NORTH LINCOLNSHIRE GREEN ENERGY PARK

Planning Act 2008

Infrastructure Planning (Applications Prescribed Forms and Procedure) Regulations 2009

APFP Reg. 5(2)(a)

Infrastructure (Environmental Impact Assessment) Regulations 2017

North Lincolnshire Green Energy Park

Volume 6

Environmental Statement

6.2.6 Climate

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Acronyms and Abbreviations

Name	Description
BPF	British Plastics Federation
CCGT	Combined cycle gas turbine
CCS	Carbon capture and storage
CCUS	Carbon capture, utilisation and storage
CFCs	Chlorofluorocarbons
CH_4	Methane
CHP	Combined heat and power
CO_2	Carbon Dioxide
DDOC	Degradable decomposable organic content
ERF	Energy recovery facility
ES	Environmental statement
FGTr	Flue gas treatment residues
GHG	Greenhouse gas
HCFCs	Hydrochlorofluorocarbons
IBA	Incinerator bottom ash
IPCC	Intergovernmental Panel on Climate Change
MBT	mechanical biological treatment
MJ/kg	Mega Joules per kilogram
MWh	Electrical generation in megawatt-hours
N2O	Nitrous Oxide
NCV	Net calorific value
RDF	Refuse derived fuel
SCR	Selective catalytic reduction
WEEE	Waste electrical and electronic equipment

1. INTRODUCTION

1.1 Introduction

1.1.1.1 This chapter of the ES sets out the approach and scope of the greenhouse gas (GHG) assessment of the Project. A GHG assessment determines the extent to which a project affects the climate by quantifying the emissions of GHGs and comparing this to the baseline (GHG emissions without the Project development).

1.1.1.2 The development and operation of the energy recovery facility (ERF) is a key feature of the Project, both as a waste management facility per se and in its role in recovering ERF fuel that is used at the site and beyond. Therefore, the focus of the GHG assessment is on the impacts associated with the operation of the ERF.

1.1.1.3 The assessment has been undertaken in accordance with the guidance document Environmental Impact Assessment Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance developed by the Institute of Environmental Management & Assessment (IEMA, 2017) and through the application of professional judgement.

1.1.1.4 An evaluation of whether and how the potential future effects of climate change could impact the Project or exacerbate impacts identified by other technical topics has been included in Chapter 16 – Major Accidents and Hazards (**Document Reference 6.2.16**), and in the site-specific flood risk assessment presented in Annex 3 (**Document Reference 6.3.3**).

1.2 GHG emissions from waste management and energy recovery

1.2.1.1 All households and businesses produce waste. Whilst an increasing proportion of these arisings are separated and recycled, the residues that remain must be managed reliably, cost-effectively, and with careful consideration of the environmental impacts of the management technologies available.

1.2.1.2 UK government policies over the last 20 years have sought to reduce the amount of waste disposed to landfill and the use of waste to energy plants, such as the proposed ERF, have and will continue to play a key role in this.

1.2.1.3 When wastes are disposed to landfill, the biodegradable materials in residual wastes (food and garden wastes, paper and card, some textiles etc.) decompose, resulting in the release of landfill gas. Landfill gas is largely composed of a mixture of carbon dioxide and methane, which are the most important GHGs that contribute to climate change, and with methane the more powerful. Methane has a global warming potential (GWP) 28 times that of CO_2 over a 100-year time horizon (IPCC, 2013).

1.2.1.4 Landfills that have gas capture and power generation still emit a significant quantity of methane. These emissions can be substantially reduced by diverting waste away from landfill. Therefore, the GHG assessment calculates GHG emissions for a future alternative baseline scenario in which treated waste would otherwise be sent to landfill and compares this to the GHG emissions for the Project.

1.2.1.5 Additionally, the new ERF will produce beneficial products in the form of electricity exported to the National Grid, and heat, which will be used by local businesses and dwellings.

1.2.1.6 In the absence of the ERF, this electricity and heat would be produced by other means, which include the combustion of fossil fuels (e.g. natural gas) with associated GHG emissions. Therefore, the likely impact on GHG emissions as a result of the change in mode of energy production is also assessed.

1.2.1.7 The ERF is designed to provide emission reductions over alternative residual waste management and marginal electricity generation methods. The emissions savings are considered to be designed within the Project and the Project emissions are presented net of these benefits.

1.2.1.8 In addition, the ERF is strategically placed to take advantage of recycling opportunities and mitigation. Ash (used as an aggregate) and metals, that might otherwise go to landfill, will also be recovered after the residual waste is burned, and will displace other ‘virgin’ sources of these materials and the GHG releases associated with their mining, processing and transport.

1.2.1.9 Residual waste has a significant organic carbon content and so the energy recovered is partially from renewable sources. However, there is also a fossil carbon component of the waste, in the form of plastics etc., resulting in emissions of CO_2 from fossil carbon sources when combusted in the ERF. Therefore, to mitigate these emissions a carbon capture, utilisation and storage (CCUS) system will be installed at the site. The impact of this mitigation on the net GHG emissions from the Project is also assessed.

2. POLICY CONTEXT, LEGISLATION, GUIDANCE AND STANDARDS

2.1.1.1 A review has been undertaken of general planning and strategic policy and guidance such as national policy documents, Local Development Frameworks (LDF), International Agreements, and community strategies. This is presented in Chapter 2 of the ES (**Document Reference 6.2.2**). The policy context of greatest relevance to Climate is summarised below.

2.2 International agreements

2.2.1.1 The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty to address climate change to which the UK is a signatory. The UNFCCC sets out a framework and targets for signatories to commit to regarding climate change and greenhouse gas emissions.

2.2.1.2 Under the Paris Agreement on climate change, the UK submitted its first report titled the 'United Kingdom of Great Britain and Northern Ireland's Adaptation Communication to the United Nations Framework Convention on Climate Change' to the UNFCCC in December 2020, outlining the UK's activities with respect to mitigating climate change and how it will support international efforts. This outlines the new UK target for at least a 68% reduction in greenhouse gas emissions by 2030, compared to 1990 levels.

2.3 Legislation

The Infrastructure Planning (Environmental Impact Assessment) Regulation 2017

2.3.1.1 Relevant to climate change, the Regulations state that:

- the EIA must "*identify, describe and assess in an appropriate manner, in light of each individual case, the direct and indirect significant effects of the proposed development on...climate"* and other factors specified; and
- where relevant to the specific characteristics of a particular development or type of development and to the environmental features likely to be significantly affected, the ES is to include "*a description of the factors... likely to be significantly affected by the development…climate (for example greenhouse gas emissions, impacts relevant to adaptation)"* and "*a description of the likely significant effects of the development on the environment resulting from...the impact of the project on climate (for example the nature and magnitude of greenhouse gas emissions) and the vulnerability of the project to climate change"*;

2.3.1.2 The nature and scale of the Project mean that it is very likely to produce significant GHG emissions. Therefore, the ES includes a GHG assessment.

The Climate Change Act 2008 leading to the Adaptation Reporting Power (ARP) and the national Climate Change Risk Assessments (CCRA) (2012 and 2017).

2.3.1.3 The UK Climate Change Act (2008) sets targets related to GHG emissions and establishes that a UK-wide CCRA for carbon budgets must be undertaken every five years.

2.3.1.4 The Sixth Carbon Budget report Policies for the Sixth Carbon Budget for net zero (2020) states that "New waste conversion plants (including incineration, gasification & pyrolysis facilities) must be built with carbon capture and storage (CCS) or 'CCS ready'". All existing energy recovery plants should start retrofitting CCS from the late 2020s onwards, with the aim of having full CCS coverage by 2050.

2.3.1.5 The Sixth Carbon Budget also recommends that all biodegradable waste should be banned from landfill. However, any shift of waste from landfill to energy recovery should not increase GHG emissions from energy recovery by more than 20%, considering that these wastes will contain a mixture of fossil and biogenic carbon content.

2.3.1.6 In June 2021 the UK government set into law the Sixth Carbon Budget to reduce GHG emissions by 78% of 1990 levels by 2035 and for the UK to be net-zero by 2050. The strategy and policies proposed to by the UK government to achieve this are outlined in the Net Zero Strategy (BEIS 2021a).

2.3.1.7 The Net Zero Strategy (BEIS 2021a) has a number of objectives relating to waste management. This includes the elimination of almost all biodegradable wastes from landfill by 2028 and have provided resources to implement free separate food waste collections for all households from 2025. The Net Zero Strategy does not include a requirement for all ERFs to be fitted with CCS, as recommended in the Sixth Carbon Budget report (2020). However, the UK government recognises CCS as an important option for decarbonisation of energy from waste and in November 2021 stated that "a decision has been taken to enable waste management CCS projects to be eligible for support through the ICC business model for Phase-2 of the Cluster Sequencing process" (BEIS 2021b). This means that funding may be available for CCS schemes which meet the required criteria. It has therefore proposed that ERFs could be funded by the Industrial Carbon Capture Business Model

2.3.1.8 The UK Climate Change Risk Assessment (2017) outlines the priority risk areas such as water shortages, flooding and coastal change and opportunities the UK faces from climate change. The third CCRA for the UK is due in 2022.

2.3.1.9 The Climate Change Act 2008 also provided for the National Adaptation Programme (NAP) and the Third Strategy for Climate Adaptation Reporting (2018-2023), to address climate change risks following each CCRA. It provides further action addressing priority risks identified in the UK CCRA 2017, outlining policies and objectives for adaptation such as increasing 'the resilience of energy infrastructure from all forms of flooding'.

2.4 National Planning Policy

2.4.1.1 The National Policy Statements for Energy Infrastructure (2011) are complementary documents which set out the objectives, policy and framework for nationally significant infrastructure developments related to energy.

2.4.1.2 The Overarching Energy National Policy Statement (NPS) EN-1 sets out the policies for UK energy infrastructure and advises that EIAs consider climate change including the impact of the Project on climate change and its resilience to future climate change risks.

2.4.1.3 NPS EN-1 is clear on the role of ERFs in future large-scale renewable energy generation, whilst the Government's Review of Waste Policy in England 2011 indicated an expected trebling of the contribution from ERF derived renewable electricity from thermal combustion, stating that:

> *"Our horizon scanning work up to 2020, and beyond to 2030 and 2050 indicates that even with the expected improvements in prevention, re-use and recycling, sufficient residual waste feedstock will be available through diversion from landfill to support significant growth in this area, without conflicting with the drive to move waste further up the hierarchy."*

2.4.1.4 Further to this, NPS EN-1 (part 4.6) outlines the clear preference for plants that provide combined heat and power (CHP):

> *'Utilisation of useful heat that displaces conventional heat generation from fossil fuel sources is to be encouraged where, as will often be the case, it is more efficient than the alternative electricity/heat generation mix. To encourage proper consideration of CHP, substantial additional positive weight should therefore be given by the IPC to applications incorporating CHP'*

2.4.1.5 The National Policy Statement for Renewable Energy Infrastructure (EN-3) sets out the policies for UK renewable energy infrastructure and outlines how the policies and objectives contained within NPS EN-3 are considered likely to have positive effects on the climate change objective and the transition to a low carbon economy.

2.4.1.6 NPS EN-3 demonstrates the role of ERFs in meeting the urgent need for energy infrastructure.

> *"The recovery of energy from the combustion of waste, where in accordance with the waste hierarchy, will play an increasingly important role in meeting the UK's energy needs. Where the waste burned is deemed renewable, this can also contribute to meeting the UK's renewable energy targets. Further, the recovery of energy from the combustion of waste forms an important element of waste management strategies in both England and Wales."*

2.4.1.7 NPS EN-3 outlines how the secretary of state (previously the Infrastructure Planning Commission) should assess GHG emissions.

> *"Although an ES on air emissions will include an assessment of CO_2 emissions, the policies set out in Section 2.2 of EN-1 will apply." [The secretary of state] "does not, therefore need to assess individual applications in terms of carbon emissions against carbon budgets and this section does not address CO_2*

> *emissions or any Emissions Performance Standard that may apply to plant."*

2.4.1.8 A Draft revision of these NPS were issued for consultation in September 2021 with the consultation period ending in November 2021. The guidance set out above from the current 2011 NPS remains valid.

2.4.1.9 The latest National Planning Policy Framework (NPPF) was published in 2021 and sets out the government's planning policies for England and how these are expected to be applied.

2.4.1.10 The NPPF is a relevant consideration in decisions on NSIPs, although in cases of any inconsistency, the NPS takes precedence.

2.4.1.11 The NPPF includes a chapter on meeting the challenge of climate change, flooding and coastal change and provides guidance on climate change allowances to be used in flood risk assessments as set out in the NPPF. This outlines how the planning system should plan for a changing climate and support a low carbon future transition. At paragraph 154 it states that new development should be planned for in ways that:

- avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure; and
- can help to reduce greenhouse gas emissions, such as through its location, orientation and design. Any local requirements for the sustainability of buildings should reflect the Government's policy for national technical standards.

2.4.1.12 The principles of the NPPF relevant to climate change are provided in Section 14 'Meeting the challenge of climate change, flooding and coastal change', which states:

> *'the planning system should support the transitions to a low carbon future in a changing climate… 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'.*

2.5 Local Planning Policy

2.5.1.1 In local policy terms, the Project lies entirely within the administrative district of North Lincolnshire Council (North Lincolnshire), which is a unitary authority.

2.5.1.2 The key local planning policy and guidance documents considered relevant to the Project are outlined in Chapter 2 of the ES (**Document Reference 6.2.2**).

2.5.1.3 The North Lincolnshire Council Local Plan (2003), Saved Policies (2007) and North Lincolnshire Core Strategy (2011) Policies include the following policies related to climate change and relevant to the Project:

- Policy DS21: Renewable energy: Supports proposals for the generation of energy from renewable resources where any detrimental impacts are outweighed by environmental benefits and proposals include details of associated developments.
- Policy CS18: Promotes development that utilises natural resources as efficiently and sustainably as possible.

2.5.1.4 The forthcoming North Lincolnshire Local Plan went through Regulation 19 consultation in October 2021. It sets out the long-term plan for local area development over a 10 to15-year period. The Local Plan sets out the visions and objectives for the future development, addressing needs and opportunities including those in relation to infrastructure. The Local Plan (once adopted) will remain in place until 2036.

2.5.1.5 The following policies are among those related to climate change:

- Policy SS3: Development Principles: Minimise the impacts arising from climate change and mitigate against its effect, including, reducing flood risk.
- Policy DQE7: Climate Change & Low Carbon Living specifies how developments should facilitate climate change and low carbon living, including stating that proposals for ‘Large-scale schemes that would generate a significant source or demand for heat should be supported by evidence considering the feasibility of serving the development by means of a district heating system’.

2.6 Guidance

2.6.1.1 The EIA Guide to Climate Change Resilience and Adaptation (IEMA, 2020) provides best practice guidance for considering climate change resilience and adaptation in EIA. Furthermore, the EIA Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA, 2017) provides further guidance to practitioners assessing GHG emissions on climate change. This assessment follows the GHG emissions assessment methodology outlined in the guidance. However, this assessment does not follow guidance on for assessing the significance of GHG emissions provided in the IEMA guidance as this is incompatible with the Climate Change Act (see 5.2.1.1).

2.6.1.2 In 2014, Defra produced Energy from Waste – A Guide to the debate (DEFRA, 2014) (‘the Guide’). It sets out the environmental case for EFRs versus other waste destinations such as landfill and gives an insightful overview of the key issues relating to energy recovery and the planning and development of ERFs. This assessment draws on the method outlined in the Guide to compare GHG emissions from wastes managed in the ERF to disposal to landfill.

2.7 Industry net zero strategy

2.7.1.1 The Environmental Services Association (ESA) is the trade body representing approximately 85% of the UK's resource and waste management companies, including all major companies. In June 2021 the ESA released A net-zero greenhouse gas emissions strategy for the UK recycling and waste sector (ESA, 2021). The strategy outlines how the UK recycling and waste sector will develop to meet the UK national net zero targets for 2050. The strategy outlines four priority actions to reduce emission from ERFs:

- develop effective methods of diverting increasing volumes of fossil-based materials (e.g. plastics and textiles) from input waste to ERFs. This will be achieved by increased upstream recycling (e.g., increasing participation and segregation via kerbside or commercial recycling collection systems) and effective 'end-of-pipe' solutions to remove recyclable fossil-based materials;
- maximise and better quantify the operational efficiency and heat offtake from ERFs, and collaborate with available stakeholder groups to ensure the deployment of ERF heat;
- maximise the recycling of residues (i.e. Incinerator Bottom Ash (IBA), Air Pollution Control residues (APCr) and metals) from the ERF process; and
- deploy carbon abatement technologies, CCUS.

3. CONSULTATION

3.1.1.1 Table 1 and Table 2 below respectively present excerpts from the scoping opinion received from the Planning Inspectorate and consultation responses on the PEIR specific to the Climate Change and Greenhouse Gas assessment. The tables describe how each response has been addressed, and, as appropriate where more information can be found in the ES.

Table 1: Scoping Consultation Responses

PINS ID	Issue	Inspectorate's comments	Response / Action	Reference within this document
Table 5-2	Proposed to be scoped out: Climate Change Risk Assessment	"The Inspectorate notes that the Applicant does not intend to provide a separate Climate Change Risk Assessment, as impacts on the Climate will be considered in a greenhouse gas (GHG) assessment and the effects of climate change on flooding will be included in the site-specific flood risk assessment. The Inspectorate agrees that a standalone Climate Change Risk Assessment can be excluded from the ES, provided that an assessment of the likely significant effects on climate arising from the Project and the vulnerability of the Project to climate change is clearly described and identified in the relevant aspect chapters of the ES."	Climate change risk impacts are addressed within Chapter 16– Major Accidents and Disasters (**Document Reference 6.2.16**), and in the site-specific flood risk assessment presented in Annex 3 (**Document Reference 6.3.3**)	Chapter 16 (**Document Reference 6.2.16**) and ES Annex 3 **(Document Reference 6.3.3)**
7.7	Proposed to be scoped out: GHGA	The Scoping Report states that the GHGA will include assessment of direct emissions as a result of the Project and emissions associated with purchased electricity/ steam/ heat/ cooling. However, the following activities are proposed to be scoped out of the GHG assessment: ■ The heat and power distribution connection because there are expected to be minimal operational emissions associated with this, except for maintenance activities which are not expected to occur annually; ■ Shipping because the fuel used by vessels and therefore the associated GHG are not under the operational control of the Project;	Based on this consultation response, we have re-scoped all elements of the Project based on the IEMA guidance. All construction and decommissioning GHG emissions have been excluded. The following operational elements have been included; -waste transport, ERF with electricity and heat distribution, CO_2 capture,	Section 5

PINS ID	Issue	Inspectorate's comments	Response / Action	Reference within this document
		■ Use of rail spur due to the minor emissions expected as a result of these activities in comparison to other modes of transport; and ■ All activities associated with the construction phase because construction represents a relatively small proportion of total emissions during the life cycle of an ERF, which are largely associated with the operational phase. The ES should quantify the GHG emissions relating to the Project. The calculation methods used should be explained. The ES should state any assumptions made in calculating the predicted GHG emissions, any limitations to the calculations and any uncertainties this presents for the assessment of GHG emissions.	ash treatment and concrete block manufacturing, and plastic recycling facility. The following operational elements have been excluded; H_2 production and distribution and battery storage (see Table 4 for details).	
7.3	GHG emissions	There are a number of gases that are considered Greenhouse Gas (GHG). The Scoping Report does not define which GHG emissions will be assessed in the ES Chapter. The ES should assess GHGs where they are likely to cause significant effects and these should be named in the ES to understand the extent of the assessment.	Emissions of CO_2, methane and N_2O are the primary GHGs assessed.	Section 5
N/A	Cross-referencing	Impacts from the Flood Risk and Drainage, Ecology and Transport Chapters have potential to overlap with impacts identified in the Climate Change Chapter. It should be clear within the ES how the outcomes of any related assessments have informed the Chapter assessment and appropriate cross-referencing should be made to other relevant aspect Chapters explaining where potential impacts are assessed.	Where potential for overlap is identified with other technical topics, cross-references to those other applicable Chapters will be included in those Chapters.	N/A
7.2	Guidance	Where relevant, the ES should take into account the following guidance: ■ IEMA (2017) Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance, ■ IEMA (2020) Environmental Impact Assessment Guide to:	The assessment has been completed taking into account the IEMA (2017) and IEMA (2020) guidance.	Section 5

PINS ID	Issue	Inspectorate's comments	Response / Action	Reference within this document
		Climate Change Resilience and Adaptation.		
N/A	Assumptions, limitations and constraints	The ES should state any assumptions made in calculating the predicted GHG emission; any limitations to the calculations; and any uncertainties this presents for the assessment of GHG emissions.	Details of all exclusions and assumptions are provided. Uncertainties are assessed using sensitivity analysis	Section 5 and Section 8
N/A	Climate/ GHG assessment	The climate/ GHG assessment should cover all components of the Project.	All components of the Project have been considered within the method provided in IEMA 2017 and scoped in or out accordingly.	Section 5 (Table 4)

3.1.1.2 Table 2 presents excerpts from the consultation responses on the PEIR specific to the climate and greenhouse gasses assessment. The table describes how each response has been or will be addressed by the Project, and, as appropriate where more information can be found in the ES.

Table 2: Pre-application Consultation Responses

Consultee Type	Consultee	Comments	Response / Action	Reference within this document
S42(a)	Forestry Commission	The Forestry Commission would strongly encourage the applicant to consider climate change when developing their proposed development. The predicted changes in temperature along with introduced plant pests and diseases mean that we there is a need to create and manage woodlands that are more resilient to these threats. Woodland adaption for resilience can be achieved through: ■ Planting a wider range of tree species ■ Using seed from a wider range of origins and provenances, including planting native trees outside their natural range. ■ Encouraging natural regeneration where it is likely to be successful, to encourage evolutionary adaptation and as the climate changes. Protecting from damaging animals.	We recognise the importance of ensuring that the Project's planting is resilient to climate change. We have held further discussions with North Lincolnshire Council and North Lincolnshire Wildlife Trust to inform landscaping designs and species lists, with up to 20% of trees comprising native species outside their natural range.	N / A

Consultee Type	Consultee	Comments	Response / Action	Reference within this document
S47	Local Community	Incinerator for household waste is not really a green energy project as stated.	The Project meets the R1 energy efficiency criteria set out in the Waste Framework Directive 2008/98/C (WFD) to qualify as an energy recovery operation and is therefore an ERF rather than an incinerator. NLGEP combines technologies to capture, store and use by-products from the energy recovery process. We have assessed impacts on climate change - how 'green' the Project is - in Chapter 6: Climate of the ES (**Document Reference 6.2.6)**. Compared to the alternative of managing waste through landfill, we expect operation of the Project to result in an overall reduction in the release of the greenhouse gases which contribute to climate change.	N / A
S47	Local Community	I am writing to voice my concerns about the plans for the proposed 'Energy Park.' In 2019 the UK Parliament was the first in the world to declare a climate emergency and signed into law a commitment to become net zero by 2050. To achieve this pledge, decisive action must be taken to reduce carbon emissions and protect people from the effects of climate change. I am concerned that by building an incinerator so close to residential and commercial properties, we are taking a step in the opposite direction. Incinerators have long lifespans of approximately 30-50 years, meaning that any new construction is locking us into a carbon intensive method of waste disposal for years to come.	The Project meets the R1 energy efficiency criteria set out in the Waste Framework Directive 2008/98/C (WFD) to qualify as an energy recovery operation and is therefore an ERF rather than an incinerator. The Project will make a positive contribution to the UK's commitment to reaching net zero carbon emissions by 2050. Compared to the alternative of managing waste through landfill, we expect that it will result in an overall reduction in the	N / A

Consultee Type	Consultee	Comments	Response / Action	Reference within this document
			release of the greenhouse gases which contribute to climate change. We have also included Carbon Capture, Storage and Utilisation as part of the proposals for the Project. This helps to reduce the CO_2 emissions from the ERF by capturing carbon so it can be used in the manufacture of concrete blocks on site. Further information on our assessment of the Project's impact on climate change is set out in Chapter 6: Climate of the ES (**Document Reference 6.2.6**).	
S47	Local Community	There's nothing 'green' about transporting and burning thousands of tonnes of rubbish every year.	The Project combines technologies to capture, store and use by-products from the energy recovery process. We have assessed impacts on climate change - how 'green' the Project is - in Chapter 6: Climate in the ES (**Document Reference 6.2.6**). Compared to the alternative of managing waste through landfill, we expect operation of NLGEP to result in an overall reduction in the release of the greenhouse gases which contribute to climate change. In addition, with regards to transport, the Project seeks to "maximise sustainable methods and approaches" as set out in the Design Principles and Codes document	N / A

Consultee Type	Consultee	Comments	Response / Action	Reference within this document
			(**Document Reference 5.12**). One of the reasons that the site was chosen was because it has the potential for transport by river and rail. We will reduce road movements as much as possible by providing a new rail link and using the existing port. Indeed, rail transport has a crucial role to play in delivering significant reductions in pollution and congestion. Tonne for tonne, rail freight produces 70% less CO_2 than road freight, up to fifteen times lower NOx emissions and nearly 90% lower PM10 emissions. It also has de-congestion benefits – depending on its load, each freight train can remove between 43 and 77 HGVs from the road.	
S47	Local Community	Have you taken into account the CO_2 generated by incineration of waste in order to produce H_2 by electrolysis and also the amount of CO_2 produced by waste.	The RDF will not be burned for the purpose of producing H_2 by electrolysis. The inclusion of H_2 production and storage in the Project increases energy storage capacity for the UK. This provides opportunities to maximise the benefits of renewable electricity generation as electricity can be stored at time of high renewable generation and low demand, when low carbon electricity might otherwise be wasted. We have considered	N / A

Consultee Type	Consultee	Comments	Response / Action	Reference within this document
			carbon emissions from the Project in Chapter 6: Climate of the ES (**Document Reference 6.2.6**). Compared to the alternative of managing waste through landfill, we expect the operation of the Project to result in an overall reduction in the release of the greenhouse gases which contribute to climate change.	

4. ASSESSMENT PARAMETERS

4.1.1.1 A detailed description of all elements of the Project is provided in Chapter 3 – The Project Description and Alternatives (**Document Reference 6.2.3**).

4.1.1.2 All components of the Project are considered in the GHG assessment process.

4.1.1.3 The Project will include;

- an ERF including;
  - switchyard;
  - a water treatment facility;
- a carbon dioxide (CO_2) capture, utilisation and storage (CCUS) facility;
- a bottom ash and flue gas residue handling and treatment facility (RHTF);
- a concrete block manufacturing facility (CBMF);
- a plastic recycling facility (PRF);
- an electric vehicle (EV) and hydrogen (H_2) re-fuelling station;
- H_2 and natural gas above ground installation (AGI);
- H_2 production and storage facility;
- battery storage;
- hydrogen and natural gas above ground installations (AGI);
- railway reinstatement works including, sidings at Dragonby, reinstatement and safety improvements to the 6km private railway spur, and the construction of a new railhead with sidings south of Flixborough Wharf;
- a new access road and parking;
- a gatehouse and visitor centre with elevated walkway;
- a northern and southern district heating and private wire network (DHPWN);
- an electrical grid connection, and lighting and utilities;
- new public rights of way and cycle ways including footbridges; and
- Sustainable drainage system and flood defences.

4.1.1.4 However, in line with the IEMA guidance, components and life cycle stages which will not have a significant impact on the total GHG emissions from the Project have been excluded (see Section 5.3.3).

4.1.1.5 Based on an initial screening assessment, GHG emissions from construction and decommissioning were identified to be not significant compared with operational GHG emissions and are therefore excluded from the assessment (see Section 5.3.3.3).

5. ASSESSMENT METHOD AND SIGNIFICANCE CRITERIA

5.1 Overview

5.1.1.1 The method for the GHG assessment is in line with the IEMA GHG assessment guidance document (IEMA 2017). This sets out the following process steps for the calculation:

- define scope and study boundaries;
- data collection;
- calculate GHG emissions; and
- sensitivity analysis to assess uncertainties.

5.1.1.2 Furthermore, the assessment of GHG emissions from the management and disposal of wastes is consistent with the modelling framework proposed by Defra in the report Energy recovery for residual waste: a carbon-based modelling approach WR1910 (2014). This outlines methods for comparing GHG emissions from the treatment of waste in an ERF to the counterfactual of disposal to landfill and supply of energy from alternative sources.

5.2 Significance Criteria

5.2.1.1 There are no established thresholds for defining the significance of climate impacts in EIA resulting from GHG emissions of different magnitudes. The IEMA guidance states that "in the absence of any significance criteria or a defined threshold, it might be considered that all GHG emissions are significant and an EIA should ensure the project addresses their occurrence by taking mitigating action" and assessors should seek to contextualise GHG emissions, for example "against sectoral, local or national carbon budgets". However, The Climate Change Act 2008 does not impose any legal duties to require particular geographical areas within the UK to achieve particular reductions in carbon emissions by particular dates or any sector of the economy, including the energy sector, to achieve any particular target for carbon reductions. There is no NPS or development policy provision that provides such targets, either. Therefore, in the absence of a baseline against which the likely significance of GHG emissions from the ERF could be assessed at a local or regional level, the approach taken in this assessment is to contextualise the predicted operational GHG emissions against predictions of alternative residual waste management and marginal electricity generation Therefore, no significance threshold has been set for the Project and the significance of effects on climate is considered subjectively.

5.3 Scope and study boundaries

Greenhouse gases and global warming potentials

5.3.1.1 The GHG emissions most likely to have significant effects are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The emissions of these greenhouse gases are the primary focus of this assessment. There are a wide range of other greenhouse gases, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). Other GHGs are only included in the assessment where they represent a significant part of the total GHG emissions for emission factors from secondary sources for materials and energy produced off-site.

5.3.1.2 The global warming potentials (GWP) of the main GHG considered in the assessment are shown in Table 2 below.

Table 2: Global warming potentials of key greenhouse gases assessed

Greenhouse gas	Global warming potential ($kgCO_2e$ / kg)	Source
CO_2 (fossil carbon)	1	IPCC 5th assessment (2013)
CO_2 (biogenic carbon)	0	
CH_4	28	
N_2O	265	

5.3.1.3 Fossil carbon dioxide refers to CO_2 produced from carbon which has come from long term terrestrial storage, such as fossil fuels. The combustion of these resources leads to a release that results in a net increase in CO_2 to the atmosphere. The carbon physically stored in biomass is known as biogenic carbon. Under the IPCCs guidelines and the methods promoted by the Greenhouse Gas Protocol, emissions of biogenic CO_2 are typically excluded from, or reported separately in, carbon accounting. This choice is made on the basis that these removals of carbon from, and emissions to, the atmosphere are on such a short timeframe that the net impact is effectively zero.

5.3.1.4 However, emissions of methane containing biogenic carbon, for example, if wood were to be sent to landfill, degrade anaerobically and the subsequent methane emissions were not prevented from escaping to the atmosphere, are still required to be included in carbon accounting. This is because the carbon molecule released into the atmosphere is in the form of a much more powerful GHG (i.e. methane) than the CO_2 that was captured. (i.e. 28 times as potent). Thus, the balance in terms of GWP is not neutral.

5.3.2 Baseline

5.3.2.1 The IEMA guidance states the GHG assessment should consider:

- a baseline which considers current GHG emissions from the physical boundary; and
- alternative baseline / counterfactual associated with future operational emissions.

5.3.2.2 There are no direct baseline GHG emissions data from the Project to review, as GHG emissions prior to the Project are considered to be zero. However, by creating new waste management capacity, the Project will influence future management of waste streams in the UK and the balance of UK energy production. Therefore, for the alternative baseline, which presents the counterfactual to the Project, GHG emissions of waste management and energy supply beyond the physical boundary of the Project are considered.

5.3.2.3 Millions of tonnes of residual waste annually are landfilled in the UK (Defra 2021). Although the commercial contracts for the Project, and therefore the exact source(s) of waste, are not yet confirmed, it is reasonable to assume that the Project will contribute to the national capacity of energy recovery facilities and reduce the need for landfill.

5.3.2.4 Landfills that have gas capture and power generation still emit a significant quantity of methane, which is a potent GHG. These emissions can be significantly reduced by diverting waste away from landfill. Therefore, the alternative baseline for the GHG assessment will calculate GHG emissions for a baseline scenario in which waste would otherwise be sent to landfill and compare this to the scenarios for GHG emissions from the Project.

5.3.2.5 The Project will generate electricity and heat which can be exported to the national grid and local users. Under the alternative baseline, this energy would otherwise need to be produced by other means, such as a natural gas fired power station, with associated GHG emissions (see Section 5.3.3.8).

5.3.2.6 Materials such as metals and aggregates, will also be recovered from the Project that would otherwise be sent to landfill. Under the alternative baseline these materials would otherwise need to be extracted through mining with the associated GHG emissions.

5.3.2.7 The Project will also accept source segregated plastic waste at the plastic processing facility for recycling, that would likely otherwise be exported for recycling due to a lack of plastic recycling plastic capacity in the UK. Under an alternative baseline scenario without the Project, it is assumed that the source segregated plastic would be recycled in a similar facility to the Project but in a different country.

5.3.3 Study boundaries

5.3.3.1 The IEMA GHG guidance outlines four life cycle stages which should be considered as part of the GHG assessment, summarised in Table 3 below.

Table 3: GHG assessment lifecycle stages

Lifecycle stage	Description
Before use (construction)	■ Direct GHG emissions from on-site construction activities (e.g. combustion of fuel); ■ Indirect GHG emissions from the production and transport of materials and electricity used during construction; and ■ GHG emissions from the transport and disposal of wastes.
Operation / use	■ Direct GHG emissions from on-site operational activities; ■ Indirect GHG emissions from the production and transport of materials and electricity used during operation/use; ■ GHG emissions from the transport and disposal of wastes.
End of life (decommissioning)	■ Direct GHG emissions from on-site decommissioning activities (e.g. combustion of fuel), ■ Indirect GHG emissions from the production and transport of materials and electricity used during decommissioning ■ GHG emissions from the transport and disposal of wastes.
Beyond asset life cycle	■ Benefits and impacts beyond the system boundary including; avoided GHG emissions from recovered energy/materials which displace alternative production.

5.3.3.2 For this assessment, the construction and decommissioning stages have been scoped out from a detailed quantitative assessment (see Section 4.1.1.5).

5.3.3.3 The construction stage of the Project has been scoped out through high-level screening calculations undertaken using values taken from published literature for the construction of similar facilities, scaled based on the area/length or operational capacity of the facility. This screening step indicated that GHG emissions for construction are not significant compared to the operational GHG emissions (<2% of direct operational CO_2 emissions from the ERF over a 25-35-year lifetime) and so no further calculations have been undertaken.

5.3.3.4 Based on this, the decommissioning life cycle stage has also been excluded. There is little certainty surrounding the timing of this activity and the processes and emissions-generating activity which will occur. Decommissioning activities are similar to construction, therefore it is assumed that these emissions will be of the same order or smaller than those for the construction stage and therefore it is not considered likely that they will be significant.

5.3.3.5 A detailed quantitative assessment of the GHG emissions from the operation of the Project has been undertaken, reflecting their overwhelming contribution to the overall total life cycle emissions. Full details of GHG emissions included and excluded from the assessment of the operation stage are shown in Table 4, together with details of further assumptions.

5.3.3.6 The principal direct GHG emissions from the operation of the Project will be from the combustion of waste in the ERF. Waste management technologies can both release GHGs, and prevent their release, through the recovery of materials and energy. This recovery avoids the emission of GHGs that would occur associated with the use of alternative sources of materials and energy, in the absence of recovery, which occur outside of the system boundary.

Avoided GHG emissions from electricity and heat generation

5.3.3.7 Electricity and heat produced by the ERF displace the need for production by other means, such as combustion of natural gas, and so a net benefit for the Project, as negative GHG emissions, is applied.

5.3.3.8 Electricity generated by the ERF will be exported to the national grid or used by other facilities within the Project, including the PRF, H_2 production facility and other businesses in the local area. This assessment assumes that in the absence of the ERF, capacity for the production of this electricity would otherwise be met by a gas-fired power station. This is in line with the Guide which states

> *"A gas fired power station (Combined Cycle Gas Turbine CCGT) is a reasonable comparator as this is the most likely technology if you wanted to build a new power station today".*

5.3.3.9 As the UK completes the phasing out of producing electricity from coal, CCGT will continue to be a significant contributor to the UK grid electricity fuel mix. Construction of the ERF will not impact decisions relating to the development of renewables such as solar and wind, given the GHG emission reduction targets which have been set by the UK. Given the intermittency of solar and wind power, alternative generation methods which can respond to demand, such as CCGT and ERFs, are likely to be required for some time yet.

5.3.3.10 For heat generation, the predominant fuel source within the UK, both domestically and industrially, is natural gas. Therefore, heat produced by the ERF is assumed to displace heat produced from natural gas in an industrial heating system.

Avoided GHG emissions from recovery of materials from bottom ash and FGTr

5.3.3.11 Bottom ash and flue gas treatment residues including flue gas condensate residues (FGTr) from the ERF will be treated in a dedicated recovery facility. This facility will be attached to the ERF for the recovery of materials including aggregates, ferrous and non-ferrous metals from bottom ash, which displaces the need to produce virgin materials.

5.3.3.12 As part of the FGT recovery process, CO_2 will be reacted with the FGTr, such that the CO_2 is mineralised with the FGTr to form a manufactured limestone that can be used as an aggregate. This process is a carbon capture, utilisation and storage (CCUS) process, with CO_2 permanently captured as stable carbonates. This captured CO_2 is included in the assessment as stored carbon, which avoids the release of CO_2 into the atmosphere.

5.3.3.13 Recovered aggregates and bottom ash will be converted into concrete blocks at the site. There is uncertainty as to the exact specification of the concrete blocks produced and therefore also uncertainty as to the GHG emissions displaced by avoided production of conventional concrete blocks. Therefore, average values for concrete production have been used to represent the production of virgin concrete blocks.

Carbon capture, utilisation and storage (CCUS)

5.3.3.14 CO_2 will be captured from flue gas using an amine stripping process, with all electricity and heat energy requirements supplied by the ERF. Captured CO_2 will either be used in the carbonation process to produce aggregates used in concrete block production for long term storage of the carbon, as outlined above, or compressed/exported for utilisation off-site in industry. Where CO_2 is used in a gaseous form in industry (e.g. to boost growth of greenhouse crops), the CO_2 will be returned to the atmosphere over a short timeframe (e.g. when the crops are consumed and decompose), with the associated contribution to GHGs in the atmosphere. While this does not represent long term storage, it will displace CO_2 currently produced or recovered by other means, such as the combustion of natural gas. CO_2 recovered from the ERF is a combination of biogenic and fossil carbon, so where this displaces CO_2 produced from fossil sources, there is a net reduction in GHG emissions, as some CO_2 from fossil carbon sources is displaced by CO_2 from biogenic carbon.

Avoided GHG emissions and carbon storage in landfill

5.3.3.15 When waste is sent to the ERF, this avoids the need to send waste to landfill. Therefore, the GHG assessment will calculate GHG emissions for a baseline scenario in which waste would otherwise be sent to landfill and compare this to the GHG emissions for the operation of the Project, to calculate the net benefit.

5.3.3.16 In landfill, methane emissions from the anaerobic degradation of primarily biogenic wastes, represent a significant source of GHG emissions. Landfills that have gas capture and power generation still emit a significant quantity of methane, which far outweighs the avoided GHG emissions from energy produced from captured methane.

5.3.3.17 However, within landfills, wastes containing fossil carbon, typically in the form of plastics, are stored in the medium to long term, and there is no contribution to GHG emissions. Biogenic carbon can also be stored, if the carbon-containing compounds are resistant to the processes of decomposition that take place in the landfill. In this case, there is a net reduction in the GHG balance (i.e. a benefit), since carbon that was recently in the atmosphere has been fixed by plants, and then sequestered in the landfill. It should be noted that carbon will be emitted at some point in the future, but whether this is in hundreds/thousands of years or much sooner (for example if the site is excavated for development or if there is a fire within the landfill), is uncertain and is not considered further in the assessment. There is also uncertainty as to the proportion of biogenic carbon that will decompose in landfill. Therefore, the assumptions used in this assessment provide a conservative assessment of the GHG emissions from landfill.

Table 4: Scope of GHG assessment

Scenario / Project element	Included in scope	Excluded from scope	Assumptions
Alternative baseline (Landfill)			
Waste transport	■ Production and combustion of fuels to transport waste.	■ Transfer station operations and temporary storage of waste.	■ All waste is transported by road (a worst case).
Landfill	■ Non-CO_2 GHG emissions (i.e. methane) from degradation of biogenic carbon. ■ Benefit for avoided GHG emissions from electricity generation. ■ Long term storage of biogenic carbon in landfill.	■ CO_2 emissions from degradation of biogenic wastes. ■ Operational material and water inputs. ■ Fuel use for site vehicles. ■ Production of RDF.	■ All degradable biogenic carbon is converted to landfill gas. ■ Long-term storage of remaining biogenic carbon in landfill is greater than 100 years. ■ Waste composition is the same as RDF used in ERF.
Plastic production facility	■ Production and combustion of fuels to transport plastic. ■	■	■ Currently significant quantities of source-segregated plastic collected in the UK are exported for recycling, as there is insufficient capacity within the UK to recycle all domestically collected plastics. Therefore, GHG emissions from the export segregated plastics is included in the assessment. Currently, key export destinations include Turkey, Malaysia and Poland (Greenpeace, 2021). In June 2021 Turkey banned imports of HDPE and LDPE but continues to allow the import of PET plastics. ■ However, it is not possible accurately to assess the plastic recycling technology that will be displaced in the future. Therefore, it is assumed that source-segregated plastics are

Scenario / Project element	Included in scope	Excluded from scope	Assumptions
			recycled using the same or a similar process, energy requirements and recovery efficiency as the Project scenario. Therefore, only GHG emissions representing the difference between the scenarios have been assessed. ■ Grid electricity and heat generated from natural gas are assumed to be used in the alternative baseline scenario using a projected average electricity grid carbon intensity for OECD[1] countries for 2040 (EIA, 2021). The OECD average is used to represent the country in which the plastic recycling will take place, as this is unknown. ■ Rejects are assumed to be sent to an ERF with the same functional characteristics as the Project scenario. ■ GHG emissions for displacement of virgin materials are assumed to be the same as the Project scenario. The tonnage proposed for the PRF is limited to 25,000 tonnes per annum.
Project			
Waste transport	■ Production and combustion of fuels to transport waste.	■ Transfer station operations and temporary storage of waste.	■ Waste is transported by road to transfer stations. ■

[1] Organisation for Economic Co-operation and Development

Scenario / Project element	Included in scope	Excluded from scope	Assumptions
ERF[2]	■ CO_2 emissions from combustion of fossil carbon in RDF. ■ N_2O emissions from combustion of RDF. ■ Production and use of fuels for start-up, shut down and combustion support. ■ Production and transport of material inputs for Selective Catalytic Reduction ■ (SCR) (i.e. ammonia, hydrated lime and activated carbon). ■ Benefit from avoided GHG emissions from electricity generation supplied to the grid and other local users. ■ Benefit from avoided GHG emissions from heat generation supplied to local users (e.g. PRF).	■ Production of RDF ■ CO_2 emissions from biogenic wastes. ■ Methane emissions from storage and combustion of RDF. ■ Other operational material and water inputs. ■ Production of consumable material inputs for SCR (e.g. lime and ammonia) ■ Fuel use for site vehicles ■	■ RDF would otherwise be sent to landfill. ■ Bottom ash and FGTr are 1% carbon. The remainder of carbon in RDF is converted to CO_2 during combustion. ■ Natural gas and small amounts of grid electricity are used during start up. ■ No grid electricity will be used at the ERF. ■ Waste composition is the same as assumed for alternative baseline. ■ Heat will be used within the ERF for SCR and carbon capture and will be exported off-site for uses which may include future housing development, business park and hospital, and use in the plastics recycling facility.
IBA treatment	■ Benefit of avoided GHG emissions from ferrous metal and non-ferrous metal recovery	■ Other operational material and water inputs. ■ Fuel use for site vehicles.	■ Electricity and heat required for process is supplied from ERF. ■ All recovered aggregates are used to produce concrete blocks.
FGTr treatment	■ Production and transport of cement and filler materials used in the process ■ Mineralisation of CO_2 in aggregates	■ Other operational materials and water inputs. ■ Fuel use for site vehicles.	■ Electricity and heat required for process is supplied from ERF. ■ CO_2 for mineralisation is supplied from the on-site carbon capture plant and is considered to be stored long term. ■ All recovered aggregates are used to produce concrete blocks.

2 Includes wastewater treatment plant, waste / RDF feedstock storage and offices / utilities and stream storage

Scenario / Project element	Included in scope	Excluded from scope	Assumptions
Concrete block manufacture	■ Production and transport of cement and sand used in the process.	■ Other operational material and water inputs.	■ Aggregates produced from recovered ash used to make the concrete blocks. ■ Exact specifications of concrete blocks are not yet determined and so a UK average value for concrete production is used to calculate avoided emissions. ■ Electricity and heat required for process supplied from ERF.
Carbon dioxide capture utilisation	■ Production of amine solution used and not recovered for reuse in amine stripping process. ■ Avoided GHG emissions from storage of carbon in concrete block. ■ Avoided GHG emissions from utilisation of captured CO_2 in place of CO_2 from 100% fossil sources. ■ Transport of captured CO_2.	■ Other operational materials and water inputs. ■ Fuel use for site vehicles.	■ Electricity and heat required for carbon capture process is supplied from ERF. ■ CO_2 mineralised in concrete blocks is assumed to be long term storage (>100 years). ■ All CO_2 other than CO_2 used in mineralisation will be utilised in horticulture or other industrial processes and will displace CO_2 from fossil sources (e.g. natural gas). ■ There is a net benefit for carbon utilised in horticulture through the displacement of fossil CO_2 by the proportion of CO_2 from biogenic carbon within the waste combusted in the ERF. This is equal to the proportion of total carbon from biogenic sources in the RDF for each tonne of CO_2 utilised. ■ GHG emissions from the production and use of materials and energy required per tonne of CO_2 captured via alternative

Scenario / Project element	Included in scope	Excluded from scope	Assumptions
			means are also assumed to be avoided. ■ All the utilised CO_2 is ultimately released into the atmosphere. Given the final utilisation of captured CO_2 is uncertain at this stage, a very conservative estimate for the release of captured CO_2 within a short timeframe (< 2 years) has been applied.
PRF	■ Production and combustion of fuels to transport plastic. ■ Recycling of plastic outside the UK.	■ Recovery of metals from the input plastics is excluded. ■ Energy recovery from combustion of rejects.	■ Electricity and heat requirements for PRF will be met by the ERF. ■ It is assumed that source-segregated plastics are recycled using the same or a similar process, energy requirements and recovery efficiency as in the alternative baseline scenario. ■ Only GHG emissions relating to the difference between the scenarios have been assessed. Therefore: ■ GHG emissions for the displacement of virgin materials are assumed to be the same as for the alternative baseline scenario. ■ Rejects are sent to the ERF and have the same impact as in the alternative baseline scenario.
H_2 production for transport fuels			■ H_2 production has been excluded as related emissions will be relatively small (<1%) compared to the direct emissions from the ERF.

Scenario / Project element	Included in scope	Excluded from scope	Assumptions
			■ H_2 produced will primarily be used as fuel for buses, to displace diesel fuel. Recent work by the Zemo partnership (a UK government backed initiative) into the relative impacts from H_2 and diesel as a transport fuel shows reduced GHG emissions per km travelled when H_2, produced from by electrolysis using UK grid electricity in 2020 or 2030, is used in place of diesel (Zemo 2021). ■ The Project will be able to use grid electricity to produce H_2 and can also provide opportunities to maximise the benefits of renewable electricity generation as electricity can be stored at times of high renewable electricity generation and low electricity demand, when low carbon electricity might otherwise be wasted.
H_2 production for energy storage			■ H_2 production at the site is principally a form of energy storage which may use electricity produced by the ERF or grid electricity, depending on the energy market and storage requirements, as outlined above. ■ It is assumed that, where electricity requirements are met from ERF, this will displace electricity generated by CCGT.

5.4 Data collection

5.4.1.1 The following sections outline the data used to calculate the GHG emissions for the Project scenario (the operational phase of the Project) and the alternative baseline scenario (waste disposed to landfill).

5.4.2 Refuse Derived Fuel (RDF) composition

5.4.2.1 A key factor in determining the GHG emissions from the treatment and disposal of waste is the composition of the waste. It is planned for the ERF to accept RDF produced from mixed residual waste, after mechanical separation and the removal of recyclable materials or any other similar waste streams. However, the composition of waste varies from day to day over the year. Therefore, a characteristic average composition has been used (see Table 5) to represent the composition of RDF for the proposed ERF.

5.4.2.2 The source of the waste to produce the RDF has not yet been confirmed and it is very likely that the composition of waste will change over the next 10 – 20 years during the operation of the ERF. Therefore, a projected composition, based on current waste compositions and key policy interventions is used, rather than data from the limited available samples of current RDF.

5.4.2.3 Whilst a significant proportion of the source waste is likely to be mixed residual municipal waste, it is also very likely that other residual commercial and industrial waste will also be a large component of the source waste, as a significant proportion of residual waste is already committed to other treatment and disposal schemes. Therefore, in this assessment 50% of the source waste is assumed to be residual commercial and industrial waste and 50% residual municipal waste.

5.4.2.4 There are waste, environmental and sustainability policies in place that aim to increase recycling rates for both municipal and commercial/industrial wastes. A key area for change is the replacement of fossil-based single use plastic materials with alternatives which can be more easily recycled or are made of biogenic materials, such as paper, card or bioplastics. In the UK, the ESA has committed to reducing the amount of plastic waste reporting to ERFs as a priority action in its net zero strategy (ESA 2021), whilst the British Plastics Federation has developed a roadmap (BPF 2021) for reducing plastics waste combusted. Under this roadmap, by 2030, compared to a 2020 baseline, the amount of plastics disposed as residual waste is projected to decrease by approximately 50% and the amount of plastics sent to ERFs is projected to decrease by approximately 35%.

5.4.2.5 In addition to the potential substitution of fossil-based plastics with biodegradable materials such as paper and card, the amount of non-recyclable biodegradable waste present in RDF is likely to increase as this material is diverted from landfill. The Waste Strategy for England 2018 (Defra 2018) present strategies that envisage no biodegradable waste being be sent to landfill by 2030. In 2021 the UK Net Zero Strategy set an objective of eliminating almost all biodegradable wastes from landfill by 2028 and have provided resources to implement free separate food waste collections for all households from 2025.

5.4.2.6 RDF is produced in a mechanical biological treatment (MBT) plant. There can be substantial variation in the composition of the waste used to produce RDF and the MBT processes employed. Therefore, for the purposes of this assessment, the composition for RDF has been estimated within constraints of engineering design assumptions for the net calorific values of the RDF received and the amounts of ferrous and non-ferrous metal recovered.

5.4.2.7 The RDF composition is used to establish the following key parameters for the assessment of the GHG emissions from the ERF and landfill:

- carbon content of RDF (% of total waste by weight);
- percentage of carbon which is biogenic carbon (as % of total C);
- degradable decomposable organic content (DDOC) (as % of biogenic C), which is the percentage of biogenic carbon which will degrade anaerobically in landfill;
- net calorific value (NCV) of the waste (MJ/kg); and
- total tonnage of RDF treated.

5.4.2.8 A single RDF composition has been selected for the assessment. To assess the potential variability in the results, due to differences in the RDF composition, a sensitivity analysis has been undertaken.

5.4.2.9 Literature data for the percentage change in the composition of mixed residual waste have been used to convert an equal mix of an average residual municipal waste composition for the UK and residual commercial and industrial waste to a composition of RDF in order to calculate the parameters outlined above.

5.4.2.10 The waste composition for the operational ERF which takes account of proposed policies to reduce plastic waste inputs to ERFs has been developed from the following sources:

- Average municipal residual waste composition: National municipal waste composition, England 2017 (WRAP 2020); and
- Residual commercial and industrial waste composition for Wales 2019 (WRAP Cymru 2020).

5.4.2.11 This data provides the composition of the residual waste according to waste fraction (e.g. paper and card and plastic film etc.). This information was converted into a fuel composition using data representing RDF produced through a dry stabilisation and mechanical separation process available in the WRATE environmental life cycle assessment software for waste management (WRATE 2017). Further to this, 95% of food waste, glass, fines, waste electrical and electronic equipment (WEEE), hazardous and non-combustible fractions are assumed to be removed from the RDF. The estimated amount of plastics present in the RDF was also reduced by 30% in line with the BPF roadmap described above.

5.4.2.12 No significant reduction is assumed for the proportion of paper and card and other non-food biodegradable materials, as biodegradable materials are diverted from landfill in line with proposed actions outlined in the Waste Strategy for England 2018 and the Sixth Carbon Budget.

5.4.2.13 The process steps for the dry stabilisation and mechanical separation process are as follows:

- untreated residual waste is heaped up for up to three days to allow excess moisture to evaporate;
- residual waste is shredded and ferrous metals are removed;
- the material is passed through a combination of screens, wind sifters and density separation to separate the RDF from inert and organic waste and further separate recyclable materials; and
- the RDF material is then baled for shipping to the ERF.

5.4.2.14 The required parameters have been calculated based on the relevant data for each waste fraction and are shown in Table 5.

Table 5: Waste characteristics as received at ERF

Parameter	Value	Reference
Carbon content (% mass)	36.0%	Calculated based on WRATE data for each waste fraction
Biogenic carbon (as % of total C)	58.4%	Calculated based on WRATE data for each waste fraction
DDOC (as % of biogenic C)	46.1%	Calculated based on MELMod DDOC (WR1908 – Table 4) for each waste fraction
Moisture content (% mass)	24.5%	Engineering design assumption
NCV (MJ/kg)	14	Engineering design assumption
RDF Throughput (tpa)	650,000	Engineering design assumption

5.4.3 Model parameters

5.4.3.1 Details of the parameter values used to assess the operational GHG emissions from the Project scenario and the alternative baseline scenario are shown in Table 6 to Table 8. These values are drawn from engineering design data for the Project and other relevant sources, as described in the table itself. They represent conservative assumptions for the transport of RDF and the operation of the ERF and associated recovery operations.

Table 6: Model parameters – Project scenario

Parameter	Value	Units	Reference / Comment
Annual RDF throughput at ERF	650,000	Tpa	Engineering design assumption based on NCV of 14 MJ/kg
Operational hours per year of ERF	8000	Hours	Engineering design assumption
Electricity and heat generation/use			
Net electricity generation for ERF (once electricity for SCR and	641,896	MWh / year	Calculated on the basis of the engineering design assumption of 91 MW with 9.5 MW parasitic load

Parameter	Value	Units	Reference / Comment
carbon capture are removed)			and 1.33MW CCUS electrical load.
Electricity required for ash treatment	1,500	MWh / year	Engineering design assumption
Electricity required for concrete block manufacture	1,016	MWh / year	Engineering design assumption
Electricity required for PRF	30,500	MWh / year	Engineering design assumption
Electricity export: to grid and other uses [3]	608,880	MWh / year	Engineering design assumption
Heat use for SCR	63,215	MWh / year	Engineering design assumption
Heat use for carbon capture	52,262	MWh / year	Engineering design assumption
Heat required for PRF	5,650	MWh / year	Engineering design assumption
Material/fuel inputs to ERF			
Natural gas for start up	7,234	MWh / year	Engineering design assumption
Grid electricity imported for start-up and non-availability	2,290	MWh / year	Engineering design assumption
Hydrated lime	13.5	kg / t RDF	Engineering design assumption
Activated carbon	0.4	kg / t RDF	Engineering design assumption
Ammonia	4.5	kg / t RDF	Engineering design assumption
N_2O emissions from ERF			
N_2O emissions per tonne of waste	0.0057	kg N2O / t waste	Defra WRT 237 Table B1-10
Bottom ash and FGTr treatment			
Bottom ash as a percentage of tonnage input	14.6%	%	Engineering design assumption
FGTr as a percentage of tonnage input	2.7%	%	Engineering design assumption
Percentage of ash rejected from treatment and sent to landfill	2.45%	%	Engineering design assumption
Ferrous metal as a percentage of tonnage input	0.55%	%	Engineering design assumption
Non-Ferrous metal as a percentage of tonnage input	0.55%	%	Engineering design assumption
Percentage ferrous metal recovery from IBA	90%	%	Engineering design assumption
Percentage non-ferrous metal recovery from IBA	90%	%	Engineering design assumption
Cement for FGTr treatment	0.5	t / t FGTr	Engineering design assumption
Fillers for FGTr treatment	0.5	t / t FGTr	Engineering design assumption

[3] Other uses may include hydrogen production and battery storage.

Parameter	Value	Units	Reference / Comment
Concrete block manufacture			
Recovered aggregate	0.45	t / t concrete block	Engineering design assumption
Sand	0.33	t / t concrete block	Engineering design assumption
Cement	0.18	t / t concrete block	Engineering design assumption
Carbon Capture			
Total CO_2 emissions captured from ERF	54,387	t CO_2	Engineering design assumption
Amine solutions	0.3	kg / t CO_2	Engineering design assumption
CO_2 utilised in horticulture	48,664	t CO_2	Engineering design assumption
Proportion of net CO_2 emissions avoided through use in horticulture	0.756	t CO_2e / t CO_2 utilised	Assumed to displace CO_2 from natural gas combustion equal to the biogenic carbon content of the waste (as shown in Table 5). GHG emissions from the production of natural gas are also assumed to be avoided (0.171 t CO_2e / t CO_2 utilised based on a carbon factors 2021).
CO_2 stored in concrete blocks by carbonisation	5,723	t CO_2	Engineering design assumption
Proportion of net CO_2 emissions avoided through storage in concrete blocks	1	t CO_2e / t CO_2 utilised	CO_2 mineralised in concrete blocks is assumed to be long term storage

Table 7: Model parameters – Alternative baseline scenario (Landfill)

Parameter	Value	Units	Reference
Net CV Methane (MJ/kg)	49	MJ/kg	Defra carbon factors 2021
Percentage methane in landfill gas	57%	%	Defra WR1908
Landfill gas capture rate	68%	%	Defra WR1908
Oxidation of uncaptured methane in cap	10%	%	Defra WR1908
Efficiency of landfill gas engine	36%	%	Defra WR1908
Percentage captured landfill gas flared	24%	%	Defra WR1908 – calculated from Table 15
Percentage of biogenic carbon in waste stored in landfill	53.9%	%	Calculated as 100% minus value for DDOC as shown in Table 5

Table 8: Model parameters – Avoided GHG emissions

Parameter	Value	Units	Reference
Marginal energy generation			
Electricity CCGT	0.371	tCO_2e/ MWh	Defra fuel mix disclosure table 2020
Heat – Natural gas CHP	0.209	tCO_2e/ MWh	Defra carbon factors 2021, including well to tank and distribution losses
Grid electricity use & Natural Gas			
OECD countries projected average grid electricity (2040)	0.197	tCO_2e/ MWh	U.S. Energy Information Administration (2021)
Natural gas	0.230	tCO_2e/ MWh	Defra carbon factors 2021, including well to tank
UK grid electricity (2035)	0.024	tCO_2e/ MWh	BEIS (2021) Table 1: Electricity emission factors to 2021
Material recovery parameters			
Avoided emissions ferrous metals	1.829	tCO_2e/t	WRAP (2016) Table 13, 'Steel Cans'
Avoided emissions non-ferrous metal recovery	8.7	tCO_2e/t	WRAP (2016) Table 13, 'Aluminium Cans'
Concrete blocks	0.132	tCO_2e/t	Defra Carbon factors 2020 – Primary concrete production

5.4.3.2 Assumptions regarding the transport of waste and materials to and from the Project are shown in Table 9 and Table 10. The source location of RDF and other materials required for the ERF has not yet been established. Therefore, conservative assumptions have been based on expert knowledge.

5.4.3.3 RDF may be delivered to the ERF by a combination of rail, road, and ship. Full details of where RDF will be sourced from and the mode of transport are not available currently. However, the site intends to prioritise the use of rail transport where possible, particularly over longer distances. Transport usually only makes a minor contribution to the overall carbon balance of waste management, it being of far greater consequence how wastes are managed once they arrive at a facility than how far (within reason) they have been transported to get there. Therefore, a conservative assumption is considered appropriate for this.

5.4.3.4 The final location for the utilisation of CO_2 captured from the ERF has not yet been determined. For the purposes of this assessment, it is assumed that CO_2 will initially be transported by rail and road.

Table 9: Transport assumptions

Activity	Mode of transport	One way distance (km)	Reference

Activity	Mode of transport	One way distance (km)	Reference
RDF to ERF	50% road	75	Assumption
	50% rail	200	Assumption
Materials for ERF (e.g. lime, ammonia and activated carbon)	50% road	250	Assumption
	50% rail	250	Assumption
Reject from ash treatment to landfill	100% road	50	Assumption
Captured CO_2 to utilisation	100% rail	20	Assumption
	100% road	100	Assumption
RDF to landfill	100% road	50	Assumption
Plastics to recycling plant at site	100% rail	150	Assumption
	100% road	75	Assumption
Plastics exported to recycling plant	100% ship	6500	Assumed boat from UK to Turkey (as actual future destination for plastics exports is unknown)
	100% road	500	Assumption

Table 10: Transport emission factors

Parameter	Value	Units	Reference
Rail transport	0.034	$kgCO_2/tkm$	Defra carbon factors 2021 – freight rail
Articulated lorry	0.076	$kgCO_2/tkm$	Defra carbon factors 2021 articulated (>33t)
Ship transport	0.016	$kgCO_2/tkm$	Defra carbon factors 2021 – general cargo (average)

5.5 Calculate GHG emissions

5.5.1.1 The GHG emissions and avoided emissions are calculated based on the methods outlined in Defra WR1910 using the parameters outlined above.

5.5.1.2 In addition, the GHG emissions for additional materials and transport considered in this assessment are calculated using the following equation:

5.5.1.3 GHG emissions = AD x EF

- Activity Data (AD) relate to the emission-causing activity, e.g. the combustion of a quantity of diesel or the use of a quantity of refrigerant gases.

- Emission Factors (EF) convert the activity data collected into GHG emissions, expressed as CO_2 equivalent (tCO_2e). This is the sum of all GHG emissions, relevant to the AD, scaled by the appropriate Global Warming Potential (GWP) to convert the result to a standardised unit of tCO_2e. Where GHG emissions are avoided, then a negative EF is used.

5.6 Sensitivity analysis

5.6.1.1 Sensitivity analysis has been undertaken to look at the impact of key assumptions including:

- **Biogenic content of RDF**: the GHG emissions from both the ERF and landfill are heavily influenced by the biogenic carbon content of the waste. A RDF produced primarily of fossil-derived plastics will have a significantly greater carbon and fossil carbon content than RDF produced from biogenic materials, such as paper and card and natural fibres.
- **Biodegradability of waste in landfill (DDOC):** the DDOC of the waste defines both the amount of biogenic carbon which is converted to methane in landfill and the amount of biogenic carbon that will remain stored in landfill. There is significant uncertainty around the values for DDOC, as accurately assessing or monitoring this is difficult, given the long lifetimes of landfills. The data selected represent a conservative assumption for the GHG emissions from landfill over the whole life of the landfill.
- **Landfill gas recovery rate**: *A Review of landfill methane emissions modelling* (Defra WR1908) reports an average landfill gas recovery rate of 68% for large modern landfill operations in the UK. However, this is based on a sample of modern UK landfills. Observations across larger portfolios of landfills in the UK indicate a 55-65% recovery rate over the managed gas abstraction period, which is less than the site's gassing lifetime. Therefore, over the whole gassing lifetime it is likely that recovery is lower. The Defra report (WR1908) calculates a 52% average recovery rate over the gassing lifetime for landfills in the UK.
- **Avoided GHG emission for electricity produced from waste**: this assessment assumes that electricity by CCGT will be displaced by the ERF and this represents a significant source of avoided GHG emissions from the Project. When renewable generation capacity has increased sufficiently and is supported by reliable and economic energy storage capacity, the production of electricity from fossil fuels, such as CCGT, will be substantially decreased, reducing the avoided GHG emissions for the development of new infrastructure.

6. BASELINE

6.1.1.1 There are no direct baseline GHG emissions data from the Project site to review, as GHG emissions prior to the Project are considered to be zero. However, by creating new waste management capacity, the Project will influence waste management streams in the UK and the balance of UK energy production. Therefore, for the alternative baseline, which presents the counterfactual to the Project, GHG emissions of waste management and energy supply beyond the physical boundary of the Project are considered.

6.1.1.2 Millions of tonnes of residual waste are landfilled in the UK annually (Defra 2021). Although the commercial contracts for the Project and therefore the exact source of waste, are not yet confirmed, it is reasonable to assume that the Project will contribute to the national capacity of ERFs and reduce the need for landfill.

6.1.1.3 Landfills that have gas capture and power generation still emit a significant quantity of methane, which is a potent GHG. This emission can be significantly reduced by diverting waste away from landfill. Therefore, the alternative baseline for the GHG assessment will calculate GHG emissions for a baseline scenario in which waste would otherwise be sent to landfill and compare this to the scenarios for GHG emissions from the Project. Full details of these scenarios are provided in Section 5.

7. MITIGATION

7.1.1.1 This section describes the mitigation measures considered in the assessment to date as reported in this ES. This includes mitigation that is integral to the design of the Project and good practice mitigation measures that the Project is committed to adopting. In some instances and based on the outcomes of the assessment to date, there may be opportunities further to mitigate impacts and this is discussed in Section 9. With respect to GHG emissions, such mitigation includes:

- An efficient CHP design for the ERF to recover electricity and heat from the combustion of the RDF. This greatly increases the overall efficiency of energy recovery from the ERF and maximises the displacement of energy produced from fossil fuels.
- Recovery of ferrous and non-ferrous metals from the bottom ash will avoid GHG emissions from the extraction and production of virgin metals.
- Materials recovered from the bottom ash and FGTr as substitutes for virgin aggregates will be used to produce concrete blocks, avoiding the GHG emissions from the extraction of virgin aggregates.
- Carbon capture technology will be used on the Project to capture approximately 55,000 t CO_2 from the ERF flue gases. Subsequently, this will either be mineralised as carbonates for long term storage within aggregates or sent for utilisation off-site in horticulture. This captured CO_2 and its subsequent use represents a reduction in the total net GHG emissions from the Project.
- The development and use of rail and ship transportation to bring RDF, captured CO_2 and other materials to and from the site offers the potential for reductions in GHG emissions compared to transport by road.

7.1.1.2 The assessment in this section takes such design mitigation into account.

8. ASSESSMENT OF LIKELY EFFECTS

8.1 Main assessment results

8.1.1.1 The quantity of GHG emissions for the Project and the baseline scenarios have been modelled considering using the method outlined in Section 6. The results of this assessment are shown in Table 11.

8.1.1.2 There is a net carbon benefit of 6,066 tCO_2e per annum for the Project compared to the alternative baseline landfill scenario. Therefore, over the lifetime of the Project (assumed to be 25 years), the total carbon benefit is approximately 152,000 tCO_2e.

8.1.1.3 The combined GHG emissions from waste transport, materials production and transport and direct emissions of CO_2 (from ERF) and methane (from landfill) are similar in each scenario at approximately 400,000 tCO_2e per annum.

8.1.1.4 Avoided GHG emissions from the recovery of energy and materials at the Project are substantially larger than those realised for the alternative baseline landfill scenario.

8.1.1.5 Storage of biogenic carbon in the landfill (approx. 270,000 tCO_2e per annum) represents the majority of the total avoided GHG emissions in the landfill scenario. However, this storage is temporary, and this carbon will be released at some point in the future, however distant. Therefore, including these avoided GHG emissions provides a very conservative assessment of the total GHG emissions from landfill of the waste. If the biogenic carbon storage in landfill is excluded, the net GHG emissions from the Project compared to the alternative baseline would be approximately 276,000 t CO_2e per annum.

8.1.1.6 The results show the benefit of carbon capture technology and subsequent storage in concrete blocks or utilisation in horticulture. Further to this there is the potential for the captured CO_2 to be removed from the atmosphere through long term storage (e.g. geological storage). If the captured CO_2 emissions from the site were sent to long term storage, this could increase the net carbon benefit for the Project compared to landfill to approximately 12,000 tCO_2e per annum.

Table 11: Breakdown of net GHG emissions for Project and alternative baseline (negative values indicate avoided GHG emissions or net storage of carbon)

Greenhouse gas source	Project (tCO_2e per annum)	Alternative baseline Landfill (tCO_2e per annum)
Waste transport	4,083	2,461
Direct emission of fossil CO_2 from combustion of waste	356,629	0
Direct emission of fossil N_2O from combustion of waste	982	0
Direct emission of methane in landfill gas	0	386,698
Raw material production (reagents for ERF and cement / fillers for concrete blocks)	53,321	0
Raw material transport	301	0
Avoided GHG emissions from electricity generation	-225,894	-47,172
Avoided GHG emissions from heat generation	0	0
Avoided GHG emissions from production of virgin ferrous metal	-5,875	0
Avoided GHG emissions from production of virgin non-ferrous metal	-27,944	0
Avoided GHG emissions from production of virgin source of concrete blocks from primary aggregates	-37,680	0
Biogenic carbon stored in landfill	0	-270,294
ERF: Carbon capture and utilisation	-42,109	0
Plastic transport to recycling facility	194	3,063
Plastic recycling energy use (grid electricity and heat)	0[4]	7,318
Net GHG emissions for Scenario	**76,008**	**82,074**
Net GHG emissions from the Project compared to alternative baseline (including biogenic carbon storage in landfill)	**-6,066**	
Net GHG emissions from the Project compared to alternative baseline (excluding biogenic carbon storage in landfill)	**-276,360**	

8.2 Sensitivity analysis

8.2.1.1 As outlined in Section 5.6, additional sensitivity analyses have been undertaken to assess key uncertainties in the assessment.

[4] Electricity and heat provided by the ERF, with associated reduction in electricity exported to the national grid

8.2.2 Landfill gas recovery rate and electricity generation displacement factor

8.2.2.1 Defra WR1908 reports an average landfill gas recovery rate of 68% for large modern landfill operations over the active gassing phase of the landfill in the UK, but provides a larger range of 50% 85%, depending on landfill conditions. However, over the whole gassing lifetime, it is likely that recovery is lower. The Defra report calculates a 52% recovery rate over the gassing lifetime.

8.2.2.2 Whilst the ERF for the Project is most likely to displace CCGT with significantly increased renewable electricity generation supported by reliable and economic energy storage capacity, the production of electricity from fossil fuels, such as CCGT, will be substantially decreased, reducing the avoided GHG emissions. The impact of a percentage change in the avoided GHG emissions from CCGT on the net GHG emissions from the Project compared to the alternative baseline scenario is presented in Table 12, together with the impact of changing the landfill gas recovery rate. The values from the main scenario are shown in bold.

Table 12: Net GHG emissions with Project compared to alternative baseline with varying landfill gas recovery rate and electricity generation displacement factor

LF gas recovery rate (%)	Electricity generation displacement factor (t CO_2e / MWh)		
	0.371	0.315 (-15%)	0.26 (-30%)
52%	-208,955	-180,716	-152,477
60%	-107,511	-79,987	-52,463
68%	**-6,066**	20,742	47,551
75%	82,698	108,880	135,062

8.2.2.3 Table 12 shows that, when the electricity generation displacement factor is reduced by 15%, to 0.315 t CO_2e / MWh, there is no longer a net carbon benefit for the Project.

8.2.2.4 If the landfill gas recovery rate is 60% or less, then there is a net benefit with the Project compared to the alternative baseline. However, if the landfill gas recovery rate is 75%, there is no longer a net carbon benefit for the Project. A 75% landfill gas capture rate far exceeds most estimates for the life gassing recovery rate of a landfill and it should also be noted that the net GHG emission values calculated for landfill also include storage of biogenic carbon, associated with which there is also significant uncertainty. As observed above, biogenic carbon will eventually be released from landfill at some point in the future and the actual amount of carbon which can be considered permanently stored, with regard to GHG emissions accounting (i.e. more than 100 years) is not known. This contrasts with direct GHG emissions from the ERF, which can be calculated with more certainty.

8.2.3 RDF Composition (Biogenic content and biodegradability of waste)

8.2.3.1 RDF composition may vary, depending on the processes employed in treatment and the residual waste stream feedstock. A waste feedstock with a high proportion of organic waste will have a high biogenic carbon content and biodegradability (DDOC). Conversely, RDF produced primarily from wastes with a high plastic content will have a low biogenic content and low biodegradability.

8.2.3.2 Given the long lifetime of landfill and variation in conditions within the fill, it is difficult to assess real world DDOC values over the long term. Therefore, there is significant uncertainty as to how accurately DDOC represents the biodegradability of biogenic carbon in landfill over its whole lifetime.

8.2.3.3 Table 13 below shows the estimated net benefit in GHG emissions of the Project compared to the alternative baseline landfill scenario for different combinations of biogenic content (as % of total C in RDF) and biodegradability (as DDOC), when varied by +/-10% from the values used in the main assessment. The values from the main scenario are shown in bold.

8.2.3.4 The analysis shows that a 10% reduction in either the biogenic carbon content or DDOC results in a net increase in GHG emissions from the Project compared to the alternative baseline landfill scenario. However, if the DDOC is increased by 10%, this largely negates a 10% decrease in the biogenic carbon content.

Table 13: Net GHG emissions from Project compared to alternative baseline with biogenic carbon content and biodegradability (DDOC) at 68% landfill gas recovery rate

DDOC (%)	Biogenic carbon (% of carbon)		
	52.6%	58.4%	64.3%
41.5%	102,160	51,022	-116
46.1%	50,781	**-6,066**	-62,913
50.7%	-598	-63,154	-125,710

8.2.3.5 Given the number of potential variables in these scenarios, it is difficult to assess all potential combinations. However, the variables with the greatest uncertainty are those which relate to the long-term fate of waste in the landfill, principally the DDOC and landfill gas recovery rate. If the landfill gas recovery rate is assumed to be 60% (as shown in Table 14) there is a net carbon benefit from the Project compared to the alternative baseline landfill scenario in all cases except where there is a 10% reduction in both the biogenic carbon content and DDOC.

Table 14: Net GHG emissions from Project compared to alternative baseline with biogenic carbon content and biodegradability (DDOC) at 60% landfill gas recovery rate

DDOC (%)	Biogenic carbon (% of carbon)

	52.6%	58.4%	64.3%
41.5%	19,990	-40,278	-100,546
46.1%	-40,519	-107,511	-174,502
50.7%	-101,029	-174,743	-248,458

9. CONCLUSIONS

9.1.1.1 The design of the ERF is in line with government planning policy objectives to consider and implement uses of CHP. Also, with the inclusion of CCUS, the Project is aligned with government objectives for all new energy recovery facilities to have CCUS or be CCUS ready from the end of the 2020s.

9.1.1.2 With the implementation of the mitigation as set out in Section 7, this assessment has concluded that there will be a net reduction in GHG from the Project compared to the alternative baseline landfill scenario.

9.1.1.3 The development of a procurement strategy for materials required for the Project, which prioritises the identification and purchase of materials with lower embodied GHG emissions, would further limit the GHG emissions from the Project. The transport of materials to or from the site by train or boat, rather than road, would also provide benefits.

9.1.1.4 In addition to the above, long-term storage of captured CO_2 (e.g. in geological storage), instead of utilisation, would provide further net reductions in GHG emissions, if practicable access to suitable storage schemes becomes available. North Lincolnshire Green Energy Park Limited (the Applicant) is a member of Zero Carbon Humber (ZCH), which represents the Humber region in the East Coast Cluster partnership. The East Coast Cluster has been selected by BEIS as one of two regions to supported for carbon capture, usage and storage. The Project has been short-listed for funding under the BEIS Phase 2 funding round. It is the intention that this facility will ultimately join up with the proposed ZCH pipeline which will transport the CO_2 to the disused gas fields in the North Sea. This government-backed program has just commenced its own DCO process and early options for the route of the pipeline pass very close to the Application Land.

9.1.1.5 Therefore, based on having implemented the mitigation described in Section 7, the conclusion of this assessment is that there will be a net reduction in GHG from the Project compared to the alternative baseline landfill scenario and therefore there will be no significant residual effects from the Project and there should be a positive impact.

9.1.1.6 However, as noted in the sensitivity analysis, with a lower biogenic content in the RDF, this net benefit could potentially be lost. Should insufficient processing facilities exist to manage the organic fines present in MSW, these will by default remain mixed with the RDF. Therefore, monitoring of the biogenic carbon content of the RDF used at the site will be undertaken to give confidence that the net benefit in GHG emissions is being maintained or improved upon.

10. REFERENCES

- BEIS (2019) Valuation of energy use and greenhouse gas emissions
- BEIS (2021a) Net Zero Strategy: Build Back Greener
- BEIS (2021b) November 2021: Updates on the industrial carbon capture and dispatchable power agreement business models
- Committee on climate change (CCC), 2020, The Sixth Carbon Budget The UK's path to Net Zero
- Defra WR1910 (2014) Energy recovery for residual waste, A carbon based modelling approach. Defra.
- Defra WR1908 (2014) Gregory, R; Stalleicken, J.; Lane, R.; Arnold, S. and Hall, D. Review of landfill methane emissions modelling (13514290381.506/A.1). Golder Associates.
- Defra WRT237 (2006) Carbon Balances and Energy Impacts of the Management of UK Wastes Golder Associates and Environmental Resources Management.
- Defra (2018) Our waste our resources: A strategy for England Our waste
- Defra (2020) Fuel Mix disclosure data table
- Defra Carbon factors 2020, UK Government GHG Conversion Factors for Company Reporting,
- Defra (2021) Household waste to landfill in 2018, Table 5.4, UK Statistics on Waste
- U.S. Energy Information Administration (EIA) (2021) International Energy Outlook 2021
- IEA, (2019) Global Energy & CO_2 Status Report 2019: The latest trends in energy and emissions in 2018, International Energy Agency,
- IEMA, (2017) Environmental Impact Assessment Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance by the Institute of Environmental Management Assessment
- IPCC 5th assessment (2013), Anthropogenic and Natural Radiative Forcing
- The Overarching Energy National Policy Statement (NPS EN-1) DECC, (2011)
- Government Review of Waste Policy in England (2011) Defra
- National Policy Statement for Renewable Energy Infrastructure (NPS EN-3) DECC, (2011)
- SBTI (2021) Science based target setting tool – Version 1.2
- Tolvik, (2017) Briefing Report: Mechanical Biological Treatment – 15 Years of UK
- WRATE (v4.0.1.0) 2017 Golder Associates
- WRAP (2016) The Climate Change Impacts of Recycling Services in Wales, COL 121-001, WRAP Sept 2016
- WRAP (2020) National municipal waste composition, England 2017, WRAP

- WRAP Cymru (2020) Commercial and Industrial Waste in Wales
- Zemo partnership (2021) Hydrogen Vehicle Well-to-Wheel GHG and Energy Study