero requirements with a beneficial climate impact.

13.4.49. In order to provide context to the GHG emissions, and as set out in the IEMA Guidance[28] the estimated GHG emissions arising from the Proposed Scheme will be compared with the respective UK carbon budgets, shown in **Table 13-4,** which have been set by the UK Government covering years 2023 to 2037.

Table 13-4: GHG UK Carbon Budgets[9,13]

Carbon Budget Period	UK Carbon Budget ($MtCO_2e$)
Fourth: 2023-2027	1,950
Fifth: 2028-2032	1,725
Sixth: 2033-2037	965

13.4.50. Although recent case law has made it clear that there is no obligation to do so in policy terms or to ensure compliance with the EIA Regulations, further contextualisation against the London carbon budgets has also been considered, see **Table 13-5** below to provide further context.

Table 13-5: GHG – London Carbon Budgets[48]

Carbon Budget Period	London Carbon Budget ($MtCO_2e$)
Years: 2018-2022	27.1
Years: 2023-2027	22.4
Years: 2028-2032	18

13.4.51. To provide additional context, a breakdown of GHG Emissions for 2021 within Bexley, London, and the UK (as reported by UK National Statistics[49]) is presented in **Table 13-6**.

Table 13-6: GHG Emissions Sources for Bexley, London and the UK (2021)

Emissions Sources	Bexley ($ktCO_2e$)	London ($ktCO_2e$)	UK ($ktCO_2e$)
Industry Electricity	39	1,192	17,109
Industry Gas	110	883	20,037
Large Industrial Installations	0.5	46	29,268
Industry 'Other'	30.6	941.4	17,927
Industry Total	**180**	**3,063**	**84,341**
Commercial Electricity	26	2,325	10,964
Commercial Gas	15.5	1,354.5	6,239
Commercial 'Other'	0.4	27	223
Commercial Total	**42**	**3,707**	**17,426**
Public Sector Electricity	15	1,163	5,380
Public Sector Gas	16	1,864.6	10,581
Public Sector 'Other'	0.0	0.3	63
Public Sector Total	**31**	**3,028**	**16,024**
Domestic Electricity	75	2,616	22,245
Domestic Gas	243	8,058	63,613
Domestic 'Other'	3	93	11,064
Domestic Total	**321**	**10,767**	**96,921**
Landfill	10	1,550	13,618
Waste Management 'Other'	18	387	5,196
Waste Management Total	28	1,937	18,814
Other Total (transport, land use, land use change, forestry and agriculture)	215	7,446	165,520
Grand Total	**816**	**29,948**	**399,046**

13.5. STUDY AREA

13.5.1. The GHG assessment is not restricted by geographical area but instead includes any increase or decrease in emissions as a result of the Proposed Scheme, wherever that may be. This includes:

- construction emissions generated within the Site and resulting from the transport of materials to and from the Proposed Scheme and their manufacture (this may be distant from the Proposed Scheme location); and
- operation emissions (increase or reduction) resulting from operation of the Proposed Scheme. In this case, GHG emissions include those for embodied emissions arising from materials and waste for the operation of the Proposed Scheme, carbon capture and operational energy and water use.

SENSITIVE RECEPTORS

13.5.2. The impacts of GHG emissions relate to their contribution to global warming and climate change. These impacts are global and cumulative in nature, with every tonne of GHG contributing to impacts on natural and human systems. The receptor is therefore the global atmosphere.

13.5.3. GHG emissions result in the same global effects wherever and whenever they occur. Therefore, the sensitivity of different human and natural receptors is not considered in this assessment.

13.5.4. A carbon budget is the cumulative amount of CO_2 emissions permitted over a period of time to keep within a certain temperature threshold (i.e. the cumulative limit on carbon emissions for those areas in that time period). This assessment has been compared against the UK and London carbon budgets, as set out in **Section 13.4** (Assessment Methodology)', to provide context for the estimated emissions (the former being legally binding carbon budgets for the UK, the latter being provided for contextual purposes only).

13.6. BASELINE CONDITIONS AND FUTURE BASELINE

BASELINE

13.6.1. In the baseline, GHG emissions occur constantly and widely as a result of natural and human activity, including land use and land use change, energy consumption (e.g. fossil fuels, purchased energy from the grid and/or other sources) and industrial processes. The GHG assessment would only consider the scenario in which the Proposed Scheme results in additional or avoided emissions in comparison to the baseline. The baseline therefore focuses on those sources of emissions subject to change between the baseline and the Proposed Scheme.

13.6.2. The baseline for the Proposed Scheme includes Riverside 1 operating, without Riverside 2.

13.6.3. The construction baseline involves no construction activities and therefore the construction baseline is zero emissions.

13.6.4. For this chapter baseline emissions for Crossness LNR have been incorporated in the overall assessment of LULUCF, comprising those emissions released as a result of the change in land use from the baseline scenario. With respect to Munster Joinery (UK) Limited, the assessment has taken into account emissions arising from its removal and recycling of materials.

13.6.5. Riverside 1 is one of the largest EfW facilities in the UK, with a maximum consented waste throughput of 850,000 tonnes per annum (tpa); it received 789,000 tonnes of non-recyclable waste in 2022. Heat produced from the combustion process drives a turbine to generate electricity, enough to power 195,000 homes[50]. The emissions arising from the processing of maximum consented waste throughout for Riverside 1 has formed the basis of the operational baseline for the Proposed Scheme.

FUTURE BASELINE

13.6.6. The future baseline takes into consideration any changes to the quantity of residual waste incinerated, which assumes that Riverside 1 and Riverside 2 are both in operation. For both Riverside 1 and Riverside 2, operation is assumed to be at consented maximum throughput for processing waste (and thus producing GHG) into the future. The operation of the Proposed Scheme will not change this.

13.6.7. Therefore, the future baseline for Riverside 1 will be 850,000 tpa of waste. Riverside 2 will be operational in 2026 and will be one of the most efficient EfW facilities in the UK. Riverside 2 is consented to have a maximum waste throughput of 805,920 tpa of non-recyclable waste.

13.6.8. Waste processed by Riverside 1 and Riverside 2 will generate CO_2 from fossil sources (derived from plastics) and biogenic sources (derived from wood, paper and cardboard). Based on operational information provided by the Applicant over the period 2019-2023, the five year average CO_2 emissions for Riverside 1 comprised 49.34% fossil carbon and 50.66% biogenic carbon, which are assumed to be the proportions that would apply to the baseline operation of Riverside 1 and the future baseline for operation of Riverside 1 and Riverside 2.

13.6.9. **Table 13-7** below outlines the baseline and future baseline results for the Proposed Scheme. This identifies the total CO_2 emissions generated by Riverside 1 and Riverside 2 attributable to fossil sources, i.e. the 49% of emissions from sources considered to be additional CO_2 in the atmosphere that contribute to global warming.

13.6.10. The baseline and future baseline do not include emissions for Riverside 1 and Riverside 2 arising from processing waste from biogenic sources, as these form part of the natural carbon cycle. These are not considered to contribute additional CO_2 in the atmosphere as waste derived from biogenic sources would absorb an equivalent amount of CO_2 during the growth phase as the amount of CO_2 that would be released through combustion. This is in accordance with IPCC Guidelines for National Greenhouse Gas Inventories[27] and UK Government GHG Conversion Factors for

Company Reporting[51], where the GHG emissions from fossil sources are included in Scope 1 reporting and emissions from the combustion of biogenic sources are set as net '0' to account for the CO_2 absorbed by fast-growing bioenergy sources during their growth (but are listed separately in reporting as 'outside of scope' GHG emissions).

13.6.11. Additionally, **Table 13-7** identifies GHG emissions related to the release of N_2O in the atmosphere generated from processing of waste by Riverside 1 and Riverside 2.

Table 13-7: Baseline and Future Baseline Emissions of the Proposed Scheme (fossil sources only)

Description	Total Baseline and Future Baseline GHG Emissions for Operation of Riverside 1 and Riverside 2 (tCO_2e)
Riverside 1 annual emissions from fossil sources based on throughput of 850,000 tpa	440,360
Riverside 1 annual N_2O emissions based on throughput of 850,000 tpa	250
Riverside 2 annual emissions from fossil sources based on throughput of 805,920 tpa	417,523
Riverside 2 annual N_2O emissions based on throughput of 805,920 tpa	237
Riverside 1 and 2 annual GHG emissions (assuming both in operation in 2026 at start of Proposed Scheme construction)	858,370
Total over 55 years (2026 to 2080)	**47,210,373[a]**

13.7. EMBEDDED DESIGN, MITIGATION AND ENHANCEMENT MEASURES

13.7.1. This section sets out the embedded design, mitigation and enhancement measures relevant to the GHG assessment.

CONSTRUCTION PHASE

13.7.2. The embedded design, mitigation and enhancement measures for the construction phase are:

[a] Total value over 55 years allows for rounding margin in annual data value.

- Environmental mitigation required during construction will be recorded in the **Outline CoCP (Document Reference 7.4)**. The **Outline CoCP (Document Reference 7.4)** provides a tool to ensure the successful management of the likely environmental effects as a result of construction activities. **A Framework CTMP (Document Reference 7.7)** has also been prepared**.** These plans include for the following principles:
- Construction Contractor(s) will be expected to ensure optimal performance of plant and equipment through correct and efficient operation, maintenance, and servicing of vehicle fleet to minimise emissions. Options will be considered for using efficient low emission plant, equipment and vehicles where possible (i.e. those using electricity or lower carbon fuels).
- The Proposed Scheme will be designed to minimise material consumption and waste generation, as far as reasonably practicable.
- Depending on design specification requirements the Proposed Scheme will consider options to specify construction materials with lower embodied carbon (e.g. using steel with a higher than average recycled content or considering material alternatives).
- Transportation of materials will be optimised to minimise GHG emissions, including sourcing construction materials from local suppliers, making use of local waste management facilities where practicable and ensuring the construction programme considers requirements for onsite storage of materials and waste.
- The Proposed Scheme will take into account the potential carbon emissions and removals within the design of the onsite Mitigation and Enhancement Area and offsite BNG Opportunity Area, including opportunities to maintain natural habitats where possible and minimise impacts during construction.
- Construction waste will be recycled or reused where practicable to avoid disposal to landfill, including the reuse of excavated arisings on the Proposed Scheme, where suitable. Further embedded measures on material reuse and recycling are outlined in **Chapter 16: Materials and Waste (Volume 1)**, which will result in reductions in construction waste emissions and also embodied GHG emissions from materials where reuse of the material can be favoured onsite.

OPERATION PHASE

13.7.3. The following embedded design, mitigation and enhancement measures are considered for the operation phase:

- The inherent purpose of the Proposed Scheme is to capture CO_2 generated by Riverside 1 and Riverside 2 for permanent storage, avoiding those GHG emissions being released to the atmosphere and aiding decarbonisation of waste management services and electricity generation.
- To minimise energy consumption, the design of the Proposed Scheme will include selection of high energy efficiency capture technology, high efficiency electric motors and the use of variable frequency drives for pumps.

- To maximise operational efficiency, the Proposed Scheme will incorporate a Back Pressure Turbine and Generator to maximise the extraction of energy within the steam and make it suitable for use in the Solvent Regeneration System.
- Onsite regeneration of solvent will maximise reuse of this material and reduce embodied emissions associated with procuring fresh solvents for use in the process.
- The carbon capture process produces heat, which is typically wasted. The Proposed Scheme will incorporate a Heat Recovery and Heat Transfer System so that this energy can be redirected into a district heating network, such as the Riverside Heat Network (currently under development). See **Chapter 2: Site and Proposed Scheme Description (Volume 1)** for further detail on the components of the Heat Recovery and Heat Transfer System.
- A Heat Transfer Station will be installed as the interface between the Proposed Scheme and the Riverside Heat Network, which will reduce dependence on alternative fossil fuel sources for generating heat and consequently the associated GHG emissions.
- The design of the Proposed Scheme will be undertaken with a view to maximising the lifespan of operational components, minimising the need for maintenance and refurbishment (thus reducing the frequency of release of associated GHG emissions).
- Process emissions arising from operation of the Proposed Scheme will be managed and regulated under an Environmental Permit which will be applied for from the Environment Agency.
- The Proposed Scheme will be providing habitat mitigation, compensation and enhancement within the Mitigation and Enhancement Area and the BNG Opportunity Area as described in **Chapter 2: Site and Proposed Scheme Description (Volume 1)**.
- Embedded mitigation measures for operation include maximising efficiencies in the use of materials for the Proposed Scheme.

13.7.4. Reference is also made to the **Planning Statement (Document Reference 5.2)**, which provides information on how carbon emissions have been accounted for in the development of the Proposed Scheme to date.

13.8. ASSESSMENT OF LIKELY IMPACTS AND EFFECTS

13.8.1. This section details the assessment of impacts and effects for the Proposed Scheme during both the construction and operation phases (as detailed in **Section 13.4**), taking into account the embedded design, mitigation and enhancement measures detailed in **Section 13.7.**

CONSTRUCTION PHASE IMPACTS

13.8.2. **Table 13-8** below presents the construction phase GHG emissions for the Proposed Scheme.

Table 13-8: Proposed Scheme Estimated Construction GHG Emissions

Emissions Sources	Emissions (tCO_2e)
Product Stage (manufacture and transport of raw materials to suppliers) (A1-3)	73,895
Transport of Materials to Site (A4)	10,130
Plant and Equipment Use during Construction (A5)	9,085
Transport of Waste (A5)	4,489
Disposal of Waste (A5)	271
Land use, Land Use Change And Forestry (A5)	463
Total	**98,332**

13.8.3. The total estimated construction GHG emissions of the Proposed Scheme is 98,332 tCO_2e. The assessment indicates that embodied emissions (Product Stage (A1-3)) make up 75% of the total construction GHG emissions.

13.8.4. A further breakdown of the embodied carbon for materials expected to be used in construction of the Proposed Scheme is provided in **Table 13-9.** This indicates that metals, glass reinforced plastic (GRP) and concrete would account for approximately 71% of emissions during the construction phase. The next largest contributors to the overall construction phase emissions are for the Transport of Materials to Site (A4) at 10%, Plant and Equipment Use (A5) at 9% and the Transport of Waste (A5) at 5%, with the remaining elements attributing less than 1% each.

Table 13-9: Emissions for key materials identified for Product Stage (A1-3)

Construction Material	Emissions (tCO_2e)
Metals	44,101
GRP	17,983
Concrete	8,086
Aggregates	2,224
Plastics	1,007
Bitumen	459
Timber	28
Rubber	7
Total	**73,895**

OPERATION PHASE IMPACTS

13.8.5. As noted in **Section 13.6**, baseline GHG emissions (Without Proposed Scheme Operating) relate to the emissions generated from processing waste from fossil sources, which are considered to contribute to additional CO_2 in the atmosphere. However, operation of the Proposed Scheme will capture CO_2 from both fossil sources (plastics) and biogenic sources (wood, paper and cardboard). In the case of emissions captured from fossil sources this represents a reduction in CO_2 entering the atmosphere, and in the case of emissions captured from biogenic sources this represents a removal of CO_2 in the atmosphere.

13.8.6. **Table 13-10** below presents the operation phase GHG emissions relative to the baseline for the Proposed Scheme. The total emissions for the 'With Proposed Scheme Operating' scenario include the biogenic emissions captured through the Carbon Capture Process (-836,792 tCO_2), which would be sequestered and removed from the atmosphere. **Table 13-10** also identifies the fossil emissions that would be captured and sequestered through the Carbon Capture Process (-814,988 tCO_2); however, to avoid double counting these are not included in the total emissions for the 'With Proposed Scheme Operating' scenario as they represent CO_2 emissions accounted for in the overall net saving on baseline emissions for the Proposed Scheme.

Table 13-10: Proposed Scheme Estimated Operation GHG Emissions Relative to Baseline

Emissions Sources	Emissions per Annum (tCO_2e)	
	Without Proposed Scheme Operating	With Proposed Scheme Operating
CO_2 emissions from fossil sources for Riverside 1 and Riverside 2 (B1)	857,882	42,894 ($-814,988$ tCO_2 are captured from fossil sources but not included in the total)
CO_2 emissions from biogenic sources captured through the Carbon Capture Process (B1)	0	-836,792
N_2O emissions from Riverside 1 and Riverside 2 (B1)[b]	488	488
Operation Refrigerants (B1)	0	<0.5
Maintenance, Repair, Replacement, Refurbishment (B2-5)	0	1,129

[b] N_2O related GHG emissions from Riverside 1 and Riverside 2 not captured by the Proposed Scheme

Emissions Sources	Emissions per Annum (tCO_2e)	
	Without Proposed Scheme Operating	With Proposed Scheme Operating
Operational Energy Use (B6)	0	58
Operational Water Use (B7)	0	<0.5
Land Use, Land Use Change and Forestry (B8)	0	6
Process Consumables used for the Operation of the Proposed Scheme (B8)	0	2,100
End-user Emissions (B9/D) (Transport)	0	27,885
Total	**858,370**	**-762,232**
Net operational emissions savings		**-1,620,603**

13.8.7. When considering GHG emissions for the operation phase without including savings from the Carbon Capture Process the assessment indicates that operational activities would generate approximately 74,559 tCO_2e annually, which includes residual fossil CO_2 and N_2O emissions of 43,382 tCO_2e from Riverside 1 and Riverside 2, estimated to be 58% of this total. The next greatest contribution to operational GHG emissions would be from the transport by sea of liquefied CO_2 captured by the Proposed Scheme, to the proposed underground storage facility (End-user Emissions (B9/D), estimated to be 37% of the operational GHG emissions. The remaining operational elements are estimated to contribute less than 5% to this total.

13.8.8. However, a fundamental aspect of the Proposed Scheme's operation is the capture of CO_2 that would otherwise be released to the atmosphere. When the sequestration of biogenic CO_2 emissions by the Carbon Capture Process is included for the operation phase, the assessment shows that emissions with the Proposed Scheme operating represent an aggregate removal of -762,232 tCO_2e/yr from the atmosphere.

13.8.9. With respect to impacts attributable to the Proposed Scheme, the GHG assessment needs to consider the overall change in GHG emissions in the atmosphere relative to the baseline, from both fossil and biogenic sources. Therefore, in **Table 13-10** the net emissions savings identified for the Proposed Scheme during the operation phase are -1,620,603 tCO_2e annually. This is the difference between the emissions that would otherwise be released to the atmosphere without the Proposed Scheme operating (858,370 tCO_2e/yr) in combination with the aggregate emissions that would be removed with the Proposed Scheme operating (-762,232 tCO_2e/yr).

CONSTRUCTION PHASE EFFECTS

13.8.10. Based on the assessment, the construction phase will result in an increase in GHG emissions compared to the baseline, of 19,666 tCO_2e/yr over the five year construction period.

13.8.11. Due to the scale of emissions, there is likely to be a direct, permanent, long term, **Moderate Adverse (Significant)** effect.

13.8.12. In relation to the IEMA Guidance[28], the GHG impacts are expected to be partially mitigated (by the measures set out at **Section 13.7**) and therefore may partially meet the applicable existing and emerging policy requirements. However, they would not fully contribute to decarbonisation in line with local and national policy goals, falling short of fully contributing to the UK's trajectory towards net zero.

OPERATION PHASE EFFECTS

13.8.13. The outcome of the assessment for the operation phase suggests that it will result in a substantial decrease in GHG emissions compared to the baseline scenario.

13.8.14. The technology to be used for the Proposed Scheme has an estimated minimum capture rate of 95% of all CO_2 from Riverside 1 and Riverside 2. This equates to 847,875 and 803,905 tCO_2 respectively per annum for Riverside 1 and Riverside 2, a total of 1,651,780 tCO_2 (of which approximately 49% would be from fossil sources and 51% would be from biogenic sources).

13.8.15. Allowing for residual emissions from Riverside 1 and Riverside 2 and emissions associated with operation of the Proposed Scheme, the net operational emissions savings estimated during the 50 year operation phase are 1,620,603 tCO_2e/yr. This represents the overall change in emissions that are attributable to the Proposed Scheme during the operation phase, accounting for the capture and sequestration of CO_2 from both fossil and biogenic sources.

13.8.16. Due to the scale of emissions, there is likely to be a direct, permanent, long term, **Beneficial (Significant)** effect. This is because it is anticipated that the net GHG impacts are below zero and will cause a reduction in atmospheric GHG concentration, whether directly or indirectly, compared to the baseline, substantially exceeding net zero requirements with a beneficial climate impact.

PROPOSED SCHEME LIFECYCLE IMPACTS

13.8.17. The lifecycle impacts associated for the Proposed Scheme, representing each phase, are as set out in **Table 13-11** and illustrated below in **Figure 13-1**. As reported in **Table 13-10**, the operation phase takes into account: the residual fossil CO_2 and N_2O emissions from Riverside 1 and Riverside 2 released to the atmosphere (B1: 43,382 tCO_2e/yr); emissions for operating the Proposed Scheme (B1-B9/D: 31,177 tCO_2e/yr); and the biogenic CO_2 captured through the Carbon Capture Process (B1: -836,792 tCO_2e/yr).

13.8.18. As shown in **Table 13-11**, the whole life emissions for the Proposed Scheme (accounting for construction and operation phases), represent an overall saving in GHG emissions of -85,223,660 tCO_2e relative to the future baseline.

Table 13-11: Proposed Scheme Total GHG Emissions

Phase	Data Period	Annual Emissions (tCO_2/yr)	Total Emissions (tCO_2)
Future Baseline			
Future Baseline (Table 13-7)	2026-2080 (55 years)	858,370	47,210,373
Proposed Scheme			
Construction (Table 13-8)	2026-2030 (5 years)	19,666	98,332
Operation (Table 13-10)	2031-2080 (50 years)	-762,232	-38,111,620
Proposed Scheme Total Emissions	2026-2080 (55 years)	-691,151 (average over 55 years)	-38,013,287
Net Impact of Proposed Scheme relative to Future Baseline			
Net Emissions Savings	2026-2080 (55 years)	-1,549,521 (average over 55 years)	-85,223,660

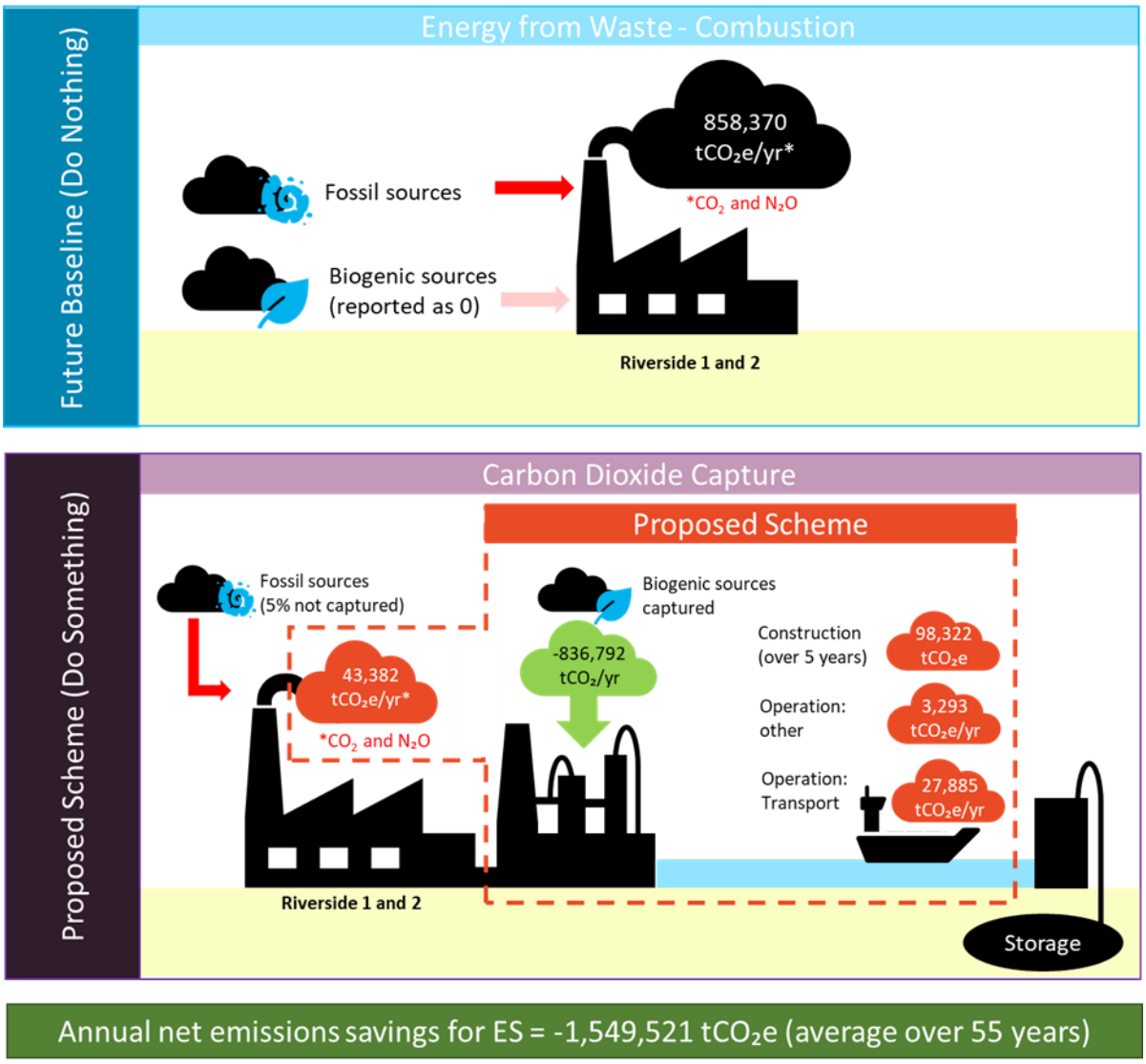

Figure 13-1: GHG – Illustrated Scope of the Future Baseline and the Proposed Scheme

EMISSIONS CONTEXT

13.8.19. To aid in the determination of significance in line with the methods outlined in **Section 13.4**, the CO_2 emissions from the Proposed Scheme, as currently calculated, have been presented in the context of the UK's Carbon Budgets in **Table 13-12** and the London Carbon Budgets in **Table 13-13.**

13.8.20. The capture of CO_2 from both fossil and biogenic sources represents the change in atmospheric GHG emissions attributable to the Proposed Scheme; these are therefore considered in combination when determining the relative emissions savings from the Proposed Scheme in the context of UK and London Carbon Budgets.

Table 13-12: Proposed Scheme GHG Emissions with UK Carbon Budgets

Carbon Budget Period	UK Carbon Budget tCO_2e	Proposed Scheme Emissions tCO_2e	Proportion of Carbon Budget (%)
Fourth: 2023-2027	1,950,000,000	39,333	0.002
Fifth: 2028-2032	1,725,000,000	-3,095,442	-0.179
Sixth: 2033-2037	965,000,000	-7,886,104	-0.810

Table 13-13: Proposed Scheme GHG Emissions with London Carbon Budgets

Time Period	Carbon Budget tCO_2e	Proposed Scheme Emissions tCO_2e	Proportion of Carbon Budget (%)
2023-2027	22,400,000	39,333	0.176
2028-2032	18,000,000	-3,095,442	-17.197

13.8.21. The assessment of GHG emissions relative to the UK Carbon Budgets and London Carbon Budgets has considered GHG emissions from the Proposed Scheme in two separate phases: construction and operation, with emissions applied from the first full year of construction and operation.

13.8.22. With respect to UK Carbon Budgets (summarised in **Table 13-12**):

- GHG emissions from the construction phase will fall within part of the UK fourth (2023 to 2027) carbon budget but there would be no emissions from the operation phase during this period. This assessment has determined that emissions from the Proposed Scheme would equate to 0.002% of the UK fourth carbon budget.
- As the construction phase extends to 2030 further GHG emissions from construction activities will fall within the UK fifth (2028 to 2032) carbon budget, along with net savings in GHG emissions from the start of operational activities during this period. The assessment has established that on balance there will be a net reduction in GHG emissions from the Proposed Scheme during this period, which would contribute to a reduction of 0.18% for the UK fifth carbon budget.
- During the UK sixth (2033 to 2037) carbon budget there will be no GHG emissions from construction activities and there will continue to be net savings in GHG emissions from operational activities. The net reduction in GHG emissions from the Proposed Scheme during this period would contribute to a reduction of 0.81% for the UK sixth carbon budget.

13.8.23. With respect to London Carbon Budgets (summarised in **Table 13-13**):

- GHG emissions from the construction phase will fall within part of the London 2023 to 2027 carbon budget but there would be no emissions from the operation phase during this period. This assessment has determined that emissions from the Proposed Scheme would equate to 0.18% of the London 2023 to 2027 carbon budget.
- GHG emissions from the construction phase will also extend partially into the London 2028 to 2032 carbon budget, and there will also be net savings in GHG emissions from the start of operational activities during this period. The assessment has established that on balance there will be a net reduction in GHG emissions from the Proposed Scheme during this period, which would contribute to a reduction of 17.2% for the London 2028 to 2032 carbon budget.

13.8.24. The estimated carbon payback period for the Proposed Scheme is presented in **Table 13-14**, which represents the time it would take for carbon emissions calculated for the construction and operation phases to be offset by the savings in carbon emissions from the Proposed Scheme. This indicates that the carbon payback period for the Proposed Scheme would be 0.1 years (under 5 weeks).

Table 13-14: Proposed Scheme Carbon Payback Period

Item	Units	Proposed Scheme Emissions
Proposed Scheme – total construction emissions	tCO_2e	98,332
Annual net emissions saving from Proposed Scheme	tCO_2e/yr	-1,620,603
Carbon payback period	years	0.1

13.8.25. When considering net GHG emissions for the Proposed Scheme in the context of energy sector policy (as outlined in **Section 13.2**), the Proposed Scheme supports a move towards carbon capture and storage as part of the transition to a net zero economy low carbon. The UK's Net Zero Strategy[17] supports the use of carbon capture and storage to capture emissions from energy from waste activities.

13.8.26. The Proposed Scheme would contribute towards the UK Net Zero Strategy[17] aim is "to use CCUS technology to capture and store 20-30 $MtCO_2$ per year by 2030".

13.8.27. **Table 13-16** below identifies the relative contribution the Proposed Scheme would make to projected UK Carbon Budget for the Power Sector, which take into account the uptake of Net Zero policies listed in the latest Carbon Budget Delivery Plan[13]. During the fourth carbon budget emissions from construction of the Proposed Scheme would equate to 0.03% of the projected Power Sector emissions. When the Proposed Scheme is operational it is estimated that it would contribute to a reduction of 4.9% in projected Power Sector emissions for the fifth carbon budget, and a reduction of 18.8% in projected Power Sector emissions for the sixth carbon budget.

Table 13-15: Proposed Scheme GHG Emissions with UK Carbon Budget Projections for Power Sector

Carbon Budget Period	Projected Sectoral Emissions for Power Sector tCO_2e	Proposed Scheme Emissions tCO_2e	Proportion of Power Sector Carbon Budget Projection (%)
Fourth: 2023-2027	143,000,000	39,333	0.03
Fifth: 2028-2032	63,000,000	-3,095,442	-4.9
Sixth: 2033-2037	42,000,000	-7,886,104	-18.8

LCO_2 GEOLOGICAL STORAGE

13.8.28. As noted in **Section 13.4,** the final storage of captured LCO_2 and the development of proposed storage locations offshore is outside the scope of this assessment (End-User Emissions (B9/D): Storage), however the transport of carbon to those stores is included. Although emissions related to the storage of LCO_2 in geological facilities are outside the scope of the GHG assessment for the Proposed Scheme, based on experience on other CCS projects it can be helpful to provide further information on potential emissions associated with the final storage of LCO_2 in a geological facility. Therefore, for contextual purposes this section provides an outline comparison of the GHG emissions associated with both the transport and final storage of LCO_2 from the Proposed Scheme for the following two geological storage options:

- **Storage location in North Sea**: considered to be representative of a reasonable worst-case scenario, requiring transportation of LCO_2 from the Proposed Scheme for geological storage at a location in the North Sea, approximately 1,150km shipping distance from the Site Boundary. The main GHG assessment has accounted for this scenario in terms of emissions within scope for the assessment: those related to the transport of LCO_2 to a geological storage location (End-user Emissions B9/D: Transport).
- **Viking (Humber, UK):** considered to be the most likely destination option for final storage of CO_2 captured by the Proposed Scheme. This would require transportation of LCO_2 to the Immingham Green Terminal approximately 450km shipping distance from the Site Boundary, and onward transfer via pipeline to the Viking offshore geological storage location in the southern North Sea[52].

13.8.29. The following extract has been taken from the Viking CCS Pipeline DCO application (Document reference: EN070008/APP/6.2.3)[53] outlining the proposals for storage capacity in the Viking area of the southern North Sea:

> *"The utilisation of world class storage potential within the depleted gas reservoirs in the Viking area of the southern North Sea for CO_2 injection and storage, with an independently verified storage capacity of 300 million tonnes. The Viking reservoirs are located approximately 140km offshore in the Southern North Sea (SNS) and 2.7km beneath the seabed. The depth of storage, combined with a regional "Superseal" caprock, makes the reservoirs secure for storing captured*

CO_2. The caprock is made up primarily of layers of salt, hundreds of feet thick, which acts as a high-strength barrier through which the CO_2 cannot pass. This caprock gives Harbour a high confidence in the ability of the storage site to keep CO_2 in place. Furthermore, a secondary permeable formation above the primary storage site, known as the Bunter Sandstone, has the capability to act as secondary containment which adds to the security of the site."

Comparative Assessment Methodology

13.8.30. The comparative assessment of the two geological storage options presented here is based on the following methodology and assumptions, which has taken account of outline information available from publicly available sources to determine the embodied carbon emissions in the construction of infrastructure used to transfer LCO_2 for geological storage infrastructure and the operational emissions associated with the transport and storage of the LCO_2 captured by the Proposed Scheme.

13.8.31. For the storage location in the North Sea, information related to GHG emissions for the use of storage infrastructure is based on a carbon footprint available for the proposed Northern Lights CCS facility[54], which is assumed to be representative of a proxy CCS facility operating in the North Sea aligned with the worst case LCO_2 transport scenario included in the main GHG assessment.

13.8.32. For the Viking storage location, information related to the transfer and storage of LCO_2 is based on the following sources:

- GHG emissions for the construction and operation of relevant elements of the Immingham Green Terminal is based on the Environmental Statement (ES) for this project, including the project description in Chapter 2: The Project[55] and reporting on GHG emissions in Chapter 19: Climate Change[56].
- GHG emissions for the construction and operation of the Viking CCS Pipeline are based on the reporting of emissions in Chapter 15: Climate Change[57] of the ES for the Viking CCS Pipeline DCO application. There is no publicly available information for the offshore elements of Viking and so these elements have not factored into the numbers set out below. It is noted however that the Viking project website states that it is intended to repurpose an existing pipeline for the majority of the route, with a 20km section added at the end. Given the predominant re-use nature of the proposal, it is considered that any additional embodied or leakage emissions would likely be minimal in any event

North Sea

13.8.33. ***Construction:*** Embodied emissions for construction of storage infrastructure for the representative North Sea storage option are based on the following aspects reported for the Northern Lights CCS facility:

- The estimated project lifetime emissions for the Northern Lights CCS facility is 3.32MtCO_2e, of which 9% is reported to relate to the storage infrastructure (including pipelines from the vessel unloading to the store), and of this 52% is reported to relate to construction of the storage infrastructure (including materials, equipment and transportation). This has been used to estimate the *Construction*

emissions associated with the use of this representative CCS facility for the North Sea storage option, which results in an estimated 155,376 tCO_2e of construction emissions attributable to the Proposed Scheme.

- The indicative storage capacity of this representative CCS facility is 1.5 $MtCO_2/yr$ in the first phase, increasing to 3.5 $MtCO_2/yr$ in a second phase. The estimated quantity of LCO_2 captured by the Proposed Scheme is 1.65 $MtCO_2/yr$, which is within this range. For the comparative assessment it is assumed that all of the embodied carbon emissions associated with construction of the North Sea storage infrastructure would apply to the Proposed Scheme.

13.8.34. ***Operation – Transport:*** The method used to determine emissions for the transport of captured LCO_2 to the North Sea storage location is described in **Section 13.4** (B9/D – End-user Emissions (Transport)), which assumes a distance of 1,150km for transport by ship. This has been used to estimate the *Operation – Transport* emissions associated with the use of this representative CCS facility for the North Sea storage option.

13.8.35. ***Operation – Storage:*** Operational emissions for the use of storage infrastructure for the representative North Sea storage option are based on the following aspects reported for the Northern Lights CCS facility:

- The estimated project lifetime emissions for the Northern Lights CCS facility is 3.32 $MtCO_2e$, of which 9% is reported to relate to the storage infrastructure, and of this 34% is reported to relate to operational aspects for storage of CO_2 received by the facility (covering aspects such as use of electricity and fugitive emissions). This has been used to estimate the *Operation – Storage* emissions associated with the use of this representative CCS facility for the North Sea storage option, which results in an estimated 203,184 tCO_2e of operational emissions attributable to the Proposed Scheme.
- For the comparative assessment it is assumed that all of the operational carbon emissions associated with use of the North Sea storage infrastructure would apply to the Proposed Scheme.

Viking

13.8.36. ***Construction:*** Embodied emissions for construction of storage infrastructure for the Viking storage option are based on the following aspects reported for Immingham Green Terminal and the Viking CCS Pipeline:

- For the Immingham Green Terminal, total GHG emissions of 830,226 tCO_2e are reported for construction of Terrestrial and Marine infrastructure, which as well as facilitating the import of CO_2 for onward transfer would also support the import of green ammonia and the related hydrogen production facility. It is likely that the import and transfer of CO_2 would mainly involve the use of Marine infrastructure with limited use of the proposed Terrestrial infrastructure; however, there is insufficient detail to the determine the extent to which this applies. Therefore, for the purposes of this comparative assessment the following precautionary approach has been taken:

- Total GHG emissions for construction of both the Terrestrial and Marine infrastructure have been considered in the assessment.
- A factor of 15.8% has been applied to the total construction emissions according to the quantity of LCO_2 from the Proposed Scheme (1,651,780 tonnes/yr) as a proportion of the total annual imports of green ammonia and CO_2 forecast for the Immingham Green Terminal (10,460,000 tonnes/yr).
- This results in embodied carbon emissions of 131,104 tCO_2e attributable to the Proposed Scheme related to use of the Immingham Green Terminal (although as noted this is considered to be an overestimate given uncertainties related to the use of Terrestrial infrastructure).

- For the Viking CCS pipeline, total emissions of GHG emissions of 84,279 tCO_2e are reported for construction of the infrastructure, all of which are relevant to the transfer of CO_2. For purposes of this comparative assessment the following approach has been taken:
  - Total GHG emissions for construction of the pipeline infrastructure have been considered in the assessment.
  - A factor of 16.5% has been applied to the total construction emissions according to the quantity of LCO_2 from the Proposed Scheme (1,651,780 tonnes/yr) as a proportion of the total CO_2 estimated to be transferred annually by the Viking CCS pipeline (10,000,000 tonnes/yr).
  - This results in embodied carbon emissions of 13,921 tCO_2e attributable to the Proposed Scheme related to use of the Viking CCS pipeline.

13.8.37. ***Operation – Transport:*** The method used to determine emissions for the transport of captured LCO_2 to the Viking storage location is the same as that described in **Section 13.4** (B9/D – End-user Emissions (Transport)), which for the Viking storage location assumes a distance of 450km for transport by ship to the Port of Immingham. This has been used to estimate the *Operation – Transport* emissions associated with the use of the Vking storage option.

13.8.38. ***Operation – Storage:*** Operational emissions for the use of storage infrastructure for the Viking storage option are based on the following aspects reported for Immingham Green Terminal and the Viking CCS Pipeline:

- For the Immingham Green Terminal, total annual operational GHG emissions of 165,653 tCO_2e/yr are reported for use of the Terrestrial and Marine infrastructure, however; the majority of these emissions are reported to either relate to aspects unrelated to the import of CO_2 at the Terminal (105,988 tCO_2e/year of landside operational emissions associated with hydrogen production) or relate to Sea Freight Transport (49,059 tCO_2e/yr) which for this comparative assessment is already considered in the above estimate for *Operation – Transport*. Therefore, for the following approach has been taken:
  - Total operational emissions considered for the use of Immingham Green Terminal are 10,607 tCO_2e/yr, which excludes emissions related to landside operations for hydrogen production and sea freight transport.

- As for the construction emissions, a factor of 15.8% has been applied to the operational emissions according to the quantity of LCO_2 from the Proposed Scheme (1,651,780 tonnes/yr) as a proportion of the total annual imports of green ammonia and CO_2 forecast for the Immingham Green Terminal (10,460,000 tonnes/yr).
- This results in estimated operational emissions of 83,750 tCO_2e (over a 50 year period) attributable to the Proposed Scheme related to use of the Immingham Green Terminal.

- For the Viking CCS pipeline, total operational GHG emissions of 2,514 tCO_2e are reported over a 25 year period. For purposes of this comparative assessment the following approach has been taken:
  - Total operational GHG emissions for use of the pipeline infrastructure have been considered in the assessment.
  - As for the construction emissions, a factor of 16.5% has been applied to the operational emissions according to the quantity of LCO_2 from the Proposed Scheme (1,651,780 tonnes/yr) as a proportion of the total CO_2 estimated to be transferred annually by the Viking CCS pipeline (10,000,000 tonnes/yr).
  - This results in operational emissions of 421 tCO_2e (over a 50 year period) attributable to the Proposed Scheme related to use of the Viking CCS pipeline.
- Fugitive emissions relating to potential leakage of CO_2 from the CCS pipeline or geological storage do not appear to be reported in the ES for the Viking CCS pipeline. Therefore, for purposes of this comparative assessment the following approach has been taken to account for fugitive emissions related to the Viking storage option:
  - An emissions rate of 14 tCO_2/km/yr is assumed for fugitive CO_2 emissions during pipeline transport[58], over a total pipeline distance of 203 km for the Viking CCS pipeline and offshore elements. Applying the 16.5% factor for the quantity of LCO_2 from the Proposed Scheme as a proportion of the Viking CCS pipeline capacity, results in 23,472 tCO_2 of potential fugitive pipeline emissions attributable to the Proposed Scheme (over a 50 year period).
  - An emissions rate of 0.1% is assumed for fugitive CO_2 emissions during geological storage[59], which applied to the 1,651,780 tonnes/yr of LCO_2 to be stored for the Proposed Scheme results in 82,589 tCO_2 of potential fugitive geological storage emissions attributable to the Proposed Scheme (over a 50 year period).

Assumptions

13.8.39. Operational emissions reported in the Northern Lights Carbon Footprint[54], the Immingham Green Terminal ES[56] and the Viking CCS Pipeline ES[57] are based on a 25 year lifetime for operational activities. To ensure consistency with the main GHG assessment for the Proposed Scheme, in each case the relevant operational emissions have been extrapolated over 50 years in this comparative assessment.

13.8.40. Reporting of emissions for decommissioning of storage infrastructure is not consistently available across the information sources for the North Sea storage option and the Viking storage option. Therefore, emissions associated with decommissioning are not included in this comparative assessment, which is in line with the main GHG assessment.

Comparative Assessment Impacts

13.8.41. **Table 13-16** below presents the GHG emissions determined for the transport and storage of LCO_2 from the Proposed Scheme for the two storage options considered in this comparative assessment.

Table 13-16: LCO_2 Transport and Storage Emissions – Comparative Scenarios

Emissions sources for CO_2 transport and storage	North Sea storage location (tCO_2e)	Viking storage location (tCO_2e)
Construction		
North Sea facility	155,376	-
Immingham Green Terminal Viking CCS Pipeline	-	131,104 13,921
Operation – Transport		
LCO_2 transport by ship from Proposed Scheme	1,394,236	545,571
Operation – Storage		
North Sea facility – storage (incl. fugitive emissions)	203,184	-
Immingham Green Terminal – import for Viking Viking CCS Pipeline – transfer Viking CCS Pipeline – pipeline fugitive emissions Viking - geological storage fugitive emissions	-	83,750 421 23,472 82,589
Total	**1,752,796**	**880,827**

13.8.42. **Table 13-17** below identifies the relative effect that transport and storage of LCO_2 for the two geological storage options would have with respect to the overall GHG emissions determined in the main GHG assessment for the Proposed Scheme.

13.8.43. As noted previously, the North Sea storage location is assumed to be representative of a worst case scenario for the transport of LCO_2 from the Proposed Scheme (1,394,236 tCO_2e over a 50 year period), which has already been accounted for in the emissions savings identified in main GHG assessment. This comparative assessment shows that factoring in an estimated 358,560 tCO_2e of additional emissions for construction and operation of the North Sea storage option has the potential to reduce the original GHG emissions savings identified for the Proposed Scheme by 0.4%.

13.8.44. For the more likely Viking storage location, the comparative assessment identifies operational emissions for transport of LCO_2 by ship to Immingham Green Terminal of 545,571 tCO_2e (over a 50 year period), which would be approximately 60% lower than the transport of LCO_2 to the North Sea location (as used in the main GHG assessment). When accounting additionally for construction and operational emissions associated with use of the Immingham Green Terminal, Viking CCS pipeline and geological storage, the assessment indicates that the Viking storage option has the potential to improve the original GHG emissions savings identified for the Proposed Scheme by 0.6%.

Table 13-17: CO_2 Transport and Storage relative to Proposed Scheme Emissions Savings

Emissions category	Proposed Scheme GHG Emissions (tCO_2e) over 50 years	
Total emissions savings identified in main GHG assessment (Table 13-11)	-85,223,660	
	North Sea storage location (tCO_2e)	**Viking storage location (tCO_2e)**
Emissions for transport of CO_2	1,394,236	545,571
Emissions for storage of CO_2 (construction and operation)	358,560	335,257
Total emissions savings including options for transport and storage (change relative to main GHG assessment)	-85,223,660 (+0.4%)	-85,737,069 (-0.6%)

13.9. ADDITIONAL DESIGN, MITIGATION AND ENHANCEMENT MEASURES

13.9.1. This section sets out the additional design, mitigation or enhancement measures that could be considered to reduce GHG emissions.

DESIGN EVOLUTION

13.9.2. Potential measures to further reduce GHG emissions through the ongoing design of the Proposed Scheme and to be secured through requirement of any DCO granted could include:

- detailed design optimisation to reflect the PAS 2080:2023[24] carbon reduction hierarchy;
- reducing the requirement for construction materials (designing out material redundancy) where practicable;
- substituting construction elements for lower carbon alternatives where practicable;

- considering the specification of materials and products with reduced embodied GHG emissions including through material substitution, recycled or secondary content and from renewable sources;
- considering the sustainability credentials of material suppliers and construction Contractor(s) and, where practicable, taking into account their policies and commitments to reduction of GHG emissions, including embodied emission in materials;
- designing, specifying and constructing the Proposed Scheme with a view to maximising the operational lifespan and minimising the need for maintenance and refurbishment (and all associated emissions);
- designing, specifying and constructing the Proposed Scheme with a view to maximising the potential for reuse and recycling of materials/elements at the end-of-life stage; and
- considering opportunities to minimise operational energy use, including the specification of efficient plant and ancillary infrastructure.

CONSTRUCTION PHASE

13.9.3. Measures to reduce GHG emissions during the construction of the Proposed Scheme are set out in an **Outline CoCP (Document Reference 7.4)** and will be set out in the full CoCP(s). The **Outline CoCP (Document Reference 7.4)** will provide a review, monitoring and audit mechanism to determine the effectiveness of, and compliance with, environmental control measures, which include the consideration of manufacture, transport and supply of materials. Measures incorporated into the **Outline CoCP** will include:

- use of efficient construction processes, such as design for manufacture and assembly;
- development and implementation of a full Site Waste Management Plan (SWMP) to be in substantial accordance with the **Outline SWMP (Document Reference 7.10)**. This is secured by a requirement in the **Draft DCO (Document Reference 3.1)**;
- development and implementation of a Materials Management Plan (MMP) in accordance with the **Outline CoCP (Document Reference 7.4)**;
- specification of materials and products with reduced embodied GHG emissions including through material substitution, recycled or secondary content and from renewable sources;
- recovery and reuse/recycling of site arisings (ideally, onsite); and
- selection and engagement of materials suppliers and construction Contractor(s) taking into account their proximity to the Proposed Scheme, as well as policies and commitments to reduction of GHG emissions, including embodied emission in materials.

OPERATION PHASE

13.9.4. Operational enhancement measures to meet the anticipated GHG emission reduction will require the Proposed Scheme to capture as much CO_2 as practicable and maintain, as a minimum, the expected 95% carbon capture rate. This may be achieved through:

- selection of best available techniques (BAT) for equipment and technology specifications which will optimise carbon capture rates secured through an Environmental Permit; and
- development and implementation of a planned and preventative maintenance and replacement regime to ensure operation of the plant remains efficient for the minimum design life.

13.10. MONITORING

13.10.1. Process emissions arising from operation of the Proposed Scheme will be managed and regulated under an Environmental Permit. to be applied for from the Environment Agency, which may identify a requirement to monitor and report on GHG emissions. Beyond the measures to be included in the **Outline CoCP (Document Reference 7.4)**, no monitoring of GHG effects is expected to be required.

13.11. RESIDUAL EFFECTS

13.11.1. **Table 13-18** below summarises the residual effects associated with the Proposed Scheme.

Table 13-18: GHG - Summary of Residual Effects

Description of the Impact	Sensitive Receptor	Significance of Effect with Embedded Mitigation	Additional Design, Mitigation, Enhancement measure	Residual effect
Construction Phase				
GHG Emissions	Global Atmosphere	**Moderate Adverse (Significant)**	Construction emissions could be minimised through design optimisation in line with PAS 2080:2023[24] principles to reflect the carbon reduction hierarchy as well as other measures detailed in **Section 13.8**.	**Minor Adverse (Not Significant)**
Operation Phase				
GHG Emissions	Global Atmosphere	**Beneficial (Significant)**	No additional mitigation required. Enhancement measures are to review opportunities to improve operational performance in line with BAT and maintenance to ensure efficient process operations.	**Beneficial (Significant)**

13.12. LIMITATIONS AND ASSUMPTIONS

13.12.1. The following limitations and assumptions have been identified:

- the most accurate and representative emission factors have been used where practicable, however in some circumstances (e.g. where that level of detail is not available, or if the exact emission factors were not available) a suitable representative emission factor was chosen using professional judgement;
- some items in the preliminary BoQ were not available in the format required for the selected emission factor to be applied. In these instances, assumptions have been made in regard to dimensions or specification to obtain the correct values, based on publicly available information of similar products or industry standard;
- where available, primary raw data or information on plant or equipment has been used in calculations. Where this information is not available then proxies or industry benchmarks have been used to estimate emissions to address gaps, with justification for the approach used;
- a worst case scenario has been assumed for the emissions factor applied to the supply of electricity to the Proposed Scheme by Riverside 1 and or Riverside 2, which does not account for any avoided emissions for the management of waste by the Energy from Waste process;
- the assessment of GHG emissions arising from Riverside 1 and Riverside 2 is limited to the extent of emissions that pass directly to the Proposed Scheme (i.e. GHG emissions generated from the combustion of waste only). The assessment does not account for GHG emissions related to the day to day operation of Riverside 1 and Riverside 2, which are already consented;
- if there is any time when the LCO_2 transport and storage system is not available it is assumed that Riverside 1 and Riverside 2 will release GHG emissions to the atmosphere, in line with the emissions identified for the current and future baseline;
- GHG emissions from construction plant and equipment have been calculated based on the estimated construction cost (adjusted for inflation) of the Proposed Scheme applied to an estimate of GHG emissions calculated using the Royal Institute of Chartered Surveyors[29] assumption; and
- the assessment of significance has been based, in part, on professional judgement.

13.13. REFERENCES

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