Gate Burton Energy Park Environmental Statement

Volume 1, Chapter 6: Climate Change
Document Reference: EN010131/APP/3.1
January 2023

APFP Regulation 5(2)(a)
Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Gate Burton Energy Park Limited

Prepared for:

Gate Burton Energy Park Limited

Prepared by:

AECOM Limited

Gate Burton
ENERGY PARK

Table of Contents

Tables

Figures

6. Climate Change

6.1 Introduction

6.1.1 This chapter of the Environmental Statement (ES) presents the findings of an assessment of the likely significant effects on climate change as a result of the Scheme. For more details about the Scheme, refer to **Chapter 2: The Scheme** of this ES **[EN010131/APP/3.1]**.

6.1.2 This chapter identifies and proposes measures to address the potential impacts and likely effects of the Scheme on climate change, during the construction, operation, and decommissioning phases. It also identifies the impact of climate change on the Scheme and the combined impact of future climate conditions on the surrounding environment.

6.1.3 In line with the requirements of The Infrastructure Planning (Environmental Impact Assessment) Regulations (2017) (0), consideration has been given to the following aspects of climate change assessment:

- **Lifecycle greenhouse gas (GHG) impact assessment** – the impact of GHG emissions arising over the lifetime of the Scheme on the climate;
- **Climate change resilience (CCR) assessment** – the resilience of the Scheme to the impacts of future climate change; and
- **In-combination climate change impact (ICCI) assessment** – the resilience of receptors in the surrounding environment to the combined impact of future climate conditions and the Scheme.

6.1.4 This chapter is supported by the following figures in **ES Volume 2 [EN010131/APP/3.2]**:

- **Figure 2-4:** Indicative Site Layout Plan.

6.1.5 This chapter is supported by the following appendices in **ES Volume 3 [EN010131/APP/3.3]**:

- **Appendix 1-B**: Scoping Opinion;
- **Appendix 1-C**: Scoping Opinion Response Table; and
- **Appendix 6-A**: Climate Change Summary of Non-significant Effects.

6.1.6 A glossary and list of abbreviations are defined in the **Chapter 0: Contents, Glossary and Abbreviations** of the ES **[EN010131/APP/3.1].**

6.2 Consultation

6.2.1 A request for an EIA Scoping Opinion was sought from the Secretary of State through the Planning Inspectorate in 2021 as part of the EIA Scoping process. The Scoping Opinion was received on 20 December 2021 (**ES Volume 3: Appendix 1-B [EN010131/APP/3.3]**). Consultation responses to scoping opinion comments are presented in **ES Volume 3: Appendix 1-C [EN010131/APP/3.3]** and responses to statutory consultation are presented in the **Consultation Report [EN010131/APP/4.1]**. Further detail on consultation can also be found in **Chapter 4: Consultation [EN010131/APP/3.1]**

6.2.2 In the Preliminary Environmental Information (PEI) Report, the following changes were made to the climate change assessment as a result of responses to the Scoping Opinion:

- GHG Impact Assessment – No change to proposed scope.
- CCR Review – Sea level rise is now scoped into the climate resilience assessment on the basis that the River Trent is tidal in the area of the Order limits.
- ICCI Assessment – In-combination effects on surface water or groundwater levels have been incorporated as part of the ICCI assessment. This includes reference to **Chapter 9: Water Environment [EN010131/APP/3.1]** which addresses flood management and mitigation options through a Flood Risk Assessment (**ES Volume 3: Appendix 9-B: Flood Risk Assessment [EN010131/APP/3.3]**) and Surface Water Drainage Strategy (**ES Volume 3: Appendix 9-E [EN010131/APP/3.3]**).

6.3 Legislation and Planning Policy

6.3.1 Legislation, planning policy and guidance relating to climate change, and pertinent to the Scheme comprises:

Legislation

6.3.2 This section lists the legislation and planning policy relevant to the assessment methodology for climate change. These comprise:

- Climate Change Act 2008 (Ref 6-2) which sets a target for the year 2050 for the reduction of targeted greenhouse gas emissions and to provide for a system of carbon budgeting (amongst others);
- Climate Change Act 2008 (2050 Target Amendment) Order 2019 (Ref 6-3) which amended the 2050 target in the Climate Change Act 2008 to "net zero" i.e. that the net UK carbon account, in terms of carbon dioxide and other targeted greenhouse gases, for the year 2050 is at least 100% lower than the relevant baseline year; and
- Carbon Budgets Order 2009 (Ref 6-4), Carbon Budget Order (2011) (Ref 6-5), Carbon Budget Order (2016) (Ref 6-6) and Carbon Budget Order (2021) (Ref 6-7) which set the carbon budgets for relevant budgetary periods.

National Planning Policy

- National planning policy identifies the requirement for consideration of climate change adaptation and resilience. specifically NPS EN-1 Section 4.8 (Ref 6-8), NPS EN-3 Section 2.3 (Ref 6-9) and NPS EN-5 Section 2.6 (Ref 6-10). In accordance with national policy, climate projections should be (and have been) analysed, and appropriate climate change adaptation measures considered throughout the design process. Specific climate change risks identified within these policies include flooding, drought, coastal change, rising temperatures and associated damage to property and people. The EIA has incorporated the climate change risks identified, for example by designing the Scheme to avoid areas of flood risk.

- National planning policy identifies the requirement for consideration of climate change adaptation and resilience. In accordance with national policy, climate projections should be (and have been) analysed, and appropriate climate change adaptation measures considered throughout the design process. Specific climate change risks identified within national policy include flooding, drought, coastal change, rising temperatures and associated damage to property and people. The relevant provisions of national policy are set out below.
- Overarching National Policy Statement (NPS) for Energy EN-1 (Ref 6-8) – with particular reference to paragraphs 2.2.9 and 4.8.2 in relation to climate impacts and adaptation; paragraphs 4.1.3 to 4.1.4 in relation to adverse effects and benefits; paragraphs 4.2.1, 4.2.3, 4.2.4, 4.2.8 to 4.2.10 and 5.1.2 in relation to EIA and ES requirements; paragraphs 4.5.3 and 4.8.1 to 4.8.12 in relation to adaptation measures in response to climate projections; and paragraphs 5.7.1 to 5.7.2 in relation to climate projections, flood risk and the importance of relevant mitigation. A revised draft NPS EN-1 (Ref 6-40) is currently under review but retains these provisions: paragraph 4.9.8 of the draft would also require applicants to assess the impacts on and from proposed energy projects across a range of climate change scenarios, while paragraph 5.3.4 would require all proposals for energy infrastructure projects to include a carbon assessment as part of their ES.
- NPS EN-3 (Ref 6-9) for Renewable Energy Infrastructure – paragraph 2.3.1 regarding NPS EN-1 and the importance of climate change resilience, and paragraph 2.3.5 in relation to ES requirements regarding climate change resilience. A revised draft NPS EN-3 (Ref 6-41) is currently under review but retains these provisions;
- NPS EN-5 for Electricity Networks Infrastructure (Ref 6-10) – paragraph 2.4.1 regarding NPS EN-1 and the importance of climate change resilience, and paragraph 2.4.2 in relation to ES requirements regarding climate change resilience. A revised draft NPS EN-5 (Ref 6-42) is currently under review but retains these provisions, albeit at paragraphs 2.6.1 and 2.6.2; and
- National Planning Policy Framework (NPPF) (Ref 6-11) – paragraphs 8, 20 and 153 in relation to adaptation, mitigation and climate change resilience; paragraphs 154 and 158 in relation to reduction of CO_2 emissions through design and reduced energy consumption; and paragraphs 152 and 159 to 169 in relation to climate projections, associated flood risk and adaptation.

National Guidance

- Planning Practice Guidance for Climate Change (March 2019) (Ref 6-12).

Local Planning Policy

6.3.3 Relevant local planning policy is set out in Table 6-1.

Table 6-1 Local Planning Policy

Local Policy Document Title	Relevant Local Policy
Central Lincolnshire Local Plan 2012 - 2036 (2017) (Ref 6-13)	• Policy LP14 (Managing Water Resources and Flood Risk); • Policy LP18 (Climate Change and Low Carbon Living); • LP19 (Renewable Energy Proposals); and

Local Policy Document Title	Relevant Local Policy
	• LP20 (Green Infrastructure Network).
Central Lincolnshire Local Plan Proposed Submission Draft March 2022 (Ref 6-14)	• Policy S11 (Embodied Carbon); • Policy S12 (Water Efficiency and Sustainable Water Management); • Policy S14 (Renewable Energy); • Policy S15 (Protecting Renewable Energy Infrastructure); • Policy S16 (Wider Energy Infrastructure) • Policy S17 (Carbon Sinks); and • Policy S20 (Resilient and Adaptable Design).
Draft Bassetlaw Local Plan 2020 – 2037 (2021) (Ref 6-15)	• Policy ST50 (Reducing Carbon Emissions, Climate Change Mitigation and Adaptation); • Policy ST51 (Renewable and Low Carbon Energy Generation); and • Policy ST52 (Flood Risk and Drainage).
Bassetlaw District Council Core Strategy & Development Management Policies DPD (2011) (Ref 6-16)	• Strategic object SO6 related to ensuring that all new development addresses the causes and effects of climate change by, as appropriate, reducing or mitigating flood risk; realising opportunities to utilise renewable and low carbon energy sources and/or infrastructure, alongside sustainable design and construction; taking opportunities to achieve sustainable transport solutions; and making use of Sustainable Drainage Systems; and • Development management policies DM10 (Renewable and Low Carbon Energy) and DM12 (Flood Risk, Sewerage and Drainage) are also relevant.
Sturton Ward Neighbourhood Plan – Under Review (Draft 2020) (Ref 6-17)	• Policy 4 (reducing the risk of flooding); and • Policy 12 (Energy efficiency, renewable energy and climate change).

6.3.4 Local planning policies identify the need to consider and, where appropriate, mitigate GHG emissions associated with new development (Central Lincolnshire Local Plan LP 18 (Ref 6-13), Central Lincolnshire Local Plan Proposed Submission Policy S11 (Ref 6-14)). New development should aim for reduced or zero carbon development by incorporating renewable or low carbon energy sources and maximising energy efficiency where practicable and should build in resilience to projected climate change impacts (Draft Bassetlaw Local Plan Policy ST50 (Ref 6-15)). Embedded and additional mitigation measures are described in Section 6.9 below. Overall GHG impacts of the Scheme are discussed in Section 6.10.

6.3.5 The Scheme has incorporated the need to consider GHG emissions and is working towards minimising carbon emissions by incorporating low carbon energy sources and maximising energy efficiency such as through encouraging lower carbon modes of transport to/from the Scheme during construction. The Scheme has been designed to be resilient to projected climate change impacts, for example the Scheme has sought to avoid areas of flood risk. The design of the Scheme has also considered the impact of surface water flood risk by excluding PV panels (and other infrastructure) from areas of medium (chance of flooding of between 1% and 3.3% AEP) and high risk (chance of flooding of greater than 3.3% AEP). See **Chapter 9: Water Environment [EN010131/APP/3.1]** for further information.

6.4 Assessment Assumptions and Limitations

6.4.1 This section outlines the limitations of the data used, and any key assumptions made within the lifecycle GHG impact assessment, CCR review and ICCI assessment.

Scheme Parameters Assessed

6.4.2 The climate assessment has been based on the parameters outlined in **Chapter 2: The Scheme [EN010131/APP/3.1]** of this ES, supplemented with additional information needed to assess the embodied carbon associated with the Battery Energy Storage System (BESS). The technology for solar photovoltaic (PV) and BESS continues to evolve, to maintain commercial flexibility to meet the changing demands of the UK market. The 'Rochdale Envelope' approach has been applied within the EIA to ensure a robust assessment of the likely significant environmental effects of the Scheme, however any adverse impacts are expected to be lower as a result of developing technology. We have assumed a Scheme energy generation capacity of 531 MW and anticipated yields based on existing PV technology. We further note that the consent sought will not limit the maximum generation capacity of the Scheme to allow flexibility for developments in technology to maximise the potential for renewable energy generation.

Components and materials

6.4.3 The largest single source of GHG emissions from the Scheme is likely to result from the manufacture and transport of solar PV panels and the BESS. The infrastructure manufacturer has not been confirmed and therefore for the purposes of estimating the GHG impact of the Scheme, a conservative estimate is to assume that the PV panels will be sourced from China (or a country of similar distance from the UK) as this will increase the embodied carbon in materials and transport emissions compared to panels being sourced from Europe.

6.4.4 A description of the PV panel components is provided within **Chapter 2: The Scheme [EN010131/APP/3.1]**. An Indicative Site Layout Plan is provided within **ES Volume 2: Figure 2-4 [EN010131/APP/3.2].**

6.4.5 The Environmental Product Declaration (EPD) used as a reference for embodied carbon from the manufacture and supply of PV panels is for the Jolywood JW-D144N-166 module rated at 470 Watts (W) (Ref 6-17) (the "Jolywood EPD"). The Jolywood EPD includes data on embodied carbon in kilograms carbon dioxide equivalent per kilowatt hour (kg CO_2e/kWh) of electricity generated for various lifecycle stages including supply of raw materials, manufacture, and transport to a solar farm in China. The Jolywood EPD was published in November 2020, prepared in accordance with ISO 14025 and EN 15804, and subject to independent third-party verification.

6.4.6 The Jolywood EPD shows upstream manufacturing with an embodied carbon figure of 0.00748 kg CO_2e/kWh, but the generation data is from an actual site in southern China with 22% higher yield than anticipated for the Scheme. When a correction is made for the lower anticipated generation for the Scheme, the embodied carbon figure rises to 0.00956kg CO_2e/kWh generated over the development's operational lifetime.

6.4.7 Minimum yields for the Scheme are assumed to be 922 kilowatt hours per year per kilowatt peak (kWh/yr/kWp), with the output of the PV panels assumed to degrade by 2% in the first year and by 0.45% per year thereafter (Ref 6-17). For an installation rated at 531 MWp operating for 60 years, lifetime generation is estimated at 26.986 terawatt hours (TWh) of electricity.

6.4.8 The Scheme will also require other components and materials during the construction phase, including PV inverters, BESS inverters, cables, a steel framework to support the PV Panels, concrete and aggregates. Emissions factors for each of these have been derived from a literature review (PV and BESS inverters) or standard factors (cables, steel framework and building materials). Total battery storage capacity for the scheme has been assumed to be 500 MWh.

6.4.9 For the embodied carbon within the PV inverters and BESS inverters, embodied energy benchmarks reported by Rajput and Singh (2017) (Ref 6-19) have been applied to the Scheme specifications, as set out in **Chapter 2: The Scheme [EN010131/APP/3.1]**. The embodied energy was then converted from kilowatt hours (kWh) to kilograms of CO_2 equivalent (kgCO_2e) using the energy intensity of the countries in which they are produced (Ref 6-20;Ref 6-21), assuming that the energy used in the factories is predominantly electricity.

6.4.10 The embodied carbon of switchgear was estimated using a benchmark reported by FutureFirma (Ref 6-22), while the embodied carbon of lithium ion batteries (for the BESS) was estimated using a benchmark reported by Philippot et al (2019) (Ref 6-23). To estimate the embodied carbon within cabling, it has been assumed that the cables are 50% plastic, 40% copper, and 10% aluminium by weight. Embodied carbon factors for each of these materials from the ICE v3 database (Ref 6-24) have been applied.

6.4.11 Another substantial source of embodied carbon is the steel structure supporting the panels. The embodied carbon factor for galvanised steel from the ICE v3 database (Ref 6-24) has been applied to the total module structure weight to estimate the embodied carbon of module structures.

Transport of components, materials, and waste

6.4.12 Emissions from the transportation of components and materials to the Order limits have been calculated based on assumed transport modes and distances for all materials and components.

6.4.13 Heavy Goods Vehicle (HGV) and sea freight distances assumed for transportation of materials and waste are outlined below. The longest distance (worst-case) country of origin has been assumed for each of the key components of the Scheme, and assumptions have been made around the specific ports used based on proximity to relevant manufacturing facilities within each country:

- HGV transport of materials within China prior to sea freight transportation – 150km (based on the average distance of a number of major manufacturing centres in and around Shanghai to the nearest port)[1];
- HGV transport of materials within South Korea prior to sea freight transportation – 50km (based on the proximity of various BESS manufacturers to the nearest port);
- HGV transport of materials within Europe, including distance prior to, and following, sea freight transportation – 1,770km (based on half of the reasonable maximum distance equipment might be transported within Europe, plus the distance between Dover and the Order limits);
- Sea freight distance from China to England (Ref 6-25) – 22,315km (based on the sea freight distance between Shanghai and Immingham);
- Sea freight distance from South Korea to England (Ref 6-25) – 23,352km (based on the sea freight distance between Port of Jinhai and Immingham);
- Sea freight distance from Europe to England (Ref 6-25) – 50km (based on the sea freight distance between Calais and Dover)
- HGV transport of materials following sea freight – 370km (based on the road distance between Dover and the Order limits); and
- Building materials such as concrete and aggregate are assumed to be sourced locally and transported by HGV a maximum of 50km which is considered to be a reasonable worst-case scenario based on the availability of the local supply chain.

6.4.14 For sea freight transportation, the BEIS 2022 emissions factor for 'Products tanker – Average' has been applied, including well-to-tank (WTT) emissions (Ref 6-26).

6.4.15 For HGV transportation during construction and decommissioning, the BEIS 2022 emissions factor for 'Rigid HGV – 7.5-17t' has been applied, including WTT emissions (Ref 6-26). It has been assumed that HGVs are on average 50% laden as they will be empty travelling one way (e.g. to the Scheme for waste collections), and 100% laden for other leg of the journey.

6.4.16 Emissions from the transport of materials and components away from the Order limits at the end of design life have been estimated on the assumption that all recycling and landfilling will take place in the UK at a maximum distance of 50km for concrete and aggregate, and no more than 200km for other materials. These are considered to be reasonable assumptions for the purposes of this assessment following discussions with waste management specialists. Transport is assumed to be by HGV and applies the most recent emissions factor from the conversion factors for company reporting published by the UK Government (Ref 6-26). As HGV transport is very likely to be decarbonised, these emissions are almost certainly an overestimate.

[1] Please note, HGV transportation of PV modules within China has been omitted here to avoid double counting as the upstream emissions data used to calculate the embodied carbon of the PV modules already includes transportation from the manufacturing facility to a solar farm in China.

Waste management

6.4.17 Emissions from the disposal of construction waste assume standard wastage rates for materials (5% for concrete and aggregate; 2.5% for steel, aluminium and plastics). Volumes of packaging waste have been estimated on a pro-rata basis of installed capacity from other, similar, schemes. To calculate GHG emissions associated with waste treatment during construction and decommissioning, a conservative assumption that 70% of waste will be recovered, while 30% will be sent to landfill, has been applied. This is less than the latest waste recovery rate for construction and demolition waste in England which is 93.2% (Ref 6-27). Emissions factors for waste disposal are taken from the UK Government conversion factors for company reporting (Ref 6-26). Transport emissions from the disposal of waste assume that all disposal will take place within a 100km radius of the Order limits.

6.4.18 Emissions from the disposal of materials and components at the end of the design life are subject to significant uncertainty. For the purposes of this assessment, emissions factors for recycling of different categories of products and materials have been taken from the conversion factors for company reporting published by the UK Government (Ref 6-26). At the decommissioning stage a conservative assumption that 70% of waste will be recycled, while 30% will be sent to landfill, has also been applied.

Use of plant and machinery

6.4.19 Emissions from the use of plant and machinery during construction and decommissioning have been calculated based on a stated assumption that consumption of diesel for running machinery and generators will average 3,300 litres per week. However, it is hoped that consumption will be reduced to lower levels as there is a prospect of connecting construction compounds into the local electrical distribution network at either 11kV or 33kV. The emissions factors for diesel were taken from the 2021 conversion factors for company reporting published by the UK Government (Ref 6-26).

Consumption of water

6.4.20 As provided in **Chapter 2: The Scheme [EN010131/APP/3.1]** consumption of water during the construction phase assumes that based on an assumed 20 litres/day/person, an estimated 2,200m^3 total (1,700m^3 for welfare and 500m^3 for wheel washes) of water will be required during construction to support welfare facilities onsite and other uses. Emissions factors for water supply and wastewater treatment are taken from the 2022 conversion factors for company reporting (Ref 6-26); as a conservative estimate, it is assumed that all water supplied is removed for treatment via the wastewater network (refer to **Chapter 2: The Scheme [EN010131/APP/3.1]**).

Worker travel

6.4.21 Emissions from construction worker travel have been calculated based on information provided in **Chapter 2: The Scheme [EN010131/APP/3.1]** and **Chapter 13: Transport and Access [EN010131/APP/3.1]**. In terms of construction staff vehicles, the following has been included as part of this assessment:

- 55% of construction staff (220 persons) to be transferred to/from the Scheme by shuttle service (each with capacity for 50 staff) e.g. to/ from Gainsborough (north) and Lincoln (south), as well as Retford (west) and Newark on Trent (south). On the assumption that an average of 55 staff would reside within each of the four areas listed above, two shuttle services would be required to/from each area equating to a total of eight shuttle services in the morning (16 movements) and eight shuttle services in the evening (16 movements).
- 45% of construction staff (180 persons) to travel by private vehicle with an average occupancy of 1.3 staff per vehicle, resulting in 138 staff vehicles (276 two-way daily movements).

6.4.22 A maximum one-way distance of 30km per journey has been assumed for the worker transportation calculations, which is a conservative estimate as, it is expected staff will reside closer to the Order limits, and employees not from the local area would stay in local accommodation as stated within **Chapter 12: Socio-economics and Land Use [EN010131/APP/3.1]**. An emissions factor for a typical van of unknown fuel has been applied, taken from the 2021 conversion factors for company reporting published by the UK Government (Ref 6-26).

6.4.23 Operational worker travel data has been estimated based on an assumption of 14 workers on site every day over the design life of the scheme. In addition, there is expected to be approximately 3-4 visitors per week for deliveries, and replacement of any components that fail. Workers are assumed to travel alone by car a maximum of 30km each way. Operational staff are expected to travel to site by four-wheel drive vehicle or medium/large van. An emissions factor for an average van of unknown fuel has been applied. These emissions are likely to be a worst-case scenario, as private vehicles are increasingly likely to be powered by electricity rather than by internal combustion engines.

6.4.24 Worker travel during decommissioning has been assumed to be equivalent to that during construction. This is a conservative estimate as there is likely to be significantly less work involved in decommissioning compared to construction.

Land use change

6.4.25 An assessment of GHG impacts from land use change associated with the conversion of arable land to grassland has been omitted from this chapter. Land use change as a result of the Scheme is anticipated to have a beneficial GHG impact due to the conversion of large areas of cropland to grassland, which has a higher carbon sequestration value than cropland. However, it is assumed that the new areas of grassland will be returned to cropland following decommissioning of the Scheme, with any carbon stored in soil or vegetation re-released to the atmosphere. The beneficial GHG impact from land use change is therefore considered to only be temporary (approximately 60 years) and has therefore been excluded from the lifecycle GHG impact assessment. This is considered to be a robust worst-case approach and likely to underestimate the beneficial effect of the Scheme, as tree and hedgerow planting may be retained after decommissioning. Any carbon sequestered in these areas would remain in the soil and vegetation following decommissioning.

Construction Phase

6.4.26 As stated in **Chapter 5: EIA Methodology [EN010131/APP/3.1]** construction is assumed to commence in Q1 2025 and the Scheme will be built over an estimated 24 to 36 months, with operation therefore anticipated to commence around Q1 2028. A 36-month construction programme has been assumed for the purposes of this assessment. This is expected to be a realistic worst-case assumption for this assessment, as it represents the expected maximum build time and therefore the maximum total emissions and impacts occurring as a result of the construction phase.

Operational phase

6.4.27 It is assumed that the on-site control building will have an average power demand of 10kW, and that this will be supplied from the distribution network. Projections of future grid carbon intensities are taken from data published by the UK Government (Ref 6-27). Energy consumption and associated carbon emissions of the heating, ventilation, and air conditioning (HVAC) system associated with the BESS have not yet been confirmed[2]. Additionally, it is assumed that all power losses and associated carbon footprint of connecting cables will be counted for in transmission and distribution losses. The UK Government publishes annual emission factors for transmission and distribution losses that will be accounted for in Scope 3 emissions of the final electricity users.

6.4.28 Operational energy generation data has been based on an assumed Scheme capacity of 531MW and anticipated yield (922 kWh/kWp/yr). This data accounts for efficiency losses of the PV Panels over time based on an initial degradation factor of 2% for the first year, and 0.45% degradation for each subsequent year to the end of the warranty of the panels (25 years).

6.4.29 Operational maintenance from the replacement of components during the design lifetime of the Scheme are based on replacement rates for similar schemes and based on the design life of the components. It is assumed that all of the PV Panels will require replacement once during the Scheme's design life, with a further 10% requiring replacement to cover equipment failures, at a constant rate throughout the 60-year project life. All the inverters and BESS cells are assumed to require replacement twice, with a further 50% requiring replacement to cover equipment failures, at a constant rate throughout the 60-year project life. All transformers are assumed to require replacement once, with a further 10% requiring replacement to cover equipment failures.

6.4.30 Sulphur hexafluoride (SF_6) is an extremely powerful GHG with a global warming potential of 23,900. Fugitive emissions of SF_6 from certain electrical items such as gas insulated switchgear have historically been a significant source of emissions. Manufacturers of such equipment are now increasingly able to offer SF_6-free components, and those that do continue to use SF_6 are sealed-for-life with extremely low leakage rates. For this reason, it is assumed that emissions of SF_6 from this Scheme will be minimal and not material to this GHG assessment.

[2] The potential for functioning of the BESS to result in a localised microclimate has been assessed and dismissed. Relative to other generation technologies, such as a gas-fired power station, the risk of a microclimate is considered extremely low.

Decommissioning phase

6.4.31 Emissions from the decommissioning process at the end of the design life are very difficult to estimate due to the substantial uncertainty surrounding decommissioning methodologies and approaches so far into the future. It has been assumed that the resources and effort required for decommissioning will be equivalent to those required for construction. Once again, this is considered to be a worst-case scenario.

6.4.32 There is a lot of research around recycling of solar panels. Methods for recycling PV modules are being developed worldwide to reduce the environmental impact of PV waste and to recover valuable materials from the waste. Current recycling practices are inefficient as WEEE recycling plants are not equipped with specialised PV recycling equipment. The overall recycling rate achieved by current recycling processes is around 24%, well below the current minimum target of 80% (in mass) of reuse and recycling, as set by the WEEE Directive. However, much more efficient recycling processes are already being developed. For example, the Full Recovery End-of-Life Photovoltaic (FRELP) process is recognised as one of the most advanced PV waste recycling process currently developed. The FRELP process is capable of achieving recycling rates for aluminium, copper, glass, silicon and silver of at least 88% (as much as 95% for some materials). Due to this, over the lifetime of the Scheme, developments in PV waste recycling are expected to improve.

6.5 Study Area

Lifecycle GHG Impact Assessment

6.5.1 The study area for the lifecycle GHG impact assessment considers all GHG emissions arising over the lifecycle of the Scheme. This includes direct GHG emissions arising from activities within the Order limits and indirect emissions from activities outside the Order limits (for example, the transportation of materials to the Order limits and embodied carbon within construction materials).

Climate Change Resilience (CCR) Review

6.5.2 The study area for the CCR review is the Order limits i.e. it covers all assets and infrastructure which constitute the Scheme, during construction, operation, and decommissioning.

In-Combination Climate Change Impact (ICCI) Assessment

6.5.3 The study areas used for the ICCI assessment for this ES is the Order limits and is limited to the assessment of in-combination effects on surface water and groundwater receptors as defined in **Chapter 9: Water Environment [EN010131/APP/3.1]** of this ES. This assessment aims to determine the influence of climate change and project-related impacts to the identified receptors in this chapter.

6.6 Assessment Methodology

Impact Assessment Methodology

Lifecycle GHG Impact Assessment

6.6.1 The potential effects of the Scheme on the climate during construction have been calculated in line with the GHG Protocol (Ref 6-30) and the GHG 'hot spots' (i.e. materials and activities likely to generate the largest amount of GHG emissions) have been identified. This will enable priority areas for mitigation to be identified. This approach is consistent with the principles set out by the Institute for Environmental Management and Assessment (IEMA) document 'Assessing Greenhouse Gas Emissions and Evaluating their Significance (Ref 6-31).

6.6.2 This lifecycle approach considers emissions from the following lifecycle stages of the Scheme: construction, operation and maintenance, and decommissioning.

6.6.3 Where activity data allows, expected GHG emissions arising from the construction, operation and maintenance, and decommissioning activities, and embodied carbon in materials of the Scheme, have been quantified using a calculation-based methodology as per the following equation as stated in the methodology paper accompanying the conversion factors for company reporting published by the UK Government (Ref 6-26):

Activity data x GHG emissions factor = GHG emissions value

6.6.4 In line with 'The GHG Protocol' (Ref 6-30), when defining potential impacts the seven Kyoto Protocol GHGs have been considered, specifically:

- Carbon dioxide (CO2);
- Methane (CH4);
- Nitrous oxide (N2O);
- Sulphur hexafluoride (SF6);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs); and
- Nitrogen trifluoride (NF3).

6.6.5 These GHGs are broadly referred to in this chapter under an encompassing definition of 'GHG emissions', with the unit of tCO_2e (tonnes CO_2 equivalent).

6.6.6 Where data are not available, a qualitative approach to addressing GHG impacts has been followed, in line with the IEMA guidance on assessing GHG emissions in EIA (Ref 6-31).

6.6.7 Table 6-2 summarises the key anticipated GHG emissions sources associated with the Scheme, which were scoped in during the consultation process.

Table 6-2 Potential sources of GHG emissions

Lifecycle stage	Activity	Primary emission sources
Product Stage	Raw material extraction and manufacturing of products required to build the equipment for the Scheme. Due to the complexity of the equipment, this stage is expected to make a significant contribution to overall GHG emissions. Transportation of materials for manufacturing.	Embodied GHG emissions from energy use in extraction of materials and manufacture of components and equipment. Emissions of GHG from transportation of products and materials. Due to the nature of the equipment, this could require shipment of certain aspects over significant distances.
Construction process stage	On-site construction activity including emissions from construction compounds. Transportation of construction materials (where these are not included in product-stage embodied GHG emissions). Travel of construction workers	Consumption of energy (electricity; other fuels) from plant, vehicles, generators and worker travel. Fuel consumption from transportation of materials to site, where these are not included in product-stage embodied emissions.
	Disposal of waste materials generated by the construction process. Land use change. Water use	GHG emissions from transportation and disposal of waste. GHG impact of changes to carbon sink value of the Site. Provision of clean water, and treatment of wastewater.
Operation stage	Operation and maintenance of the scheme	GHG emissions from energy consumption, provision of clean water and treatment of wastewater. These operational emissions are expected to be negligible in the context of the overall GHG impact. GHG emissions from energy consumption, material use and waste generation resulting from ongoing site maintenance. Emissions from routine maintenance are expected to be negligible, but the periodic replacement of components has the potential to have significant impacts given the complexity of the equipment involved.
Decommissioning stage	On-site decommissioning activity. Transportation and disposal of waste materials. Worker travel.	Consumption of energy (electricity and other fuels) from plant, vehicles and generators on-site. Emissions from the disposal and transportation of waste. GHG emissions from transportation of workers to the Site.

Climate Change Resilience Assessment

6.6.8 The EIA Regulations (0) require the inclusion of information on the vulnerability of the Scheme to climate change. Consequently, an assessment of climate change resilience for the Scheme has been undertaken which identifies potential climate change impacts in accordance with IEMA Environmental

Impact Assessment Guide to: Climate Change Resilience & Adaptation (Ref 6-32).

6.6.9 The assessment has included all infrastructure and assets associated with the Scheme. It covers resilience against both gradual climate change, and the risks associated with an increased frequency of extreme weather events as per the United Kingdom Climate Change Projections 2018 (UKCP18) projections (Ref 6-29).

6.6.10 The assessment of potential impacts and the Scheme's vulnerability considers the mitigation measures that have been designed into the Scheme as discussed in Section 6.9 on Embedded and Additional Mitigation Measures. Potential impacts considered include higher temperatures in the future, and more extreme rainfall events.

6.6.11 The assessment also identifies and accounts for existing resilience measures for each risk either already in place or in development for infrastructure and assets.

6.6.12 As agreed during the consultation process, the scope of the CCR assessment is detailed in Table 6-3.

Table 6-3 Scope of the CCR assessment

Climate Risk	Scoped In/Out	Rationale
Extreme weather events	In	The Scheme may be vulnerable to extreme weather events such as storm damage to structures and assets.
Increased average temperatures and incidence of heatwaves	In	Extremes in temperatures may result in heat stress of materials and structures.
Increased frequency of heavy precipitation events	In	The Scheme may be vulnerable to changes in precipitation, for example, land subsidence and damage to structures and drainage systems during periods of heavy rainfall.
Increase in strong wind events	In	The Scheme may be vulnerable to changing wind patterns, for example, high winds and falling trees could damage structures and assets.
Sea level rise	In	Based on the Scoping Opinion, sea level rise has been scoped into the climate resilience review on the basis that the River Trent is tidal in the area of the Grid Connection. However, according to **Chapter 9: Water Environment [EN010131/APP/3.1]** the National Tidal Limit (NTL) is approximately 28km upstream of the Order limits, and whilst there is a tidal influence in this area it is reasonable to assume that the fluvial influence is likely to outweigh the tidal influence and therefore the risk from tidal flooding is considered low based on the distance upstream from river mouth and flood defences in the area.

6.6.13 Once potential climate risks have been identified, the likelihood of their occurrence during the project phase is categorised. Likelihood is categorised into five levels depending on the probability of the hazard occurring. Table 6-4 presents the likelihood levels and definitions used. This is in line with the definitions presented in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (Ref 6-33).

Table 6-4 Level of likelihood of a climate risk occurring

Likelihood Category	Description (probability of occurrence)
Very likely	>90-100% probability that the impact will occur
Likely	>66-90% probability that the impact will occur
Possible, about as likely as not	>33-66% probability that the impact will occur
Unlikely	>10-33% probability that the impact will occur
Very unlikely	0-10% probability that the impact will occur

6.6.14 The consequence of an impact has been measured using the criteria detailed in Table 6-5. The probability and consequence have taken into account embedded design and impact avoidance measures. The embedded design and impact avoidance measures are secured via implementation of the **Framework Construction Environmental Management Plan (CEMP) [EN010131/APP/7.3], Operational Environmental Management Plan (OEMP) [EN010131/APP/7.4]** and **Decommissioning Environmental Management Plan (DEMP) [EN010131/APP/7.5]** which will be a requirement of the DCO.

Table 6-5 Level of consequence of a climate risk occurring

Consequence of Impact	Measure of Consequence for Climate Change Risk
Very high	Permanent damage to structures/assets; Complete loss of operation/service; Complete/partial renewal of infrastructure; Serious health effects, possible loss of life; Extreme financial impact; and Exceptional environmental damage.
High	Extensive infrastructure damage and complete loss of service; Some infrastructure renewal; Major health impacts; Major financial loss; and Considerable environmental impacts.
Medium	Partial infrastructure damage and some loss of service; Moderate financial impact; Adverse effects on health; and Adverse impact on the environment.
Low	Localised infrastructure disruption and minor loss of service; No permanent damage, minor restoration work required; and Small financial losses and/or slight adverse health or environmental effects.
Very low	No damage to infrastructure; No impacts on health or the environment; and No adverse financial impact.

In-Combination Climate Change Impact Assessment

6.6.15 The ICCI assessment considers the ways in which projected climate change will influence the significance of the impact of the Scheme on receptors in the surrounding environment. As agreed with the Planning Inspectorate via the

Scoping process, the scope of the ICCI assessment is limited to effects on surface water or groundwater levels as solar panels have the potential to alter runoff rates and patterns, as detailed in Table 6-6.

6.6.16 The ICCI assessment considers the existing and projected future climate conditions for the geographical location and assessment timeframe. It identifies the extent to which identified receptors in the surrounding environment are potentially vulnerable to and affected by these factors. The receptors for the ICCI assessment are those that will be impacted by the Scheme. These impacts will be assessed in liaison with the technical specialists responsible for preparing the applicable technical chapters.

Table 6-6 Scope of the ICCI assessment

Climate Risk	Scoped In/Out	Rationale
Temperature change	Out	While impacts are expected as a result of projected temperature increases, these temperature increases in combination with the Scheme are not expected to have a significant impact upon receptors identified by other environmental disciplines. For example, temperature increases in combination with the scheme are unlikely to have any direct relationship with ecological receptors, local residents etc.
Sea level rise	In	Based on the Scoping Opinion, sea level rise has been scoped into the ICCI assessment on the basis that the River Trent is tidal in the area of the Grid Connection. However, according to **Chapter 9: Water Environment [EN010131/APP/3.1]** the National Tidal Limit (NTL) is currently approximately 28km upstream of the Order limits, and whilst there is a tidal influence in this area it is reasonable to assume that the fluvial influence is likely to outweigh the tidal influence and therefore the risk from tidal flooding is considered low based on the distance upstream from river mouth and flood defences in the area.
Precipitation change (frequency and magnitude of precipitation events and droughts)	In	Climate change may lead to an increase in substantial precipitation events that could lead to flash flooding or changes to groundwater levels. Impacts to surface water or groundwater levels as a result of precipitation changes, may occur in combination with the Scheme, as the flow of precipitation to ground may be affected by the installation of the solar modules. The Scheme, in combination with projected changes in precipitation, is not expected to have a significant impact upon receptors identified by other environmental disciplines.
Wind	Out	The Scheme, in combination with projected changes in wind patterns, is not expected to have a significant impact upon receptors identified by other environmental disciplines.

6.6.17 Once potential ICCIs have been identified, the likelihood of their occurrence during the project phase is categorised. This is the same process as was undertaken for the CCR, as detailed in Table 6-4.

6.6.18 In consideration of the likelihood of the climate risk occurring, the sensitivity of the receptor, the likelihood of an impact occurring to the receptor is then defined. This includes any embedded mitigation measures. These classifications are defined in Table 6-7.

Table 6-7 Likelihood of climate risks impacting receptor

Level of likelihood of climate impact occurring	Definition of likelihood
Likely	>66-100% probability that the impact will occur during the life of the project
Possible, about as likely as not	>33-66% probability that the impact will occur during the life of the project
Unlikely	0-33% probability that the impact will occur during the life of the project

6.6.19 The likelihood of a climate risk occurring and the likelihood of an impact to a receptor is then combined to determine the likelihood of an ICCI occurring. This matrix is illustrated in Table 6-8.

Table 6-8 Level of likelihood of an ICCI occurring

		Likelihood of a climate risk occurring				
		Very Unlikely	Unlikely	Possible	Likely	Very Likely
Likelihood of Impact to Receptor	Unlikely	Low	Low	Low	Medium	Medium
	Possible	Low	Low	Medium	Medium	Medium
	Likely	Low	Medium	Medium	High	High

6.6.20 Once the likelihood of an ICCI impact occurring on a receptor has been identified, the assessment then considers how this will affect the significance of the identified effects.

6.6.21 The ICCI consequence criteria are defined in Table 6-9 and are based on the change to the significance of the effect already identified by the environmental discipline. To assess the consequence of an ICCI impact, each discipline will assign a level of consequence to an impact based on the criteria description and their discipline assessment methodology.

Table 6-9 Consequence of ICCI occurring

Consequence	Consequence criteria
High	The climate change parameter in-combination with the effect of the proposed development causes the significance of the effect of the proposed scheme on the resource/receptor, as defined by the topic, to increase from negligible, minor or moderate to major.
Medium	The climate change parameter in-combination with the effect of the proposed development causes the effect defined by the topic, to increase from negligible or minor to moderate.
Low	The climate change parameter in-combination with the effect of the proposed development, causes the significance of effect defined by the topic, to increase from negligible to minor.
Very low	The climate change parameter in-combination with the effect of the proposed development does not alter the significance of the effect defined by the topic.

Gate Burton ENERGY PARK

Significance Criteria

Lifecycle GHG Impact Assessment

6.6.22 IEMA guidance (Ref 6-31) states that there are currently no agreed methods to evaluate thresholds of GHG significance, that the application of the standard EIA significance criteria is not considered to be appropriate for climate change mitigation assessments, and that professional judgement is required to contextualise a project's GHG emission impacts.

6.6.23 The guidance explains that "*the crux of significance therefore 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*."

6.6.24 Table 6-10 presents the different significance levels as per the latest version of IEMA guidance. The guidance emphasises that *"a project that follows a 'business-as-usual' or 'do minimum' approach and is not compatible with the UK's net zero trajectory, or accepted aligned practice or area-based transition targets, results in a significant adverse effect. It is down to the practitioner to differentiate between the 'level' of significant adverse effects e.g. 'moderate' or 'major' adverse effects."*

6.6.25 Moderate, Major adverse, and beneficial impacts are considered to be significant while all other significance levels are deemed to be not significant.

Table 6-10. Significance levels as per IEMA guidance (as per Box 3 in IEMA Guidance Ref 6-30)

Significance Levels	Definition	Significant
Major Adverse	The project's GHG impacts are not mitigated or are only compliant with do-minimum standards set through regulation, and do not provide further reductions required by existing local and national policy for projects of this type. A project with major adverse effects is locking in emissions and does not make a meaningful contribution to the UK's trajectory towards net zero.	Yes
Moderate adverse	The project's GHG impacts are partially mitigated and may partially meet the applicable existing and emerging policy requirements but would not fully contribute to decarbonisation in line with local and national policy goals for projects of this type. A project with moderate adverse effects falls short of fully contributing to the UK's trajectory towards net zero.	Yes
Minor adverse	The project's GHG impacts would be fully consistent with applicable existing and emerging policy requirements and good practice design standards for projects of this type. A project with minor adverse effects is fully in line with measures necessary to achieve the UK's trajectory towards net zero.	No
Negligible	The project's GHG impacts would be reduced through measures that go well beyond existing and emerging policy and design standards for projects of this type, such that radical decarbonisation or net zero is achieved well before 2050. A project with negligible effects provides GHG performance that is well 'ahead of the curve' for the trajectory towards net zero and has minimal residual emissions.	No
Beneficial	The project's net GHG impacts are below zero and it causes a reduction in atmospheric GHG concentration, whether directly	Yes

Significance Levels	Definition	Significant
	or indirectly, compared to the without-project baseline. A project with beneficial effects substantially exceeds net zero requirements with a positive climate impact.	

6.6.26 As noted, it is down to the practitioner's professional judgement on how best to contextualise a project's GHG impact. In GHG accounting, it is considered good practice to contextualise emissions against pre-determined carbon budgets. The UK has a defined national carbon budget and budgets set by industry bodies which have been determined as being compatible with net zero and international climate commitments. For this Scheme, the most appropriate sector carbon budget is for the electricity supply sector. Currently, indicative carbon budgets are available for the electricity supply sector (Ref 6-40). The electricity supply sectoral carbon budgets (Table 6-11) are in place to track sector's pathway to being carbon neutral by 2050. Progress against these budgets is reviewed annually and future budgets are set 12 years in advance.

6.6.27 To assess the impact of GHG emissions from the Scheme, the carbon budgets for the electricity supply sector (Ref 6-40) have been used as a proxy for the climate (Table 6-11). To provide further perspective, emissions from the Scheme have also been considered in the context of the UK carbon budgets (Ref 6-36) (Table 6-11). The UK carbon budgets are in place to restrict the amount of GHG emissions the UK can legally emit in a five-year period. The UK is currently in the 3rd carbon budget period, which runs from 2018 to 2022. The 3rd, 4th and 5th Carbon Budgets reflect the previous 80% reduction target by 2050. The 6th carbon budget aligns with the legislated 2050 net zero commitment.

6.6.28 UK National carbon budgets are currently available to 2037 (Ref 6-36). The Carbon Budget Order 2021, containing details of the 6th carbon budget for the period 2033-37 was signed into law in June 2021 (Ref 6-7). Beyond 2037, the Committee on Climate Change has not issued formal advice on later carbon budgets, nor have these been approved and ratified by the UK parliament. But the CCC has published annual emissions totals that are consistent with a so-called Balanced Net Zero Pathway, and it is possible to aggregate these annual figures into indicative 5-year totals for the 7th, 8th and 9th carbon budget periods.

6.6.29 Table 6-11 shows the approved UK carbon budgets up to 2037, which highlights a reduction in the amount of GHG the UK can legally emit in the future. Beyond 2037, the table shows indicative carbon budgets derived from the CCC's Balanced Net Zero Pathway. Clearly, any source of emissions contributing to the UK's carbon inventory will have a greater impact on the UK carbon budgets in the future.

6.6.30 A qualitative approach has been taken for assessing the significance of GHG emissions arising as a result of the Scheme for the years beyond 2037. A quantitative approach is not possible beyond 2037 as although the carbon budgets are set to decrease over time, there will still be permitted GHG emissions beyond 2050, but with offsetting measures in place to ensure net emissions are zero. The rate at which they will decrease is not known, so it is not possible to predict the quantity of emissions permitted within the carbon budgets beyond 2037.

6.6.31 The construction phase of the Scheme is estimated to commence no earlier than Q1 of 2025 and run for an estimated 24-36 months. Construction is therefore expected to fall within the period of the 4th UK national carbon budget which will run from 2023 to 2027.

6.6.32 Where possible, the operational phase of the Scheme (estimated to be not earlier than Q1 2028) has been compared to the relevant and available carbon budgets within the design life of the Scheme: the 5th and 6th carbon budgets covering the periods 2028-32 and 2033-37, respectively. Beyond 2037, the operational phase of the Scheme has been compared to indicative carbon budgets.

6.6.33 As sectoral (electricity supply) carbon budgets exist, the UK carbon budgets have been used as a secondary measure to contextualise the impact of the Scheme.

6.6.34 It is noted that the contribution of most individual projects to national-level budgets will be small and so the UK context will have limited value. This GHG emissions assessment therefore uses the IEMA guidance to assess the significance of effects (Table 6-10), with the sectoral and UK carbon budgets being used to provide context to the GHG emissions (Table 6-11).

Table 6-11 Relevant Carbon Budgets for this Assessment

Carbon Budget	Total budget ($MtCO_2e$)	Sectoral Carbon Budget year	Annual Sectoral Carbon budget (MtCO2e)
3rd (2018-2022)	2,544	-	-
		-	-
		2020	51.26
		2021	49.71
		2022	48.48
4th (2023-2027)	1,950	2023	44.01
		2024	44.44
		2025	41.65
		2026	32.36
		2027	26.70
5th (2028-2032)	1,725	2028	23.75
		2029	22.40
		2030	18.55
		2031	15.77
		2032	12.09
6th (2033-2037)	965	2033	9.86
		2034	8.00
		2035	6.20

Carbon Budget	Total budget ($MtCO_2e$)	Sectoral Carbon Budget year	Annual Sectoral Carbon budget (MtCO2e)
		2036	6.01
		2037	5.67
7th (2038-2042)	526	2038	5.52
		2039	5.39
		2040	5.11
		2041	3.75
		2042	3.45
8th (2043-2047)	195	2043	3.32
		2044	3.15
		2045	2.27
		2046	2.02
		2047	1.61
9th (2048-2050)	17	2048	1.49
		2049	1.33
		2050	1.21

6.6.35 From 2050 onwards, the UK is legally obliged to offset any residual emissions in line with its net zero target for 2050. Therefore, over time, the level of impact of any emissions, or emissions reductions, could be considered to become more significant in the context of the UK meeting its carbon reduction target as the quantity of permitted emissions gets smaller.

Climate Change Resilience Review

6.6.36 The significance of CCR is determined as a function of the likelihood of a climate change risk occurring and the consequence to the receptor if the hazard occurs. This is detailed in Table 6-12. Where a risk is determined as High or Very high, this has been deemed significant.

Table 6-12 Level of effect criteria for climate change resilience impacts

		Likelihood of a climate impact occurring				
		Very unlikely	Unlikely	Possible, about as likely as not	Likely	Very likely
Consequence	Catastrophic Adverse/ Substantial Beneficial	L	M	VH	VH	VH
	Major	L	M	H	H	VH
	Considerable	L	M	H	H	H
	Moderate	L	M	M	M	H
	Minor	L	L	L	M	M
	Insignificant	L	L	L	L	L

	Likelihood of a climate impact occurring				
	Very unlikely	Unlikely	Possible, about as likely as not	Likely	Very likely
No change	L	L	L	L	L

VH = Very high effect, H = High effect, M = Moderate effect, L = Low effect

In-Combination Climate Change Assessment

6.6.37 The significance of potential effects is determined using the matrix in Table 6-13. Where an effect has been identified as moderate or major will be classed as a significant ICCI effect. If significant ICCI effects are assessed, then appropriate additional mitigation measures (secondary mitigation) are identified.

Table 6-13 ICCI Significance Matrix

		Likelihood of an ICCI occurring		
		Low	Medium	High
Consequence of an ICCI occurring	Very low	Negligible	Negligible	Minor
	Low	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	High	Moderate	Major	Major

6.7 Baseline Conditions

6.7.1 This section describes the baseline environmental characteristics for the Scheme and surrounding areas with specific reference to GHG emissions and climatic conditions.

Lifecycle GHG Impact Assessment

6.7.2 The land within the Solar and Energy Storage Park consists mainly of arable land, managed hedgerows, and trees. Trees are present individually in some areas as well as rows of trees and small woodland areas. Also, the current use of the Solar and Energy Storage Park has minor levels of associated GHG emissions as the land use is largely agricultural. Baseline agricultural GHG emissions are dependent on soil and vegetation type's present, and fuel use for the operation of vehicles and machinery.

6.7.3 The lifecycle GHG impact assessment for the Order limits, comprising the Solar and Energy Storage Park and the Grid Connection Corridor are included in Section 6.1.

6.7.4 For the lifecycle GHG impact assessment, the future baseline is a 'business as usual' scenario whereby the Scheme is not implemented, for those lifecycle stages that have been scoped into the assessment, presented in Table 6-2. The future baseline comprises existing carbon stock and sources of GHG emissions within the Order limits from the existing activities on-site.

6.7.5 While the current land use within the Order limits will have minor levels of associated GHG emissions, it is anticipated that these emissions will not be material in the context of the overall Scheme. Therefore, for the purposes of the lifecycle GHG impact assessment, a GHG emissions baseline of zero is applied.

Climate Change Resilience Assessment and In-Combination Climate Change Impact Assessment

Existing Baseline

6.7.6 The current baseline for the CCR review and ICCI assessment is the current climate in the location of the Scheme. Historic climate data obtained from the Met Office website (Ref 6-28) recorded by the closest Met Office station to the Scheme (RAF Scampton) for the 30-year climate period of 1981-2010 (the standard baseline for climate data) is summarised in Table 6-14 below. The period 1991-2020 is also shown below although is not yet available as a baseline within future projections from UKCP18. Therefore, both time periods have been presented.

Table 6-14 Historic climate data

Climatic Factor	1981-2010		1991-2020	
	Month	Figure	Month	Figure
Average annual maximum daily temperature (°C)	-	13.44	-	13.84
Warmest month on average (°C)	July	21.32	July	21.62
Coldest month on average (°C)	February	0.64	February	1.02
Mean annual rainfall levels (mm)	-	613.15	-	619.40
Wettest month on average (mm)	June	60.48	June	64.96
Driest month on average (mm)	February	35.93	March	35.87

6.7.7 The Met Office historic 10-year averages for the ‘England East and North East’ region identify gradual warming between 1972 and 2021, with increased rainfall. Information on mean maximum annual temperatures (°C) and mean annual rainfall (mm) is summarised in Table 6-15.

Table 6-15 Historic 10-year averages for temperature and rainfall for the East and North East region

Climate Period	Climate Variable	
	Mean maximum annual temperatures (°C)	Mean annual rainfall (mm)
1972-1981	12.7	1,195.7
1982-1991	13.1	1,214.5
1992-2001	13.4	1,392.9
2002-2011	13.8	1,210.0
2012-2021	13.9	1,322.9

6.7.8 A site-specific flood risk assessment is provided in **ES Volume 3: Appendix 9-D [EN010131/APP/3.3]**. Details of the baseline flood risk can be found within **Chapter 9: Water Environment [EN010131/APP/3.1]** of this ES.

Future Baseline

6.7.9 The future baseline scenarios are set out in **Chapter 5: EIA Methodology [EN010131/APP/3.1]**.

6.7.10 The future baseline is expected to differ from the present-day baseline described above. UKCP18 (Ref 6-29) provides probabilistic climate change projections for pre-defined 30-year periods for annual, seasonal, and monthly changes to mean climatic conditions over land areas. For the purpose of the assessment, UKCP18 probabilistic projections for pre-defined 30-year periods for the following average climate variables have been obtained:

- Mean annual temperature;
- Mean summer temperature;
- Mean winter temperature;
- Maximum summer temperature;
- Minimum winter temperature;
- Mean annual precipitation;
- Mean summer precipitation;
- Mean winter precipitation;
- Mean annual cloud cover;
- Mean summer cloud cover; and
- Mean winter cloud cover.

6.7.11 Projected temperature, precipitation, and cloud cover variables are presented in Table 6-16, Table 6-17 and Table 6-18 respectively.

6.7.12 UKCP18 probabilistic projections have been analysed for the 25km^2 grid square within which the Scheme is located (487500, 387500). These figures are expressed as temperature/precipitation anomalies in relation to the 1981-2000 baseline.

6.7.13 UKCP18 uses a range of possible scenarios, classified as Representative Concentration Pathways (RCPs), to inform differing future emission trends. These RCPs "… *specify the concentrations of greenhouse gases that will result in total radiative forcing increasing by a target amount by 2100, relative to preindustrial levels.*" RCP8.5 has been used for the purposes of this assessment as a worst-case scenario.

6.7.14 As the design life of the Scheme is expected to be at least 60 years, the CCR assessment has considered a scenario that reflects a high level of GHG emissions at the 10%, 50%, and 90% probability levels up to 2089 to assess the impact of climate change over the lifetime of the Scheme.

6.7.15 The projections were updated on 4th August 2022. The methodology was updated to improve: consistency between maximum, minimum and mean temperature; consistency in the downscaling; statistical treatment of precipitation particularly at the wet and dry extremes; representation of annual and decadal variability; and adjustment of the data in the 1981-2000 baseline period to ensure the anomalies average to zero. The combination of the improvements means that all variables are modified to some degree.

6.7.16 The tables below show projected changes in temperature (expected to increase), precipitation (expected to increase in winter and decrease in summer) and cloud cover (expected to increase in winter and decrease in summer). The climate projections do not take account of the Scheme.

Table 6-16 Projected changes in temperature variables (°C)

Climate Variable	Time Period		
	2020-2049	2040-2069	2060-2089
Mean annual air temperature anomaly at 1.5 m (°C)	+1.05 (+0.51 to +1.64)	+1.86 (+0.97 to +2.79)	+2.93 (+1.65 to +4.27)
Mean summer air temperature anomaly at 1.5 m (°C)	+1.29 (+0.44 to +2.10)	+2.29 (+1.02 to +3.56)	+3.64 (+1.76 to +5.56)
Mean winter air temperature anomaly at 1.5 m (°C)	+0.92 (0.15 to +1.71)	+1.63 (+0.49 to +2.84)	+2.48 (+0.90 to +4.21)
Maximum summer air temperature anomaly at 1.5 m (°C)	+1.43 (+0.27 to +2.50)	+2.53 (+0.87 to 4.20)	+4.02 (+1.62 to 6.48)
Minimum winter air temperature anomaly at 1.5 m (°C)	+0.92 (+0.09 to +1.84)	+1.71 (+0.41 to +3.12)	+2.57 (+0.73 to +4.64)

Table 6-17 Projected changes in precipitation variables (%)

Climate Variable	Time Period		
	2020-2049	2040-2069	2060 - 2089
Annual precipitation rate anomaly (%)	+0.19 (-6.59 to +6.82)	-2.72 (-11.41 to +6.04)	-2.14 (-12.49 to +8.14)
Summer precipitation rate anomaly (%)	-3.72 (-21.36 to +14.27)	-14.89 (-37.57 to +8.59)	-24.18 (-48.24 to +0.84)
Winter precipitation rate anomaly (%)	+3.53 (-4.27 to +12.12)	+6.84 (-4.11 to +19.12)	+13.00 (-2.11 to +30.79)

Table 6-18 Projected changes in cloud cover variables (%)

Climate Variable	Time Period		
	2020-2049	2040-2069	2060 - 2089
Annual total cloud anomaly (%)	-1.42 (-4.10 to +1.20)	-2.75 (-6.56 to +0.88)	-4.74 (-10.21 to +0.40)
Summer total cloud anomaly (%)	-4.36 (-12.14 to +3.37)	-7.78 (-18.32 to +2.27)	-11.35 (-25.91 to +2.22)
Winter total cloud anomaly (%)	-0.16 (-2.94 to +2.51)	+0.34 (-2.56 to +3.23)	+0.39 (-3.12 to +3.65)

6.8 Potential Impacts

6.8.1 Mitigation measures being incorporated in the design and construction of the Scheme are set out below. The potential impacts of the Scheme during construction, operation and during decommissioning, which will be considered in the assessment are summarised in:

- Table 6-2 Potential sources of GHG emissions;
- Table 6-3 Scope of the CCR assessment; and
- Table 6-6 Scope of the ICCI assessment.

Summary of Sensitive Receptors

6.8.2 Based on a review of the baseline conditions, the global climate is the receptor for the lifecycle GHG impact assessment. The sensitivity of this receptor is high, in line with the IEMA guidance on assessing GHG emissions in EIA (Ref 6-31), which highlights the importance of mitigating GHG emissions to reduce the impacts of climate change.

6.8.3 The receptor for the review of climate change resilience is the Scheme itself, including all infrastructure, assets, and workers on-site during construction, operation, and decommissioning. The sensitivity of the receptor has not been defined for the CCR review as only a review of the impacts is required in line with UK industry (IEMA) guidance (Ref 6-31), rather than an assessment of the significance.

6.8.4 In the ICCI assessment, sensitive receptors are determined by each socio-environmental discipline in their assessment, in this case that relates to **Chapter 9: Water Environment [EN010131/APP/3.1]**. The ICCI assessment is undertaken by individual technical disciplines in regard to the identified sensitive receptors in each assessment.

6.9 Embedded and Additional Mitigation Measures

6.9.1 A **Framework CEMP** is included within the DCO application **[EN01-131/APP/7.3]**. This identifies various mitigation measures to be embedded within the Scheme to reduce the GHG impact including:

- Increasing recyclability by segregating construction waste to be re-used and recycled where reasonably practicable;
- Adopting the Considerate Constructors Scheme (CCS) to assist in reducing pollution, including GHGs, from the Scheme by employing best practice measures which go beyond the statutory requirements;
- Designing, constructing, and implementing the Scheme in such a way as to minimise the creation of waste and maximise the use of alternative materials with lower embodied carbon such as locally sourced products and materials with a higher recycled content;
- Encouraging the use of lower carbon modes of transport by identifying and communicating local bus connections and pedestrian and cycle access routes to/from the Scheme to all construction staff, and providing appropriate facilities for the safe storage of cycles;

- Liaising with construction personnel for potential to implement staff minibuses and car sharing options;
- Implementing a Travel Plan to reduce the volume of construction staff and employee trips to the Order limits;
- Switching off vehicles and plant when not in use and ensuring construction vehicles conform to current EU emissions standards; and
- Conducting regular planned maintenance of the Scheme to optimise efficiency.

6.9.2 Further climate change resilience measures embedded within the Scheme, particularly in relation to flood risk, are outlined below. The specific flood risk impacts and associated mitigation measures are discussed in more detail in **Chapter 9: Water Environment [EN010131/APP/3.1]** of this ES. These measures include:

- The design of drainage systems will ensure that there will be no significant increases in flood risk downstream during storms up to and including the 1 in 100 (1%) annual probability design flood, with an allowance of 40% for climate change;
- Sustainable Drainage Systems (SuDS) features will be utilised to ensure the surface water drainage strategy adequately attenuates and treats runoff from the Scheme, whilst minimising flood risk to the Order limits and surrounding areas; and
- The rate of runoff from each development location within the whole Solar and Energy Storage Park would ensure nil detriment in terms of no increase in runoff rate from the Site to receiving watercourses.

Construction and Decommissioning

6.9.3 A **Framework CEMP** is submitted as part of the DCO application **[EN010131/APP/7.3]** and includes various climate change resilience measures embedded within the Scheme. These include:

- Minimising the duration of topsoil and construction material storage within the 1 in 100-year floodplain extent (Flood Zone 3); and
- Appointing at least one designated Flood Warden who is familiar with the risks and remains vigilant to news reports, Environment Agency flood warnings, and water levels of the local waterways.

6.9.4 Health and safety plans developed for construction and decommissioning activities will be required to account for potential climate change impacts on workers, such as flooding and heatwaves.

6.9.5 A **Framework DEMP** has been submitted as part of the DCO application **[EN010131/APP/7.5]** and includes mitigation measures to encourage the use of lower-carbon and more climate change resilient methods. The Framework DEMP will be developed into a DEMP prior to decommissioning.

Operation

6.9.6 Adaptation measures to reduce the effect of projected temperature increases on electrical equipment over the course of the Scheme's design life have been taken into account. Inverters (PV and BESS) will have a cooling system installed to control the temperature and allow the inverters to operate efficiently in warmer conditions. The PV modules and transformers have a wide range of acceptable operating temperatures, and it has been determined that increasing temperatures will not adversely affect their operation.

6.9.7 Consideration will also be given to the UKCP18 climate change projections outlined in Section 6.6, and the resilience of the Scheme's infrastructure to these, through the detailed design process.

6.10 Assessment of Likely Impacts and Effects

6.10.1 Taking into account the committed avoidance and mitigation measures as detailed in Section 6.9 above, the potential for the Scheme to generate effects was assessed using the methodology as detailed in Section 6.6 of this Chapter.

6.10.2 The effects have been assessed following consideration of the potential impacts outlined in Section 6.8 and the mitigation measures in Section 6.9.

Lifecycle GHG Impact Assessment

6.10.3 Within this section, GHG emissions arising as a result of the Scheme are first identified and assessed for each lifecycle stage individually (construction, operation, and decommissioning).

6.10.4 While it is important to understand the GHG impacts at each individual lifecycle stage, it is also important to understand the net lifecycle GHG impact of the Scheme due to the long-term, cumulative nature of GHG emissions over the lifetime of the Scheme.

6.10.5 Therefore, the net impact of the Scheme is also identified and assessed, taking into account the renewable energy generation and the benefit of this in the context of the wider energy generation sector and the National Grid average GHG intensity. The overall assessment, which will account for all GHG emissions over the lifetime of the Scheme, will compare the GHG intensity of the Scheme with the GHG intensity of other predicted grid energy generation sources.

Construction (assumed to be 2025 to 2027-28) and Decommissioning (assumed to be 2087 to 2088-89)

6.10.6 The greatest GHG impacts occur during the construction phase as a result of the manufacture of the materials and components required. The manufacture of the PV Panels is estimated to account for 257,849 tCO_2e, with the manufacture of BESS leading to a further 77,500 tCO_2e based on the site layout plan and the description of the Scheme provided in **Chapter 2: The Scheme [EN010131/APP/3.1]**. Table 6-19 summarises the emissions resulting from the manufacture of materials required for the construction of the Scheme.

Table 6-19 Embodied emissions from the manufacture of materials and components

Emissions Source	Embodied emissions (t CO_2e)	Proportion of total embodied emissions
PV Panels	257,849	64%
PV Inverters	23,740	6%

Emissions Source	Embodied emissions (t CO_2e)	Proportion of total embodied emissions
PV framework	37,670	9%
BESS	77,500	18%
Transformers	5,130	1.3%
Cables	2,470	<1%
Concrete	845	<1%
Aggregate	120	<1%
Total Products	**405,321**	**100%**

6.10.7 Other sources of emissions during construction within the scope of the GHG emissions assessment include water, energy, and fuel use for construction activities including fuel consumed by construction plant and machinery, fuel use for the transportation of construction materials to the Order limits, transportation of construction workers to and from the Order limits and the transportation and disposal of waste. For details of assumptions and limitations refer to Section 6.4.

6.10.8 Based on the scheme details and assumptions included in Section 6.4 total GHG emissions from the construction phase are estimated to equate to around 408,446 tCO_2e. Table 6-20 below summarises overall construction emissions from various emissions sources.

Table 6-20 Emissions resulting from the construction phase

Emissions Source	Embodied emissions (t CO_2e)	Proportion of overall construction emissions
Products and materials	405,321	93.5%
Transportation of products and materials	21,370	4.9%
Worker commuting	2,910	0.7%
Waste (including transport)	2,870	0.7%
Fuel use	1,190	0.3%
Water use	0.9	<0.1%
Construction total	**433,651**	**100%**

Operation (assumed to be 2028 to 2088)

6.10.9 GHG emissions sources within the scope of the operational emissions include operational energy use (i.e. for auxiliary services and standby power), fuel used for the transportation of workers to the Order limits, and maintenance activities (including embodied carbon in replacement parts, plant and machinery requirements, fuel and water use during maintenance activities, transportation of materials and waste to and from the Order limits, and waste management activities).

6.10.10 It is assumed that the on-site control building will have an average continuous power demand of 10kW, and that this will be supplied from the national grid for a total annual grid electricity consumption of 87,600 kWh/yr. The UK Government publishes projections of grid carbon intensity for each year to 2100, with emissions per kWh of electricity generated set to decline over the period to 2050. Emissions therefore will be highest in year one of operation and fall thereafter. Applying these projected grid factors, emissions in the first year of operations are estimated to be just over 9 tCO_2e/yr, falling to just over 2 tCO_2e/yr by the final year of the design life when the national grid is assumed to be largely renewables fed. Lifetime emissions from grid power consumption total 210 tCO_2e. This is likely to be an overestimate given that the power will sometimes be generated onsite from the Solar PV or from the BESS.

6.10.11 Based on the estimated lifetime and replacement rates for PV Panels, PV Inverters, BESS cells and transformers, refer to Section 6.4, and applying the same embodied and transportation emissions factors used to quantify the impact of construction, the replacement of these components is estimated to result in embodied emissions of 435,753 tCO_2e, and additional emissions of 11,618 tCO_2e from their transportation from country of origin to the Order limits.

6.10.12 With the exception of the emissions data for PV Panels, which have been derived from an Environmental Product Declaration, the embodied carbon factors on which these figures are based are subject to considerable uncertainty, with there being no industry-standard emissions factors for many of these items. Furthermore, if the replacement of inverters and BESS cells takes place mid-way through the Scheme's 60-year design life, it is extremely likely that by the time of replacement, the embodied carbon impact of manufacturing the replacement components will be much lower than the values that have been applied in this GHG assessment, and that much more reliable data will be available.

6.10.13 Emissions from the transportation of workers assume 14 workers on site each day and approximately 3-4 visitors per week, with each worker driving to site in their own vehicle a maximum of 30km each way. This is assumed to be a conservative assumption that is likely to overestimate the distance travelled. The emissions factor applied is for an average van of unknown fuel, from the most recent conversion factors for company reporting. Based on these assumptions, emissions from commuting and visitor travel are estimated at to be just less than 121 tCO_2e per year, for a total of 7,240 tCO_2e over the 60-year design life of the Scheme. This figure is a highly conservative worst-case scenario, with the actual operational transport emissions likely to be much lower with the inevitable transition to EVs combined with the ongoing decarbonisation of UK grid electricity.

6.10.14 Emissions from the supply of water and treatment of wastewater can be estimated by applying the same emissions factors as for construction emissions. Based on 14 workers each consuming 90 litres per day, annual emissions from water and wastewater are estimated at 0.19 tCO_2e per year or 11.6 tonnes over the design life of the Scheme. This is also a worst-case scenario, as the carbon intensity of water supply and wastewater treatment are expected to fall over time.

6.10.15 While SF_6 is a potential source of GHG emissions over the lifetime of the Scheme (from its use in certain electric components such as gas-insulated switchgears and transformers during production, operation through leakage, and dismantling), it is not likely to be possible to accurately quantify the small level of fugitive emissions from the leakage of SF_6 due to insufficient data. Manufacturers of electrical switchgear and transformers are increasingly able to provide equipment that either does not contain any SF_6 or is sealed for life with extremely low leakage rates. This will therefore not be considered further in the assessment and is not expected to have a material impact on the predicted effects on GHG emissions associated with the Scheme (Ref 6-38).

6.10.16 As discussed in Section 6.4, land use change is anticipated to have a beneficial impact during the lifetime of the Scheme. However, as this beneficial impact is largely reversed during decommissioning, the GHG impact associated with land use change has been excluded from the lifecycle GHG impact assessment. This is assumed to represent a robust worst-case scenario as tree and hedgerow planted during construction may be retained beyond the decommissioning phase.

6.10.17 Total operational emissions over the design life of the Scheme are estimated at 454,350 tCO_2e. 95.9% of this figure results from the supply of replacement components, with the remaining 4.1% the result of ongoing operational emissions.

6.10.18 Table 6-21 summarises operational emissions sources.

Table 6-21 Emissions resulting from the operational phase

Emissions Source	Embodied emissions (t CO_2e)	Proportion of overall operational emissions
Materials (replacement components)	435,753	95.9%
Transportation of materials	11,618	2.6%
Worker transport	6,860	1.5%
Grid electricity	110	<0.1%
Water/wastewater	12	<0.1%
Operations total	**454,350**	**100%**

Decommissioning (assumed to be 2087 to 2089)

6.10.19 GHG emissions from the Scheme during decommissioning are subject to a very high degree of uncertainty, as the conditions that will apply over six decades into the future cannot be described with any confidence. Conservatively, for the purpose of this assessment, and following discussions with the Applicant's design team, it is assumed that decommissioning emissions from the use of plant, worker travel, water and wastewater consumption would be set at 100% of the corresponding emissions during the construction phase. This is very likely to be a highly conservative estimate which overestimates decommissioning emissions.

6.10.20 Emissions from the disposal and recovery of materials and components at the end of the Scheme's design life have been estimated based on an assumption that 70% of materials and components will be recovered at the end of life, with 30% going to landfill, together with the most recent emissions factors for recycling published by the UK Government. This is also likely to be a conservative estimate as it is expected that a higher proportion of materials will be recycled. Emissions from end-of-life disposal of all materials and products are estimated at 1,040 tCO_2e.

6.10.21 Emissions from the transportation of materials and products at end of life have been estimated on the assumption that concrete and aggregate will be disposed of within a 50km radius, while all other products will be disposed of within 200km. Applying the most recent BEIS emissions factor (Ref 6-26) for HGV travel gives end of life transport emissions of 4,169 tCO_2e. This is very likely to be a highly conservative estimate as HGV transport decarbonises in the future.

6.10.22 Land use change has been excluded from the GHG assessment as discussed in Section 6.4 and Section 6.10.16 due to the beneficial GHG impacts of conversion of cropland to grassland during operation, being returned to cropland following decommissioning of the Scheme, with any carbon stored in soil or vegetation re-released to the atmosphere. This is considered to be a robust worst-case approach and likely to underestimate the beneficial effect of the Scheme, as tree and hedgerow planting may be retained after decommissioning. Any carbon sequestered in these areas would remain in the ground following decommissioning.

6.10.23 Table 6-22 summarises the emissions resulting from the decommissioning phase.

Table 6-22 Emissions resulting from the decommissioning phase

Emissions Source	Embodied emissions (t CO_2e)	Proportion of overall decommissioning emissions
Transportation of materials	4,169	37%
Worker commuting	2,910	28%
Fuel use	3,170	26%
Waste recycling/disposal	1,040	9%
Water use	0.6	<0.01%
Decommissioning sub-total	**11,324**	**100%**

6.10.24 A **Framework DEMP [EN010131/APP/7.5]** has been submitted as part of the DCO Application which includes mitigation measures to reduce or prevent potential adverse impacts. The DEMP also includes monitoring to ensure the effectiveness of mitigation measures, and corrective action and procedures.

6.10.25 Lifetime emissions from the construction, operation and decommissioning of the Scheme are summarised in Table 6-23. The sum is **899,933 tCO_2e** being emitted over the Scheme lifetime. This is prior to consideration of the CO_2e avoidance that can be attributed directly to the Scheme.

Table 6-23 Emissions resulting over the lifetime of the Scheme

Phase	Embodied emissions (t CO_2e)	Proportion of overall lifetime emissions
Construction	434,259	48.3%
Operations	454,350	50.5%
Decommissioning	11,324	1.3%
Lifetime total	**899,933**	**100.0%**

Carbon intensity of the Scheme

6.10.26 Renewable energy generation from the Scheme during the first year of operation is estimated to be 479,790 MWh based on the scheme description and layout plan contained within **Chapter 2: The Scheme [EN010131/APP/3.1]**, taking into consideration a 2% reduction in PV Panel performance during the first year. A 0.45% degradation factor has been applied for each subsequent year, and the entire array is assumed to be replaced midway through the design life resulting in an estimated energy generation figure of 420,967 MWh in the final year of operation, and a total energy generation figure of around 26.986 TWh over the 60-year Scheme lifetime. It is possible this is a slightly conservative estimate, however, as future climate projections indicate a reduction in annual cloud cover over time (see Section 6.7) which may have a beneficial impact on the energy generation potential of the Scheme and has not been taken into account in the calculations.

6.10.27 Dividing this lifetime generation figure into the lifetime emissions total shown in Table 6-23 gives a total carbon intensity value of 33.35 gCO_2e/kWh.

6.10.28 The current UK grid carbon intensity is 212 gCO_2e/kWh, however these figures cannot be directly compared as the published UK grid carbon intensity figure only takes into account operational emissions from the generation of electricity, overwhelmingly from the fossil fuels used to power gas-fired and occasionally coal-fired power stations (Ref 6-37). For a meaningful comparison to be made between the Scheme and the UK grid, the operational carbon intensity of the Scheme must only include emissions from the ongoing operations of the Scheme and exclude emissions from construction and decommissioning.

6.10.29 Combining lifetime generation figures and operational emissions figures gives an operational carbon intensity value of 15.86 gCO_2e/kWh.

6.10.30 Comparing the Scheme against a gas-fired Combined Cycle Gas Turbine (CCGT) generating facility, currently the most carbon-efficient fossil-fuelled technology available, a representative figure for the carbon intensity of a CCGT is 354g CO_2e/kWh (Ref 6-39). The operational carbon intensity of the Scheme is therefore 95% lower than that of the counterfactual CCGT. Each kilowatt hour of electricity generated by the Scheme will emit 338g CO_2e less than if it was generated by a gas fired CCGT generating facility.

6.10.31 Combining this figure with the estimated lifetime output from the Scheme indicates an overall lifetime carbon reduction, relative to the counterfactual CCGT, of over 9 million tonnes CO_2e.

6.10.32 A range of other low-carbon electricity generation technologies are available, such as on- and offshore wind, biomass and nuclear power. Each of these technologies will have a different carbon intensity in terms of total emissions per kWh of electricity generated. A literature review indicates a range of carbon intensity figures for each power source, making it challenging to directly compare the carbon impact of a specific installation, such as the Proposed Development, with data for a broad generation technology.

6.10.33 As the UK electricity sector continues to decarbonise, a range of different low-carbon generation technologies will be required to support an electricity generation system that can balance emissions reductions, security of supply and affordability.

Additional carbon savings from use of the BESS

6.10.34 Use of the battery energy storage system provides additional carbon saving opportunities. Relatively fast response power sources such as battery storage have an important role to play in helping to balance supply and demand within the electricity grid. This grid balancing function is often performed using high-carbon intensity power sources such as open cycle gas turbines (OCGT), so the use of a battery charged from solar PV generation can deliver a direct carbon saving relative to an OCGT.

6.10.35 Should the BESS be charged from the Scheme, and discharged back into the grid once each day, at a typical round trip efficiency of 85% and an overall lifetime degradation rate of 80%, it will be able to supply 7,446,000 MWh to the electricity grid over its 60 year operational lifetime. As the operational carbon intensity of the Scheme is 0.016 tCO_2e/MWh and the comparable figure for an OCGT is 0.460 tCO_2e/MWh, the use of the BESS for grid balancing purposes would deliver a saving of 3.3 million tonnes CO_2e over its operational lifetime. The overall carbon reduction when the BESS is used for a daily charge-discharge cycle as described here is around 10.3 million tonnes CO_2e, or over 1.1 million tonnes CO_2e higher than if the entire output of the Scheme is supplied to the grid without the use of a BESS.

6.10.36 The BESS can also be used for additional grid balancing purposes independent of the solar PV element of the Scheme, charging the battery from the grid overnight during periods of low demand and feeding it back when demand increases in the morning. The carbon impact of this scenario can be modelled on the assumption that the average carbon intensity of the electricity used to charge the battery is 0.014 tCO_2e/MWh (the projected average for the operational lifetime of the Proposed Development) and the battery is used in place of an OCGT operating at a carbon intensity of 0.460 tCO_2e/MWh. Should the BESS be used for an additional overnight charge-discharge cycle as described here, it would result in savings of over 3.3

million tonnes CO_2e over its operational lifetime, over and above the savings from use of the battery when charged directly from the solar farm.

6.10.37 All of these figures are inevitably subject to a degree of uncertainty, but they illustrate the fact that the use of the battery system, when used for grid balancing purposes, is likely to result in significant additional carbon savings over its operational lifetime. These additional carbon savings from use of the BESS for grid balancing are not factored into the overall GHG assessment summarised below.

Overall GHG Impact

6.10.38 In light of UK's climate objective to achieve net zero carbon by 2050, and in line with IEMA guidance on Assessing Greenhouse Gas Emissions and Evaluating their Significance, UK's fourth, fifth and sixth carbon budgets have been used to contextualise emissions from the Scheme.

6.10.39 The Scheme has significantly lower emissions compared to the carbon budget. However, the ongoing operation of the Scheme will inevitably result in some residual emissions by 2050. The vast majority of these residual emissions are operational emissions. The Scheme will achieve substantial emissions reductions compared to the without-project baseline, i.e. in a scenario in which the Scheme does not go ahead and the power it generates is provided by a higher carbon generator.

6.10.40 Beyond 2037, it is anticipated that direct operational emissions will decrease over time due to continuing grid decarbonisation, and of machinery and vehicle electrification, in line with the UK's net-zero carbon emissions target for 2050. Indirectly, the generation of electricity with a much lower carbon intensity than the grid average will result in reduced GHG emissions overall. This indirect emissions reduction will far outweigh any direct emissions resulting from the operations of the Scheme over its lifetime and overall, the operation of the project will provide GHG performance that supports the trajectory towards net zero.

6.10.41 The UK's fourth, fifth and sixth carbon budgets have also been used to contextualise the magnitude of GHG emissions from the Scheme in Table 6-24, depending on the years in which the emissions are expected to occur. Construction emissions will fall under the 4th UK carbon budget. The Scheme will be operational from no earlier than 2027, and therefore operational emissions up to 2037 (the end of the 6th carbon budget) will fall under the 4th, 5th and 6th UK carbon budgets, beyond which point no carbon budgets have yet been published.

Table 6-24. Estimated GHG emissions as a proportion of the estimated carbon budgets to 2037

Carbon budget period	Lifecycle Stage	Carbon budget (tCO_2e)	Scheme GHG emissions (tCO_2e)	% of carbon budget emissions
4th carbon budget (2023-2027)	Construction	1,950,000,000	434,259	0.02%

5th carbon budget (2028-2032)	Operation	1,725,000,000	37,862	0.002%
6th carbon budget (2033-2037)	Operation	965,000,000	37,862	0.003%

6.10.42 UK carbon budgets are based on production emissions, rather than consumption. It should be noted that the bulk of manufactured components in this Scheme are manufactured overseas and imported to the UK.

6.10.43 In line with IEMA guidance on Assessing Greenhouse Gas Emissions and Evaluating their Significance, the sectoral carbon budgets for electricity supply have also been used to contextualise emissions from the Scheme.

6.10.44 The Scheme has significantly lower emissions compared to the sectoral carbon budget, and while the Scheme will result in residual emissions post 2050, it will achieve substantial emissions reductions relative to the without-project baseline.

6.10.45 However, beyond 2037, it is anticipated that direct operational emissions will decrease over time due to continuing grid decarbonisation, machinery and vehicle electrification, in line with the UK's net-zero carbon emissions trajectory. Indirectly, the generation of electricity with a much lower carbon intensity than the grid average will result in reduced GHG emissions overall. This indirect emissions reduction will far outweigh any direct emissions resulting from the operations of the Scheme over its lifetime and overall, the operation of the project will provide GHG performance that supports the trajectory towards net zero.

6.10.46 The sectoral carbon budgets (electricity supply) have also been used to contextualise the magnitude of GHG emissions from the Scheme in Table 6-24, depending on the years in which the emissions are expected to occur. Construction emissions will fall in 2025, 2026, and 2027. The Scheme will be operational from no earlier than 2028, and therefore annualised operational emissions up to 2050 will fall during the operation of the Scheme, which is expected to include one set of equipment replacements in 2046 (which is estimated to result in an anomalous spike in GHG emissions). The emissions in the Table 6-25 assume that the carbon intensity of components remains constant throughout the Scheme's design life, however this is not expected to happen in reality and therefore the figures are anticipated to be an overestimate.

Table 6-25. Estimated GHG emissions as a proportion of the estimated Sectoral carbon budgets to 2050

Carbon budget year	Lifecycle Stage	Carbon budget (tCO_2e)	Scheme GHG emissions (tCO_2e)	% of carbon budget emissions
2025	Construction	41,650,081	217,129	0.52%
2026	Construction	32,364,327	217,129	0.67%
2027	Operation	26,698,395	310	0.00%
2028	Operation	23,753,320	310	0.00%

2029	Operation	22,398,435	310	0.00%
2030	Operation	18,553,339	310	0.00%
2031	Operation	15,771,201	310	0.00%
2032	Operation	12,090,757	310	0.00%
2033	Operation	9,857,164	310	0.00%
2034	Operation	8,004,075	310	0.00%
2035	Operation	6,201,104	310	0.00%
2036	Operation	6,013,285	310	0.01%
2037	Operation	5,665,422	310	0.01%
2038	Operation	5,523,168	310	0.01%
2039	Operation	5,389,428	310	0.01%
2040	Operation	5,105,198	310	0.01%
2041	Operation	3,752,185	310	0.01%
2042	Operation	3,452,359	310	0.01%
2043	Operation	3,323,141	310	0.01%
2044	Operation	3,149,805	310	0.01%
2045	Operation	2,267,351	310	0.01%
2046	Operation	2,016,269	218,186	10.8%
2047	Operation	1,605,366	310	0.02%
2048	Operation	1,489,110	310	0.02%
2049	Operation	1,331,872	310	0.02%
2050	Operation	1,205,459	310	0.03%

6.10.47 As detailed in Section 6.9, a **Framework CEMP [EN010131/APP/7.3]** is provided as part of the DCO application which includes mitigation to reduce the GHG impact of the scheme during construction.

6.10.48 The without project scenario has been assumed to be a gas-fired CCGT generating facility. The operational energy intensity allows isolated comparison of the emissions associated with operation of the Scheme compared to the alternative (Figure 1). The operational intensity of the Scheme is 16gCO_2e/kWh, while the operational carbon intensity of a CCGT facility is 354gCO_2e/kWh, showing substantial carbon savings.

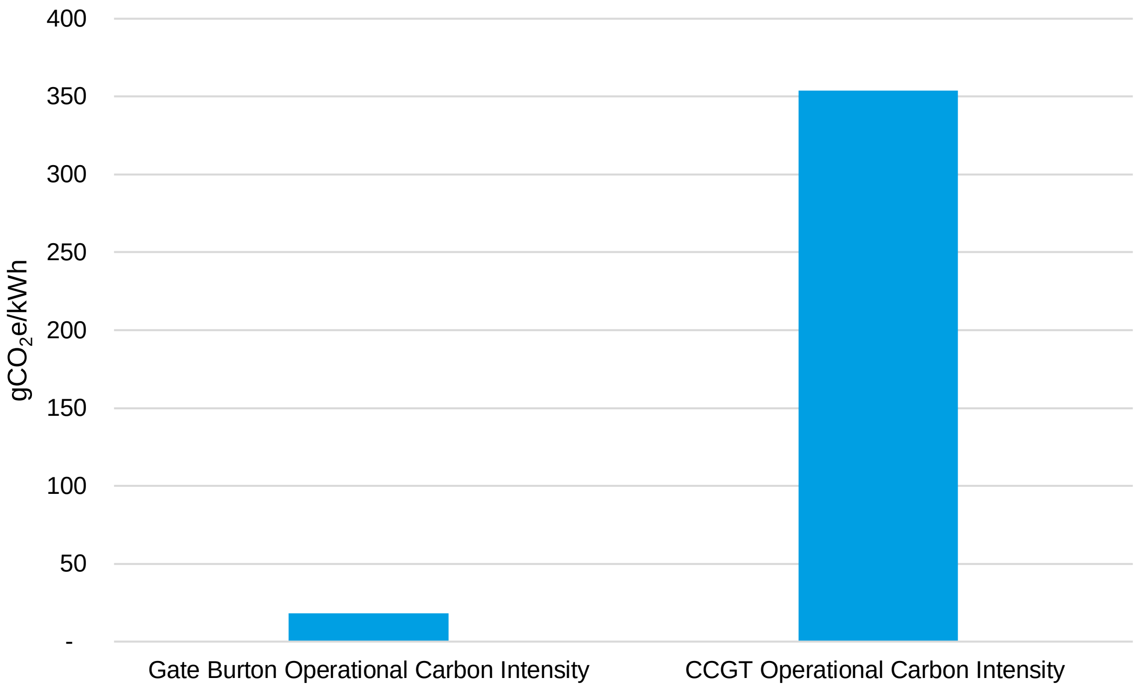

Figure 1. Comparison of the operational carbon intensity of the scheme to the without-project scenario

6.10.49 As the GHG electricity generation intensity figure for the Scheme is anticipated to sit continually below the forecast grid average, GHG emissions savings are expected to be achieved throughout the lifetime of the Scheme compared to other fossil fuel energy generation types. Therefore, the GHG emissions during construction, operation, and decommissioning of the Scheme can be considered to be 'offset' by the net positive impact of the Scheme on GHG emissions and the UK's ability to meet its carbon targets. It would be possible for a low-carbon energy generation project to have a GHG intensity below the projected grid for most of its lifetime, but above it towards the end of its lifetime and still have an overall positive impact on the UK's ability to meet its carbon targets. However, comparison to grid emissions is not a suitable comparison as decarbonisation of the grid relies on investment in low carbon technologies, such as this Scheme. Emissions associated with the grid are also based only on the fuel consumed by power stations and are therefore not relevant in the context of the Scheme.

6.10.50 The GHG savings achieved throughout the lifetime of the Scheme demonstrate the role solar energy generation has to play in the transition to, and longer-term maintenance of, a low carbon economy. Without low-carbon energy generation projects such as the Scheme, the average grid GHG intensity will not decrease as is projected, which could adversely affect the UK's ability to meet its carbon reduction targets.

6.10.51 As the operational carbon intensity of the Scheme remains below the CCGT facility throughout its lifetime, it is considered that the overall GHG impact of the Scheme is **beneficial** and **significant,** as it will play a part in achieving the rate of transition required by nationally set policy commitments and supporting the trajectory towards net zero. The without-project baseline alternative of a CCGT facility would result in substantially higher GHG emissions. This Scheme demonstrates carbon savings, therefore it is beneficial and has a positive impact on climate.

Significance of Effect (Decommissioning)

6.10.52 Decommissioning of the scheme falls outside of national and sectoral carbon budgets. While there will be GHG emissions associated with the decommissioning phase of the Scheme, actual emissions are anticipated to be lower as the figures that will be estimated and presented in the ES will represent a worst-case scenario. Also, the overall GHG reductions achieved by the Scheme are considered to offset and outweigh any GHG impacts associated with the decommissioning phase of the Scheme. Therefore, it is considered that the overall GHG impact of decommissioning is negligible.

Climate Change Resilience Assessment

6.10.53 Potential climate risks to the construction, operation and decommissioning phase, including the likelihood, consequence and significance are detailed in **ES Volume 3, Appendix 6-A: Summary of Non-Significant Effects [EN010131/APP/3.3]**.

6.10.54 Future climate change projections have been reviewed and the sensitivity of assets have been examined, before commenting on the adequacy of the climate change resilience measures built into the Scheme. As a result of the proposed resilience measures **no significant** climate change risks during the construction, operation or decommissioning phase have been identified.

In-Combination Climate Change Assessment

6.10.55 Future climate change projections have been reviewed and the sensitivity of identified sensitive receptors to these hazards examined. Project risks to receptors are examined together with climate hazards to understand if the impact is exacerbated. The influence of climate change combined with potential impacts from the construction, operation and decommissioning of the Scheme on sensitive receptors are included in **ES Volume 3: Appendix 6-A [EN010131/APP/3.3].**

Monitoring

6.10.56 As no potential significant effects have been identified for climate change, no monitoring of significant effects is required and/or proposed.

6.11 Cumulative Assessment

6.11.1 Climate change is the result of cumulative impacts as it is the result of innumerable minor activities, a single activity may itself result in a minor or insignificant impact, but when combined with many other activities, the cumulative impact could be significant. The nature of greenhouse gases is such that their impact on receptors (the global climate) is not affected by the location of their source. As stated in IEMA guidance (Ref 6-31), due to this the GHG emission impacts and resulting effects are global rather than affecting one localised area. The GHG emissions assessment is inherently a cumulative assessment as it considers whether the Scheme would contribute significantly to emissions on a national level and sectoral level.

6.11.2 The global atmosphere is the receptor for climate change impacts and has the ability for holding GHG emissions. Nevertheless, as stated by IEMA (Ref 6-31), all GHG emissions are considered significant and therefore would contribute to climate change. While the impact of any individual Scheme may be limited, it is the cumulative impact of many Schemes over time that could have a significant impact on climate change.

6.11.3 As such it is not possible to define a study area for the assessment of cumulative effects of GHG emissions nor to undertake a cumulative effects assessment, as the identified receptor is the global climate and effects are therefore not geographically constrained. Consequently, as stated in the IEMA guidance (Ref 6-31), effects of GHG emissions from specific cumulative projects therefore in general should not be individually assessed, as there is no basis for selecting any particular (or more than one) cumulative project that has GHG emissions for assessment over any other.

6.11.4 The ICCI assessment is, by nature, a cumulative assessment, and any effects are detailed in **ES Volume 3: Appendix 6-A [EN010131/APP/3.3].** As the CCR Review is only concerned with the assets of the Scheme and a broader consideration of existing interdependent infrastructure, a cumulative assessment is not required.

References

Ref 6-1. Her Majesty's Stationery Office (HMSO) (2017). The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017. Available at: https://www.legislation.gov.uk/uksi/2017/572/contents/made

Ref 6-2. HMSO (2008) *Climate Change Act 2008*. Available at: https://www.legislation.gov.uk/ukpga/2008/27/contents

Ref 6-3. H.M Government (2008). *Climate Change Act 2008 (2050 Target Amendment) Order 2019*. Available at: https://www.legislation.gov.uk/ukdsi/2019/9780111187654

Ref 6-4. H.M Government (2009). *The Carbon Budgets Order 2009*. Available at: https://www.legislation.gov.uk/uksi/2009/1259/contents/made

Ref 6-5. HM Government (2011). *The Carbon Budget Order 2011*. Available at: https://www.legislation.gov.uk/ukdsi/2011/9780111511688/body

Ref 6-6. HM Government (2016). *The Carbon Budget Order 2016*. Available at: https://www.legislation.gov.uk/uksi/2016/785/contents/made

Ref 6-7. HM Government (2021). *The Carbon Budget Order 2021*. Available at: https://www.legislation.gov.uk/ukdsi/2021/9780348222616

Ref 6-8. Department of Energy & Climate Change (2011). *Overarching National Policy Statement for Energy (EN-1)*. Available at: https://www.gov.uk/government/publications/national-policy-statements-for-energy-infrastructure

Ref 6-9. Department of Energy & Climate Change (2011). *National Policy Statement for Renewable Energy Infrastructure (EN-3)*. Available at: https://www.gov.uk/government/publications/national-policy-statements-for-energy-infrastructure

Ref 6-10. Department of Energy & Climate Change (2011). National Policy Statement for Electrical Networks Infrastructure (EN-5). Available at: https://www.gov.uk/government/publications/national-policy-statements-for-energy-infrastructure

Ref 6-11. Ministry of Housing, Communities & Local Government (2019). National Planning Policy Framework. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2

Ref 6-12. Ministry of Housing, Communities & Local Government (2018). *Planning Practice Guidance for Climate Change (2019 update).* Available at: https://www.gov.uk/guidance/climate-change.

Ref 6-13. Lincolnshire County Council, Central Lincolnshire Local Plan 2012-2036," adopted April 2017. Available at: https://www.n-kesteven.gov.uk/central-lincolnshire/local-plan/

Ref 6-14. Lincolnshire County Council, Central Lincolnshire Local Plan Proposed Submission Draft March 2022 (under consultation).

Ref 6-15. Draft Bassetlaw Local Plan 2020 – 2037 (2021). Available at: https://www.bassetlaw.gov.uk/bassetlawplan.

Ref 6-16. Bassetlaw District Council, *Bassetlaw Core Strategy & Development Management Policies DPD*, Bassetlaw District Council, Retford, 2001. Available at: https://www.bassetlaw.gov.uk/planning-and-building/planning-services/planning-policy/core-strategy-and-development-policies/core-strategy-adopted-development-plan/what-is-the-core-strategy/

Ref 6-17. Sturton Ward Neighbourhood Plan 2020-2037 (2020 DRAFT).

Ref 6-18. EPD International AB (2020). *Environmental Performance Declaration (EPD) for Jolywood N-type Bifacial Double Glass Photovoltaic Modules*.

Ref 6-19. Rajput, S. K. and Singh, O. (2017). *Reduction in CO2 Emission through Photovoltaic System: A Case Study*.

Ref 6-20. Carbon Transparency Initiative (2016). *ClimateWorks Foundation, San Francisco, CA*.

Ref 6-21. European Environment Agency (2021). *Overview of Electricity Production and Use in Europe*.

Ref 6-22. FutureFirma Sustainability Consulting (2018) *Life-Cycle Carbon Impact Assessment of the Respond Project*.

Ref 6-23. Philippot, M., Alvarez, G., Ayerbe, E., Van Mierlo, J. and Messagie, M. (2019). *Eco-Efficiency of a Lithium-Ion Battery for Electric Vehicles: Influence of Manufacturing Country and Commodity Prices on GHG Emissions and Costs*.

Ref 6-24. Bath University and Circular Ecology (2019). *Inventory of Carbon and Energy (ICE) Database V3.0*.

Ref 6-25. Sea-Distances (2022). *Ports Distances Calculator*.

Ref 6-26. Department for Environment, Food and Rural Affairs (DEFRA) and the Department of Business, Energy and Industrial Strategy (BEIS) (2022) *Conversion Factors for Company Reporting*. Available at: https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

Ref 6-27. Department for Business, Energy & Industrial Strategy (BEIS) (202). *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - Data Tables 1 to 19*. Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Ref 6-28. UK Met Office (2019). Historic climate data. https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcpuckhb6

Ref 6-29. UK Met Office (2018). *UK Climate Projections 2018 (UKCP18)*. Accessed via: https://ukclimateprojections-ui.metoffice.gov.uk/ui/home.

Ref 6-30. World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI). *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*.

Ref 6-31. Institute of Environmental Management and Assessment (IEMA) (2022). *Institute of Environmental Management and assessment (IEMA) Guide: Assessing Greenhouse Gas Emissions and Evaluating their Significance.*

Ref 6-32. Institute of Environmental Management and Assessment (IEMA) (2020) *Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation*

Ref 6-33. IPCC. Fifth Assessment Report 2014 [online].

Ref 6-34. Department of Energy and Climate Change (DECC) (2013). *Guidance on Annual Verification for emissions from Stationary Installations*. Available at: https://www.gov.uk/government/publications/eu-electronic-trading-system-faqs-on-annual-verification-on-emissions-from-stationary-installations

Ref 6-35. British Standards Institution (2011). *PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*.

Ref 6-36. Committee on Climate Change (2021). *UK Carbon Budgets*.

Ref 6-37. Department for Environment, Food and Rural Affairs (DEFRA) and the Department of Business, Energy and Industrial Strategy (BEIS) (2022). *Conversion Factors 2021: Methodology*. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021

Ref 6-38. Widger, P. and Haddad, A. (2018). *Evaluation of SF6 Leakage from Gas Insulated Equipment on Electricity Networks in Great Britain*.

Ref 6-39. UK Parliament (2015). *Fossil fuelled power stations: carbon emissions and nitrogen oxides – answer to written question 17799 tabled by Dr Alan Whitehead MP*.

Ref 6-40. Committee on Climate Change (2021). *Sixth Carbon Budget – Dataset (Version 2 – December 2021)*.

Ref 6-41. Department of Energy & Climate Change (2021). *Draft Overarching National Policy Statement for Energy (EN-1)*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015233/en-1-draft-for-consultation.pdf

Ref 6-42. Department of Energy & Climate Change (2021). *Draft National Policy Statement for Renewable Energy Infrastructure (EN-3)*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015236/en-3-draft-for-consultation.pdf

Ref 6-43. Department of Energy & Climate Change (2021). *Draft National Policy Statement for Electrical Networks Infrastructure (EN-5)*. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015238/en-5-draft-for-consultation.pdf