Table of Contents

14. Climate Change 14-1
14.1 Introduction 14-1
14.2 Legislation and Planning Policy Context 14-1
14.3 Assessment Methodology and Significance Criteria 14-5
14.4 Baseline Conditions 14-16
14.5 Development Design and Impact Avoidance 14-25
14.6 Likely Impacts and Effects of the Proposed Developments 14-30
14.7 Mitigation and Adaptation Measures 14-48
14.8 Residual Effects and Conclusions 14-49
14.9 References 14-51

Tables

Table 14.1: Proposed scope of the GHG emissions impact assessment 14-6
Table 14.2: Climate variable considered in this CCRA 14-8
Table 14.3: Description of likelihood for climate change hazard 14-10
Table 14.4: Measure of consequence for climate change risk 14-11
Table 14.5: Significance of effects for GHGs impact assessment 14-13
Table 14.6: CCRA Significance Criteria Matrix 14-14
Table 14.7: Consultation summary table 14-15
Table 14.8: Existing baseline (2021): Direct and indirect emissions 14-16
Table 14.9: Existing baseline (2021): Secondary emissions 14-17
Table 14.10: Baseline climate data 14-18
Table 14.11: Historic 10-year Averages for temperature and rainfall for the east and north-east England 14-19
Table 14.12: Future baseline (2028): direct and indirect emissions 14-20
Table 14.13: Future baseline (2028): secondary emissions 14-20
Table 14.14: Climate change baseline and projected data, 50% probability (10% and 90% probability in parenthesis) 14-21
Table 14.15: Embedded control measures during construction and operation 14-25
Table 14.16: Construction and operation mitigation measures 14-27
Table 14.17: Construction GHG emissions 14-31
Table 14.18: Construction period resultant emissions 14-32
Table 14.19: Operation of the Proposed Developments (2028): direct and indirect emissions 14-36
Table 14.20 Phillips 66 alternative scenario (2028): direct and indirect emissions 14-38
Table 14.21: Operation of the Proposed Developments (2028): secondary emissions 14-39
Table 14.22: Difference in emissions between assessment scenarios 14-40
Table 14.23: Estimated GHG emissions as a proportion of the estimated carbon budgets to 2037 14-47
Table 14.24: Summary of initial risk ratings 14-47
Table 14.25: Construction and operation adaptation measures 14-48
Table 14.26: Summary of initial and residual ratings 14-49

Plates

Plate 14.1 Annual global historical temperature with projected annual global carbon emissions (left) and projected global temperatures (right) (NOAA, 2022b) 14-5
Plate 14.2 CCRA Methodology..... 14-9
Plate 14.3 Illustrative diagram of the Phillips 66 Well to Tank emissions..... 14-34
Plate 14.4 Diagram of the Proposed VPI Development operational emissions... 14-38
Plate 14.5 Diagram of the Proposed Phillips 66 Development operational emissions 14-38
Plate 14.6: VPI: existing baseline vs with the Proposed VPI Development..... 14-41
Plate 14.7: Phillips 66: existing baseline vs with the Proposed Phillips Development 14-41
Plate 14.8 UK's Balanced Net Zero Pathway and projected trajectory to 2050... 14-42
Plate 14.9: Proposed Developments (no upstream emissions) against the UK's Balanced Net Zero Pathway..... 14-44
Plate 14.10: Proposed Developments (with upstream emissions) against the UK's Balanced Net Zero Pathway..... 14-45

14. Climate Change

14.1 Introduction

14.1.1 This Chapter of the Environmental Statement (ES) assesses the potential effects of the construction and operation (including maintenance) of the proposed Post-Combustion Carbon Capture (PCC) developments located at VPI Immingham's Combined Heat and Power (CHP) Plant and Phillips 66 Limited's Humber Refinery (referred to as 'the Proposed Developments'), in terms of climate change and sustainability. As well as considering potential effects of the Proposed Developments on the climate, this assessment also considers the potential impact of future climate change on the Proposed Developments and the surrounding environment.

14.1.2 The Proposed Developments will be designed to be capable of capturing 95% of carbon emissions during steady state operation. It is intended that the CO_2 will be exported at high pressure via an interface to a CO_2 transportation network adjacent to the Sites.

14.1.3 To align with the requirements of the Town and Country Planning (Environmental Impact Assessment) Regulations 2017 (as amended in 2018) (the 'EIA Regulations'), consideration has been given within this chapter to the following aspects of climate change assessment:

- Greenhouse Gas (GHG) Impact Assessment – considers the impact on the climate of GHG emissions arising from the Proposed Developments during their lifetime. This considers the Proposed Developments in the context of the UK carbon budgets and how they would affect the ability of Government to meet its carbon reduction targets;
- Climate Change Risk Assessment (CCRA) – considers the resilience of the Proposed Developments to climate change impacts, including how the Proposed Developments are designed to reduce their vulnerability to the projected impacts of climate change; and
- In-combination Climate Change Impact (ICCI) Assessment – The combined impact of the Proposed Developments and future climate change on receptors in the surrounding environment.

14.2 Legislation and Planning Policy Context

14.2.1 The Legislation and Planning Policy Context section of this chapter provides a brief overview of the relevant legislation, planning policy and technical guidance relevant to the climate change and sustainability assessment.

Legislation

Paris Agreement

14.2.2 The Paris Agreement (enforced since 2016) is a legally binding agreement within the United Nations Framework Convention on Climate Change (UNFCCC) dealing with GHG emissions mitigation, adaptation and finance starting in the year 2020 (UNFCCC, 2015). It requires all signatories to set a target known as the nationally determined contribution (NDC), which strengthens their climate change mitigation efforts to keep global warming to well below 2°C this century and to pursue efforts to limit global warming to 1.5°C. The agreement contains a 'ratchet' mechanism by which NDCs must be strengthened every five years. In 2020, the UK communicated its new NDC to the UNFCCC committing to reduce GHG emissions by at least 68% by 2030 compared to 1990 levels (UK Government, 2020).

Climate Change Act 2008

14.2.3 The Climate Change Act 2008 originally set a legally binding target for the UK to reduce its GHG emissions from 1990 levels by at least 80% by 2050. This was amended in 2019, requiring the government to reduce the UK's net emissions by 100% (net zero) relative to 1990 levels by 2050 (HMSO, 2019).

14.2.4 This target is supported by a system of legally binding five-year 'carbon-budgets' that restrict the amount of GHG emissions the UK can legally emit (UK Government, 2021). This requirement is addressed in Section 14.3, under subheading Significance where project GHG emissions are compared against relevant carbon budgets.

The Town and Country Planning (Environmental Impact Assessment) Regulations 2017

14.2.5 The 2017 Regulations state that an Environmental Impact Assessment (EIA) (where relevant): *"must include 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 vulnerability of the project to climate change".* (UK Government, 2017)

National Policy

National Planning Policy Framework (NPPF)

14.2.6 The revised National Planning Policy Framework (NPPF) published by the Ministry of Housing, Communities and Local Government (MHCLG, 2021), sets out the Government's planning policies for England. Policies of relevance to climate change include those meeting the challenge of moving to a low carbon economy, climate change, flooding and coastal change. The NPPF states that the planning system should support this transition by supporting low carbon energy and associated infrastructure.

National Planning Practice Guidance on Climate Change

14.2.7 This National Planning Practice Guidance (NPPG) for Climate Change advises on how to identify and implement suitable mitigation and adaptation measures in the planning process. The guidance states that *"effective spatial planning is an important part of a successful response to climate change as it can influence the emission of greenhouse gases… Planning can also help increase resilience to climate change impact through the location, mix and design of development"* (Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government (DLUHC), 2014).

14.2.8 Again, it is noted that the Proposed Developments are not an NSIP, however a number of National Policy Statements are of relevance.

Draft Overarching National Policy Statement for Energy (EN-1)

14.2.9 Whilst this project is not considered a Nationally Significant Infrastructure Projects (NSIP), National Policy Statements are of relevance to this chapter's assessment. Published by the Department of Energy and Climate Change (DECC) (DECC, 2011a), the Draft Overarching National Policy Statement for Energy describes the national policy for energy infrastructure in relation to climate impacts and adaptation; adverse effects and benefits; in relation to the European Union (EU) Directive and ES requirements; and in relation to adaptation measures in response to climate projections; in relation to climate projections, flood risk and the importance of relevant mitigation.

National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2)

14.2.10 Published by the DECC, the National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (DECC, 2011b) describes the need for all new fossil fuel electricity generating plants to assess the viability for supporting carbon capture and storage technologies. This policy has been used to inform this Chapter and the wider submission.

Local Policy

Core Strategy and Housing and Employment Land Allocations

14.2.11 The policies within the Core Strategy and Housing and Employment Land Allocations DPD (NLC, 2016) that are considered to be relevant to this chapter include:

- Policy CS2: Delivering more Sustainable Development;
- Policy CS18: Sustainable Resource Use and Climate Change;
- Policy CS19: Flood Risk;
- Policy CS20: Sustainable Waste Management; and
- Policy CS25: Promoting Sustainable Transport.

North Lincolnshire Council Local Plan

14.2.12 The 'Saved' policies of the Local Plan (NLC, 2007) that are considered to be relevant to this chapter include:

- Policy DS16: Flood Risk.

North Lincolnshire Local Plan – Publication Draft

14.2.13 The 'emerging' policies of the Publication Draft of the North Lincolnshire Local Plan (NLC, 2021) that are considered to be relevant to this chapter include:

- Policy DQE5: Managing Flood Risk;
- Policy DQE7: Climate Change; and
- Policy DM3: Environmental Protection.

Government Strategy

The Clean Growth Strategy

14.2.14 The Clean Growth Strategy was published in 2017 and updated in 2018 (HM Government, 2018b). This Strategy details the increased investment and collaboration in carbon capture usage and storage in the UK to drive industrial innovation and its importance in long-term emissions reduction.

Clean Growth: The UK Carbon Capture Usage and Storage (CCUS) Deployment Pathway- An Action Plan

14.2.15 The UK Government (HM Government, 2018a) has identified Carbon Capture Usage and Storage (CCUS) as having a significant part to play in the UK's transition to a low carbon economy. CCUS has been identified as a low-cost energy system decarbonisation pathway to 2050. In their Clean Growth CCUS action plan it is stated that:

"CCUS has economy-wide qualities which could be very valuable to delivering clean industrial growth. It could deliver tangible results in tackling some of the biggest challenges we face in decarbonising our economy, contributing to industrial competitiveness and generating new economic opportunities – a key part of our modern Industrial Strategy."

Net Zero Strategy: Build Back Greener

14.2.16 In October 2021, the Department of Business, Energy & Industrial Strategy (BEIS) published the Net Zero Strategy: Build Back Greener which sets out policies and proposals for decarbonising all sectors of the UK economy to meet our net zero target by 2050 (BEIS, 2021d).

Net Zero - Opportunities for the Power Sector

14.2.17 This report states that decarbonising the power sector is integral to achieving the goal of Net Zero by 2050 (BEIS, 2021). The National Infrastructure Commission (NIC) provides impartial advice to the government on infrastructure requirements, strategic drivers, and solutions. The NIC terms of reference are set by government, and while NIC recommendations do not constitute government policy, the government is required to formally respond to the recommendations, and they may form the evidence base for future policy.

Guidance

The GHG Protocol

14.2.18 The GHG Protocol, published by the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) provides overarching guidance on developing GHG inventories and reporting standards (WRI, 2015).

Guidance for the Calculation of Land Carbon Stocks

14.2.19 EU Commission published a calculation methodology for calculating carbon stocks from land use (European Commission, 2010).

British Standards

14.2.20 The British Standards Institution BS EN ISO 14064-1:2019 and 14064-2:2019 provides specifications for organisational-level and project-level guidance for the quantification and reporting of GHG emissions and removals (BSI, 2019a and 2019b).

Institute of Environmental Management and Assessment (IEMA): Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance

14.2.21 The IEMA Guidance for assessing GHG and evaluating their significance (IEMA, 2022) in EIA has been followed within this assessment. It is a revision of the 2017 IEMA guidance. This provides a framework for the consideration of GHG emissions in the EIA process, in line with the 2014 European Union (EU) Directive. The guidance sets out how to:

- identify the GHG emissions baseline in terms of GHG current and future emissions;
- identify key contributing GHG sources and establish the scope and methodology of the assessment;
- assess the impact of potential GHG emissions and evaluate their significance;
- consider mitigation in accordance with the hierarchy for managing project related GHG emissions (avoid, reduce, substitute, and compensate).

IEMA: Environmental Impact Assessment Guide to: Climate Chance Resilience and Adaptation

14.2.22 The IEMA Guidance for assessing climate change resilience and adaptation in EIA (IEMA, 2020) has also been followed. It provides guidance for consideration of the impacts of climate change within project design. The guidance sets out how to:

- define potential climate change concerns and environmental receptors vulnerable to climate factors;
- define the environmental baseline with projections for changing future climate parameters; and
- determine the resilience of project design and define appropriate mitigation measures to increase resilience to climate change.

EU Commission Notice: Technical Guidance on the Climate Proofing of Infrastructure in the Period 2021-2027

This technical guidance (EU, 2021) has also been used to assess climate change resilience and adaptation. The guidance contained in this document is consistent with the Paris Agreement and EU climate objectives (climate neutrality by 2050). The technical guidance also follows the principle of 'energy efficiency first'[1] and 'do no significant harm'[2]. The risk framework, likelihood and consequence descriptors from the technical guidance have been used in the CCRA as described in Section 14.3.

[1] Article 2(18) of Regulation (EU) 2018/1999 of the European Parliament
[2] Regulation (EU) 2020/852 of the European Parliament

14.3 Assessment Methodology and Significance Criteria

Climate Change Context

Climate Change Emission Pathways

14.3.1 The Intergovernmental Panel on Climate Change (IPCC) has confirmed in their Assessment Reports that the anthropogenic influence on the climate system is clear and growing with impacts observed across all continents and oceans (IPCC, 2014). Human activities have increased the concentration of CO_2 in the atmosphere, with observed levels of global atmospheric CO_2 rising from their pre-industrial levels of 280 parts per million (ppm) up to 420.99 ppm as of May 2022 (National Oceanic and Atmospheric Administration NOAA, 2022a). Given CO_2 is a GHG that absorbs and radiates heat, these increases have resulted in the warming of Earth's atmosphere. According to an ongoing temperature analysis by NASA, the average global temperature on Earth has increased by at least 1.1 °C since 1880, with the rate of warming since 1981 at roughly 0.18 °C per decade (NOAA, 2022b). In order to understand how the global climate may change in the future, the IPCC's Fifth Assessment Report (AR5) developed Representative Concentration Pathways (RCPs) that describe four different 21st Century pathways of GHG emissions depending on the level of mitigation action undertaken between now and then (IPCC, 2014). The RCPs are based on global research and existing literature and comprise a stringent mitigation pathway (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and a high emissions scenario (RCP8.5). Plate 14.1 shows the emission trajectories and projected global temperatures up to 2100 in terms of the IPCC's RCPs.

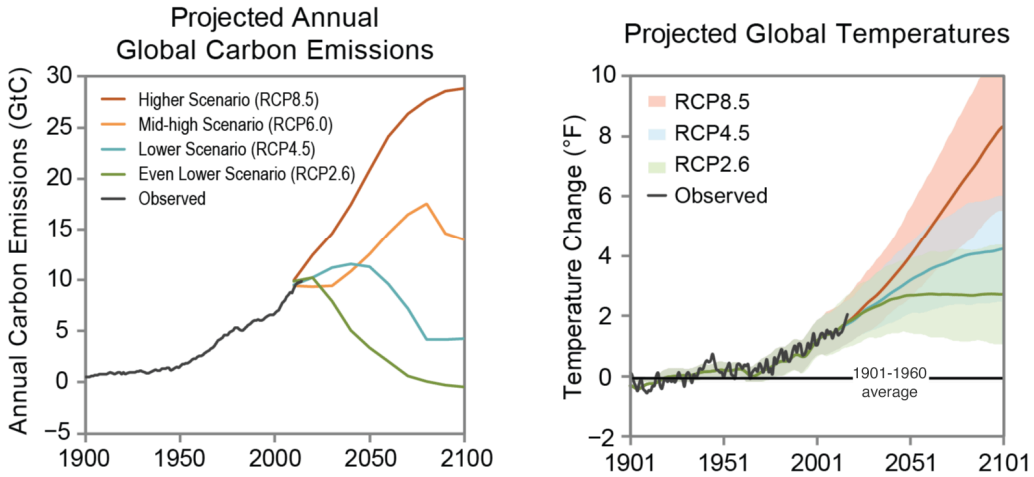


Plate 14.1 Annual global historical temperature with projected annual global carbon emissions (left) and projected global temperatures (right) (NOAA, 2022b)

Assessment Methodology

GHG Emissions Impact Assessment

14.3.2 The GHG assessment for the Proposed Developments estimates the amount of carbon emissions produced during construction and operation and uses this to understand to what extent the Proposed Developments will contribute towards the UK achieving a science-based 1.5ºC aligned transition towards net zero. This is calculated in line with the GHG Protocol.

14.3.3 GHG 'hot spots' (i.e. sources likely to generate the largest amount of GHG emissions) have been identified to enable priority areas for mitigation to be targeted. This approach is consistent with the principles set out in IEMA guidance.

14.3.4 The Proposed Developments will collectively deliver up to 3.8 megatonnes per annum (Mtpa) of abated carbon dioxide (CO_2) emissions via:

- PCC retrofit to two gas turbines (GT1 and GT2) and two auxiliary gas boilers at the VPI Immingham CHP Plant ('the Proposed VPI Development'); and

- PCC retrofit to the Fluid Catalytic Cracker (FCC) stack at the Humber Refinery ('the Proposed Phillips 66 Development').

14.3.5 The GHG study area includes all GHG emissions from within the Proposed Development Sites boundaries arising during the lifecycle of the Proposed Developments. It also includes emissions arising from off-site activities which are directly related to the on-site activities, such as transport of materials, waste and construction workers, and treatment and disposal of waste.

14.3.6 A lifecycle approach, based on the Publicly Available Specification (PAS) 2080 guidance (BSI, 2016), has been used to identify emission sources within the impact assessment. The construction stage is approximately 3 to 4 years whilst the operation stage is based on an assumed design life of at least 25 years[3]. The proposed scope of the GHG emissions impact to be assessed are described Table 14.1.

Table 14.1: Proposed scope of the GHG emissions impact assessment

Lifecycle stage	Stage Activities	Primary emission sources
Pre-construction	Enabling works (i.e. demolition, earthworks, etc)	GHG emissions from energy consumption during pre-construction activities (i.e., electricity, fuel, LPG, etc.)
		Construction workers travelling to and from the Sites
		GHG emissions from enabling works waste disposal
		GHG emissions from transportation of enabling works waste
Production of materials	Raw material extraction and manufacturing of products required to build the Proposed Developments	Embodied carbon associated with enabling works/ construction materials
	Transport of materials to site	GHG emissions from transportation of materials to site
Construction	On-site construction activities	GHG emissions from energy consumption during construction (i.e. electricity, fuel, LPG, etc.)
	Construction worker commuting	Workers travelling to and from the Sites
	Disposal of construction waste	GHG emissions from construction waste disposal
		GHG emissions from transportation of construction waste from the Sites
Operation	Energy consumption	GHG emissions from electricity consumption[4]
		GHG emissions from gas consumption[5]
	Process emission	GHG emissions from other industrial processes (e.g. chemicals and water consumption)
		GHG emissions from operational waste disposal

[3] Operational life could potentially be longer subject to market conditions which will be appraised as the project operates
[4] Philips 66 purchases its electricity from VPI
[5] Phillips 66 purchases its steam from VPI

Disposal of operational waste	GHG emissions from transportation of operational waste
Vehicle journeys	GHG emissions from the transport of staff and materials
Maintenance	GHG emission from maintenance activities (e.g. maintenance embodied carbon, maintenance transport)
Fugitive	GHG emissions from gas leakage

14.3.7 The timescale and methods for decommissioning are unknown as it is difficult to predict emission associated with this lifecycle stage; therefore, it has been scoped out of the GHG emission impact assessment for the Proposed Developments.

14.3.8 The activities listed in Table 14.1 are recognised as the direct and indirect emissions associated with the Proposed Developments. Direct emissions are defined by the GHG Protocol as *"emissions from sources that are owned or controlled by the reporting entity"* (GHG Protocol, 2022). This includes consumption of fuel, steam, and electricity, as well as fugitive and process emissions.

14.3.9 Indirect emissions are defined as *"emissions that are a consequence of the activities of the reporting entity but occur at sources owned or controlled by another entity"* (GHG Protocol, 2022). This includes embodied carbon, transportation of materials, commuting, disposal of waste, maintenance, and the extraction, refining and transportation of natural gas/ crude oil.

14.3.10 The EIA Regulations require the consideration of not only direct and indirect effects, but also secondary effects. The secondary effects within the GHG emission impact assessment involve the recognition of the secondary emissions. Secondary emissions are generally defined as emissions that are a consequence of the activities of the reporting entity but occur at sources owned or controlled by another entity **through the purchase of the reporting entity's goods and services**. This includes the emissions emitted from the use of end products (i.e. fuel combustion).

14.3.11 The secondary emissions are included within this GHG assessment to provide a better perspective of emissions that are affiliated with the Proposed Developments but also offer an improved understanding of the secondary impacts.

14.3.12 As stated within the *NIC's Net Zero: Opportunities for the power sector* report, decarbonisation of the power sector is integral to achieving UK's 2050 goal of net zero emissions. Acknowledging all affiliated emissions is an important step towards improving one's GHG accountability and transparency.

14.3.13 Where activity data will allow, expected GHG emissions arising from the lifecycle activities associated with the Proposed Developments are quantified using a calculation-based methodology as per the following equation:

Activity data x GHG emissions factor = GHG emissions value

14.3.14 Activity data is a quantifiable measure of activity, such as the number of operating hours or volumes of fuels used. Activity data has been sourced from the Applicants and their engineering designers. Where specific data are not available, a mix of assumptions and industry benchmarks have been used to fill data gaps. Where this is not possible, then a qualitative approach to assessing the GHG impacts has been followed, in line with the IEMA guidance.

14.3.15 Emission factors have been sourced from the ICE database (University of Bath, 2019), EcoInvent Database v3.5 (EcoInvent, 2018) and BEIS 2021 Emission factors (BEIS, 2021).

14.3.16 In line with the GHG Protocol, when defining potential impacts (or 'hot spots'), the seven Kyoto Protocol GHGs have been considered, specifically:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N2O);
- Sulphur hexafluoride (SF_6);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs); and
- Nitrogen trifluoride (NF_3).

14.3.17 These gases are broadly referred to in this Chapter under an encompassing definition of 'GHG', with the unit of tCO_2e (tonnes CO_2 equivalent) or Mt CO_2e (mega tonnes of CO_2 equivalent).

14.3.18 The IEMA guidance states that activities which are expected to emit less than 1% of emissions can be excluded from the assessment and where all such exclusions total a maximum of 5% of total emissions. Exclusions and assumptions are detailed within Section 14.6.

CCRA

14.3.19 A CCRA has been undertaken for the Proposed Developments to identify potential climate change impacts, and to consider their potential consequence and likelihood of occurrence, taking account of the measures incorporated into the design of the Proposed Developments.

14.3.20 The types of receptors considered vulnerable to climate change are:

- construction phase receptors (i.e. workforce, plant, and machinery);
- the Proposed Developments assets and their operation, maintenance, and refurbishment (i.e. pavements, structures, earthworks and drainage, technology assets, etc.); and
- end-users (i.e. staff and commercial operators etc.).

14.3.21 The climate variables considered in this CCRA are set out in Table 14.2. These variables were deemed relevant to the location and type of asset being assessed. They will be compared to the future baseline throughout the life of the Proposed Developments.

14.3.22 Consideration of climate change impacts within EIAs is an area of emerging practice. There is no single prescribed format for undertaking such assessments; therefore, the approach adopted to undertaking and reporting the assessment has drawn on good practice from other similar developments and studies and is aligned with existing guidance such as that published by IEMA.

Table 14.2: Climate variable considered in this CCRA

Climate variable	Rationale
Temperature	Increased temperatures may increase cooling requirements, alter the power plant efficiency of the Proposed Developments, and could impact on structural integrity of buildings and materials.
Rainfall	The Proposed Developments may be vulnerable to changes in precipitation, for example, pressure on water supply during periods of reduced rainfall, and damage to structures and drainage systems during periods of heavy precipitation.
Sea level rise	The Sites are located in an area that is susceptible to sea level rise.

Storms	The Proposed Developments may be vulnerable to extreme weather events such as storm damage and storm surge to structures and assets.
Wind	Severe wind event has higher wind loading than designed, causing stress to infrastructure including lights, fencing, signage, resulting in damage or reduced design life and potential safety hazard.
Drought	Extreme drought events cause the drying of pavement structures and deterioration of structures/ foundations due to decrease in soil moisture levels. Drought also increases dust in the atmosphere, affecting workers and infrastructure components.
Wildfires	Prolonged periods of extreme heat and dry conditions increase risk of fires on site which can cause damage to infrastructure assets.

14.3.23 The methodology for the CCRA is summarised in Plate 14.2.

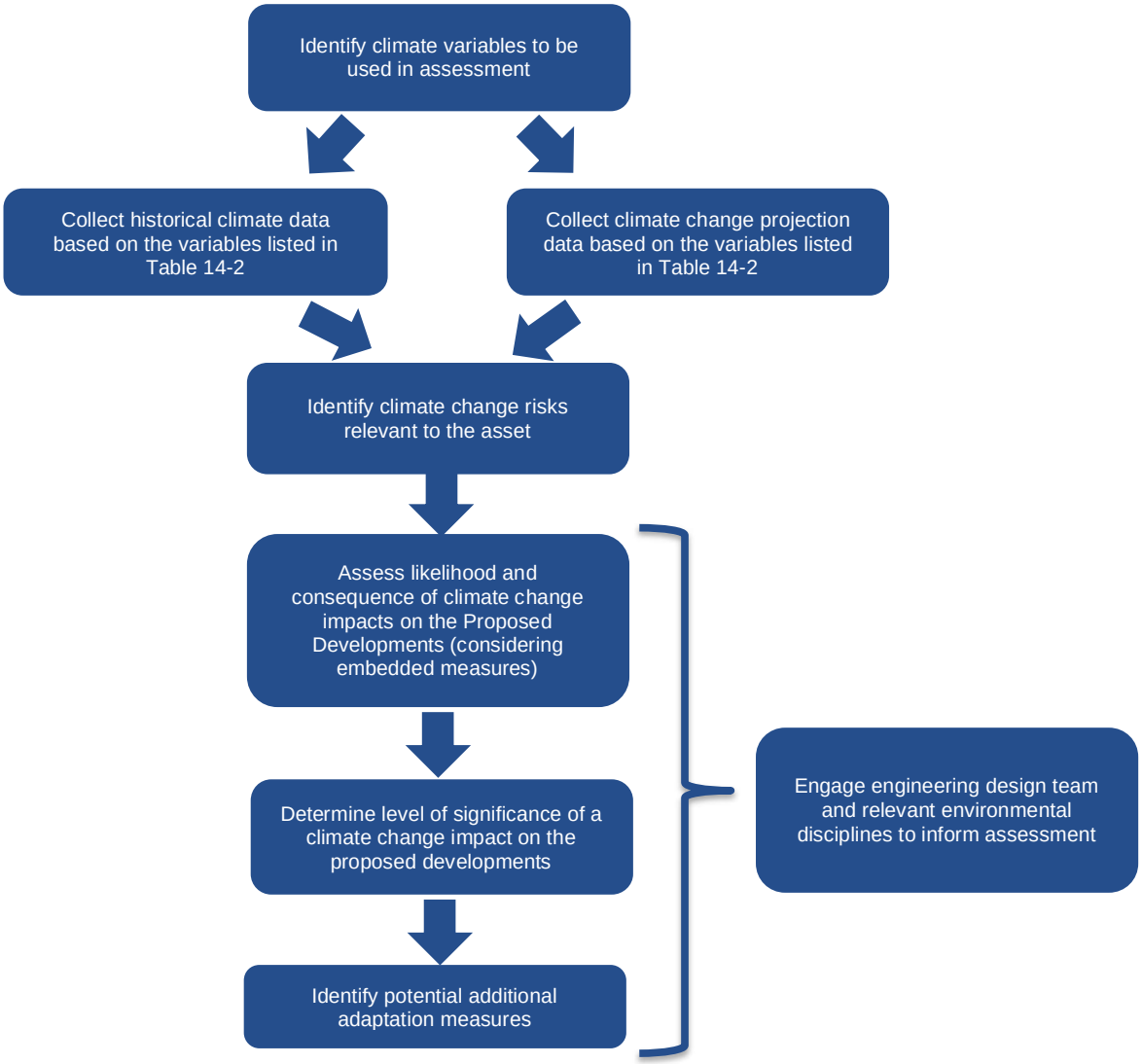


Plate 14.2 CCRA Methodology

14.3.24 The potential impacts for the CCRA are determined based on the UKCP18 Met Office projections (Met Office, 2022). The assessment evaluates the risk against both gradual climate change (i.e. chronic risks) and increased frequency and intensity of severe weather events (i.e. acute risks) for selected climate change projections. The climate change scenarios and timeframes used in the assessment are based on those available from the UKCP18 Met Office.

14.3.25 For each risk identified, the asset components impacted are noted and the planned controls identified. In this instance, planned controls represent measures already included in the design and operation of the Proposed Developments that work to mitigate the climate risk.

14.3.26 Once potential impacts are identified, the likelihood and consequence of each impact occurring (taking into consideration planned controls) are assessed for each climate change scenario considered.

14.3.27 The risk framework used in this assessment is based on that provided in the EU Technical guidance. The criteria used to determine the likelihood of an event occurring are detailed in Table 14.3, as stated within the EU Technical guidance. A qualitative and quantitative description has been provided to summarise the output of the likelihood analysis for each of the climate variables and hazards. The consequence of an impact has been measured using the criteria detailed in Table 14.4. The probability and consequence take into account embedded design and impact avoidance measures.

Table 14.3: Description of likelihood for climate change hazard

Likelihood Category	Qualitative description	Quantitative description (%)
Rare	Highly unlikely to occur	5
Unlikely	Unlikely to occur	20
Moderate	As likely to occur as not	50
Likely	Likely to occur	80
Almost certain	Very likely to occur	95

14.3.28 Engagement has been undertaken with relevant environmental disciplines considered within this EIA and the engineering design team to discuss the CCRA and identify adaptation measures for incorporation into the design of the Proposed Developments.

14.3.29 The significance criteria are detailed within paragraph 14.3.39 within the Significance Criteria section.

14.3.30 Measures to adapt the Proposed Developments to climate change hazards are detailed in Section 14.5, and the assessment of effects is detailed in Section 14.6.

Table 14.4: Measure of consequence for climate change risk[6]

Risk areas	Insignificant	Minor	Moderate	Major	Catastrophic
Asset damage/ Engineering/ Operational	Impact can be absorbed through normal activity	An adverse event that can be absorbed by taking business continuity actions	A serious event that requires additional emergency business continuity actions	A critical event that requires extraordinary/ emergency business continuity actions	Disaster with the potential to lead to shut down or collapse or loss of the asset/ network
Safety and Health	First aid case	Minor injury, medical treatment	Serious injury or lost work	Major or multiple injuries, permanent injury, or disability	Single or multiple fatalities
Environment	No impact on baseline environment. Localised in the source area. No recovery required	Localised within site boundaries. Recovery measurable within one month of impact	Moderate harm with possible wider effect. Recovery in one year	Significant harm with local effect. Recovery longer than one year. Failure to comply with environmental regulations/ consent	Significant harm with widespread effect. Recovery longer than one year. Limited prospect of full recovery
Social	No negative social impact	Localised, temporary social impacts	Localised, long-term social impacts	Failure to protect poor or vulnerable groups[7]. National, long-term social impacts	Loss of social licence to operate. Community protests
Financial (for single extreme event or annual average impact) [8]	x % Internal Rate of Return (IRR) < 2 % of turnover	x % IRR 2-10 % of turnover	x % IRR 10-25 % of turnover	x % IRR 25-50 % of turnover	x % IRR > 50 % of Turnover
Reputation	Localised, temporary impact on public opinion	Localised, short-term impact on public opinion	Local, long-term impact on public opinion with adverse local media coverage	National, short-term impact on public opinion; negative national media coverage	National, long-term impact with potential to affect the stability of the government
Cultural Heritage and cultural premises	Insignificant impact.	Short term impact. Recovery or repair.	Serious damage with wider impact to tourism industry.	Significant damage with national and international impact.	Permanent loss with resulting impact on society.

[6] The ratings and values suggested here are illustrative. Phillips 66 and VPI may choose to modify them.
[7] Including groups that depend on natural resources for their income/livelihoods and cultural heritage (even if not considered poor) and groups considered poor and vulnerable (and often that have less capacity to adapt) as well as persons with disabilities and older persons.
[8] Example indicators – other indicators that may be used including costs of immediate / long-term emergency measures; restoration of assets; environmental restoration; indirect costs on the economy, indirect social costs.

ICCI Assessment

14.3.31 Due to the scale and location of the existing VPI Immingham CHP Plant and Phillips 66 Humber Refinery, it is not anticipated there will be any ICCI. An ICCI assessment was therefore scoped out of the assessment at the EIA Scoping stage (see Appendix 1A in ES Volume II).

Rochdale Envelope

14.3.32 A focused use of the Rochdale Envelope approach has been adopted to present a worst-case assessment of potential environmental effects of the different parameters of the Proposed Developments that cannot yet be fixed. The parameters included within the Rochdale Envelope are described in Chapter 3: Project Description, Need and Alternatives (ES Volume I). The Rochdale Envelope approach has specifically been used to estimate embodied carbon for the construction of the Proposed Developments.

Significance

GHG Emissions Impact Assessment

14.3.33 The IEMA guidance on GHG states that the following three principles need to be considered when evaluating the significance:

- all project GHG emissions will contribute to climate change;
- climate change has the potential to lead to significant environmental consequences that may affect all topics in the EIA Directive (e.g. Biodiversity, Water, Landscape, Geology, Air Quality, Human Health); and
- GHG emissions have a combined environmental effect that is approaching a scientifically defined environmental limit, as such that any GHG emissions or reductions from a project might be considered significant.

14.3.34 Based on these principles, the IEMA guidance states that *"the significance of a project's emissions should therefore be based on its **net** impact over its lifetime, which may be positive, negative or negligible"*.

14.3.35 The guidance has identified two major considerations when assessing the significance of a project's GHG emissions: alignment to a trajectory towards net zero by 2050, and mitigation of GHG emissions. It is down to the professional judgment of the practitioner to determine how best to contextualise and assess the significance of a project's GHG impact.

Alignment to 2050 Net Zero Trajectory

14.3.36 The IEMA guidance states that the crux of assessing significance is *"not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050"*. The trajectory of GHG emissions associated with the Proposed Developments has therefore been factored into the assessment criteria.

GHG Mitigation

14.3.37 The IEMA guidance also emphasises the importance of implementing GHG mitigation measures to help minimise GHG emissions, regardless of the magnitude of emissions, and states that the level of mitigation should be used to assess the significance of GHG emissions. This has therefore been factored into the assessment criteria for the GHG assessment.

14.3.38 Based on the above two considerations, and in line with criteria outlined in the IEMA guidance, the following significance table, as shown in Table 14.5, is used to assess the significance of GHG emissions arising as a result of the Proposed Developments.

Table 14.5: Significance of effects for GHGs impact assessment

Effects	Significance level	Description
Significant adverse	Major adverse	• the Proposed Development's GHG impacts are not mitigated; • the Proposed Development has not complied with do-minimum standards set through regulation, nor provide reductions required by local or national policies; and • no meaningful contribution to the UK's trajectory towards net zero.
	Moderate adverse	• the Proposed Development's GHG impacts are partially mitigated; • the Proposed Development has partially complied with do-minimum standards set through regulation, and have not fully complied with local or national policies; and • falls short of full contribution to the UK's trajectory towards net zero.
Not significant	Minor adverse	• the Proposed Development's GHG impacts are mitigated through 'good practice' measures; • the Proposed Development has complied with existing and emerging policy requirements; and • fully in line to achieve the UK's trajectory towards net zero.
	Negligible	• the Proposed Development's GHG impacts are mitigated beyond design standards; • the Proposed Development has gone well beyond existing and emerging policy requirements; and • well 'ahead of the curve' for the UK's trajectory towards net zero.
Beneficial	Beneficial	• the Proposed Development's net GHG impacts are below zero and it causes a reduction in atmosphere GHG concentration; • the Proposed Development has gone well beyond existing and emerging policy requirements; and • well 'ahead of the curve' for the UK's trajectory towards net zero, provides a positive climate impact.

Further contextualisation

14.3.39 It is suggested that sectoral, local, or national carbon budgets can be used, as available and appropriate, to contextualise a project's GHG impact. IEMA guidance (2022) states that the significance of a project should not be determined based on the magnitude of the GHG emissions and whether it will release GHG emissions. It should be concluded by establishing if it will contribute to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero.

CCRA

14.3.40 The identification of likely significant effects on receptors has been undertaken using professional judgement in consultation Phillips 66 and VPI, by combining the measure of likelihood with the predicted consequence of impact, as shown in Table 14.6. As a rule, where an effect has been identified as High or Extreme, this has been deemed significant.

Table 14.6: CCRA Significance Criteria Matrix

Likelihood	Consequence: Insignificant	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Medium	High	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Moderate	Low	Medium	High	Extreme	Extreme
Likely	Medium	High	High	Extreme	Extreme
Almost certain	High	High	Extreme	Extreme	Extreme

14.3.41 The CCRA significance criteria matrix, as shown in Table 14.6, has been taken from the EU Technical guidance (EU, 2021). This matrix and the terminology within in it will be referenced and applied throughout this chapter, however, in order to present a consistent methodology across the EIA, the significance descriptors have been translated to the significance of effect terms provided in Chapter 1: Introduction and EIA Methodology (ES Volume I):

- low = negligible (not significant);
- medium = minor (not significant);
- high = moderate (significant); and
- extreme = major (significant).

Limitations

14.3.42 It is important to understand when using climate change projections that they contain inherent uncertainty. The uncertainty arises from the result of the limitations of the available measurements and the challenges that come from evaluating causation in complex and multi-component processes. This uncertainty presents itself through:

- uncertainty in how GHG emissions will change overtime due to key unknowns in the drivers of this change. Such drivers include economic and population growth, lifestyle and behavioural changes, associated changes in energy use and land use, technology, and climate policy; and
- uncertainty in variable confidence levels in how well the climate models predict different climate variables. For example, climate models perform less well in their simulation of large-scale climate change precipitation patterns than for surface temperature. The certainty in the IPCC's key assessment findings is expressed as a qualitative level of confidence (from very low to very high).

14.3.43 For these reasons it is important to use a range of projection scenarios when considering how climate may change in the future, and to ensure the participants in the risk assessment process and the ultimate user of the risk assessment outcomes are cognizant of the inherent uncertainty.

14.3.44 The Proposed Developments are part of an industrial region providing a key contribution to the UK's strategic aim to achieve a net zero carbon economy by 2050[9]. This includes developing a network to enable neighbouring industrial facilities to be able to capture and store carbon dioxide from their facilities, thereby reducing their emissions. However, these future industrial connection options and corresponding additional carbon reduction benefits

[9] Zero Carbon Humber. https://www.zerocarbonhumber.co.uk/

do not form part of the Proposed Developments and have not therefore been included in this assessment in order to present a conservative assessment.

14.3.45 Grid decarbonisation and the uptake of electric vehicles have been included in the carbon estimations. Decarbonisation of other sectors have not been included and therefore values in this chapter represent a worst-case scenario.

Consultation

14.3.46 The consultation undertaken with statutory consultees to inform this Chapter, including a summary of comments raised via the formal EIA Scoping Opinion (Appendix 1B in Volume II of this ES), and in response to the formal consultation and other pre-application engagement, is summarised in Table 14.7, below.

Table 14.7: Consultation summary table

Consultee or Organisation	Date and nature of consultation	Summary of response	How comments have been addressed in this Chapter
North Lincolnshire Council	March 2022 (Scoping Opinion)	NLC do not have any objections to the approach set out within the EIA Scoping Report at this stage. However, it should be noted that NLC does not have the expertise in some of the methods used in the study. Furthermore, the Environment Agency agree that climate change and carbon should be scoped into the assessment, covering both the effects of emissions from the proposed scheme over its lifetime (including construction) and the resilience of the scheme to climate change impacts.	Table 14.1 details the scope of the GHG emission impact assessment which includes emissions over the lifecycles of the Proposed Developments.
Natural England	March 2022 (Scoping Opinion)	Natural England noted the ES should identify how the development affects the ability of the natural environment (including habitats, species, and natural processes) to adapt to climate change, including its ability to provide adaptation for people. This should include impacts on the vulnerability or resilience of a natural feature (i.e. what's already there and affected) as well as impacts on how the environment can accommodate change for both nature and people, for example whether the development affects species ability to move and adapt. Nature-based solutions, such as providing green infrastructure on-site and in the surrounding area (e.g. to adapt to flooding, drought and heatwave events), habitat creation and peatland restoration, should be considered. The ES	The biodiversity impacts of the Proposed Developments can be found in Chapter 13: Ecology and Nature Conservation. Impact and mitigation measures associated with flooding during the construction and operation stage can be found in the Flood Risk Assessment (FRA) within Appendix 9A in ES Volume II. The CCRA within Appendix 14A in ES Volume II also considers the risks, impacts, mitigation and adaptation measures associated with extreme rainfall and increased storm intensity.

Consultee or Organisation	Date and nature of consultation	Summary of response	How comments have been addressed in this Chapter
		should set out the measures that will be adopted to address impacts.	
Environment Agency (EA)	February 2022 (Scoping Opinion)	The EA noted agreement that climate change and carbon should be scoped into the assessment, covering both the effects of emissions from the proposed scheme over its lifetime (including construction) and the resilience of the scheme to climate change impacts.	Table 14.1 details the scope of the assessment which covers emissions from the Proposed Developments over their lifetimes (including construction).

14.4 Baseline Conditions

Existing Baseline

GHG Emissions Impact Assessment

Direct and Indirect Emissions

14.4.1 The baseline environment for the GHG assessment is a 'business as usual' scenario where the Proposed Developments are not constructed. The baseline comprises existing sources of GHG emissions within the boundary of the existing Sites as described in Chapter 2: Site and Site Surroundings. Emission sources include GHG emissions from electricity consumption, steam consumption, fuel consumption, process emissions, operational waste disposal, transportation of operational waste, vehicle journey associated with current workers and other activities within the Sites.

14.4.2 It is estimated that **3,971,463** and **1,952,318 tCO_2e** are produced at the VPI and Phillips 66 Sites respectively, based on a 2021 baseline as detailed in Table 14.8. The assumptions used in the baseline calculations can be found in Section 14.6.

Table 14.8: Existing baseline (2021): Direct and indirect emissions

Lifecycle stage	Stage Activities	Primary emission sources	Emissions (tCO_2e)	
			VPI	Phillips 66
Operation	Energy consumption	GHG emissions from electricity consumption	0	30,961
		GHG emissions from steam consumption	0	15,571
		GHG emissions from fuel consumption	3,434,120	50,133
	Process emission	GHG emissions from other industrial processes (e.g. chemical and water consumption)	1,675[11]	451,201[10] 3,140[11]

[10] Emissions from the refinery process
[11] Emissions from chemical and water consumption

	Disposal of operational waste	GHG emissions from operational waste disposal	142	257
		GHG emissions from transportation of operational waste		
	Vehicle journeys	GHG emissions from the transport of staff and materials	221	280
	Maintenance	GHG emission from maintenance activities	65	3
	Fugitive	GHG emissions from gas leakage	265	0[12]
	Upstream activities	GHG emissions from the extraction, refining and transportation of natural gas/crude oil	534,976	1,400,771
		Total baseline emissions per Site	3,971,463	1,952,318
		Total baseline for both Sites	5,877,248[13]	

Secondary Emissions

14.4.3 As mentioned in Section 14.3, the secondary effects of a project should be considered. The secondary emissions for the current baseline of VPI and Phillips 66 Sites are detailed in

14.4.4 Table 14.9.

Table 14.9: Existing baseline (2021): Secondary emissions

Emissions sources	Emissions (tCO_2e)	
	VPI	Phillips 66
Use of end products	n/a	9,261,736

14.4.5 The assumptions used in these emission calculations can be found in Section 14.6.

14.4.6 Use of end products considers GHG emissions arising as a result of the use of the end product by third parties. This is an estimate as it is not possible to be certain of the exact use of the produce. These emissions are outside of the direct control of the Applicants and have been reported for transparency. They are not considered a direct or indirect emission arising as a result of the Proposed Developments.

CCRA

14.4.7 The current baseline for the CCRA is based on historic climate data obtained from the Met Office recorded by the closest meteorological station (Hull Climate Station, approximately 14.5 km north of the Sites) for the period 1981-2010 (Met Office UK, 2022a). This baseline period

[12] Phillips 66 quantifies volatile organic compounds (VOCs) as part of fugitive emission reporting. VOCs are not a direct contributor to GHG therefore it has not been included in the carbon estimations.
[13] Phillips 66 purchases steam and electricity from VPI. Emissions from purchased and electricity steam have been removed from the total to avoid double counting.

was chosen as it matches the baseline period the available climate change projections were based on.

14.4.8 The baseline data are listed below in Table 14.10.

Table 14.10: Baseline climate data

Climate Variable	Baseline (1981-2010)
Temperature	
Mean annual maximum daily temperature (°C)	14.03
Mean annual minimum daily temperature (°C)	6.69
Mean summer maximum daily temperature (°C)	20.73
Mean winter minimum daily temperature (°C)	1.97
Days of frost air (days)	32.53
Warmest month on average (°C)	July 21.64
Coldest month on average (°C)	February 1.77
Rainfall	
Mean annual rainfall levels (mm)	679.89
Mean summer rainfall (mm)	61.09
Mean winter rainfall (mm)	53.93
Wettest month on average (mm)	June 66.52
Driest month on average (mm)	February 44.10

14.4.9 A series of risks relevant to the construction and operation of the Proposed Developments have been identified for the climate variables listed in Table 14.2. For each risk identified, the asset components impacted and planned controls were noted. The consolidated risk register is provided in Appendix 14A (Volume II of this ES). The risk assessment is aligned with the climate variables identified below:

- extreme temperatures (heat);
- extreme temperatures (cold);
- extreme rainfall;
- sea level rise;
- storms (high wind and high rainfall);
- windstorms;
- drought; and
- wildfires.

Historic Events

14.4.10 The Met Office historic 10-year averages for the 'East & North-East England' district (which the Sites are considered to fall within by the Met Office grouping) identify gradual but consistent warming from 1971 to 2020, with more than 1°C since the 1970s. There has also been a near consistent increase in rainfall in each decade, as summarised in Table 14.11.

Table 14.11: Historic 10-year Averages for temperature and rainfall for the east and north-east England

Climate period	Mean maximum annual temperatures (°C)	Mean annual rainfall (mm)
1971-1980	12.0	725.6
1981-1990	12.2	748.6
1991-2000	12.6	770.7
2001-2010	13.1	801.8
2011-2020	13.3	806.7

14.4.11 The following events are examples of extreme climate conditions experienced at the two Sites:

- highest recorded temperature recorded within 'East & North-East England' district was 36.3°C on 25th July 2019;
- lowest recorded temperature recorded within 'East & North-East England' district was -23.3°C on 21st January 1881;
- highest 24-hour rainfall within the UK was 341.1 mm on 5th December 2015;
- the Environment Agency (EA) flood map shows that the Phillips 66 Site is within Flood Zone 1 as shown in the Flood Risk Assessment (FRA) within Appendix 9A in ES Volume II. The Phillips 66 Site has flooded from surface water in 2007;
- the VPI Site is within Flood Zone 3 as shown in the FRA within Appendix 9A in ES Volume II but the VPI Site benefits from flood defences. The VPI Site flooded during a tidal surge in 1953. However, this tidal surge event is considered to be an extreme weather event.

Future Baseline

GHG Emissions Impact Assessment

Direct and Indirect emissions

14.4.12 The future baseline captures emissions associated with the 'business as usual' scenario in the future if the Proposed Developments are not constructed. Future decarbonisation of the grid has been included in the baseline based on the Green Book supplementary guidance (HM Government, 2021). These projections show a decrease in electricity emission factors associated with electric vehicles; however, grid decarbonisation is dependent on the implementation of government policies. Based on these projections, it is estimated that **3,971,391** and **1,952,247 tCO_2e** are produced at VPI and Phillips 66 Sites, respectively, based on a 2028 future baseline. This is detailed in Table 14.12.

14.4.13 The key difference between the existing and future baseline is the uptake of electric vehicles. This affects the emissions associated with staff and maintenance contractors commuting journeys. The total emissions for VPI and Phillips 66 decrease by **72 tCO_2e** and **71 tCO_2e** respectively.

Table 14.12: Future baseline (2028): direct and indirect emissions

Lifecycle stage	Stage Activities	Primary emission sources	Emissions	
			VPI	Phillips 66
Operation	Energy consumption	GHG emissions from electricity consumption	0	30,961
		GHG emissions from steam consumption	0	15,571
		GHG emissions from fuel consumption	3,434,120	50,133
	Process emission	GHG emissions from other industrial processes (e.g. chemicals and water consumption)	1,675[11]	451,201[10] 3,140[11]
	Disposal of operational waste	GHG emissions from operational waste disposal	142	257
		GHG emissions from transportation of operational waste		
	Vehicle journeys	GHG emissions from the transport of staff and materials	165	210
	Maintenance	GHG emission from maintenance activities	49	2
	Fugitive	GHG emissions from gas leakage	265	0[12]
	Upstream activities	GHG emissions from the extraction, refining and transportation of natural gas/crude oil	534,976	1,400,771
		Total baseline emission per Site	3,971,391	1,952,247
		Total baseline emissions for both Sites	5,877,106[13]	

Secondary Emissions

14.4.14 The secondary emissions for the future baseline for the VPI and Phillips 66 Sites are detailed in Table 14.13.

Table 14.13: Future baseline (2028): secondary emissions

Emissions sources	Emissions (tCO_2e)	
	VPI	Phillips 66
Use of end products	n/a	9,261,736

CCRA

14.4.15 The future baseline for the CCRA is based on future UK Climate Projections 2018 (UKCP18) as shown in Table 14.14. This projection data provides probabilistic indications of how global climate change is likely to affect areas of the UK using pre-defined climate variables and time periods.

14.4.16 Given the inherent uncertainty surrounding climate change projections, it is recommended that at least two climate change scenarios be reviewed. This provides decision-makers with a more holistic understanding of the range of potential climate futures possible, which is essential when understanding risk and developing appropriate adaptation measures. For this CCRA climate change projections for the short (2010-2039) and medium-term (2040-2069) were adopted.

14.4.17 A high emission scenario has been selected (RCP8.5) as it represents a worst-case scenario, i.e. a 4.3°C temperature increase by 2081 – 2100, where greenhouse gas emissions continue to grow unmitigated. This pathway is also marked by inadequate policy response and increased potential for physical asset damage.

14.4.18 UKCP18 probabilistic projections have been analysed for the 25 km grid square in which the Proposed Developments are located. These figures are expressed as temperature/ precipitation anomalies relative to the 1981-2010 baseline, as this aligns with the period on which the historic weather data from the Met Office is based.

14.4.19 The vulnerability assessment considers an RCP scenario that reflects a high level of GHG emissions at the 10%, 50% and 90% probability levels to assess the impact of climate change over the lifecycle of the Proposed Developments. Presentation of the 10% and 90% probability projections allows for a sensitivity assessment of the climate impacts. A 10% probability result indicates that 10% of model results were below this figure. A 50% probability results indicates that 50% of model results were above and 50% below this figure. A 90% result indicated that 90% of model results were below this figure.

Table 14.14: Climate change baseline and projected data, 50% probability (10% and 90% probability in parenthesis)

Climate Variable	Baseline (1981-2010)	RCP 8.5 (2010-2039)	RCP 8.5 (2040-2069)	Projected Trend	Climate projection source
Temperature					
Mean annual maximum daily temperature (°C)	14.03	+0.8 (+0.3 to +1.4) +14.83 (+14.3 to +15.43)	+1.9 (+0.8 to +3.0) +15.9 (+14.8 to +17.0)	↑	2
Mean annual minimum daily temperature (°C)	6.69	+0.7 (+0.1 to +1.3) +7.4 (+6.8 to +8.0)	+1.7 (+0.7 to +2.9) +8.4 (+7.4 to +9.6)	↑	2
Mean winter minimum daily temperature (°C)	20.73	+0.8 (+0.3 to +1.3) +21.5 (+21.0 to +22.0)	+2.0 (+0.9 to +3.3) 22.7 (+21.6 to +24.0)	↑	2
Mean summer maximum daily temperature (°C)	1.97	+0.6 (-0.1 to +1.4) +2.6 (+1.9 to +3.4)	+1.6 (+0.4 to +3.0) +3.6 (+2.4 to +5.0)	↑	2

Days of frost air (days)[14]	32.53	Reports have shown that the number of frost air and ground frost days have decreased since the 1960s. These long-term trends, combined with detailed studies, point to a long-term warming trend of the UK's climate and a reduction in cold events.		↓	6
Heatwaves (no.)	-	Under a high emissions scenario, it is estimated that by the end of the 21st century, all areas of the UK are projected to be warmer with hotter and drier summers likely to become more common.		↑	5
Warmest month on average (°C)	July 21.64	-	-	-	1
Coldest month on average (°C)	February 1.77	-	-	-	1
Rainfall					
Mean annual rainfall levels (mm)	679.89	+1.2% (-2.1% to +4.6%) 688 (666 to 711)	-1.0% (-7.4% to +5.3%) 673 (630 to 716)	↑↓	2
Mean summer rainfall (mm)	61.09	-4.6% (-18.1% to +10.1%) 58 (50 to 67)	-17.8% (-38.9% to +4.3%) 50 (37 to 63)	↓	2
Mean winter rainfall (mm)	53.93	+2.9% (-5.5% to +11.5%) 56 (51 to 60)	+8.0% (-4.3% to +21.6%) 58 (52 to 66)	↑	2
Wettest month on average (mm)	June 66.52	-	-	-	1
Driest month on average (mm)	February 44.10	-	-	-	1
Heavy rainfall and floods	-	The latest of UK climate projections shows that the UK is expected to experience wetter winters and drier summers. In particular, rain in the summer will likely be more intense then is currently experienced. For example, rainfall from an event that typically occurs once every 2 years in the summer is expected to increase by around 25%.			7
Other					

[14] Number of days when minimum temperature are <0°C

Sea level rise (m)[15]	0	0.12 (0.09 to 0.15)	0.32 (0.24 to 0.41)	↑	3
Storms and storm surges	-	The UKCP18 model suggest a small contribution from storm surges, however it is unclear if the frequency and severity of future storm surges is going to change. Although, rising sea levels due to climate change are expected to worsen the impacts of storm surges.		↑	4
Windstorms	-	The Met Office has projected an increase in near surface wind speeds over the UK for the second half of the 21st century for the winter season when more significant impacts of wind are experienced. However, the increase in wind speeds is modest compared to natural variability from month to month and season to season, so confidence is low.		-	8
Drought/Wildfires	-	The Met Office has projected a trend towards drier summers on average, with generally stronger drying in southern parts of the UK. It also suggested that the drying trend is stronger under a high greenhouse gas emission scenario compared to a low one. However, it is the distribution of rainfall through the seasons that will determine UK drought risk.		↑	9

Projection source:

1. (Met Office UK, 2022a)
2. (UKCP18, 2018a)
3. (UKCP18, 2018b)
4. (Met Office UK, 2018b)
5. (Met Office UK, 2022b)
6. (Met Office UK, 2022c)
7. (Met Office UK, 2022d)
8. (Met Office UK, 2022e)
9. (Met Office UK, 2022f)

[15] Sea level rise is shown relative to a 1981-2000 baseline

14.5 Development Design and Impact Avoidance

GHG Emissions Impact Assessment

14.5.1 Embedded measures that have been developed through the design processes to reduce the negative impacts of GHG during the construction and operational phase are listed in Table 14.15.

Table 14.15: Embedded control measures during construction and operation

Climate Impact Aspect	Purpose of measure	Project stage	Measure description
GHG emissions	Reduce GHG emissions	Construction	Aspects of construction GHG emissions will be managed through the Construction Environmental Management Plans (CEMPs) and related plans including the Site Waste Management Plans (SWMPs). An Outline CEMP is provided in Appendix 4A (Volume II of this ES), and a detailed CEMP will be developed by the appointed contractors at a later stage to measure, monitor and report energy and water consumption and GHG emissions during construction of each Proposed Development. The Outline CEMP includes proposed measures to reduce GHG emissions through: 1. Reducing fuel consumption on site in vehicles, equipment, and plant through minimisation of idling, and switching off when not being used. Preference of lower carbon fuels such as HVO fuel, biodiesel or electric powered plant instead of traditional fossil fuels; 2. Reducing water consumption in the on-site amenity blocks and construction activities (including dampening down as part of dust mitigation); 3. Minimisation of transportation of materials to the Sites, by implementing measures set out in Construction Traffic Management Plan (Appendix 8B ES Volume II); and 4. Setting minimum rates for material recycling and re-use, through a SWMP Reducing construction works by re-using, replacing or upgrading the existing water connection infrastructure on Site, and using techniques such as the 'no dig' trenchless construction where practicable. Consideration in specifying construction materials to options for lower embodied carbon emissions i.e. higher recycled content, where this is reasonably practicable. A strategy to provide 10% Biodiversity Net Gain will be prepared for each Proposed Development.

			Construction staff are anticipated to travel to the Proposed Developments via the existing road and local networks. Minimisation of emissions through worker commuting by: 1. Encouraging group transport by the provision of minibuses; 2. Encouraging car sharing by the provisions of car share schemes; 3. Provision of facilities for cyclists; 4. On-site storage to reduce the number of tools and PPE workers would need to carry each day. This would assist those considering cycling or car sharing; and 5. Provision of information on public transport links.
GHG emissions	Reduce GHG emissions	Operation	The purpose of the Proposed Developments is to capture carbon from existing industrial processes. By overall design, the Proposed Developments offer the opportunity to reduce the carbon emissions emitted from the existing Humber Refinery FCC and the VPI Immingham CHP Plant and aid decarbonisation of the grid electricity supplied to the national grid. The Proposed Developments will capture at least 95% of the carbon dioxide from the FCC stack. Captured CO_2 will be compressed and then pumped by a third party into an offshore store instead of being released to the atmosphere. Measures that could further reduce GHG emissions during operation include: 1. Reducing materials, such as through capturing and re-using steam; 2. Reducing energy spent on transportation, through bulk delivery of materials such as chemicals; 3. Reducing energy spent on lighting, through reducing light spill; 4. Reducing emissions associated with operational worker commuting - sustainable forms of travel will be promoted including provision of cycle storage areas; 5. Reinstating natural carbon sinks, through habitats lost as a result of the Proposed Developments; and 6. Reducing energy loss from inefficient plant and vehicles, regular planned routine maintenance inspections.

CCRA

14.5.1 Each climate variable identified within the design, construction and operation stage has undergone a risk assessment to determine the impacts and risk ratings of each climate variable, e.g.: extreme temperatures (heat) causing overheating, on the identified asset components of the Proposed Developments, as shown in Appendix 14A (ES Volume II). These were discussed in a workshop held with representatives from VPI and Phillips 66 in July 2022, along with the mitigation measures within the current design that mitigate the identified risks. Table 14.16 lists the mitigation measures identified in the workshop.

Table 14.16: Construction and operation mitigation measures

Climate variable	Mitigation measures
Construction	
Extreme temperatures (heat)	-The Contractor will monitor weather forecasts and plan works accordingly, protecting workers and resources from any extreme weather conditions.
Extreme rainfall	- Suitable storage and bunding of pollutants to protect from high rainfall events. This will be further supported by the Site Emergency Response Plan
Sea level rise	- Appropriate surface water drainage and attenuation will be provided for the construction phase to manage the risk of flooding.
Storms	- The Contractor will monitor weather forecasts and receive Environment Agency flood alerts and plan works accordingly, protecting workers and resources from any extreme weather conditions such as storms, flooding
Operation	
Extreme temperatures (heat)	- Some cabling will be buried underground, insulating against overheating in times of heatwaves. -All buildings would be designed to UK standards and specifications. Electrical equipment designed to operate in temperatures of up to 40º C. -The refinery/power plant is designed to operate over a large range of ambient conditions. -Maintenance inspections planned for operation. -The carbon capture facility is designed to operate over a large range of ambient conditions. For example, the air-cooled exchangers would not be adversely affected by increased average air temperature. - No embedded planned controls for extreme temperatures (e.g. 40+ degrees). -Detailed design of air conditioning units for offices would include an allowance for future rise in ambient temperature. -All buildings would be designed to UK standards and specifications.
Extreme temperatures (cold)	- Good plant design, heat tracing of any lines susceptible to freezing.

Climate variable	Mitigation measures
	- Winterisation of plant instruments (good instrument design)
Extreme rainfall	- Suitable storage and bunding of pollutants to protect from high rainfall events. Supported by a Site Emergency Response Plan
Sea level rise[16]	- Installation of a suitable sustainable surface water drainage network and management system (SuDS) to protect the Proposed Development from high rainfall events. - Flood Resistance and Resilience Measures to be implemented, including: i. pipelines and storage tanks designed to withstand the water pressures associated with high return period event flooding; ii. tanks securely tethered in such a way to ensure the infrastructure remains secure should flooding occur; iii. electrical supply entering the Proposed Development from height and down to required connections; iv. flood proofing including the use of water-resistant coatings, use of galvanised and stainless-steel fixings and raising electrical sockets and switches; v. suitable waterproofing measures to development located below ground i.e. tanking below ground storage areas etc. vi. make use of Environment Agency flood warnings and alerts; and vii. define emergency access and egress route. - The Flood Risk Assessment (FRA) has considered climate change within its assessment. It has assessed the Proposed Developments based on a 'high emissions' future scenarios including increases in extreme rainfall, flood flow and flash flood times. - A new, separate foul and surface water drainage system will be constructed for the Phillips 66 and VPI site. Further details on the design of the drainage system, including attenuation, restricted discharge to South Killingholme Drain and accounting for climate change (factor of 25%) is provided in the Drainage Strategy presented as Annex C in the FRA within Appendix 9A in ES Volume II. - All buildings would be designed to UK standards and specifications -Maintenance inspections planned for operation.
Storms	- Wind loadings are considered within the design of plant.

[16] VPI only.

Climate variable	Mitigation measures
	- Quality control during construction to secure at risk lagging. -The Flood Risk Assessment (FRA) considers climate change considerations of the 'high end' future scenarios including increases in extreme rainfall, flood flow and flash flood times. - Maintenance inspections planned for operation. - Procedures in place for extreme weather events (including wind) e.g. minimise maintenance during high wind events. - Lightning protections (rods) built into structures. Structures are also earthed. - Redundancy in power supply from grid connection as back-up. - Further redundancy included in electrical expansion design. - In built protection measures to allow for safe shutdowns (fail-safe).
Windstorms	- Dust control management measures to be employed if required across the site e.g. operators to wearing higher level eye protection on windy/days. - Housekeeping measures in place e.g. site washdown. - Routine air-cooled exchanger cleaning program.
Drought	-Pavement design to allow for anticipated range of soil moisture levels -Maintenance inspections planned for operation.
Wildfires	- Vegetation cleared around site - Fire detection and protection built into the design of the plant e.g. fire hydrants; ring main of water - Site Emergency Response Plan & Team to manage and control fire risk

14.6 Likely Impacts and Effects of the Proposed Developments

GHG Emissions Impact Assessment

Construction Phase

14.6.1 This section presents findings of the GHG impact assessment for the construction of the Proposed Developments. It identifies any likely significant effects that are predicted to occur and then highlights the mitigation and enhancement measures that are proposed to minimise any adverse significant effects.

14.6.2 In order to assess the magnitude of the climate change impacts as a result of GHG emissions associated with construction of the Proposed Developments, the GHG emissions that would be associated with the Proposed Developments activities are calculated based on the assumptions listed below. These are divided into 3 groups: (1) Proposed Phillips 66 Development assumptions, (2) Proposed VPI Development assumptions, and (3) Shared assumptions.

- Proposed Phillips 66 Development:
  - the construction programme is anticipated to start in the second quarter of 2024 and end in the fourth quarter of 2027;
  - Phillips 66 has estimated 10,640 trips to the Phillips 66 construction site;
  - as detailed within Chapter 16: Waste and Materials (ES Volume I), cut and fill is anticipated to be balanced for the Proposed Philips 66 Development with no off-site management of material; and
  - the existing gas refinery will be running during the construction of the Proposed Phillips 66 Development.
- Proposed VPI Development:
  - the construction programme is anticipated to start in the third quarter of 2024 and end in second quarter of 2028;
  - VPI has estimated 12,550 trips to the VPI construction site;
  - as detailed within Chapter 16: Waste and Materials (ES Volume I), cut and fill is anticipated to be unbalanced for the Proposed VPI Development with a total of 133,550 m^3 of material requiring off-site management. It has been assumed to be sent to landfill as the worst-case scenario; and
  - the existing CHP Plant will be running during the construction of the PCC.
- Shared assumptions:
  - where sufficient detail was available; volumes of materials were provided by the Applicants and converted to carbon using emission factors from the ICE and EcoInvent database;
  - Using the worker location distribution from Chapter 8: Traffic & Transport (ES Volume I), an average distance for construction worker transport was estimated. The one-way distance was estimated to be 45 km. It is assumed all transport has an occupancy rate of 1 per vehicle;
  - based on the Climate Change Committee's report on UK's transition to electric vehicles (EV)[17], it has been estimated that 55% of all vehicles will be EV by 2032

[17] including battery, electric and plug-in hybrid models

and 100% by 2050 in order to reach net zero (Climate Change Committee, 2020). This has been considered within the transport emissions. Plugged-In Hybrid vehicles have been assumed for EVs and petrol cars have been assumed for non-EV;

- for material product transport, the following has been assumed based on percentage of material weight:
  - 40% of total weight to be transported within the UK via HGV;
  - 20% of total weight to be transported from the EU via HGV;
  - 20% of total weight to be transported from EU via ship;
  - 10% of total weight to be transported from the Far East via ship;
  - 10% of total weight to be transported from the US via ship.
- an emission factor for water supply to the Sites has been added, which has been assumed to be 72.5 litres per construction worker, per day which is half of the average daily water use in England (Discover Water, 2022). An emission factor for wastewater treatment has also been added, assuming that 90% of the water supply will require treatment;
- energy usage on-site has been estimated based on a median on-site emission rate of 1400 kg CO_2 per £100k for each Site (RICS, 2017). This benchmark includes energy consumption for site accommodation, plant use and the impacts associated with any waste generated through the construction process, its treatment and disposal. This figure is likely to be conservative in consideration of the Development Design and Impact Avoidance measures to use lower carbon fuels such as HVO fuel, biodiesel or electric powered plant instead of traditional fossil fuels;
- material waste quantities have been estimated based on the material quantities provided. Aligned with the Chapter 16: Waste and Materials, a 5% wastage rate has been applied for aggregate, soil and concrete. For metals, no wastage rate has been applied assuming that all metal products will be manufactured off-site. A landfill emission factor has been used to assume a worst-case scenario; and
- grid decarbonisation has also been applied to the EV emission factors.

14.6.3 As detailed in Table 14.17, using the listed inclusions and exclusions, the total construction related GHG emissions from the Proposed Developments are calculated to be around **124,562 tCO_2e** with the majority of emissions being associated with the embodied carbon of construction materials.

Table 14.17: Construction GHG emissions

Lifecycle stage	Project activity	VPI		Phillips 66	
		Emissions (tCO_2e)	%	Emissions (tCO_2e)	%
Production of materials	Raw material extraction and manufacturing of products required to build the Proposed Developments	47,263	48	20,519	79
	Transport of materials to site	33,811	34	1,202	5
Construction process	On-site construction activities	12,551	13	4,016	15

Construction Worker commuting	251	0.3	213	1
Disposal of construction waste	4,735	5	0.47	0.002
Total for each Site	98,611		25,951	
Grand total for both Sites	124,562			

14.6.4 For the Proposed VPI Development, embodied carbon in construction materials accounts for the highest proportion of overall GHG construction emissions with 48%, followed by transportation of construction materials representing 34% and on-site construction activities representing 13%.

14.6.5 For the Proposed Phillips 66 Development, embodied carbon in construction materials accounts for the highest proportion of overall GHG construction emissions with 79%, followed by on-site construction activities representing 15% and transportation of construction materials representing 5%.

14.6.6 The Proposed Phillip 66 Development's emissions are lower in comparison to Proposed VPI Development's emissions because the scale of the Proposed Phillips 66 Development is smaller and therefore less material is required for construction.

14.6.7 As detailed within the assumptions above, the Phillips 66 FCC and VPI CHP plant will be running during the construction of the PCC plants. Table 14.18 below are the resultant emissions during the construction period which includes the construction of the Proposed Developments and emissions from ongoing running the FCC and CHP Plant.

Table 14.18: Construction period resultant emissions

	VPI	Philips 66
Construction period (months)	45	44
Total construction GHG emissions of PCC (tCO_2e)	98,611	25,951
Total operation GHG emissions of refinery/CHP plant (tCO_2e)[18]	14,892,828	7,158,361
Resultant GHG emissions during the construction period (tCO_2e)	14,991,439	7,184,312

Operation Phase

14.6.8 This section presents findings of the GHG impact assessment for the operation of the Proposed Developments. It identifies any likely significant effects that are predicted to occur and then highlights the mitigation and enhancement measures that are proposed to minimise any adverse significant effects.

14.6.9 In order to assess the magnitude of the climate change impacts as a result of GHG emissions associated with operation of the Proposed Developments, the GHG emissions that would be associated with the project activities are calculated based on the assumptions listed below. These will be divided into 3 groups: (1) Proposed Phillips 66 Development assumptions, (2) Proposed VPI Development assumptions, and (3) Shared assumptions.

- Proposed Phillips 66 Development:

[18] Emissions within direct and indirect responsibility

- the Proposed Phillips 66 Development is estimated to be operational for an average of 8,117 hours per year for at least 25 years3. The number of current operational hours is 8,760 hours.
- the CO_2 emission intensity associated with the operation of the industrial facility per tonne of product following the installation of carbon capture value was obtained from the Phillips 66. The emission intensity associated with the operation of the FCC stack was estimated to be 11 $kgCO_2$/metric tonne product.
- if the industrial plant operates without the Proposed Phillips 66 Development, the carbon intensity associated with the operation of the FCC stack is approximately 177 $kgCO_2$/ metric tonne product;
- emissions from fuel consumption and the refining process have been estimated based on the CO_2 emission intensity of the industrial stack and amount of product produced per year provided by Phillips 66. It has been assumed that 10% of the industrial stack emissions are from combustion of fuel consumed and the rest from the refinery process. The emissions from the refinery process have been categorised under 'other industrial process' emissions. This has been applied to the existing and future baselines, as well as operational estimations.
- the electricity consumed by Phillips 66 has been purchased from VPI. Emissions from electricity consumption has been estimated based on the purchased energy from VPI and an emission factor representing VPI's emission intensity. The emission factor was estimated based on VPI's direct emissions and total output (electricity and steam included).
- the steam consumed by Phillips 66 has been purchased from VPI. Emissions from steam consumption has been estimated based on a steam emission rate derived from VPI's emission factor.
- data from other industrial process (e.g. chemical and water consumption) have been provided by Phillips 66. Emission factors from the Life Cycle Analysis (LCA) software, Simapro and an underlying database, EcoInvent, have been used to estimate the emissions generated from the chemical consumption of the carbon capture unit. Emission from water consumption have been estimated based on the water supply and treatment emission factor obtained from BEIS;
- the operational waste for the Phillips 66 Site with PCC is estimated to be the following:
  - industrial waste: 550 tonnes/year;
  - wet scrubber waste: 1,300 tonnes/ year;
  - TRU waste: 300 tonnes/ year; and
  - wet catalyst fines: 300 tonnes/ year.
- the operational waste has been assumed to be sent to landfill as the worst-case scenario;
- the current waste for the Phillips 66 is estimated to be 550 tonnes/year of industrial waste. The waste has also assumed to be sent to landfill;
- the number of operational staff per day is estimated to be 104;
- data from operational maintenance activities has been provided by Phillips 66. The number of contractors required for the new maintenance schedule has assumed to be 29 per year. The number of maintenance contractors for the current maintenance schedule has assumed to be 16 per year. The number of outage days for the FCC is estimated to be 47 days over 5 years. The number of outage days for the carbon capture unit is also estimated to be 47 days over 5 years to mirror FCC outage duration. The distance travelled by maintenance contractors during operation has

been assumed to be the same distance travelled by construction workers, estimated to be 45km.

- fugitive emissions for the carbon capture unit have been provided by Phillips 66. They have been estimated to be 5 tCO_2e per year;
- the fugitive emissions for the current baseline are estimated to be none. The fugitive emissions are voltaic organic compounds and hence are not direct contributor to GHG therefore it has been scoped out of this assessment;
- the upstream Well to Tank (WTT) emissions for Phillips 66 accounts for the following sources (as shown in Plate 14.3):
  - extraction of refinery feed stock;
  - transportation of feeds stock from source to Phillips 66 refinery;
  - refining process; and
  - transportation of raw fuel from the Phillips 66 refinery to end users.
- the GHG emission intensity of the refining process for the existing baseline has been provided by Phillips 66. An average WTT emission factor of 629 $kgCO_2e$/tonne has been estimated based on Phillips 66 fuel products. The emission factors have been obtained from BEIS. To calculate the remaining extraction and transportation emissions associated with the raw fuel, the emission intensity of Phillips 66 Refinery is subtracted from the WTT emission factor. This residual value represents the extraction and transportation associated with raw fuel sources for the existing baseline.

  Residual factor = ***629 $kgCO_2e$/tonne - 177 $kgCO_2e$/tonne***

  = 452 $kgCO_2e$/tonne

  452 $kgCO_2e$/tonne accounts for remaining emissions in the upstream and downstream of the Phillip 66 Refinery.

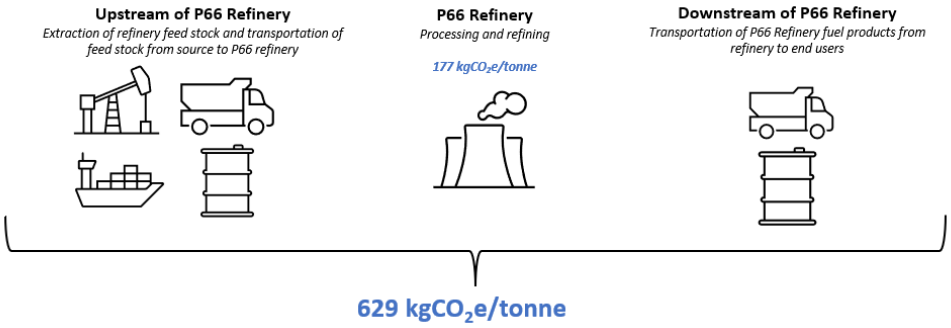


Plate 14.3 Illustrative diagram of the Phillips 66 Well to Tank emissions

- The upstream emissions for the operation baseline with the Proposed Phillips 66 Development has been scaled accordingly based on the reduction in operational hours. This factor remains constant throughout the operation of Proposed Phillips 66 Development.
- Secondary emissions have been estimated based the downstream supply chain. The downstream emissions within Proposed Phillips 66 Development have been estimated using an average emission factor based on the on Phillips 66 fuel products. This is based on the assumption that all fuel products produced by the refinery has been used. Transportation and distribution of products has assumed to be minimal, therefore it has been excluded from this assessment.

- Proposed VPI Development:

- the Proposed VPI Development is estimated to be operational 8,322 hours per year. This is the same number of operational hours assumed for current operations;
- the mass flow rate for the mixed flue gas per train in the current CHP Plant is 2,630,000 kg/hour. The mass flow rate of carbon dioxide is estimated based on its molar weight;
- VPI does not purchase any electricity or steam as it generates its own, therefore emissions from electricity and steam consumption have been assumed to be zero;
- data from other industrial process (e.g. chemical and water consumption) have been provided by VPI. Emission factors from the Life Cycle Analysis (LCA) software, Simapro and an underlying database, EcoInvent, have been used to estimate the emissions generated from the chemical consumption of the carbon capture unit. Emission from water consumption have been estimated based on the water supply and treatment emission factor obtained from BEIS;
- the operational waste for the VPI Site per year is estimated to be the following:
  - industrial waste: 379 tonnes;
  - O_2 Catalyst removal: 4 tonnes;
  - activated carbon: 7 tonnes;
  - dehydration desiccant: 6 tonnes; and
  - amine reclaimer waste: 2,760 tonnes.
- the operational waste has been assumed to be sent to landfill as the worst-case scenario;
- the current waste for the VPI is estimated to be 300 tonnes/year of industrial waste. The waste has also assumed to be sent to landfill;
- the number of operational staff per day is estimated to be 120. This includes the existing 70 staff and proposed 50 staff once the Proposed VPI Development is operational;
- emissions generated from operational maintenance activities has been based on information provided by VPI. The number of contractors required for the new maintenance schedule has assumed to be 280 per outage day. The number of outage days is estimated to be 24 days per year. The number of contractors for the current maintenance scheduled has assumed to be 140 per outage day.
- the fugitive emissions for the Proposed VPI Development have been estimated to be 40.2 tCO_2/year. The fugitive emissions for the current VPI CHP Plant have been estimated to be 265 tCO_2e.
- the upstream emissions associated with extraction, refining and transportation of the raw fuel sources to the VPI Site, are based on the on the fuel gas consumption and ‘Natural Gas with 100% mineral blend’ WTT emission factor obtained from BEIS;

- Shared assumptions:
  - the Proposed Developments are capable of capturing 95% of the CO_2 produced by the existing installations;
  - the grid import electricity estimations accounts for the decarbonisation of the grid based on values provided by the Green Book;
  - worker commuting has been included in this estimate using current estimates of required operational staff. This is on the assumptions that 100% of workers will travel by car with an occupancy of 1 person per vehicle. It has been assumed that staff

live locally and will travel a distance of 20 km (one-way). This is in line with the Grimsby Travel to Work Area identified in Chapter 17: Socio-Economic.

- maintenance contractor commuting has been included in this carbon assessment. This is on the assumptions that 100% of workers will travel by car with an occupancy of 1 person per vehicle. It has been assumed that the maintenance contractors will travel a distance of 45 km (similar to construction workers).
- based on the Climate Change Committee's report on UK's transition to electric vehicles (EV)[17], it has been estimated that 55% of all vehicles should be EV by 2032 and 100% by 2050 in order to reach net zero (Climate Change Committee, 2020). This has been considered within the transport emissions. Plugged-In Hybrid vehicles have been assumed for EVs and petrol cars have been assumed for non-EV; and
- it has been assumed that 5% of the total construction materials will be replaced within the Proposed Developments' design lives (25 years). Concrete has been estimated to have a longer design life than 25 years therefore it has been excluded from the material replacement estimations.

Direct and Indirect Emissions

14.6.10 As detailed in Table 14.19, using the listed inclusions and exclusions, the total operational GHG emissions from the Proposed Developments in their opening year (2028) are estimated to be **2,056,748 tCO_2e**. Operational emissions for the Proposed Developments are estimated to decrease each year due to decarbonisation of the grid. **171,706 tCO_2e** in Table 14.19 represents the emissions emitted into the atmosphere after 95% of carbon emissions are captured from the fuel consumed by the turbines and boilers at the VPI CHP Site**. 23,226[19] tCO_2e** represents the emissions emitted into the atmosphere after 95% of the carbon emissions are captured from the refining process at the Phillips 66 Site.

14.6.11 Plate 14.4 and Plate 14.5 below illustrate the emissions sources on both Proposed Development Sites in their first year of operation.

Table 14.19: Operation of the Proposed Developments (2028): direct and indirect emissions

Lifecycle stage	Stage Activities	Primary emission sources	Emissions (tCO_2e)	
			VPI	Phillips 66
Operation	Energy consumption	GHG emissions from electricity consumption	0	3,916
		GHG emissions from steam consumption	0	5,625
		GHG emissions from fuel consumption	171,706	2,323
	Process emission	GHG emissions from other industrial processes (e.g. chemical and water consumption)	3,849[11]	20,904[10] 21,484[11]
	Disposal of operational waste	GHG emissions from operational waste disposal	1,474	1,144

[19] Sum of emissions from fuel consumption and the refinery process

	GHG emissions from transportation of operational waste		
Vehicle journeys	GHG emissions from the transport of staff and materials	283	245
Maintenance	GHG emission from maintenance activities	118	14
Fugitive	GHG emissions from gas leakage	305	5
Upstream activities	GHG emissions from the extraction, refining and transportation of natural gas/crude oil	534,976	1,297,920
Total 2028 operational emissions per Site		712,710	1,353,579
Total 2028 operational emissions for both Sites		2,056,748[13]	

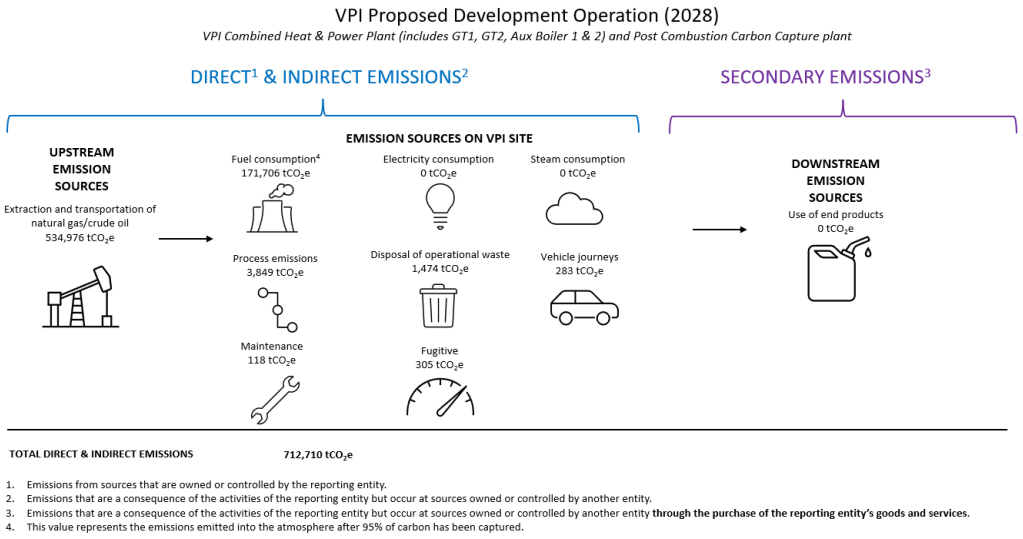


Plate 14.4 Diagram of the Proposed VPI Development operational emissions

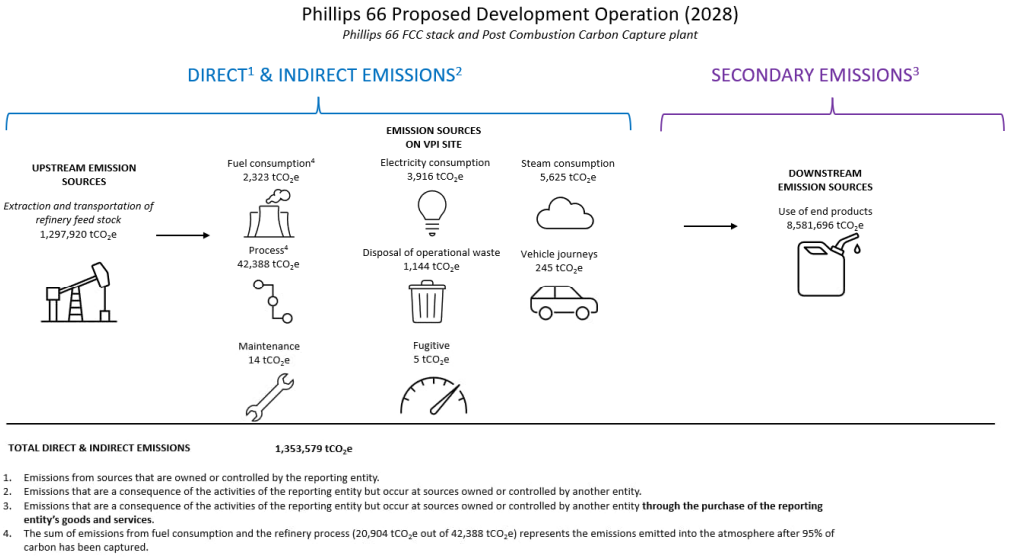


Plate 14.5 Diagram of the Proposed Phillips 66 Development operational emissions

14.6.12 The direct and indirect emissions in Table 14.20 below represent Phillip 66's alternative scenario where the construction of VPI's PCC plant does not proceed. The GHG emissions from electricity and steam consumption will be the same as those listed in the Future Baseline Table 14.12. Process, operational waste, vehicle journeys, maintenance, fugitive and upstream activities emissions will remain the same as Table 14.19. The total operational emissions increase by **36,991 tCO_2e** to **1,390,570 tCO_2e** in the alternative scenario.

Table 14.20 Phillips 66 alternative scenario (2028): direct and indirect emissions

Lifecycle stage	Stage Activities	Primary emission sources	Emissions (tCO_2e)
			Phillips 66
Operation	Energy consumption	GHG emissions from electricity consumption	30,916

	GHG emissions from steam consumption	15,571
	GHG emissions from fuel consumption	2,323
Process emission	GHG emissions from other industrial processes (e.g. chemical and water consumption)	20,904[10] 21,484[11]
Disposal of operational waste	GHG emissions from operational waste disposal	1,144
	GHG emissions from transportation of operational waste	
Vehicle journeys	GHG emissions from the transport of staff and materials	245
Maintenance	GHG emission from maintenance activities	14
Fugitive	GHG emissions from gas leakage	5
Upstream activities	GHG emissions from the extraction, refining and transportation of natural gas/crude oil	1,297,920
Total 2028 operational emissions per Site		1,390,570

14.6.13 In the scenario where the construction of Phillips 66 PCC plant does not proceed, the operational emissions for VPI remain unchanged.

Secondary Emissions

14.6.14 The secondary emissions for the operation of the Proposed Developments are detailed Table 14.21.

Table 14.21: Operation of the Proposed Developments (2028): secondary emissions

Emissions sources	Emissions (tCO_2e)	
	VPI	Phillips 66
Use of end products	n/a	8,581,696

14.6.15 As mentioned in Section 14.6 , the secondary emissions produced by the Phillips 66 Site has been estimated based on the consumption of fuel by end users. These emissions will be released into the atmosphere and contribute to global warming.

14.6.16 However, as detailed within the *Jet Zero Strategy* (DfT, 2022), Phillips 66 has started producing and providing the first commercially produced sustainable aviation fuel (SAF) in the UK. SAF reduces the amount of carbon emitted over the lifecycle of the fuel compared to the traditional fuel used for planes and jets. As the technology for SAF production improves, there is the potential for the secondary emissions associated with Phillips 66 to decrease over time.

Whole Life Emissions

14.6.17 Table 14.22 below shows the difference in emissions between baselines per Site. When the Proposed Developments are installed and fully operational, they are able to capture 82% and

31% of VPI and Phillips 66 total emissions respectively. Without upstream emissions, the carbon capture percentage increases to 95% and 90% for VPI and Phillips 66 respectively.

Table 14.22: Difference in emissions between assessment scenarios

	2021 Existing 'Do Nothing' Baseline (tCO_2e)	2028 Future 'Do Nothing' Baseline (tCO_2e)	2028 Operational Baseline with Carbon Capture Plant (tCO_2e)	Carbon capture rate
With emissions from supply chain				
VPI	3,971,463	3,971,391	712,710	82%
Phillips 66	1,952,318	1,952,247	1,353,579	31%
Without emissions from supply chain				
VPI	3,436,487	3,436,415	177,735	95%
Phillips 66	551,548	551,476	55,659	90%

14.6.18 When fully installed and operational, the Proposed Phillips 66 Development would capture 95% of the flue gases directly emitted from the FCC stack at the Phillips 66 Humber Refinery. When factoring in other emission sources identified at the Proposed Phillips 66 Development such as electricity, steam, waste, maintenance etc, the direct carbon capture rate, relative to baseline conditions, reduces to 90%. The overall carbon capture rate is further reduced to 31% when upstream and downstream emissions from the wider value chain are taken into account. These are emissions associated with the extraction, refining and transportation of the refinery feedstock and products, over which Phillips 66 have less control[20].

14.6.19 When fully installed and operational, the Proposed VPI Development would capture 95% of the flue gases directly emitted from the CHP plant at the VPI site. When factoring in other emission sources identified at the Proposed VPI Development such as waste, maintenance etc, the direct carbon capture rate, relative to baseline conditions, is estimated to be 95%. The overall outputs of VPI remain unchanged after the construction of the PCC plant therefore the carbon capture rate % remains unchanged. The overall carbon capture rate is reduced to 82% when upstream emissions from the wider value chain are taken into account. These are associated with the extraction, refining and transportation of the natural gas over which VPI have less control.

14.6.20 The Proposed VPI Development has a higher overall carbon capture rate of 82% in comparison with the Proposed Phillips 66 Development's overall carbon capture rate of 31% because relative to the overall emissions, VPI has a lower proportion of emissions from the supply chain.

[20] This does not include emissions from the combustion refinery products by end users.

14.6.21 Plate 14.6: and Plate 14.7: show the difference in emissions between the 'Business as usual' scenarios and the proposed development scenarios for the VPI and Phillips 66 Sites, respectively.

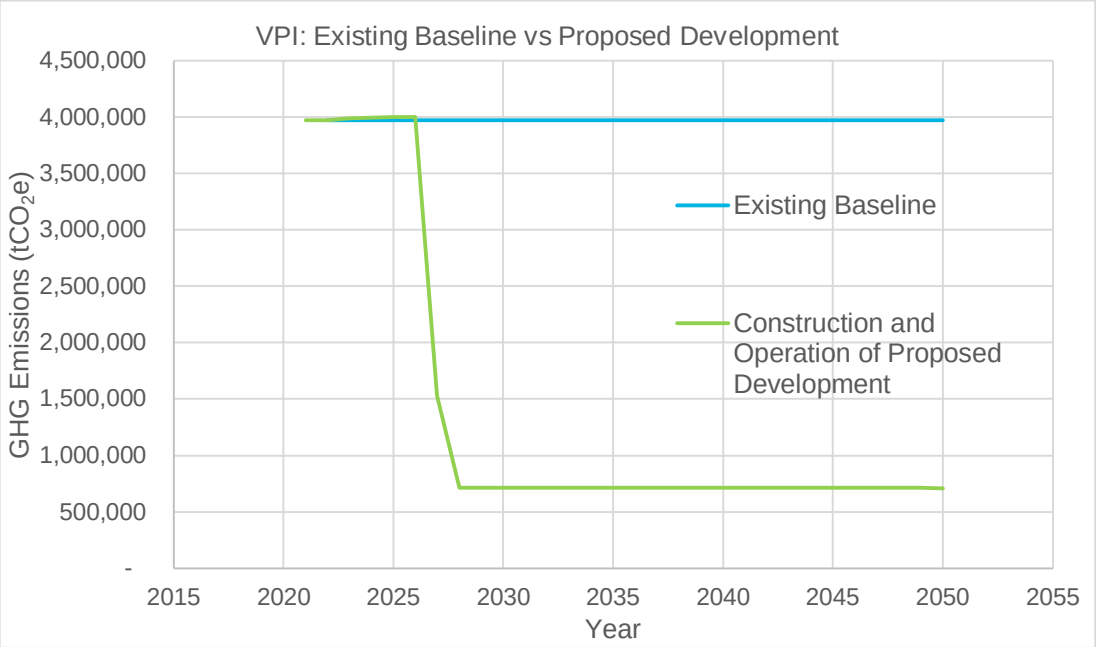


Plate 14.6: VPI: existing baseline vs with the Proposed VPI Development

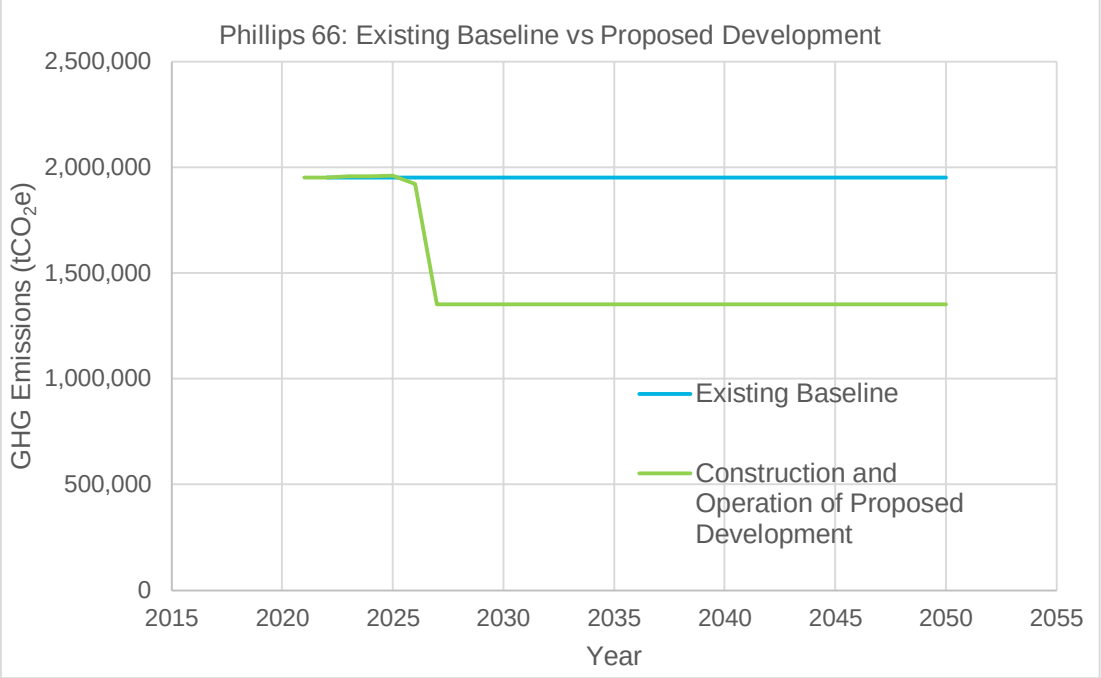


Plate 14.7: Phillips 66: existing baseline vs with the Proposed Phillips Development

Significance

Alignment to 2050 Net Zero Trajectory

14.6.22 The assessment of significance of GHG emissions from the Proposed Developments has been undertaken in accordance with the IEMA guidance. The guidance states that a project should be considered in terms of its compatibility with the UK's net zero trajectory. Based on the Climate Change Committee's *The Sixth Carbon Budget*, the UK's net zero trajectory, based on a balanced pathway, is presented in Plate 14.8. According to the report, the Balanced Net Zero Pathway represents 'a decisive transition to Net Zero, with over 60% of the necessary reduction to Net Zero achieved in the coming 15 years and the fastest rate of decarbonisation occurring in the early 2030s'.

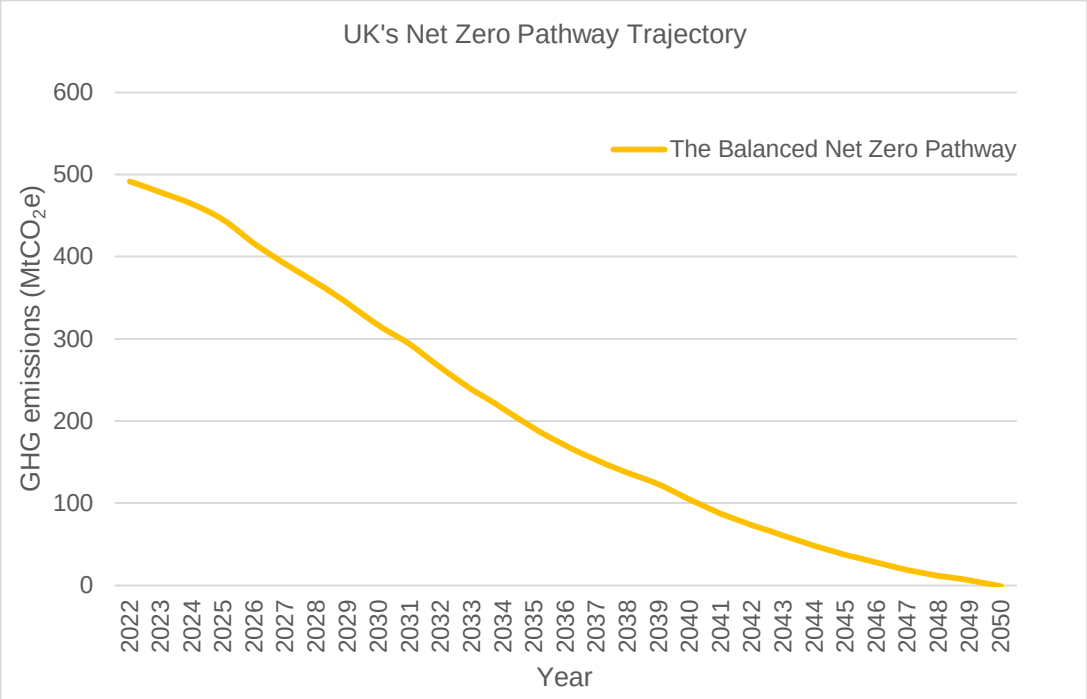
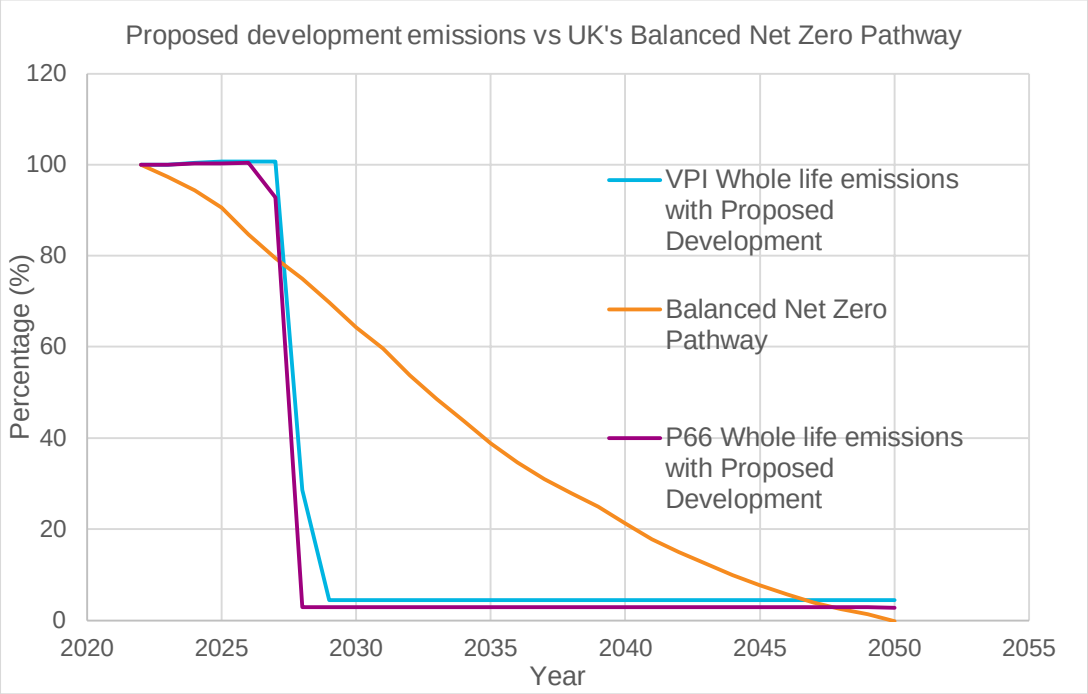


Plate 14.8 UK's Balanced Net Zero Pathway and projected trajectory to 2050

14.6.23 The emissions for the Proposed Developments are presented in



14.6.24 Plate 14.9 and Plate 14.10 with the Balanced Net Zero Pathway projection and trajectory to 2050. The emissions values and the projected trajectory have been summarised into an index graph which shows the percentage changes for each Site and scenario based on a selected point. The selected point was chosen to be a 100.

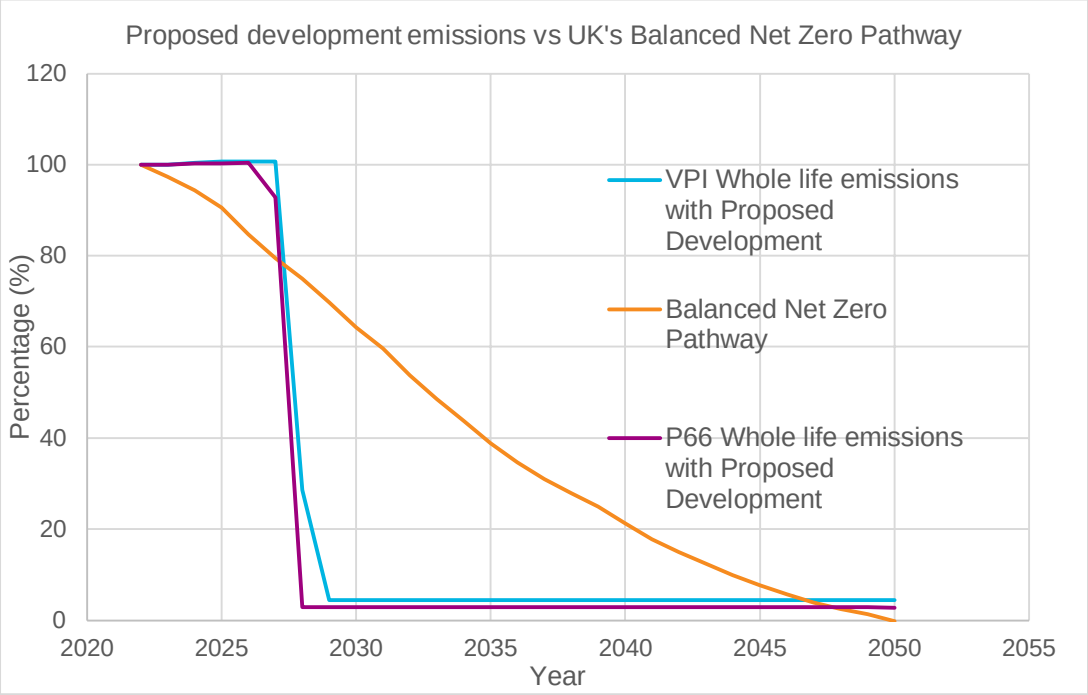


Plate 14.9: Proposed Developments (no upstream emissions) against the UK's Balanced Net Zero Pathway

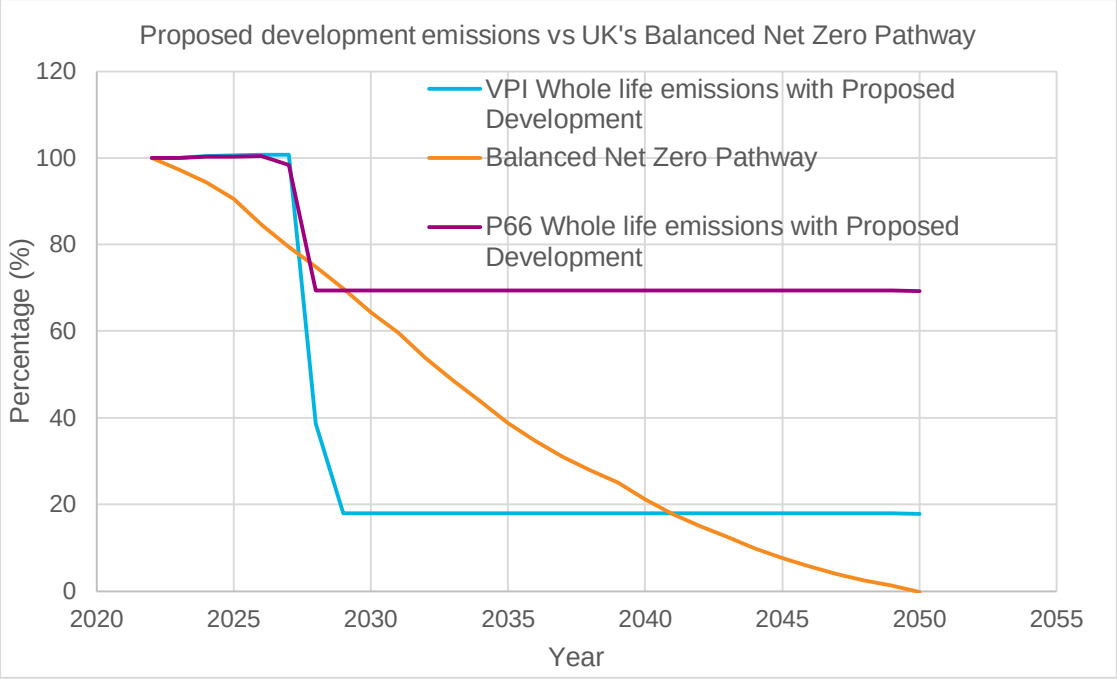
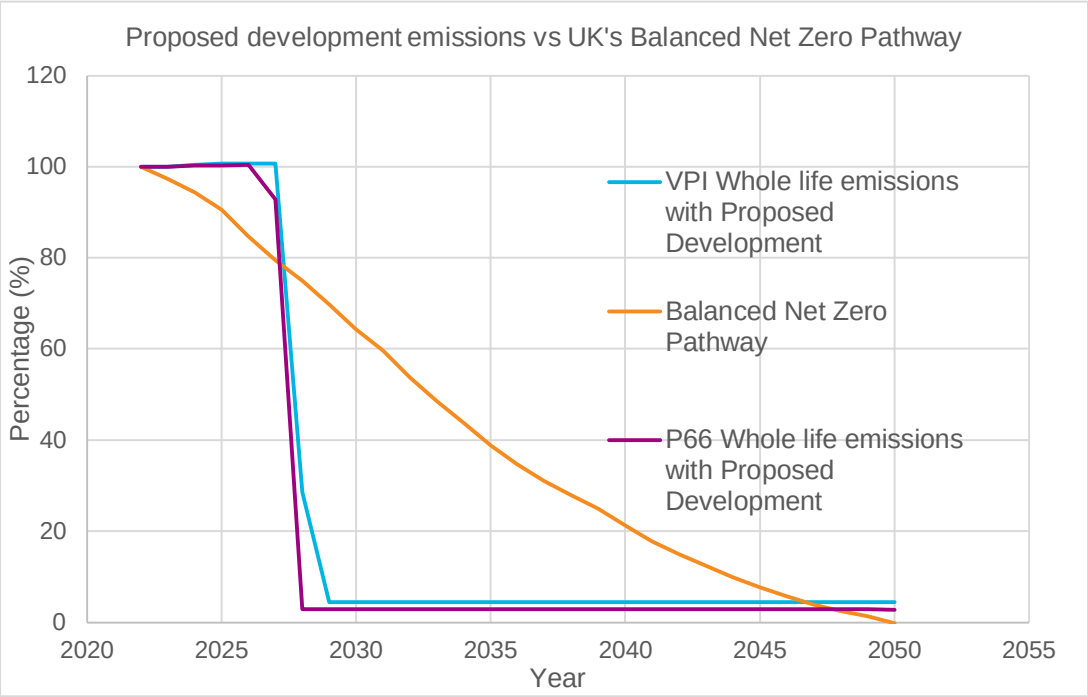
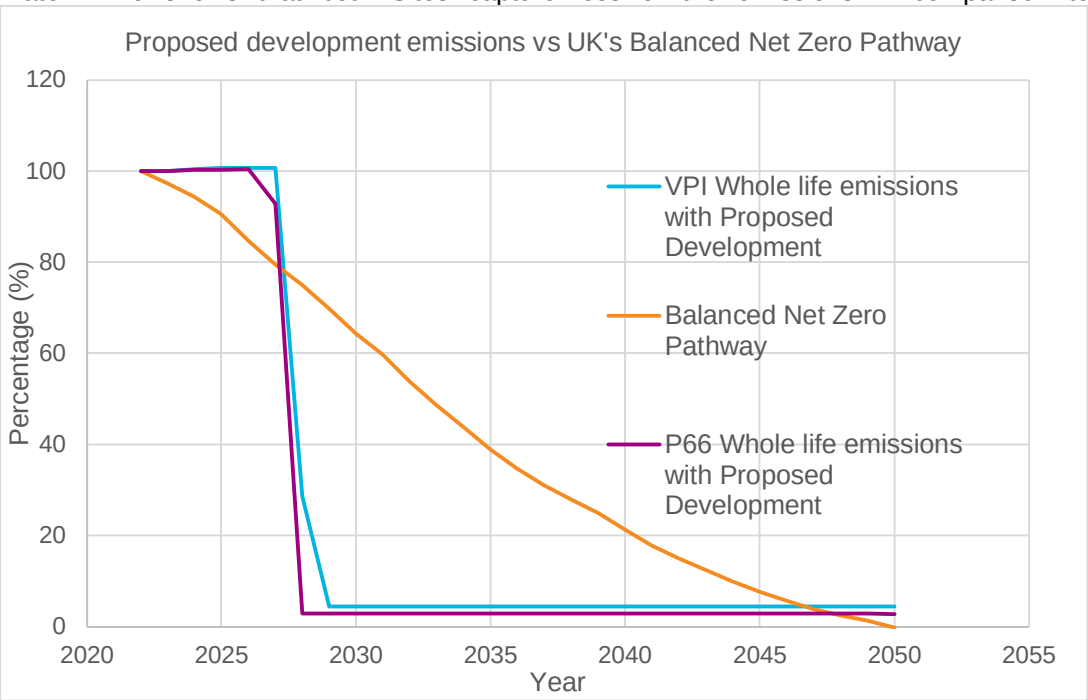


Plate 14.10: Proposed Developments (with upstream emissions) against the UK's Balanced Net Zero Pathway



14.6.25 Plate 14.9 shows that the Proposed Developments capture the majority of the emissions through the PCC plants.

14.6.26 Plate 14.10 shows that both Sites capture less of the emissions in comparison to



14.6.27 Plate 14.9. Phillips 66's upstream emissions account for a large portion of its total emissions. These are the emissions involved in the upstream extraction and transport of crude oil to Site, and from the downstream transport of refined products to the end user. Despite showing a reduced carbon capture rate, these upstream emissions are not within Phillips 66's direct control.

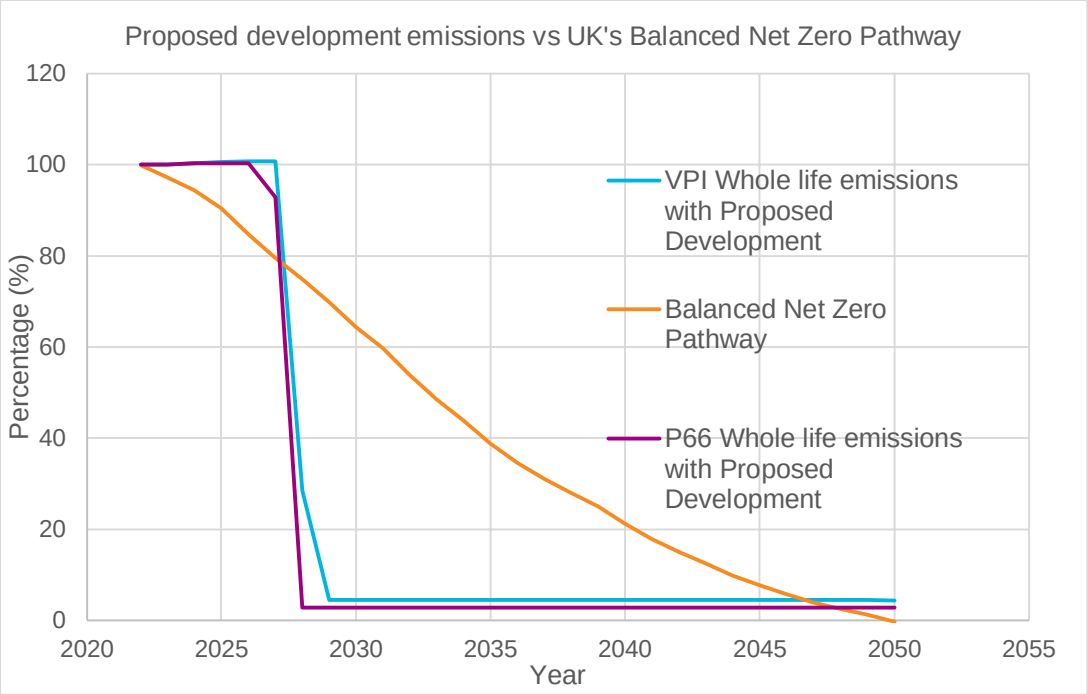
14.6.28 The upstream emissions presented in this chapter are a conservative value and do not take into account the industry's commitment to decarbonise. The industry has set targets driven by

consumer demands as well as environmental, social and governance (ESG) performance to aid transition to a low-carbon energy system.

14.6.29 The overall assessment of significance of a development may be affected by whether it is viewed in isolation, or relative to a counterfactual scenario in which the development does not go ahead.

14.6.30 When viewed in isolation, both Proposed Developments release carbon dioxide emissions to the atmosphere, but as stated within the IEMA guidance:

14.6.31 *'The project's GHG impacts would be fully consistent with applicable existing and emerging policy requirements and good practice design standards for a project of this type'*



14.6.32 Plate 14.9 shows that the trajectory of both Proposed Developments are in line with the net zero trajectory. In this narrow context, the GHG impacts of the Proposed Developments could be assessed as **minor adverse**, which would be **not significant**, in line with the descriptions in Table 14.5.

14.6.33 But when compared against an alternative counterfactual scenario in which a similar CHP plant and/or FCC operates without carbon capture, the Proposed Developments do cause:

'A reduction in atmospheric concentration, whether directly or indirectly compared to the without project baseline.'

14.6.34 Within this broader context, the Proposed Developments can be assessed as having a GHG impact that is **beneficial** and **significant**, provided that the without Proposed Developments baseline includes a similar CHP plant and FCC operating without carbon capture.

Further Contextualisation

14.6.35 UK's fourth, fifth and sixth carbon budgets have also been used to contextualise the magnitude of GHG emissions from the Proposed Developments in, depending on the years in which the emissions are expected to occur. The emissions included in Table 14.23 only include direct and indirect emitted from VPI and Phillips 66 Sites.

Table 14.23: Estimated GHG emissions as a proportion of the estimated carbon budgets to 2037

Carbon budget period	Lifecycle Stage	Carbon budget (tCO_2e)	VPI: Total GHG emissions (tCO_2e)	Philips 66: Total GHG emissions (tCO_2e)	Total GHG emissions[2]	% Of carbon budget emissions
4th carbon budget (2023-2027)	Construction & Operation	1,950,000,000	19,949,183	9,748,724	29,465,245	1.51%
5th carbon budget (2028-2032)	Operation	1,725,000,000	4,384,545	6,767,730	10,919,613	0.63%
6th carbon budget (2033-2037)	Operation	965,000,000	3,562,779	6,767,388	10,097,505	1.05%

14.6.36 The GHG emissions associated with the Proposed Developments are not considered to be material in the context of UK's carbon budgets, representing <2% of the 4th and 6th carbon budget and <1% for the 5th carbon budgets.

CCRA

14.6.37 With the mitigation measures listed in Table 14.16, an initial assessment of climate change risk and 'significance' was undertaken based on an analysis of likelihood and consequence as set out in Table 14.3 and Table 14.4. The risks identified in the CCRA apply to both Proposed Developments unless specified. For this assessment, High or Extreme risks have been assessed to have 'significance'. Table 14.24 summarises the initial risk ratings during the operation and construction stage. Where more than one risk statement has been identified for a climate variable, the risk statement with the higher risk rating has been provided to represent a worst-case scenario.

Table 14.24: Summary of initial risk ratings

Climate variable	Initial Risk Rating	
	RCP 8.5	
	(2010-2039)	(2040-2069)
Construction		
Extreme temperatures (heat)	Low	N/A
Extreme rainfall	Medium	N/A
Sea level rise	Medium	N/A
Storms	Medium	N/A
Operation		

Extreme temperatures (heat)	Low	Low
Extreme temperatures (cold)	Low	Low
Extreme rainfall	Low	Medium
Sea level rise[16]	Medium	Medium
Storms	Low	Low
Windstorms	Low	Low
Drought	Low	Low
Wildfires	Medium	Medium

14.6.38 As per paragraph 14.3.41, the significance descriptors can be translated to terminology corresponding to the rest of the EIA. The initial risk ratings mentioned in Table 14.24 there correspond to result in **negligible** and **minor** significance of effects and are therefore not considered to be significant in terms of the EIA.

14.7 Mitigation and Adaptation Measures

GHG Emission Impact Assessment

14.7.1 By design, the Proposed Developments offer the opportunity to capture the carbon emissions that are currently released and reduce the emissions emitted into the atmosphere. The captured carbon dioxide will be compressed and pumped by a third party into an offshore carbon storage system instead of being released into the atmosphere.

14.7.2 Other construction and operation GHG impacts will be mitigated through 'good practice' measures as set out in Table 14.15.

CCRA

14.7.3 Based on the initial assessment of the CCRA (Table 14.24), adaptation measures have been identified for each risk recognised, as detailed within Appendix 14A (ES Volume II). These measures were identified in a CCRA workshop held with Phillips 66 and VPI. Adaptation measures for infrastructure projects are responses to actual or expected climate and its effect to increase resilience, moderate harm and exploit beneficial opportunities. A summary of adaptation measures are detailed within Table 14.25.

Table 14.25: Construction and operation adaptation measures

Climate variable	Adaptation measure
Construction	
Extreme temperatures (heat)	-Consider developing register of vulnerable construction assets. -Consider inspection of vulnerable construction assets after a hot day. -Appropriate sun protection. -Measures and actions to combat extreme heat conditions (e.g. avoid working on hot summer days, welfare training for identifying heat illness, training for working in hot conditions, work in shaded areas, plan major activities for cooler parts of the day, wear loose fitting/breathable clothing)

Extreme rainfall	-Electrical equipment to be stored at higher ground levels. -Welfare areas to be assigned to higher ground levels.
Sea level rise	-For extreme rainfall forecasts, ensure construction plants are secure and stored at higher ground levels.
Storms	
Operation	
Extreme temperatures (heat)	- Take extreme temperature events into account with minimum capture rates designed for the plant.
Extreme temperatures (cold)	-Not further adaptation measures.
Extreme rainfall	-Not further adaptation measures.
Sea level rise[16]	-Consider incorporating additional water defences
Storms	-Not further adaptation measures.
Windstorms	-Not further adaptation measures.
Drought	-Not further adaptation measures.
Wildfires	-Not further adaptation measures.

14.8 Residual Effects and Conclusions

GHG Emission Impact Assessment

14.8.1 The Proposed Developments play a key role in the decarbonisation of industry to allow the UK to achieve net zero emissions by 2050. The Proposed Developments will connect to CO_2 gathering network(s) provided by others to enable CO_2 storage under the North Sea.

14.8.2 In summary, both of the Proposed Developments achieve emissions mitigation that are fully in line to achieve UK's trajectory towards net zero and can be assessed as having a **beneficial** effect that is **significant** in terms of GHG emissions.

CCRA

14.8.3 Following the identification of adaptation measures, an assessment of residual risk was undertaken that takes into consideration the implementation of adaptation measures. Residual risk ratings for each risk identified are summarised below in Table 14.26, in parallel with the initial risk ratings. Within the CCRA, where "No further adaptation measures required" comment can be found, it has been determined that the planned controls listed previously have been deemed sufficient for mitigating the risk.

Table 14.26: Summary of initial and residual ratings

Climate variable	Initial Risk Rating	Residual Risk Rating
	RCP 8.5	RCP 8.5

	(2010-2039)	(2040-2069)	(2010-2039)	(2040-2069)
Construction				
Extreme temperatures (heat)	Low	N/A	Low	Low
Extreme rainfall	Medium	N/A	Medium	Medium
Sea level rise	Medium	N/A	Medium	Medium
Storms	Medium	N/A	Medium	Medium
Operation				
Extreme temperatures (heat)	Low	Low	Low	Low
Extreme temperatures (cold)	Low	Low	Low	Low
Extreme rainfall	Low	Medium	Low	Medium
Sea level rise[16]	Medium	Medium	Medium	Medium
Storms	Low	Low	Low	Low
Windstorms	Low	Low	Low	Low
Drought	Low	Low	Low	Low
Wildfires	Medium	Medium	Medium	Medium

14.8.4 Both mitigation and adaptation measures identified result in the risks to be rated as low and medium, which correspond to **negligible** and **minor** respectively, in line with paragraph 14.3.41, and therefore have been deemed to have no significance. Despite the assessment of no significance, it is recommended that mitigation and adaptation measures are reviewed and implemented when appropriate. As no significant CCRA risks have been identified, no further mitigation or enhancement measures have been proposed.

14.8.5 No additional monitoring is recommended, other than that set out within the Outline CEMP (Appendix 4A ES Volume II) during construction.

14.9 References

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