Heckington Fen Solar Park

EN010123

Chapter 13 – Climate Change

Applicant: Ecotricity (Heck Fen Solar) Limited

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CHAPTER 13: CLIMATE CHANGE

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13.1 EXECUTIVE SUMMARY

13.1.1 This assessment considers the potential effects of the Proposed Development on emissions of greenhouse gases (GHGs), and both the vulnerability of the Proposed Development to climate change and the implications of climate change for the predicted effects of the project, as assessed by the other topic specialists ('in-combination climate effects').

13.1.2 The greatest volume of GHG emissions during the construction phase is as a result of the embodied carbon in construction materials, which accounts for over 96% of the total emissions. Total GHG emissions from the construction phase, when compared to applicable national carbon budgets in line with the accepted guidance, equate to an effect that is **not significant.** The Proposed Development is considered to have a **significant beneficial effect** on emissions reductions during its operational phase. GHG emissions from decommissioning activities are considerably lower than construction related emissions and are considered **not significant.**

13.1.3 It is not considered that the Proposed Development could be affected by climate change to such an extent that its construction, operation, or decommissioning could become unviable. Therefore, **no significant adverse effects** are predicted in relation to project vulnerability to climate change. With respect to 'in-combination climate effects', the assessment considered projected climate change in relation to landscape and visual amenity, cultural heritage, flooding and drainage, ecology, and noise. No new significant effects were identified for these topic areas as a consequence of projected climate change.

13.2 INTRODUCTION

13.2.1 This chapter considers potential effects with respect to climate change. In accordance with the definitions provided in **Chapter 4: Proposed Development** (document reference 6.1.4), where appropriate, a distinction has been made between the 'Energy Park' (including the solar photovoltaic (PV) infrastructure, onsite substation, and energy storage system (ESS)), and the 'Proposed Development' which also encompasses the underground cable route to, and above and below ground works at the National Grid Bicker Fen substation, and also any associated ancillary infrastructure, including temporary construction compounds and security fencing.

13.2.2 In line with the EIA Regulations, the assessment considers the following:

- **Emissions reduction[1]:** potential effects of the Proposed Development on emissions of GHGs; and
- **Climate change adaptation:** both the vulnerability of the Proposed Development to climate change and also the implications of climate change for the predicted effects of the project, as assessed by the other topic specialists ('in-combination climate effects').

13.2.3 Climate change is a relatively new topic in EIA. Guidance is evolving and there is no prescribed way in which climate change should be incorporated into an ES. By its very nature, climate change interacts with a range of other environmental and social topics and therefore elements of this topic are considered throughout the ES and other application documents.

[1] Also known as 'climate change mitigation' and this is not to be confused with EIA mitigation. Climate change mitigation seeks to specifically reduce a development's greenhouse gas emissions. EIA mitigation is measures that aim to avoid, prevent, reduce or offset any identified significant adverse effects of a development.

13.2.4 To ensure that both emissions reduction and climate change adaptation are fully and consistently considered, this chapter sets out the assessment for these two elements separately.

13.2.5 The assessment draws on recognised climate change projections, existing guidance, and emerging good practice, as well as being informed by relevant information presented in other chapters of the ES and further documents which form part of the application.

13.2.6 The chapter has been written by LUC and 3ADAPT, consultants competent in climate change impact assessment. The lead author, Joanna Wright (MA MSc FIEMA CEnv), has 30 years of professional EIA experience with LUC and postgraduate masters level qualifications in both EIA and carbon management.

13.3 EMISSIONS REDUCTION

Legislative and Policy Framework

UK Legislation, Policy and Strategy

13.3.1 This assessment is carried out in accordance with the following legislation and relevant national policy objectives:

- **Part 2 of the Overarching National Policy Statement for Energy** (NPS EN-1)[2]: this sets out the central government policy context for major energy infrastructure. This includes the need to meet legally binding targets to cut greenhouse gas emissions, transition to a low carbon economy and decarbonise the power sector.
- **Part 2 of the Draft Overarching National Policy Statement for Energy** (NPS EN-1)[3]: this updates the advice in sets out in EN-1 to align with the UK's net zero target.
- Paragraph 1.1.1 of the **National Policy Statement for Renewable Energy Infrastructure** (NPS EN-3)[4]: this underlines the importance of the generation of electricity from renewable sources by stating that electricity generation from renewable sources of energy is an important element in the Government's development of a low-carbon economy. It stresses that there are ambitious renewable energy targets in place and that a significant increase in generation from large-scale renewable energy infrastructure is necessary.
- The Revised **Draft National Policy Statement for Renewable Energy Infrastructure** (NPS EN-3)[5] including paragraphs 1.1.1 and 1.1.2 which state that there is an urgent need for new electricity generating capacity to

[2] UK Government (2011) Overarching National Policy Statement for Energy (EN-1). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf

[3] UK Government (2023) Draft Overarching National Policy Statement for Energy (EN-1). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147380/NPS_EN-1.pdf

[4] UK Government (2011) National Policy Statement for Renewable Energy Infrastructure (EN-3). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37048/1940-nps-renewable-energy-en3.pdf

[5] UK Government (2023) Draft National Policy Statement for Renewables Energy Infrastructure (EN-3). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147382/NPS_EN-3.pdf

meet our energy objectives and that electricity generation from renewable sources of energy is an essential element of the transition to net zero.

- Paragraph 152 of the **National Planning Policy Framework** (NPPF)[6]: this applies a number of core planning principles that are to underpin planning decision making, including to support the transition to a low carbon future in a changing climate. Planning should help to shape places in ways that contribute to radial reductions in greenhouse gas emissions and support renewable and low carbon energy and associated infrastructure.
- **The Climate Change Act 2008[7]:** this sets legally binding targets for reducing emissions of greenhouse gases by 2050. The net UK carbon account for 2050 must be at least 100% lower than the 1990 baseline.
- **The UK Carbon Budgets:** to support continuous efforts to achieve Net Zero by 2050 under the UK Climate Change Act 2008[7], a series of sequential carbon budgets have been developed. Each budget provides a five-year statutory cap on total GHG emissions, which should not be exceeded to meet the UK's emission reduction commitments. These legally binding targets are currently available to the 6th carbon budget period (2033-2037) which became legislation under the Carbon Budget Order 2021, and which came into force on 24 June 2021.
- **The UK's Net Zero Strategy[8]:** The 2021 Report to Parliament: Progress in Reducing Emissions highlighted that whilst the UK Government has made historic climate promises, it has been too slow to follow these with delivery. Therefore, sustained reductions in emissions will require a strong Net Zero Strategy. The Strategy includes policies and proposals for decarbonising all sectors of the UK economy to meet net zero by 2050.

Local Policy and Strategy

13.3.2 The Energy Park lies wholly within North Kesteven District, which is covered by the Central Lincolnshire Local Plan. The grid connection within the Cable Route Corridor, lies predominantly within the Boston Borough Council boundary, which is covered by the South-East Lincolnshire Local Plan.

Central Lincolnshire Local Plan 2012 - 2036[9]

13.3.3 The Central Lincolnshire Local Plan, was adopted in April 2017 and states within its Vision that **"A move to a low carbon economy and society will be supported"**.

Central Lincolnshire Local Plan Review – June 2021[10]

13.3.4 Policy S13: Renewable Energy Policy states that **"The Central Lincolnshire Joint Strategic Planning Committee is committed to supporting the transition to a net zero carbon future and will seek to maximise appropriately located**

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[6] UK Government (2021) National Planning Policy Framework. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2

[7] UK Government (2008) The Climate Change Act 2008. Available at: https://www.legislation.gov.uk/ukpga/2008/27/contents

[8] UK Government (2021) Net Zero Strategy: Build Back Greener. Available at: https://www.gov.uk/government/publications/net-zero-strategy

[9] Central Lincolnshire Joint Strategic Planning Committee (2017) Central Lincolnshire Local Plan. Available at: https://www.n-kesteven.gov.uk/residents/planning-and-building/planning/planning-policy/central-lincolnshire-local-plan/

[10] Central Lincolnshire Joint Strategic Planning Committee (2021) Central Lincolnshire Local Plan Review. Available at: https://www.n-kesteven.gov.uk/central-lincolnshire/local-plan-review/

renewable energy generated in Central Lincolnshire (such energy likely being wind and solar based)".

North Kesteven District Council Climate Emergency Strategy and Action Plan – November 2022[11]

13.3.5 The North Kesteven Action Plan includes a number of actions specifically related to renewable energy generation, with section 7. Energy Sub-theme 3 relating specifically to solar PV. This includes to investigate available local energy data and information to understand local natural resources and future generation potential building upon the Central Lincolnshire Local Plan review.

North Kesteven District Council Environment Policy – July 2021[12]

13.3.6 Expected behaviours and activities include point 12: **"Renewable and low carbon energy generation projects form an essential part of our net zero emissions target and opportunities, both stand alone and opportunistic projects, are to be actively sought"**.

South East Lincolnshire Local Plan 2011-2036[13]

13.3.7 The South East Lincolnshire Local Plan highlights the importance of considering climate change in relation to new development in its vision, noting: **"New development will be of a high standard of design and will help South East Lincolnshire mitigate and adapt to climate change. The use of renewable energy technologies and sustainable drainage systems will also help minimise carbon emissions and flood risk respectively"**.

13.3.8 Policy 31: Climate Change and Renewable and Low Carbon Energy states that the development of renewable energy facilities (with the exception of wind), associated infrastructure and the integration of decentralised technologies on existing or proposed structures will be permitted provided, individually or cumulatively, there would be no significant harm to the environment.

South and East Lincolnshire Councils Partnership Climate Change Strategy – Spring 2022[14]

13.3.9 This Strategy covers the sub-region of East Lindsey, Boston and South Holland and has a vision to achieve net zero emissions in advance of the UK Government targets. The Strategy states that **"renewable energy generation is central to a net zero future and while this sector continues to grow there is still huge scope for small-scale domestic and commercial utilisation of the technology. Supporting residents and businesses to explore this will be vital together with ensuring the region is not left behind in the innovation needed to future-proof the energy distribution network**."

[11] North Kesteven District Council (2022) Climate Emergency Strategy and Action Plan. Available at: https://www.n-kesteven.gov.uk/residents/climate-action/

[12] North Kesteven District Council (2021) North Kesteven Environment Policy. Available at: https://www.n-kesteven.gov.uk/your-council/how-the-council-works/key-plans-strategies-and-policies/policies/environment-policy/

[13] South East Lincolnshire Joint Strategic Planning Committee (2019) South East Lincolnshire Local Plan. Available at: http://www.southeastlincslocalplan.org/

[14] South & East Lincolnshire Councils Partnership (2022) Climate Change Strategy. Available at: https://www.selcp.co.uk/article/20989/South-East-Lincolnshire-Councils-Partnership-Councils-approve-the-Climate-Change-Strategy

Assessment Approach

Methodology

13.3.10 The assessment adopts a 'whole life' approach to calculating GHG emissions. This considers all major lifecycle sources of GHG emissions and includes both direct GHG emissions as well as indirect emissions from activities such as the transportation of materials and embodied carbon within construction materials.

13.3.11 As the calculated GHG emissions represent estimates, all numerical values presented below have been rounded according to either three significant figures for larger values, or to at least one decimal place for smaller values. To maintain accuracy, all values have been rounded direct from the calculated value, and therefore this may occasionally cause slight discrepancies where presented total figures may not add up exactly from other rounded values.

Study Area

13.3.12 Following the latest IEMA guidance (see below), the study area for the assessment of GHG emissions is considered to be the global climate. The assessed receptor is the global atmosphere since GHG emissions are not geographically limited, having a global effect rather than directly affecting any specific local receptor(s).

Guidance

13.3.13 This assessment is carried out in accordance with the principles contained within the following documents:

- Institute of Environmental Management (IEMA) (2022): Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance. Second Edition.
- Department for Business, Energy and Industrial Strategy (BEIS) (2021): Green Book Supplementary Guidance: Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal.
- Department of Energy and Climate Change (DECC) (2013) Guidance on Annual Verification for Emissions from Stationary Installations
- British Standards Institute (BSI) (2016) PAS 2050:2016 Specification for the Assessment of the Life Cycle Greenhouse Gas Emissions of Goods and Services.
- World Business Council for Sustainable Development (WBCSD) (2015) The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.

Desk Based Research and Data Sources

13.3.14 A desk-based assessment has been completed to determine the potential effects of the Proposed Development on the climate. These have been calculated in line with the GHG Protocol (WBCSD, 2015) and GHG 'hot spots' (i.e. materials and activities likely to generate the largest amount of GHG emissions) have been identified. This has enabled priority areas for mitigation to be identified. This approach is consistent with the principles set out in the IEMA guidance (2022).

13.3.15 A 30-month construction programme has been assumed for the purposes of this assessment (Spring 2025 to Autumn 2027), followed by a 40-year operational lifetime (Winter 2027 to Winter 2067) and a 6 to 18-month decommissioning phase (indicatively likely to commence in 2067 or 2068). For the purposes of this assessment, a 12-month 'mid-point' decommissioning phase has been assumed.

13.3.16 Estimated GHG emissions arising from various activities during the construction, operational and decommissioning phases of the Proposed Development have been quantified using a calculation-based methodology as stated in the BEIS 2021 emissions factors guidance (BEIS, 2021).

13.3.17 Where BEIS 2021 GHG emissions factors are used in calculations, these are considered to reflect a conservative approach to project lifetime emissions. This is due to expected decarbonisation in all sectors over this time period in line with the UK's net zero carbon emissions target for 2050. This most significantly relates to transport emissions, where significant emissions reductions will be achieved from the transition to electric vehicles.

13.3.18 Where data is not available, a qualitative approach to addressing GHG effects has been followed, in line with the IEMA guidance (2022).

13.3.19 An overview of methodologies for identifying effects related to the construction phase is presented below. GHG emissions sources considered during the construction phase include the embodied carbon of products and equipment, the transportation of these materials to the Order limits boundary, land use change implications of cleared woodland and grassland areas, as well as the emissions associated with construction worker transport to the Proposed Development.

13.3.20 The product and equipment options currently proposed for the Additional Works could incorporate either Air Insulated Switchgear (AIS) or Gas Insulated Switchgear (GIS). Although no detailed design of either equipment option is available, National Grid have confirmed that no SF6 gas would be used in a GIS system. In the case of facilitating the AIS option, this would require the partial clearance of a woodland plantation as shown within area AW1 in Figure 3.9. For the GIS technology, smaller area of the plantation woodland would need to be cleared. The extent of this area is shown on Figure 4.27: Land Use Parameter Plan for Design Options at Bicker Fen Substation Extension. The wider plantation loss for the AIS design option has therefore been assumed in the calculations to represent the land use implications of the Additional Works in order to form a conservative estimate.

13.3.21 To estimate the land use change implications of the Additional Works for the AIS option, an estimated area of woodland has been calculated combining the ecologist assessment in **Appendix 8.13** for number of trees and woodland tree spacing. Corresponding carbon stocks were estimated using 200 year total cumulative carbon densities from the Woodland Carbon Code (2021) calculator to estimate released carbon stocks during construction. This represents a conservative assumption as it assumes that the woodland has reached full growth maturity, and thus maximum corresponding carbon stock.

13.3.22 Construction worker employment generation has been benchmarked from recent similar schemes, and scaled on a pro rata basis to that of the indicative capacity specifications.

13.3.23 A 1-way distance of 30km per journey has been assumed for the worker transportation calculations, which is a conservative estimate as, where possible, staff will reside much closer to the Order limits, and employees not from the local area would stay in local accommodation.

13.3.24 The BEIS 2021 emissions factors for 'Average car' and 'Average van', including well-to-tank (WTT) emissions, have been applied to this distance and total worker numbers to calculate GHG emissions. This represents a conservative approach by assuming all journeys are single occupancy (driver only), not accounting for any lift sharing measures or use of buses.

13.3.25 Products and equipment considered in this assessment include the solar panels, solar inverters, energy storage, assumed to be batteries for the purposes of assessment, with associated inverters, substations, associated transformers and below-ground grid connection cable, assuming a configuration that utilises AC coupled storage. Whilst the specific manufacturer and model of the PV modules and energy storage units have not yet been confirmed, indicative information on the number and size of modules and containerised units likely to be installed is available.

13.3.26 A likely worst-case country of origin of China has been assumed as a conservative estimate for products and equipment, with distances estimated from ports with a proximity to relevant manufacturing facilities in Shanghai. Corresponding HGV and sea freight distances of 350km and 21,900km respectively have been assumed for transportation of materials.

13.3.27 For HGV transportation of materials, the BEIS 2021 emissions factor for 'Rigid HGV–7.5-17t' has been applied, including WTT emissions. It has been assumed that HGVs are 100% laden. Emissions per unit distance have been multiplied by the assumed distance above.

13.3.28 For sea freight transportation, the BEIS 2021 emissions factor for 'Products tanker–Average' has been applied, including WTT emissions. Emissions per unit distance and weight have been multiplied by the assumed distances and product weights above.

13.3.29 The embodied carbon of the solar panel modules to be installed within the Proposed Development was estimated by taking their indicative size and weight data from comparable supplier product information (Trina Solar, 2019 - see **Table 13.1** for full ref.), and using the embodied carbon benchmark (Life Cycle Analysis stages A1-A5, B1-B7, C1-2) from the Environmental Product Declaration (EPD) for a comparably sized module manufactured in China (Trina Solar, 2020 - see **Table 13.1** for full ref).

13.3.30 To calculate the embodied carbon within the inverters, typical manufacturer information about material composition breakdown (Willmott Dixon, 2022 – see **Table 13.1** for full ref.) and unit weights (Solar Edge, 2018 – see **Table 13.1** for full ref.) were used as a benchmark to estimate material quantities associated with the inverters required for the Proposed Development. Embodied carbon factors for each of these materials from the Inventory of Carbon and Energy version 3 database (University of Bath and Circular Ecology, 2019 – see **Table 13.1** for full ref) have been applied.

13.3.31 For the embodied carbon of the energy storage cells, embodied carbon benchmarks have been applied using data from Life Cycle Analysis (LCA) of lithium-ion batteries (Dai et al., 2019 - see **Table 13.1** for full ref.) and been multiplied by the indicative energy generation specifications.

13.3.32 To calculate the embodied carbon within the grid connection cable in the Cable Route Corridor, typical manufacturer information about material composition breakdown (Willmott Dixon, 2022 see **Table 13.1** for full ref.) and unit weights (Thorne & Derrick, 2022 - see **Table 13.1** for full ref.) were used as a benchmark to estimate material quantities associated with the inverters required for the Proposed Development. Embodied carbon factors for each of these materials from the Inventory of Carbon and Energy version 3 database (University of Bath and Circular Ecology, 2019 see **Table 13.1** for full ref.) have been applied. It has been assumed for the purposes of this assessment that 'other plastics' assumes the corresponding embodied carbon factor for 'general plastics'.

13.3.33 To calculate the embodied carbon of the Site Main Substation, the material composition breakdown (Harrison et. al., 2010 see **Table 13.1** for full ref.) was used as a benchmark to estimate material quantities. Embodied carbon factors for each of these materials from the Inventory of Carbon and Energy version 3 database (University of Bath and Circular Ecology, 2019 see Table 13.1 for full ref.) have been applied.

13.3.34 To calculate the embodied carbon of the Additional Works, the same approach as the above calculation for the substations was used to assess both the potential impact of incorporating either the AIS or GIS option, with the highest impact value taken forward for the assessment in order to represent a conservative estimate. The analysis shows that despite the AIS option having a much smaller mass of high carbon intensity aluminum, it also has a slightly larger impact of 1,500 tCO2 compared to the GIS substation of 1,400 tCO2. Therefore, the slightly larger embodied carbon impact of the AIS option has been chosen to represent that of the Additional Works in order to form a conservative estimate.

13.3.35 Assumed reference values for the construction phase calculations are provided in full in **Table 13.1** below.

Table 13.1: Construction phase assessment assumptions

Description	Value	Unit	Source
Transport Emission Factors			
HGV Rigid (>7.5 tonnes-17 tonnes)	0.687	kgCO2e/km	BEIS (2021)[15]
HGV Rigid (>7.5 tonnes-17 tonnes) – WTT	0.167	kgCO2e/km	
Product tanker average	0.00903	kgCO2e/ tonne.km	
Product tanker average – WTT	0.00203	kgCO2e/ tonne.km	
Average van	0.241	kgCO2e/km	
Average van – WTT	0.0590	kgCO2e/km	
Product Weights			
Battery unit	18,000	kg per unit	Sungrow (2021)[16]
Solar panel	31.4	kg per unit	Trina Solar (2019)[17]
Inverter unit	48	kg per unit	Solar Edge (2018)[18]
Cable weight	9.1	kg per m	Thorne & Derrick (2022)[19]
Material Compositions			
Inverter unit	0.3% stainless steel, 13.4% steel, 4.6% zinc, 12.2% copper,	%	Willmott Dixon (2022)[20]

[15] BEIS (2021) Greenhouse gas reporting: conversion factors 2021. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021

[16] https://uk.sungrowpower.com/upload/file/20210909/EN%20BR%20Sungrow%20Energy%20Storage%20System%20Products%20Catalogue.pdf

[17] https://static.trinasolar.com/sites/default/files/EN_Datasheet_DuomaxM_DEG15M.20II_201907.pdf

[18] https://www.solaredge.com/sites/default/files/se_commercial_three_phase_inverters.pdf

[19] https://www.cablejoints.co.uk/upload/33kV_Single_Core__XLPE_AWA_Stranded_Copper_Conductor_HV_Cable.pdf

[20] Wilmott Dixon (2022) Whole life carbon of photovoltaic installations: Technical Report https://www.willmottdixon.co.uk/asset/17094#:~:text=Carbon%20balance%20of%20PV%20installation%20over%20life%20span&text=The%20carbon%20impact%20of%20a,and%20end%20of%20life%20decommissioning.

Description	Value	Unit	Source
	7.7% aluminium, 14.6% electronics, 3.1% ceramic and 44.1% epoxide resin		
Cable	18.3% copper wire, 2.6% copper, tin 0.3%, 2.6% polyethylene, 3.4% polypropylene, 72.8% 'other plastics'	%	
Substations	0.002% aluminium, 0.5% copper, 1.7% steel, 0.4% other, 19.3% concrete, 77.0% limestone chipping, 0.4% fencing, 0.7% oil	%	Harrison et. al. (2010)[30]
Embodied Carbon			
Battery unit	73	kgCO2e/kWh	Dai et. al. (2019)[21]
Solar panel – Upstream (A1 – A2)	0.00557	kgCO2e/kWh	EPD Trina Solar (2020)[22]
Solar panel – Core Stage (A3 – A5, B1 – B7, C1 – C2)	0.00673	kgCO2e/kWh	
Copper	2.71	kgCO2e/kg	University of Bath and Circular Ecology (2019)[23]
Tin	14.47	kgCO2e/kg	
Polyethylene	2.54	kgCO2e/kg	
Polypropylene	4.49	kgCO2e/kg	
Other Plastics	3.31	kgCO2e/kg	
Steel	3.02	kgCO2e/kg	
Zinc	4.18	kgCO2e/kg	
Aluminium	13.10	kgCO2e/kg	
Ceramics	0.70	kgCO2e/kg	
Epoxide Resin	5.70	kgCO2e/kg	
Electronics	5.30	kgCO2e/kg	
Land Use Change			
Woodland tree spacing	1.5	m	Woodland Carbon Code Calculator V2.4 (2021)[32]

[21] Dai, Q.; Kelly, J.C.; Gaines, L.; Wang, M. Life Cycle Analysis of Lithium-Ion Batteries for Automotive Applications. *Batteries* 2019, *5*, 48. https://doi.org/10.3390/batteries5020048

[22] https://www.epditaly.it/wp-content/uploads/2016/12/MR-101.1_Trina-Solar_EPD_SM-DEG15M.20-II_TSM-DEG15MC.20-II_TSM-DEG17M.20-II_TSM-DEG17MC.20-II-PV-Double-Glass-Panels.pdf

[30] Harrison, GP, Maclean, EJ, Karamanlis, S & Ochoa, LF 2010, 'Life cycle assessment of the transmission network in Great Britain', Energy Policy, vol. 38, no. 7, pp. 3622-3631. https://doi.org/10.1016/j.enpol.2010.02.039

[23] University of Bath and Circular Ecology (2019) Embodied Carbon – The ICE Database

https://circularecology.com/embodied-carbon-footprint-database.html

[32] Woodland Carbon Code Calculator V2.4, 2021. https://woodlandcarboncode.org.uk/standard-and-guidance/3-carbon-sequestration/3-3-project-carbon-sequestration

Description	Value	Unit	Source
Typical 200 year carbon stock	791	tCO_2e/ha	Woodland Carbon Code Calculator V2.4 (2021)[32]

13.3.36 An overview of methodologies for identifying effects related to the operational phase is presented below. 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 Proposed Development and maintenance activities (including embodied carbon in replacement parts, plant and machinery requirements).

13.3.37 Operational energy generation data was estimated by applying an industry standard capacity factor for solar PV to the indicative capacity specifications to estimate 386,000 megawatt-hours (MWh) for the first year of operation. Efficiency losses of the PV modules over time have been accounted for based on an assumed industry benchmark degradation factor for each subsequent year. Over the 40 year lifetime, this results in an estimated total energy generation of 14,000,000 MWh.

13.3.38 It should be recognised that, in addition to the conservative lifetime assumption, the annual energy generation estimates are also considered to represent a conservative assumption. This is because they are based on a minimum installed capacity relative to the Energy Park site footprint, and also do not take into account expected future increases in the performance and efficiency of solar technologies.

13.3.39 Operational energy use (i.e. for auxiliary services and standby power) for the Proposed Development during the night has been estimated as a proportion of estimated energy generation. Energy requirements will be met by energy imported from the National Grid. Therefore, the night-time energy use will result in GHG emissions as a result of the production of grid electricity, using current 2022 and projected decarbonised grid GHG intensities (BEIS, 2021) over the operational phase of the Proposed Development. These GHG intensity factors are shown in more detail in **Inset 13.1** below.

13.3.40 GHG emissions associated with operational maintenance have been represented by the embodied carbon emissions resulting from the replacement of product components. Averaged annual part replacement rates were applied on a pro rata basis to the proportion of embodied emissions from those in the construction phase.

13.3.41 Emissions associated with the land use change of intensive arable to solar park have been calculated on the basis of the carbon footprint that would arise from the necessary transport and import of food and crops from elsewhere, which could otherwise have been grown on this land. For the purpose of this assessment, the average UK annual yield for the crop of wheat has been applied to the Proposed Development (Ritchie and Roser, 2022[24]).

13.3.42 The GHG footprint of food arises from multiple sources across the production and distribution supply chain. To estimate the emissions related to the transport of the offset food production, benchmarked GHG emissions were used per kilogram of food, using only the proportion of GHG footprint related to the transport of the produced food (Ritchie and Roser, 2022).

[24] Ritchie, H.; Roser, M.; and Rosado, P. (2022) Crop Yields. Published online at OurWorldInData.org. https://ourworldindata.org/crop-yields

13.3.43 Assumed reference values for the operational phase calculations are provided in full in **Table 13.2** below.

Table 13.2: Operational phase assessment assumptions

Description	Value	Unit	Source
Energy Generation			
Annual degradation factor	0.5	%	Industry benchmark
Operation and Maintenance			
Night-time energy demand	0.01	kWh/kWh generation	Industry benchmark
Replacement rate of solar panels	0.2	% per year	Industry benchmark
Replacement rate of solar inverters	4.4	% per year	Industry benchmark
Replacement rate of battery inverters	3.1	% per year	Industry benchmark
Replacement rate of substations	10.0	% per year	Harrison et. al. (2010)[30]
Lifespan of battery unit	7,500	Cycles	Industry benchmark
Replacement rate of cable	0.1	% per year	Industry benchmark
Land Use Change			
Wheat yield UK 2018 (average)	7.75	tonnes/ha	Hannah Ritchie and Max Roser (2022)[24]
Transport emissions contribution to carbon footprint of wheat and rye	0.1	tCO2e/tonne	Hannah Ritchie and Max Roser (2022)

13.3.44 An overview of methodologies for identifying effects related to the decommissioning phase is presented below. GHG emissions sources within the scope of the decommissioning emissions include the transportation of products and equipment from the Proposed Development boundary, as well as the emissions associated with worker transport.

13.3.45 For HGV transportation of materials and waste to their disposal point, an average distance of 50km has been assumed to reflect a conservative estimate. Correspondingly, the BEIS 2021 emissions factor for 'Rigid HGV–7.5-17t' has been applied, including WTT emissions. It has been assumed that HGVs are 100% laden. Emissions per unit distance have been multiplied by the assumed distance above.

13.3.46 For worker transportation, it has been assumed that an equivalent number of workers will be required on site at decommissioning as per the construction stage. Correspondingly, a 1-way distance of 30km per journey has been assumed for the worker transportation calculations, which is a conservative estimate as, where possible, staff will reside much closer to the site limits, and employees not from the local area would stay in local accommodation. The BEIS 2021 emissions factors for 'Average car' and 'Average van', including WTT emissions, have been applied to this distance and total worker numbers to calculate GHG emissions.

13.3.47 To reduce the lifetime impact associated with the embodied carbon of all products and equipment, recycling of reclaimed materials would be strongly encouraged upon end of life decommissioning. However, this assumption has not been applied to the calculation methodologies to be consistent with the conservative approach to impact assessment.

Assessment Limitations and Additional Assumptions

13.3.48 Whilst some information gaps such as the detailed energy generation modelling have been identified, it is considered that there is sufficient information to enable an informed decision to be taken in relation to the identification and assessment of likely significant effects in relation to GHG emissions associated with the Proposed Development.

13.3.49 Where available, product or design data specific to the Proposed Development required to undertake the lifecycle GHG emissions assessment has been provided by the project design team. Where data was unavailable, reasonable assumptions have been made and industry benchmarks (representing 'good practice' performance measures) adopted, based on professional judgement. These have then fed into the assessment using methodologies and data sources previously outlined in this Section.

Assessment of Significance

Sensitivity

13.3.50 The sensitivity of the receptor (global atmosphere) to increases in GHG emissions is always considered 'High', following IEMA Guidance (IEMA, 2022). This reflects the severe consequences of global climate change and the cumulative contributions of all GHG emission sources.

Magnitude

13.3.51 The magnitude of effect on the climate has been assessed as the change in mass of GHG emissions, in units of tonnes of carbon dioxide equivalent (tCO2e).

Significance

13.3.52 The predicted significance of the effect was determined through a standard method of assessment based on professional judgement, considering both sensitivity and magnitude of change. Major and moderate effects are considered significant in the context of the EIA Regulations.

13.3.53 The updated IEMA guidance (IEMA, 2022) has been adopted for assessing the significance of GHG effects for EIA, in addition to standard GHG accounting and reporting principles which have also been followed to assess impact magnitude. According to the IEMA guidance (2022):

> **"The crux of significance is not whether a project emits GHG emissions, nor even the magnitude of GHG emissions alone, but whether it contributes to reducing GHG emissions relative to a comparable baseline consistent with a trajectory towards net zero by 2050."**

13.3.54 The guidance describes five distinct levels of significance **"which are not solely based on whether a project emits GHG emissions alone, but how the project makes a relative contribution towards achieving a science-based 1.5°C aligned transition towards net zero"**. The guidance also states that it is down to the professional judgement of the practitioner to determine how best to contextualise a project's GHG impact and assign the level of significance.

13.3.55 In line with IEMA guidance, UK national carbon budgets have been used for the purposes of this assessment to determine the level of significance for both the construction and decommissioning phases. Since the effects of GHG emissions cannot be geographically constrained, more localised budgets or targets can be less meaningful, especially since it is unclear as to whether emerging local authority or regional budgets will add up coherently to the UK budget. In addition, national carbon budgets have the advantage of being clearly defined and based on robust scientific evidence.

13.3.56 As shown in **Table 13.3** below, the appropriate UK national carbon budget that spans the construction programme of the Proposed Development (2023 to 2024), is the 4th carbon budget (2023 to 2027).

Table 13.3 Relevant carbon budgets for this assessment

Carbon Budget	Total budget (MtCO2e)
4th (2023-2027)	1,950
5th (2028-2032)	1,725
6th (2033-2037)	965

13.3.57 In GHG accounting, it is common practice to consider the exclusion of emission sources that are <1% of a given emissions inventory, on the basis of a 'de minimis' contribution. Both Department of Energy and Climate Change (DECC, 2013) and the PAS 2050 Specification (BSI, 2016) allow emissions sources of <1% contribution to be excluded from emission inventories, and for these inventories to still be considered complete for verification purposes. The IEMA guidance (2022) also states that projects with any non-significant adverse effects should be considered in terms of their compatibility with the budgeted, science based 1.5°C trajectory (in terms of rate of emissions reduction) and in terms of compliance with up-to-date policy and 'good practice' reduction measures.

13.3.58 Therefore, the GHG intensity of the Proposed Development (defined as the operational emissions divided by the energy generation) has been compared with the forecasted 2022 GHG intensity of the electricity grid (136 gCO2e/kWh) as published by BEIS (BEIS, 2021) over the operational phase of the Proposed Development, considering both the Proposed Development a whole, as well as only the aspects related to the Energy Park i.e. excluding the Energy Storage components.

13.3.59 This assesses the relative contribution of the Proposed Development to the UK's trajectory towards net zero, since the projected grid intensity takes into account key variables related to climate change policies where funding has been agreed and where decisions on policy design are sufficiently advanced to allow robust estimates of policy impacts to be made.

13.3.60 The operational GHG intensity of the Energy Park is considered without the ESS because the battery replacement rate, which largely impacts the results, depends on the usage of the batteries and the frequency of their use, which at this time cannot be predicted, for example 7500 cycles might last 5 years or 15, or 25 years. Further variability is introduced by the fact that the final technology has yet to be selected and there will also be further technological advances over the operational lifetime of the Energy Park. Removing the ESS elements also provides more of a like-for-like comparison against alternative forms of energy generation (gas, nuclear, wind etc), as per **Inset 13.2**.

13.3.61 This approach to assessing the significance of construction, operational and decommissioning effects is summarised in **Table 13.4** below.

Table 13.4 Significance criteria

<table>
<tr><th>Significance of Effect</th><th>IEMA Guidance</th><th>Construction / Decommissioning</th><th>Operational</th></tr>
<tr><td>Major Adverse</td><td>"..not compatible with the UK's net zero trajectory"</td><td rowspan="2">Net annual GHG emissions represent more than or equal to 1% of the relevant annual National Carbon Budget.</td><td rowspan="2">Annual operational GHG intensity of Energy Park (excluding Energy Storage) greater or equal to the BEIS 2022 grid GHG intensity.</td></tr>
<tr><td>Moderate Adverse</td><td>"..does not fully contribute to decarbonisation"</td></tr>
<tr><td>Minor Adverse</td><td>"…compatible with the budgeted, science based 1.5°C trajectory"</td><td rowspan="2">Net annual GHG emissions represent less than 1% of the relevant annual National Carbon Budget.</td><td rowspan="2">Annual operational GHG intensity of Energy Park (excluding Energy Storage) less than the BEIS 2022 grid GHG intensity but greater than the relevant annual decarbonised grid GHG intensity.</td></tr>
<tr><td>Negligible</td><td rowspan="2">"…goes substantially beyond the reduction trajectory"</td></tr>
<tr><td>Minor Beneficial</td><td>Net annual GHG emissions are net zero.</td><td rowspan="2">Annual operational GHG intensity of Energy Park (excluding Energy Storage) less than the relevant annual decarbonised grid GHG intensity.</td></tr>
<tr><td>Moderate Beneficial</td><td rowspan="2">"…GHG emissions to be avoided or removed from the atmosphere"</td><td rowspan="2">Net annual GHG emissions are negative (i.e., net sequestration of GHG emissions).</td></tr>
<tr><td>Major Beneficial</td><td>Annual operational GHG intensity of Energy Park (excluding Energy Storage) less than zero (i.e., net sequestration of GHG emissions).</td></tr>
</table>

Consultation

13.3.62 **Table 13.5** provides a summary of matters raised within the Scoping Opinion and how these have been addressed through the ES in relation to climate change (emissions reduction).

Table 13.5: Summary of Scoping Opinion Responses

Consultee	Details of consultee response	How is matter addressed	Location of response
PINS Scoping Opinion	The assessment of climate change and greenhouse gas (GHG) emissions should be based on and refer to relevant guidance. This would include: • The Sixth UK Carbon Budget (December 2020) guidance particularly with respect to energy and transport during construction; • The British Standards Institution's Publicly Available Specification (PAS) on Carbon	Actioned, noting that IEMA's EIA Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance was updated in 2022.	Section 13.3 of Chapter 13: Climate Change (document reference 6.1.13)

Consultee	Details of consultee response	How is matter addressed	Location of response
	Management in Infrastructure (2016); and • IEMA's EIA Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance (2017).		
	The Scoping Report states that the emissions reduction assessment will be a quantified assessment where possible. The ES should explain how emissions have been calculated and where this has not been fully quantifiable the justification for this.	Noted with quantification methodologies detailed in *Desk Based Research and Data Sources* section.	Paras 13.3.14 – 13.3.45 of Chapter 13: Climate Change (document reference 6.1.13)
Lincolnshire County Council	The ES should consider the possible impact to the carbon footprint that would arise from the necessary transport/import of food and crops from elsewhere which would otherwise have been grown on this land. This is needed to understand the full carbon gains this development offers	Actioned. Included in assessment of operational effects. See calculation of 'Land Use Change' in section *'Assessment of Likely Significant Effects'.*	Paras 13.3.37 – 13.3.38 and Table 13.2 of Chapter 13: Climate Change (document reference 6.1.13)
Lincolnshire County Council	The ES chapter has to consider the cumulative impact if the climate change/carbon footprint of the known NSIP solar schemes within the county from the transportation of the food that is no longer being produced on this land.	Actioned. Food production included as an operational effect; cumulative effects also considered.	Paras 13.3.37 – 13.3.38 and Table 13.2 Paras 13.3.104-13.3.109 of Chapter 13: Climate Change (document reference 6.1.13)
North Kesteven District Council	The carbon footprint assessment needs to consider the effects of shifting the site from intensive arable to solar farms and the implications of this process	The assessment takes account of current baseline emissions associated with the site's agricultural use. See section *'Site Description and Context.* Included in assessment of operational effects. See calculation of 'Land Use Change' in section *'Assessment of Likely Significant Effects'*	Paras 13.3.37 – 13.3.38 and Table 13.2 of Chapter 13: Climate Change (document reference 6.1.13)

13.3.63 In addition, **Table 13.6** outlines a summary of Section 42 consultation responses since the PEIR.

Table 13.6: Summary of Section 42 Consultation Responses since PEIR

Consultee	Details of Consultee response	How is matter addressed	Location of response
Lincolnshire County Council	Solar PV site allocated space falls below the recommended sizing (2ha to 1MW). How will panels be packed into the space without affecting the output energy yield?	Spacing may vary across the Energy Park site depending on size of each field and is subject to change with advancements in technology. Two hectares (ha) to 1MW could be considered a rule of thumb before work is commenced on site design. Specialist teams have inputted into the layout of the Energy Park and the 524ha Energy Park is considered suitable for around 500MW DC/400MW AC of solar panels.	**Chapter 4- Project Description** (document reference 6.1.4)
	How will the batteries be decommissioned, considering they will be replaced several times over the plant's lifespan?	Batteries will be recycled where possible.	An Outline Decommissioning and Restoration Plan is included at document reference 7.9
	Operational emissions seem underestimated as ESS replacements alone could potentially amount to the total maintenance emissions. Please can you clarify?	Actioned. Operational emissions have been updated, with the operational phase assessment assumptions in Table 13.2 reflecting replacement rates of both panels and batteries. This has been integrated into the GHG assessment.	Table 13.2 Table 13.11 Inset 13.2 Inset 13.3 of Chapter 13: Climate Change (document reference 6.1.13)
	What replacement rates are considered for the main products of the plant?	Actioned. As above.	Table 13.2 Table 13.11 Inset 13.2 Inset 13.3 of Chapter 13: Climate Change (document reference 6.1.13)
	What was the contribution of the onshore wind farm initially considered to be in relation to GHG emissions?	This is not considered to be directly relevant to this assessment although comparative lifecycle GHG emissions for different types of electricity generation can be found in Inset 13.2.	Inset 13.2 of Chapter 13: Climate Change (document reference 6.1.13)
	What is the comparison of Heckington Fen solar farm (in terms of GHG offset and net savings) with other forms of Energy Generation Technologies?	As above.	Inset 13.2 of Chapter 13: Climate Change (document reference 6.1.13)
North Kesteven District Council	Estimates regarding embedded carbon should include for the replacement of batteries as well as panels and it would be helpful if the ES could present a timeline	Inset 13.3 shows the lifetime GHG emissions of the Proposed Development. This shows emissions for the Proposed Development against the combined GHG emission savings, displaying where energy generation carbon savings are	Inset 13.2 of Chapter 13: Climate Change (document reference 6.1.13)

Consultee	Details of Consultee response	How is matter addressed	Location of response
	across the 40 year operational period by which energy generation carbon savings are expected to exceed carbon embedded in scheme construction.	expected to exceed embedded carbon.	
	To confirm whether figures for construction and embodied carbon are added together.	Actioned. Updated whole life GHG emissions are outlined in Table 13.11 – totalling 563,000 tCO2e, including construction, operational and decommissioning emission sources.	Table 13.11 of Chapter 13: Climate Change (document reference 6.1.13)
	Does the GHG avoidance figure assume the allowance for embodied carbon, i.e. is the 'avoidance' figure the 'net' figure taking account of embodied carbon in materials, transport and construction and operational GHG emissions (40 years) vs the saving through the equivalent amount of electricity generation over the operational lifetime of the Energy Park from the projected grid energy mix?	The GHG avoidance figure is the difference between the operational GHG emissions of the Proposed Development (292,000 – solid orange line on Inset 13.1) against the estimated emissions that would result from sourcing the equivalent energy supply from the grid (1,910,000 – solid blue line on Inset 13.1)	Inset 13.1 of Chapter 13: Climate Change (document reference 6.1.13)
	A clear calculation of the overall net figure (with diagram to assist) and the component GHG elements would be helpful.	Noted. Table 13.11 shows the whole life GHG emissions of the Proposed Development.	Table 13.11 of Chapter 13: Climate Change (document reference 6.1.13)

Baseline Conditions

Site Description and Context

13.3.64 The land within the Order limits consists mainly of arable land and trees. Trees are present individually in some areas as well as rows of trees and small woodland areas. The baseline for the lifecycle GHG assessment is a 'do nothing' scenario whereby the Proposed Development is not implemented.

13.3.65 The baseline conditions include the existing carbon stock (e.g. carbon sequestered within vegetation present) and sources of GHG emissions (e.g. from agricultural vehicles and machinery) from the existing activities on-site. As the land use within the Energy Park site is largely agricultural, it is assumed that the baseline conditions of the land will have minor levels of associated GHG emissions.

13.3.66 This assumption is supported by data provided by the landowner detailing the total amounts of products and fuel consumed during the agricultural production in the 2021 harvest year. This includes information on the application of products such as seeds, fertiliser, herbicides and other additives, in addition to the associated diesel fuel consumption for tractor vehicle use, and number of journeys for lorry transportation of produce out of the Energy Park site.

13.3.67 Whilst the growing of crops will sequester carbon in the short term for the duration of a growing cycle, this carbon would be subsequently released in a relatively short cycle during the agricultural practices of management, harvesting and consumption.

13.3.68 These net GHG emissions of the baseline conditions are further dependent on soil and vegetation types present, as well as including fuel use for other associated vehicles and machinery. Therefore, whilst it is likely that the resulting estimate for baseline conditions would indicate at least minor levels of GHG emissions, it is anticipated that these emissions will not be material in the context of the overall Proposed Development.

13.3.69 Therefore, for the purposes of the lifecycle GHG assessment, a conservative GHG emissions baseline of zero is applied, which due to the likely existing minor levels of associated GHG emissions, represents a robust worst-case approach.

Baseline Survey Information

13.3.70 The assessment has been desk-based, drawing largely from published guidance and data, in addition to existing agricultural information provided by the landowner.

Future Baseline in Absence of Development

13.3.71 The future baseline in the absence of the Proposed Development is assumed to be the same as that of the baseline conditions previously outlined in this Section, representing a ‘do nothing’ scenario whereby the Proposed Development is not implemented.

Assessment of Likely Significant Effects

Construction

13.3.72 The greatest GHG effect during the construction phase is as a result of the embodied carbon in construction materials which accounts for 96.2% of the total emissions.

13.3.73 Total GHG emissions from the construction phase are estimated to equate to 275,000 tCO2e. A breakdown of estimated GHG emissions from the construction of the Proposed Development is presented in **Table 13.7** below.

13.3.74 GHG emissions from construction activities will be limited to the duration of the construction programme (30 months). When annualised, the total annual construction emissions equate to 110,000 tCO2e.

Table 13.7: Summary of Construction GHG Emissions

Emissions Source	Emissions (tCO2e)	% of Construction Emissions
Products (Embodied)	265,000	96.2
Transportation of materials & waste	8,460	3.1
Worker transportation	1,620	0.6
Land use change	250	0.1
Total	**275,000**	**100.0**

13.3.75 GHG emissions from construction have been assessed to identify the significance of the effect. **Table 13.8** presents the estimated construction emissions against the carbon budget period during which they arise. Construction emissions will fall under the 4th UK carbon budget.

Table 13.8: Summary of Construction GHG Emissions

Relevant UK Carbon Budget	Annualised UK Carbon Budget (tCO2e)	Annual Construction Emissions During Carbon Budget Period (tCO2e)	Construction Emissions as a Proportion of Annual Carbon Budget
4th Carbon Budget (2023 to 2027)	390,000,000	110,000	0.028%

13.3.76 Annual emissions from the construction of the Proposed Development do not contribute to equal to or more than 1% of the annualised 4th carbon budget. The magnitude of effect is therefore considered low. GHG emissions from the construction of the Proposed Development are therefore considered to have a **negligible to minor adverse (not significant) effect** on the climate.

<u>Operation</u>

13.3.77 The greatest GHG emissions during the operational phase are estimated to result from maintenance activities, associated with embodied carbon of replacement parts and equipment, which account for 93.6% of the total emissions.

13.3.78 Total operational GHG emissions are estimated to equate to 316,000 tCO2e over the 40-year design life, as presented in **Table 13.9** below. On an average annualised basis, this is equivalent to 7,900 tCO2e per year of operation.

Table 13.9: Summary of Operational GHG Emissions

Emissions Source	Emissions (tCO2e)	% of Operational Emissions
Land use change	16,200	5.1
Worker transportation	1,650	0.6

Emissions Source	Emissions (tCO2e)	% of Operational Emissions
Maintenance	296,000	93.6
Operational energy consumption	2,220	0.7
Total	**316,000**	**100.0**

13.3.79 The operational GHG emissions presented in **Table 13.9** are considered to reflect the conservative approach as the calculations for worker transportation and maintenance have been carried out using current emissions factors to estimate emissions over the operational lifetime of the Proposed Development. However, carbon and emissions associated with energy and fuel use throughout the supply chain are anticipated to be lower in the future as a result of grid decarbonisation and machinery and vehicle electrification in line with the UK's net zero carbon emissions target for 2050.

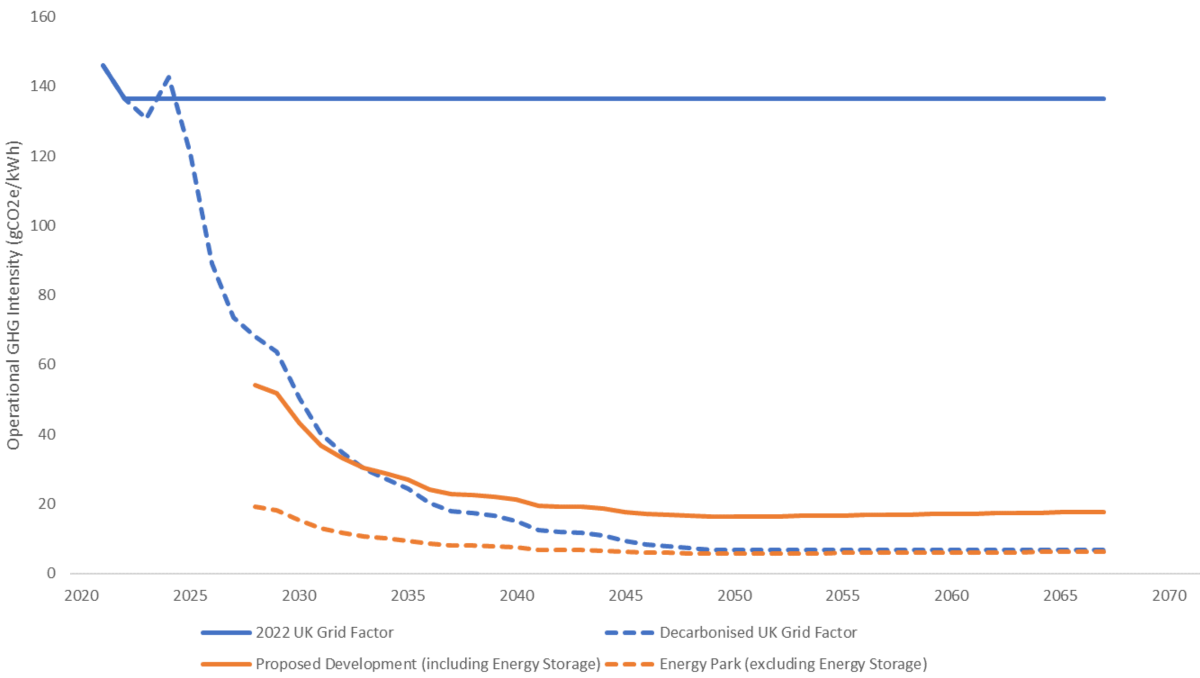
13.3.80 The average operational GHG intensity of both the Proposed Development (including Energy Storage aspects) and just the Energy Park (excluding Energy Storage aspects) have been calculated by dividing the corresponding total operational GHG emissions (outlined above) by the total energy generation of the Energy Park.

13.3.81 When considering the Proposed Development as a whole, this gives an average operational GHG intensity of 22.5 grams of CO2 equivalent per kWh (gCO2e/kWh). This operational GHG intensity is well below the 2022 GHG intensity of the grid (136 gCO2e/kWh), as published by BEIS (BEIS, 2021).

13.3.82 When considering only the aspects relating to the solar energy generation from the Energy Park, this gives an average operational GHG intensity of 7.9 grams of CO2 equivalent per kWh (gCO2e/kWh). In addition to being well below the forecasted 2022 GHG intensity of the grid, this also remains below the projected decarbonised grid GHG intensity (BEIS, 2021) over the operational phase of the Proposed Development. These comparisons can be seen in **Inset 13.1** below.

13.3.83 These decarbonised projections assume a significant extent and rate of grid decarbonisation assumed by BEIS. In fact current BEIS forecasts indicate a required newly installed energy capacity of over 150,000MW (130% the current energy generation capacity in 2022) by 2040. Over half this increase, nearly 100,000MW, is projected to be met by newly installed renewable capacity. (BEIS, 2021)

13.3.84 Projects such as the Proposed Development will contribute towards the UK achieving the forecasted decarbonised grid mix by contributing to the projected rapid increase of required new renewable capacity as indicated above.



Inset 13.1: Operational GHG intensity of UK grid projections and estimated operational Proposed Development and Energy Park emissions

13.3.85 Over the 40 year operational lifetime, the Proposed Development is estimated to produce a cumulative energy generation of 14,000,000 MWh. To contextualise the effects of the Proposed Development's GHG emissions during the operational phase, a counterfactual scenario has been assumed where the corresponding energy generation would otherwise be supplied by the National Grid, in the absence of the Proposed Development.

13.3.86 Using the 2022 Grid Factor as the GHG emission intensity for the generation of this energy supply, as shown above in **Inset 13.1**, it has been estimated that 1,910,000 tCO2e would be emitted to generate the equivalent amount of electricity over the operational lifetime of the Proposed Development from the projected grid energy mix.

13.3.87 Based on the difference between the operational GHG emissions of the Proposed Development, 316,000 tCO2e as shown above in **Table 13.8** (and represented by the solid orange line as shown above in **Inset 13.1**), and the estimated emissions that would result from sourcing the equivalent energy supply from the grid, 1,910,000 tCO2e (and represented by the solid blue line as shown above in **Inset 13.1**), (BEIS, 2021), it is therefore estimated that the Proposed Development would result in avoided GHG emissions of 1,594,000 tCO2e.

13.3.88 In addition, it should be recognised when comparing the two operational intensities, that unlike the estimate for the Proposed Development, the BEIS Grid Factor GHG intensities do not account for maintenance (including embodied carbon associated with replacement), land use change or worker transport requirements, and thus the GHG emission saving from the operational phase of the Proposed Development is even greater.

13.3.89 Even when taking into account the conservative approach taken, **Inset 13.1** clearly shows that that the estimated annual operational GHG intensity of the Energy Park is considerably less than the relevant annual projected decarbonised grid GHG intensity. Therefore, the operational phase of the Proposed Development on GHG emissions is considered to have a **moderate beneficial (significant) effect**.

Decommissioning

13.3.90 Total GHG emissions from the decommissioning phase are estimated to equate to 3,110 tCO2e. A breakdown of estimated GHG emissions from the decommissioning of the Proposed Development is presented in **Table 13.10** below.

13.3.91 GHG emissions from decommissioning activities will be limited to the duration of the decommissioning programme (6-18 months).

Table 13.10: Summary of Decommissioning GHG Emissions

Emissions Source	Emissions (tCO2e)	% of Decommissioning Emissions
Transportation of materials & waste	1,490	47.9
Worker transportation	1,620	52.1
Total	**3,080**	**100.0**

13.3.92 To contextualise the emissions associated with the decommissioning phase of the Proposed Development, these are presented alongside the total emissions from the construction phase in **Table 13.11** below.

Table 13.11: Construction and Decommissioning GHG Emissions

Emissions Source	Emissions (tCO2e)
Construction	275,000
Decommissioning	3,110

13.3.93 As shown in **Table 13.11** above, the GHG emissions associated with the decommissioning phase are considerably less than those during the construction phase, with the value of 3,110 tCO2e representing approximately 1% of the construction phase emissions.

13.3.94 To assess the significance of effect of the construction phase, the GHG emissions were compared to the relevant UK national carbon budgets. Using this approach, the residual effects from the construction phase were considered to be **negligible to minor adverse (not significant)**. This approach is not possible for the timescale of the decommissioning phase (indicative decommissioning period likely to commence in 2067 or 2068), as the current UK national carbon budgets only span up to the year 2037.

13.3.95 Since the magnitude of GHG emissions from the decommissioning phase of the Proposed Development is considerably less than those for the construction phase, it is therefore considered that the effect of these emissions is also low with a **negligible to minor (not significant) adverse effect** on the climate.

Whole Life

13.3.96 As shown previously in **Inset 13.1**, the estimated operational GHG intensities of both the Energy Park and Proposed Development are considerably lower than that of the current grid energy mix, and that of the Energy Park remains well below the projected decarbonised grid factors over its lifetime.

13.3.97 Whilst the national BEIS Energy Grid Mix is currently only projected to 2040, this shows a clear trend and assumption of increasing contribution of renewable energy sources such as solar power, such as the Proposed Development, to the UK supply. (BEIS, 2021) This long-term trend is also expected to continue beyond 2040 and over the lifetime of the Proposed Development.

13.3.98 Therefore, without low-carbon energy generation projects such as the Proposed Development, the average grid GHG intensity will not fully decrease as shown projected in **Inset 13.1** above, which would also adversely affect the UK's ability to meet its carbon reduction targets.

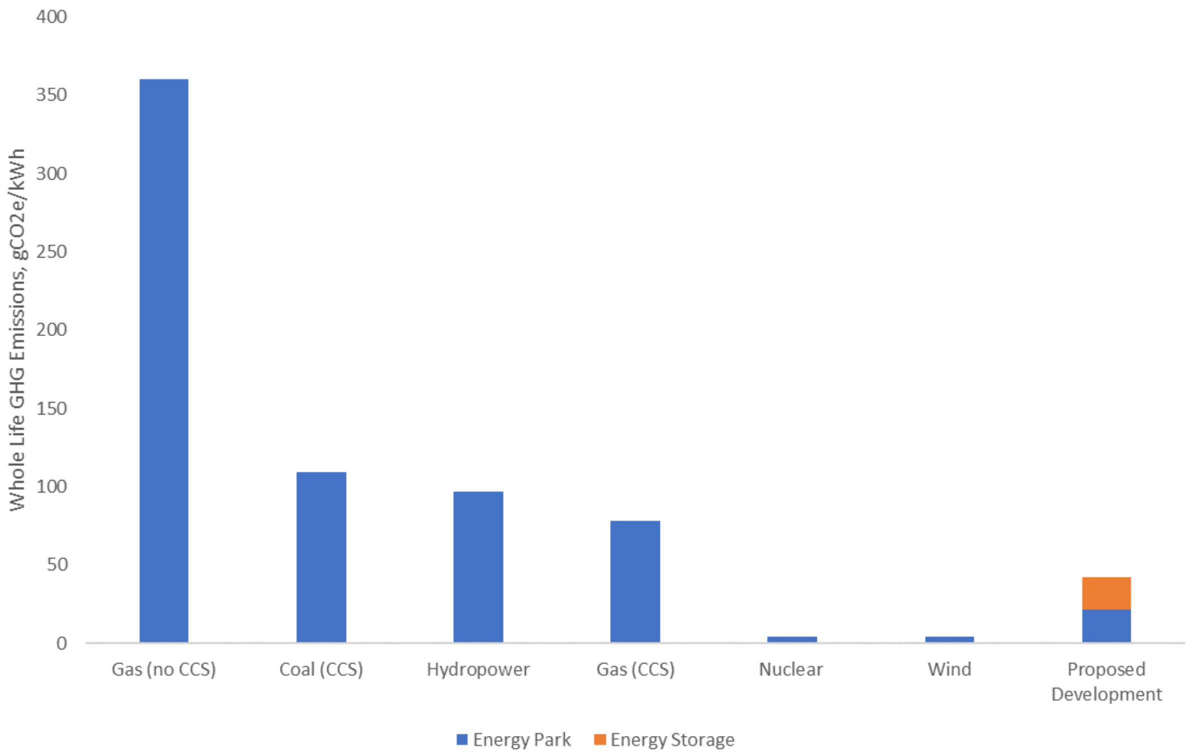
13.3.99 When considering likely effects across all phases of the Proposed Development, the total lifetime GHG emissions are presented in **Table 13.12** below.

Table 13.12: Whole Life GHG Emissions of Proposed Development

Emissions Source	Emissions (tCO2e)
Construction	275,000
Operational	316,000
Decommissioning	3,110
Total	**594,000**

13.3.100 Based on the total energy generation of the Proposed Development and the lifecycle GHG emissions of 594,000 tCO2e, the lifetime GHG intensity of the Proposed Development is 42.4 gCO2e/kWh. When considering only the aspects relating to the solar energy generation from the Energy Park, and corresponding lifecycle GHG emissions of 305,000 tCO2e, this gives a lifetime GHG intensity for the Energy Park of 21.7 gCO2e/kWh. This compares extremely favourably with fossil fuel electricity generation and is comparable with other low carbon energy generation (Pehl et. al., 2017[25]), as shown below in **Inset 13.2.**

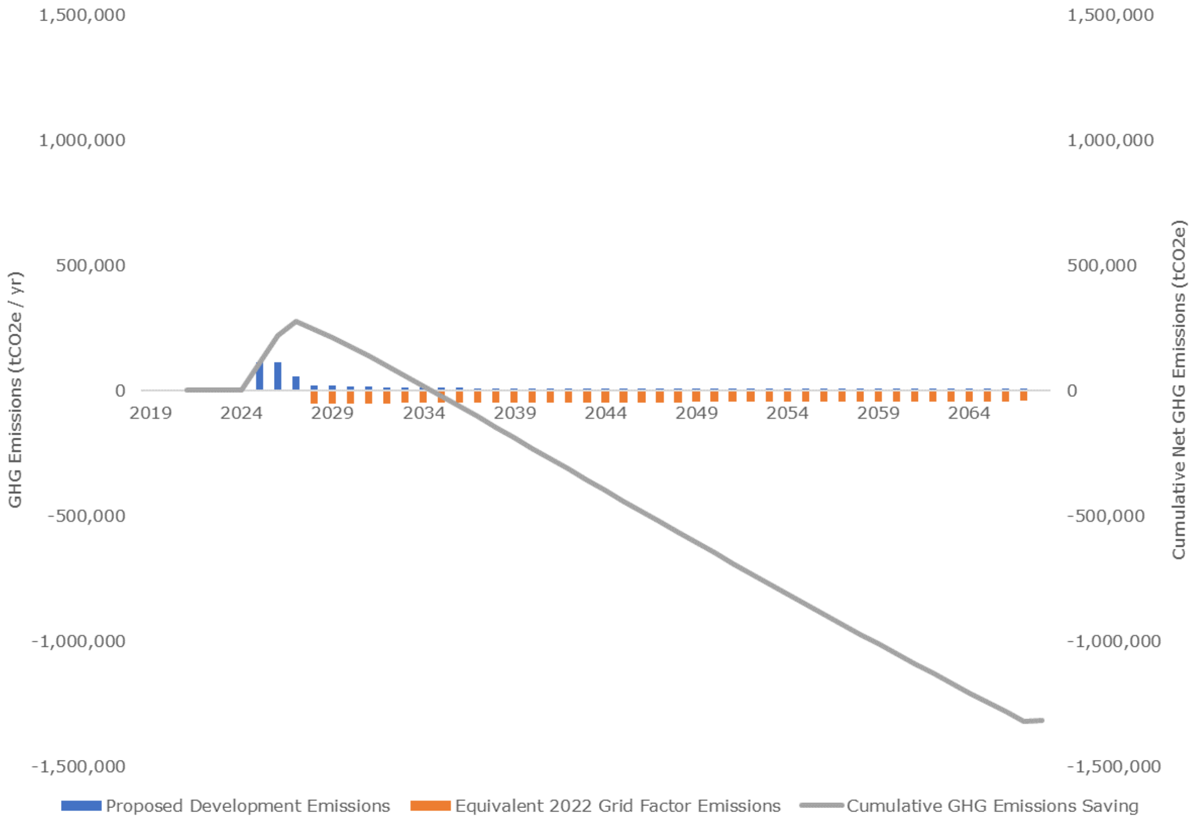
[25] Pehl, M., Arvesen, A., Humpenöder, F. *et al.* Understanding future emissions from low-carbon power systems by integration of life-cycle assessment and integrated energy modelling. *Nat Energy* 2, 939–945 (2017). https://doi.org/10.1038/s41560-017-0032-9



Inset 13.2: Whole Life Cycle GHG intensities of the Proposed Development and Alternative forms of Energy Generation (Pehl et. al., 2017)

13.3.101 In addition, the lifecycle GHG emissions of the Proposed Development of 594,000 tCO2e can be put into further context when compared against the previously estimated emissions that would result from sourcing the equivalent energy supply from the grid, 1,910,000 tCO2e (and represented by the solid blue line as shown above in **Inset 13.1**). Over the lifecycle of the Proposed Development, this would therefore result in total GHG emissions saving of 1,317,000 tCO2e, as shown by the green line below in **Inset 13.3**.

13.3.102 As also shown by the green line below in **Inset 13.3**, whilst the total ('cumulative') GHG emissions initially increase, representing the initial required 'investment' in GHG emissions during the construction phase, once operational, the avoided GHG emissions of the Proposed Development compared to the UK Grid Factors quickly offset this initial 'investment' in GHG emissions, eventually falling below zero and estimated to reach a 'carbon payback' in the year 2035, or approximately 10 years after the start of construction.



Inset 13.3: Total Lifetime GHG Emissions of the Proposed Development

Mitigation and Enhancement

Mitigation by Design

13.3.103 The following mitigation measures have been assumed to apply to the construction, operational and decommissioning phases. This is because the key activities assessed during the operational phase include the maintenance requirements for product and equipment replacement and associated transport to the Energy Park site, requiring similar mitigation measures to the initial construction activities.

13.3.104 Specific mitigation measures will include the following, which will be incorporated into the **outline Construction Environmental Management Plan (oCEMP)**(document reference 7.7) and **outline Construction Traffic Management Plan (oCTMP)** (document reference 7.10) which will accompany the ES:

- Designing, constructing, and implementing the Proposed Development 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 where feasible;
- Reusing suitable infrastructure and resources already available within the site where possible to minimise the use of natural resources and unnecessary materials (e.g., reusing excavated soil for fill requirements);
- 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 Proposed Development by employing good industry practice measures;

- Implementing staff minibuses to transport construction personnel to site or using car sharing options where possible;
- Switching vehicles and plant off when not in use and ensuring construction vehicles conform to current UK emissions standards; and
- Conducting regular planned maintenance of the construction plant and machinery to optimise efficiency.

Additional Mitigation

13.3.105 There will be unavoidable GHG emissions resulting from the construction phase of the Proposed Development as materials, energy and fuel use, and transport will be required. Therefore it is not appropriate to define any mitigation measures further to those detailed in the section referenced above.

Assessment of Residual Significant Effects

Construction

13.3.106 The residual construction effects would remain **negligible** to **minor adverse (not significant)** as presented above.

Operation

13.3.107 The residual operational effects would remain **moderate beneficial (significant)** as presented above.

Decommissioning

13.3.108 The residual decommissioning effects would remain **negligible** to **minor adverse (not significant**) as presented above.

Cumulative and In-Combination Effects

Cumulative Effects

13.3.109 Presented below in **Table 13.13** is a list of other planned solar energy projects within Lincolnshire County Council area, alongside their corresponding generation capacities. Collectively these represent an estimated 2,050MW of solar energy generation.

13.3.110 The assessment presented in this chapter has included all GHG emissions and has concluded that the effects would be **negligible to minor adverse (not significant)** for both the construction and decommissioning phases, and **moderate beneficial (significant)** for the operational phase. The same effects are anticipated for the other sites, utilising the same assessment methodology.

13.3.111 To further demonstrate the cumulative benefits of these projects, and the additional contribution of the Proposed Development, this generating capacity has been contextualised to the UK's national targets for newly installed energy generation capacity. This data has been published by BEIS to show the projected requirements of newly installed electricity generating capacity for different types of generation in order to meet the national UK Net Zero Strategy. (BEIS, 2021).

13.3.112 Whilst this data does not specify a projected capacity of solar projects specifically, it does project a newly installed capacity of 107,000MW across all types of renewable energy generation (including onshore and offshore wind, geothermal etc.) by 2040.

13.3.113 **Table 13.13** below shows that the contribution of the currently planned solar projects in the local area is estimated to represent a minimum of 2.25% of the total national projections by 2040, and with the additional generating capacity of the Proposed Development, would increase further to represent a minimum 2.65% of the total national capacity.

Table 13.13: Planned Solar Projects within Lincolnshire County Council area

Project Name and Reference	Solar Capacity (MW)	Contribution to projected UK Renewable Capacity
Land west of Cowbridge Road (B/22/0356) (H04-0849-22)	49.9	<0.1%
Tillbridge Solar Project (PINS reference EN010142)	Unknown (>50)	Unknown
Temple Oaks Renewable Energy Park (PINS reference EN010126)	250	0.25%
Cottam Solar Project (PINS reference EN010133)	600	0.6%
Gate Burton Energy Park (PINS reference EN010131)	500	0.5%
Little Hale Fen (21/1337/EIASCR)	49	<0.1%
Mallard Pass Solar Farm (PINS reference EN010127)	350	0.3%
West Burton Solar Project (PINS reference EN010132)	480	0.4%
Vicarage Drove (B/21/0443)	49.9	<0.1%
Land south of Gorse Lane (19/0060/FUL)	20	<0.1%
Land to the north of White Cross Lane (19/0863/FUL)	Unknown	Unknown
Land at Ewerby Thorpe (14/1034/EIASCR)	Unknown	Unknown
Sub-Total	**2,050**	**2.25%**
Heckington Fen Energy Park	400	0.4%
Total	**2,450**	**2.65%**

13.3.114 This shows the beneficial effects of the Proposed Development and its contribution towards meeting the UK's net zero targets, and the importance of the local area to contributing to these targets on a national scale. On this basis, cumulative operational effects are considered to be **moderate beneficial (significant)**.

In-Combination Effects

13.3.115 In-combination effects are given further consideration below.

13.4 CLIMATE CHANGE ADAPTATION (RESILIENCE)

Legislative and Policy Framework

13.4.1 This assessment reflects the legislation and relevant national policy objectives outlined below.

UK Legislation, Policy and Strategy

13.4.2 Part 2 of the **National Policy Statement for Energy** (NPS EN-1)[2]: this details the Government's energy and climate change strategy. This includes policies for adapting to climate change. Paragraph 4.8.5 of NPS EN-1 notes that **"applicants must consider the impacts of climate change when planning the location, design, build and operation, and, where appropriate, decommissioning of new energy infrastructure."** In addition, paragraph 2.3.5 of Section 4.8 of the EN-3 advises that the project's resilience to climate change should be assessed in the ES accompanying an application. This is reiterated in paragraph 4.9.9 of Part 2 of the **draft National Policy Statement for Energy**[3].

13.4.3 Paragraph 2.3.1 of **National Policy Statement for Renewable Energy Infrastructure** (EN-3)[4]: this refers to the government's energy and climate strategy in Part 2 of EN-1 and highlights the considerations that applicants and the Infrastructure Planning Commission (now the Infrastructure Planning Unit within the Planning Inspectorate) should take into account to ensure that renewable energy infrastructure is resilient to climate change. Paragraph 2.4.10 of the **draft National Policy Statement for Renewable Energy Infrastructure**[5] states that as solar PV sites may be proposed in low lying exposed sites, applicants should consider, in particular, the increased risk of flooding and the impact of higher temperatures. .

13.4.4 The **National Planning Policy Framework** (NPPF)[6] was revised in February 2019 and again in July 2021. Paragraphs 153 and 154 require developments to **"take a proactive approach to adapting to climate change"**. Section 14 of the NPPF 'Meeting the challenge of climate change, flooding and coastal change' emphasises the planning system's pivotal role in sustainable development through **"minimising vulnerability and improving resilience to the impacts of climate change"**.

13.4.5 Paragraphs 159 and 160 of the NPPF state that: **"Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere"**.

13.4.6 Planning Practice Guidance (PPG)[26] was published in March 2019 as a companion document to the NPPF. Paragraph 001 Reference ID: 6-001-20140306 recognises that the planning system can **"increase resilience to climate change impact through the location, mix and design of development"**. The PPG also sets out the required approach to considering climate change in the assessment of flood risk. It provides recommendations for sensitivity ranges and allowances for future increases in rainfall, sea levels, river flows and tidal effects such as wind speed and wave height.

[26] UK Government (2019) Planning Practice Guidance. Available at: https://www.gov.uk/government/collections/planning-practice-guidance

13.4.7 **The UK Climate Change Act 2008**[7] requires the Government, on a five-year cycle, to compile an assessment of the risks for the UK arising from climate change, and then to develop an adaptation programme to address those risks and deliver resilience to climate change on the ground.

13.4.8 **The Climate Change Committee's 2021 Progress Report to Parliament**[27] outlines the UK Government's progress to date on adapting to climate change. This noted that only five of the 34 sectors assessed had shown noticeable progress in the past two years, with no sector yet scoring highly in lowering its level of risk in relation to climate change adaptation in England.

Local Planning Policy

Central Lincolnshire Local Plan 2012 - 2036[9]

13.4.9 The Local Plan places climate change adaptation as one of its key objectives. Objective o. Climate Change Adaptation and Flood Risk is **"To ensure Central Lincolnshire adapts to the effects of climate change, both now and in the future through careful planning and designs of development, including reducing and managing the risk of flooding from all sources"**.

Central Lincolnshire Local Plan Review – June 2021[10]

13.4.10 Policy S19: Resilient and Adaptable Design states that to prevent and minimise the impacts of overheating in the built environment, applicants must demonstrate, commensurate with the scale and location of the proposal, consideration of how the design of the development minimises overheating and reduces demand on air conditioning systems, including orienting buildings to maximise the opportunities for both natural heating and ventilation and to reduce wind exposure; and considering measures such as solar shading, thermal mass and appropriately coloured materials in areas exposed to direct and excessive sunlight.

13.4.11 This policy also states that applicants should design proposals to be adaptable to future social, economic, technological and environmental requirements to make buildings fit for purpose in the long term, including resilience to flood risk, from all forms of flooding.

13.4.12 Policy S52: Design and Amenity states that development should incorporate appropriate landscape and boundary treatments to help achieve wider goals for climate change mitigation and adaptation and water management.

North Kesteven District Council Climate Emergency Strategy and Action Plan – July 2020[11]

13.4.13 Section 9: Adaptation and Resilience has actions which include to assess how extreme weather events affect service delivery, increase permeable surfaces and improve management of land so it provides the ecosystem services that support humans and nature in being more resilient to the effects of climate change.

North Kesteven District Council Environment Policy – July 2021[12]

13.4.14 The expected behaviours and activities include points 35 and 36: **"Assessment of how extreme weather events affect existing service delivery are to be**

[27] Climate Change Committee (2021) 2021 Progress Report to Parliament. Available at: https://www.theccc.org.uk/publication/2021-progress-report-to-parliament/

undertaken" and **"All new council developments should be designed to minimise hard surfaces and maximise permeable surfaces"**.

South East Lincolnshire Local Plan 2011-2036 [13]

13.4.15 The Local Plan highlights the importance of considering climate change in relation to new development in its vision, noting that ***"New development will be of a high standard of design and will help South East Lincolnshire mitigate and adapt to climate change"****.*

13.4.16 Strategic Priority 8 of the Local Plan has an action ***"to minimise the impact of and adapt to climate change by making more sustainable use of land and resources, reducing exposure to flood risk, promoting sustainable development and reducing human exposure to environmental risks"***.

13.4.17 Policy 31: Climate Change and Renewable and Low Carbon Energy notes that ***"all development proposals will be required to demonstrate that the consequences of current climate change had been addressed, minimised and mitigated"***.

Assessment Methodology

13.4.18 The assessment in relation to climate change adaptation considers both the vulnerability of the Proposed Development to climate change and also the implications of climate change for the predicted effects of the project, as assessed by the other topic specialists ('in-combination climate effects').

Study Area

13.4.19 The study areas used for the in-combination assessment is as the study area defined in each of the topic chapters of the ES. The assessment aims to determine the influence of climate change and project-related impacts on the identified receptors in each of the assessments in the scoped in topic chapters. The study area for the project resilience assessment is the Proposed Development itself.

Guidance

13.4.20 This assessment is carried out in accordance with the principles contained within the following document:

- IEMA (2020) Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation.

13.4.21 The IEMA Guidance (2020) defines the two key elements of assessing climate change adaptation in EIA as follows:

- **Project resilience:** the risks of changes in the climate to the project, i.e., the resilience or conversely the vulnerability of a project to future climate change, both to changes in average conditions and in extreme events. This considers if the Proposed Development can withstand the projected climate changes (e.g., through design features and choice of construction materials) and can be future proofed, enabling resilience modifications to be added in the future if necessary.
- **In-combination effects:** the extent to which climate exacerbates or ameliorates the effects of the project on the environment.

13.4.22 Therefore, in line with this guidance, the project resilience assessment assesses the effects of a changing climate on the Proposed Development. The in-combination assessment considers the extent to which the climate worsens or improves the effects of the Proposed Development on the environment, on a topic-by-topic basis. Topics that have been judged to have a lower sensitivity to climate change have been scoped out and are not considered further, whilst a more detailed assessment is provided for those topics that have been judged to have a higher sensitivity to climate change, and are therefore scoped into the in-combination assessment.

Desk Based Research and Data Sources

13.4.23 To establish the current climate of the Proposed Development, data was sourced from the Met Office[28] for the closest climate station located to the Proposed Development. This was Waddington climate station, located approximately 30km north-east of the Order limits.

13.4.24 As recommended in the IEMA guidance (IEMA, 2020), the UK Climate Projections 2018 (UKCP18) have been used to establish future climate change projections for the Proposed Development. The UKCP18 Projections are considered to be the most up-to-date assessment of how the UK's climate may change over the 21st century. Whilst they provide a valid assessment of the UK's future climate over land for a range of variables including temperature, precipitation and sea level rise, wind speed and storm frequency/intensity are considered separately as global modelling information is currently more limited.

13.4.25 The UKCP18 projections for temperature and precipitation are presented for the UK as a whole and also on a regional basis. The UK projections consider three variables:

- **Timeframe:** the projections are presented between the years of 2010 and 2099. These are broken down into a series of time periods including 2020-2039, 2040-2059, 2060-2079 and 2080-2099.
- **Probability:** The projections are provided as probability distributions rather than single values, with figures provided for 5, 10, 50, 90 and 95% probability.
- **Representative Concentration Pathways (RCP)**: Four pathways have been adopted; RCP2.6, RCP4.5, RCP6.0 and RCP8.5. These pathways describe different GHG and air pollutant emissions as well as their atmospheric concentrations and land use, with each one resulting in a different range of global mean temperature increases over the 21st century. RCP2.6 represents a scenario which aims to keep global warming likely below 2°C compared to pre-industrial temperatures. RCP4.5 and RCP6.0 represent intermediate scenarios while RCP8.5 describes a very high GHG emission scenario. All scenarios are considered to be equally plausible.

13.4.26 This assessment uses projections for the time period 2060-2079 and RCP8.5 and utilises the figures relating to the 10, 50 and 90% probability projections. As the most far-reaching projection, the 2060-2079 scenario is considered to be appropriate for the design life of the project. RCP8.5 is selected as a suitably precautionary approach as recommended as best practice in the IEMA guidance (2020). This RCP has been used to indicate the projected temperature, and precipitation for the East Midlands which encompasses the Proposed Development.

13.4.27 Information on wind speed and storms has also been considered, however changes in wind speeds are not currently available at the regional level and there remains considerable uncertainty in the projections, with respect to wind speed and storms.

Field Survey

[28]https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcrws0hwg

13.4.28 The assessment has been desk based, drawing largely from published guidance and data.

Assessment Limitations

13.4.29 The assessment has been carried out using the UKCP18 projections. These are not climate change predictions as they include a degree of uncertainty. As stated in the UKCP18 Science Overview Report:

> ***"While the global and regional projections of future climate use the latest climate models and are diverse, they cannot cover all potential future climate outcomes out to 2100 (or beyond in the case of sea level)….The probabilities represent the relative strength of evidence supporting different plausible outcomes for UK climate, based on the climate models, physical insight, observational evidence and statistical methodology used to produce them. However, they may not capture all possible future outcomes, because, for example, some potential influences on future climate are not yet understood well enough to be included in climate models."***

Assessment of Significance

13.4.30 This assessment considers both the vulnerability of the Proposed Development to climate change and the implications of climate change for the predicted effects of the project, as assessed by the other topic specialists ('in-combination climate effects'). Potential receptors therefore include the following:

- Solar infrastructure receptors (including building materials, equipment and construction operations/processes);
- Socio-economic receptors (e.g. construction workers, permanent employees and users of the public right of way (PRoW) crossing the site));
- Environmental receptors (e.g. habitats and species).

13.4.31 When determining the likelihood of a climate hazard occurring, a worst case scenario has been assumed, whereby all climate hazards are considered likely to occur.

13.4.32 With respect to climate change adaptation and effect significance, section 7 of the IEMA Guidance (IEMA, 2020) explains that in determining significance, account should be taken of the susceptibility of the receptor (e.g. ability to be affected by a change and the opposite of climate resilience) and the vulnerability of the receptor (e.g. potential exposure to a change).

13.4.33 A receptor with high susceptibility has no ability to withstand/not be substantially altered by the projected changes to the climate. A receptor with low susceptibility has the ability to withstand/not be altered much by the projected change to climate. A receptor with high vulnerability is directly dependent on existing/prevailing climatic factors and reliant on these specific existing climate conditions continuing in future (e.g. river flows and groundwater level) or only able to tolerate a very limited variation in climate conditions. Climatic factors have little influence on receptors with low vulnerability (and these receptors require limited consideration through the EIA process).

13.4.34 Using professional judgement, a combination of susceptibility and vulnerability, in addition to the value/importance of the receptor is used to reach a reasoned conclusion on sensitivity. The greater the susceptibility and/or vulnerability of the receptor, the greater the probability that receptor is also of higher sensitivity.

13.4.35 Magnitude of effect is based on a combination of likelihood, which takes into account the chance of the effect occurring over the relevant time period and also consequence, which reflects the geographical extent of the effect or the number of receptors affected (e.g. scale), the complexity of the effect, degree of harm to those affected and the duration, frequency and reversibility of effect. **Table 13.14** defines the likelihood of a climate effect occurring, after taking into account the mitigation measures that have been proposed.

Table 13.14: Defining likelihood of effect

Likelihood of climate effect occurring (after considering mitigation measures)	Description of likelihood
Likely	66-100% probability that the impact will occur during the life of the Proposed Development
Possible	33-65% probability that the impact will occur during the life of the Proposed Development
Unlikely	0-32% probability that the impact will occur during the life of the Proposed Development

13.4.36 The approach to defining consequence for the in-combination climate effects assessment is set out in **Table 13.15**, whilst **Table 13.16** sets out the consequence criteria for climate change resilience. To assess the consequence of an in-combination climate change effect, for each environmental topic scoped into the assessment, a level of consequence is assigned to an effect based on the approach outlined in **Tables 13.15** and **Table 13.16** and their respective assessment methodology. For climate change resilience, professional judgement has been adopted when assigning a consequence criterion to a potential effect.

Table 13.15: Defining consequence

Consequence	Description of consequence
High	The climate change factors in-combination with the effect of the Proposed Development causes the significance of the effect of the Proposed Development on the receptor, defined by the topic, to increase to major
Medium	The climate change factors in-combination with the effects of the Proposed Development causes the significance of the effect of the Proposed Development on the receptor, as defined by the topic, to increase to moderate
Low	The climate change factors in-combination with the effects of the Proposed Development causes the significance of the effect of the Proposed Development on the receptor, as defined by the topic, to increase to minor
Negligible	The climate change factors in-combination with the effect of the Proposed Development causes no change to the significance of the effect of the Proposed Development on the receptor, as defined by the topic

Table 13.16: Consequence criteria

Consequence	Consequence criteria
High	Major damage to infrastructure and complete loss of service; and/or Major financial loss; and/or Major health and environmental effects
Medium	Partial infrastructure damages and some loss of service; and/or Moderate financial impact; and/or Adverse effect on health and the environment
Low	Localised infrastructure disruption; and/or

Consequence	Consequence criteria
	No permanent damage, minor restoration work required; and/or Minor financial losses and/or slight adverse health or environmental effects
Negligible	No damage to infrastructure; and/ or No adverse financial effect, and/or No effects on health or the environment

13.4.37 The significance of potential effects is then determined using the significance criteria matrix in **Table 13.17**. Where an effect has been determined to be either moderate or major, this has been deemed a significant environmental effect in the context of the EIA Regulations. For project resilience, significance should reflect the aims/purpose of the project. For example, as a solar project has the purpose of generating renewable electricity, an effect which temporarily removes this should be considered significant.

Table 13.17: Significance Criteria

Consequence	Likelihood		
	Likely	Possible	Unlikely
High	Major	Major	Minor
Medium	Major	Moderate	Minor
Low	Moderate	Minor	Negligible
Negligible	Minor	Negligible	Negligible

Consultation

13.4.38 **Table 13.18** provides a summary of matters raised within the Scoping Opinion and how these have been addressed through the ES in relation to climate change adaptation.

Table 13.18: Summary of Scoping Opinion Responses

Consultee	Details of consultee response	How is matter addressed	Location of response
PINS Scoping Opinion	The Inspectorate agrees that the Proposed Development is not likely to give rise to significant effects in relation to the following and agrees that these topics can be scoped out of the consideration of in-combination climate effects: • air quality emissions during operation • transport and access socio-economics and human health.	No action necessary.	
	The Inspectorate does not agree that noise should be scoped out from the consideration of in-combination climate effects as there is insufficient information provided in the Scoping Report as to the likely significant effects from increased noise	Noise has been scoped into the assessment of in-combination noise effects.	Paras 13.4.84-13.4.87 of Chapter 13: Climate Change (document reference 6.1.13)

Consultee	Details of consultee response	How is matter addressed	Location of response
	from building services equipment for cooling. This should be considered as part of the overall assessment of noise effects and cross referenced to the relevant chapters within the ES.		

13.4.39 No Section 42 consultation responses since the PEIR have been received in relation to climate change adaptation.

Baseline Conditions

Current Climate

13.4.40 The current baseline is that of the current climate. Between the years of 1991 and 2020 at the Waddington climate station, the average maximum temperature summer[29] temperature was 20.7ºC and the average minimum temperature was 11.9ºC. For the same location and over the same time period, the average maximum winter temperature was 7.3ºC and the average minimum temperature was 1.7ºC.

13.4.41 The average rainfall during the same time period (1991-2020) and same climate station noted above was 60mm and 46mm respectively. The average sunshine hours during the same time period and location noted above was 196 in summer and 70 hours in winter. The average wind speed at 10m during the same time period and location noted above was 9.3 knots in summer and 10.3 knots in winter.

Extreme Weather Events

13.4.42 A heatwave and extreme drought conditions became established over most of the UK during the late winter and early spring of 2002/2003. The spring period saw a record-breaking lack of rainfall and gave way to a long, warm summer in 2003.

13.4.43 In 2010/2012, most of the UK experienced exceptional departures from normal rainfall, runoff and aquifer recharge patterns. Generalising broadly, drought conditions developed through 2010, intensified during 2011 and were severe across much of England and Wales by the early spring of 2012. Record late spring and summer rainfall then triggered a hydrological transformation, with seasonally extreme river flows common through the summer and extensive flooding during the autumn and early winter.

13.4.44 In July 2019, the UK experienced a short but intense heatwave. On the 25th of July, temperatures in eastern England widely reached 35 to 36 degrees. The all-time temperature record for the UK was set at Cambridge, recording 38.7 degrees. The weather station at Cranwell, Lincolnshire recorded an all-time high temperature of 36.3 degrees.

13.4.45 In November 2021, the UK experienced one of the most powerful and damaging winter storms of the last decade in the form of Storm Arwen. The storm, tracking south to the north-east of the UK, brought northerly winds gusting widely over 69mph.

Future Climatic Baseline Conditions

[29] In accordance with the UKCP18 Derived Projections of Future Climate over the UK report, winter is classified as the months of December to February and summer is classified as the months of June to August.

13.4.46 The UKCP18 projections show a general trend towards warmer, wetter winters and drier, hotter summers. However, it should be noted that both temperature and rainfall patterns across the UK are not consistent and will vary dependent on seasonal and regional scale and will continue to vary in the future (Met Office, 2018).

Temperature

13.4.47 The UKCP18 projections show that temperatures within the East Midlands are projected to increase, with projected increases in summer temperatures greatest. The central estimate of increase in winter mean temperature is 2.4°C; there is a 90% probability of temperature change exceeding 0.8°C and a 10% probability of temperature change exceeding 4.2°C. The central estimate of increase in summer mean temperature is 3.4°C; there is a 90% probability of temperature change exceeding 1.5°C and a 10% probability of temperature change exceeding 5.4°C.

Precipitation

13.4.48 Winter rainfall is projected to increase, and summer rainfall is most likely to decrease. The central estimate of change in winter mean precipitation is an increase of 15%; there is a 90% probability of precipitation decreasing by up to 3% with a 10% probability of precipitation increasing by 35%. The central estimate of change in summer mean precipitation is a decrease of 26%; there is a 90% probability of summer precipitation decreasing by as much as 54% and a 10% probability of summer precipitation increasing by 2%. It should be noted, however, that rainfall patterns across the UK are not consistent and will vary dependent on seasonal and regional scales and will continue to vary in the future (Met Office, 2018).

Wind Speed and Storms

13.4.49 There are small changes in projected wind speed (Defra, DECC and Met Office, 2010). Across the UK, near surface wind speeds are expected to increase in the second half of the 21st century with winter months experiencing more significant impacts of winds (Met Office, 2018). This is accompanied by an increase in frequency of winter storms over the UK. However, the increase in wind speeds is projected to be modest.

Sunshine Hours and Cloud Cover

13.4.50 Climate change is expected to alter the amount of sunshine hours and cloud cover that different regions of the UK receive. In comparing two 30-year periods (1961-1990 and 1991-2020), the Met Office has found that sunshine has increased by 5.6% across the UK (Met Office, 2021). North-eastern and eastern England have seen increases of more than 13%. A recent study from Imperial University suggested that low clouds have a cooling effect whereas high clouds have a warming effect (Imperial, 2021). There are no robust predictions on how this will affect the UK, however clouds are likely to play a significant role in the UK's future climatic condition.

Assessment of Likely Significant Effects

13.4.51 This section gives further consideration as to whether or not the projected climate change will materially affect any impact judgements, which may lead to additional potentially significant effects, taking account of relevant mitigation measures. The Proposed Development's resilience to climate change is also considered, particularly whether the project could be affected by climate change to such an extent that the construction and/or operation of the Proposed Development was potentially no longer viable.

Topics Scoped Into the Assessment of In-Combination Effects

13.4.52 For each ES topic, consideration has been given as to the relevance of the climate change projections for receptor baseline conditions. Those with a higher sensitivity to climate change have been scoped into the climate change adaptation assessment, as follows:

- landscape and visual amenity (operational phase)
- cultural heritage (construction phase)
- flooding and drainage (construction and operational phase)
- ecology (construction and operational phase)
- noise (included at the request of the Planning Inspectorate).

Topics Scoped Out of the Assessment of In-Combination Effects

13.4.53 ES topics where receptors have been identified to have a lower sensitivity to climate change are proposed to be scoped out of the climate change adaptation assessment. These topics, including the justification for scoping them out, are discussed further below.

13.4.54 **Air Quality**: Climate change can have an impact on air quality and air quality can have an impact on climate change. These interactions are complex and not fully quantifiable at a local level. Higher summer time temperatures and increased solar radiation will increase the formation of ozone and other reactive compounds in the air, affecting the concentrations of both NO_2 and PM. The net effect may be an increase in background concentrations of NO_2 and PM.

13.4.55 NO_X is an indirect greenhouse gas affecting atmospheric concentrations of ozone, methane and PM in the atmosphere. Increasing concentrations of ozone and methane leads to global warming. The effect of PM (also known as aerosols) is more complex with different components having either warming or cooling effects on the climate. For example, black carbon, a pollutant from combustion (including road transport) and particulate nitrate (formed from NO_X emissions) contributes to the warming of the Earth, while particulate sulphates cool the earth's atmosphere. In addition, PM can affect cloud formation, which also affects the climate.

13.4.56 Climate change is a long-term process and the impact of emissions depends on the atmospheric lifetime of the emitted species. Compared to greenhouse gases, many substances that affect air quality have short atmospheric lifetimes. PM for example has a substantial impact but are short-lived and reductions in emissions affect the radiation balance rapidly, in contrast to any reductions in, for example, carbon dioxide. Limits on direct emissions of both NO_X and PM set at an international level to control air quality, will also be beneficial for climate change. Emissions have reduced substantially over recent decades and are likely to continue to do so.

13.4.57 Changes in atmospheric composition and their impact on climate change are uncertain and it is not possible to quantify them at the local level. Overall, however, at this stage, it is not anticipated that air quality conditions will fail to meet relevant air quality objectives as a consequence of projected climate change

13.4.58 **Transport and Access:** Increased rainfall/storms have the potential to lead to traffic disruption during flooding episodes. Increased summer temperatures may cause some disruption and discomfort, although this is unlikely to be a significant concern, particularly for the operational phase of the development.

13.4.59 **Hydrogeology (Ground Conditions):** The projected increase in rainfall/possible storm events has the potential to result in the mobilisation of ground contaminants when the soil is saturated leading to potential consequences for human health or water quality. During the projected warmer and drier summers, there is potential for soil to become airborne leading to impacts on air quality and human health. However, as the Energy Park site is not considered to be contaminated, this topic has been scoped out of the climate change adaptation assessment.

13.4.60 **Socio-Economics and Human Health:** Recent flooding events in the UK highlighted the extent to which economic activity and human welfare can be affected by flooding from increased rainfall. Temperatures are also likely to increase, which may lead to overheating concerns, particularly during construction. However, it is considered that this topic can be scoped out of the climate change adaptation assessment as significant effects are not considered likely (noting that flooding is scoped in as a separate topic).

13.4.61 **Land Use and Agriculture:** Climate change is expected to affect agricultural practices and enterprises, due to changes in rainfall patterns and quantities, and due to increasing temperatures, which may alter cropping and stocking patterns and choices in the future. The ability of these soils to grow crops depends upon the availability of water, especially in the spring and early summer peak growing season. Climate change may necessitate different cropping in the future. It is also anticipated that climate change could affect soil properties including drainage, soil moisture content, nutrient recycling rates, carbon sequestration, changes in leaching and run-off, and soil biodiversity and stability through clay shrinkage. However, as the land is being converted from its current agricultural use into primarily a renewable energy generating site, for the duration of the consent, this topic can be scoped out of the climate change adaptation assessment (noting that project resilience to climate change is considered separately).

Assessment of Potential Effects

13.4.62 This section gives further consideration as to whether or not the projected climate change will materially affect any impact judgements, which may lead to additional potentially significant effects, taking account of relevant mitigation measures. The Proposed Development's resilience to climate change is also considered, particularly whether the project could be affected by climate change to such an extent that the construction and/or operation of the Proposed Development was potentially no longer viable.

13.4.63 Receptors identified above, as potentially sensitive to a changing climate, are as follows:

- landscape and visual amenity (operational phase)
- cultural heritage (construction and decommissioning phases)
- flooding and drainage (construction and operational phase)
- ecology (construction and operational phase)
- noise (operational phase, included at the request of the Planning Inspectorate).

<u>Landscape and Visual Amenity</u>

13.4.64 The Landscape Institute's Position Statement on climate change acknowledges that changes in average temperatures, precipitation and extreme weather events will have an effect on the landscape. Therefore, landscape and visual effects have been taken forward for further assessment for the operational phase, noting that the landscape mitigation planting will be fully delivered towards the final stages of the construction phase.

13.4.65 **Chapter 6: Landscape and Visual Amenity** (document reference 6.1.6) concludes that there will be major and moderate significant residual effects in the construction and operational phases of the Proposed Development respectively on the Fens Regional Landscape Character Type (limited to the Energy Park and its immediate context of approx. 500m). During the construction phase, temporary significant (major) residual effects are anticipated through a change to views from viewpoints and public footpaths. During the operational period, long term significant (moderate) and non-significant (minor) residual effects are predicted through a change in views from viewpoints and public footpaths.

13.4.66 Whilst acknowledging that a small area of plantation woodland and grassland scrub may need to be cleared for the facilitation of the Additional Works, the Proposed Development would bring about a net gain in the hedgerow resource within the Energy Park, recognising that habitat connectivity is one way of creating an environment resilient to climate change. The ground beneath the solar modules would be sown with a suitable grass mix to suit ground conditions and local climate. It is envisaged that the grassland mix would be able to sustain any prolonged period of wetness or other changes in the local climate. In addition, the proposed hedgerow planting would act as carbon sinks, assisting in sequestering more carbon than the structural vegetation currently present within the Application Site.

13.4.67 A rise in temperatures may have an effect on the growth rates of vegetation. Slight increases in temperature would typically stimulate growth but prolonged periods of drought are likely to stump the vegetation. Whilst there are many variables that may affect the future growth of the existing and proposed vegetation, it is envisaged that it will continue to provide screening.

13.4.68 Whilst the proposed grassland mix and hedgerow planting may be sensitive to the increased frequency of extreme weather events, the selected species would be native and of local provenance/or a suitable substitution. These are considered to be better suited to the local soil and climate and are likely to adapt and be more resilient to the climate change. Any non-native species may be regarded as incongruous to the local landscape character, with the risk of becoming invasive due to the unknown aspects and effects of climate change.

13.4.69 As such, whilst it is considered possible that an in-combination climate change effect could occur during the operational phase of the Proposed Development, the consequence of a climate effect is considered to be low. Therefore, a **minor and not significant** in-combination climate change effect is predicted for Landscape and Visual Amenity during the operational phase.

Cultural Heritage

13.4.70 Changes in temperature and rainfall patterns can affect above and below ground heritage assets. For example, waterlogged archaeological sites are susceptible to changes and fluctuations within the water table and so the remains of known and unknown archaeological remains have the potential to be affected by climate change.

13.4.71 **Chapter 10: Cultural Heritage and Archaeology** (document reference 6.1.10) identifies effects for the construction and decommissioning stages of the Proposed Development prior to mitigation. These effects relate to the loss or truncation of known buried archaeological remains of prehistoric and Roman activity. Where required, a mitigation strategy of strip map sample excavation will be implemented during construction (and follow-on mitigation as appropriate) to preserve the buried archaeological resource by record. Similarly, during decommissioning, archaeological observation and recording during the removal of ground-mounted infrastructure will take place as required. The residual effects for both construction and decommissioning are considered to be of minor significance, as the harm cannot be entirely mitigated.

13.4.72 Whilst no indirect significant effects have been identified as a result of changes to setting, planting along the northern boundary of the Energy Park will help screen visibility of the Proposed Development in designed views from the (non-listed) Mill Green Farmhouse. Consideration has been given to the resilience of this screening to future climate change.

13.4.73 It is considered unlikely that an in-combination climate change effect will occur given the conclusions outlined above. The consequences of a climate effect are considered low. Therefore, a **negligible and not significant** in-combination climate change effect is predicted for Cultural Heritage.

Flooding and Drainage

13.4.74 Consideration of climate change has formed an integral part of the assessment of flood risk. Decreased rainfall could also lead to seasonal and prolonged drying out of watercourses which may affect groundwater recharge and aquatic ecology. Changes in rainfall patterns also have the potential to reduce water flow rates in rivers within the drainage basin. An increase of silt laden run off could increase silt deposits in rivers, altering the nature of the river.

13.4.75 With respect to tidal/fluvial flooding, **Chapter 9: Hydrology, Hydrogeology, Flood Risk and Drainage** (document reference 6.1.9) explains that the majority of the Energy Park Site is located within Flood Zone 3 (High Probability – land having a 1 in 100 or greater annual probability of fluvial flooding) and benefits from flood defences offering a 1 in 10-year standard of protection. The Off-site Cable Route Corridor and National Grid Bicker Fen Substation also lie within Flood Zone 3. The majority of the Energy Park and the Off-site Cable Route Corridor and National Grid Bicker Fen Substation are at 'Very Low' risk of surface water flooding.

13.4.76 Chapter 9 explains that the baseline hydrological regime may change as a result of climate change, irrespective of any development. River flows, tide levels and rainfall intensities are predicted to increase as a result of climate change. Should such changes materialise, rates of surface water run-off, flood flows within watercourses and flood levels associated with a breach of flood defences would increase. In addition, the seasonality of rainfall and river flows is likely to become more pronounced. The baseline hydrogeological regime is unlikely to change as a result of the predicted impacts of climate change, given the unproductive nature of the geology and absence of aquifers that would be affected by changing recharge rates.

13.4.77 **Appendix 9.1- Flood Risk Assessment** (document reference 6.3.9.1) takes account of the potential future changes in the hydrological regime by incorporating appropriate allowances for climate change, as published by the Environment Agency (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances).

13.4.78 Whilst there is likely to be an increase in surface water run-off due to an increase in impermeable surfaces and there is also potential for surface water contamination, from the flushing of silts and hydrocarbons from areas of hardstanding, the chapter concludes that the likely effects of the Proposed Development are not significant given the 'mitigation by design'/embedded mitigation measures. The assessment also notes that the raising of ground levels to locate flood-sensitive infrastructure above the flood level has the potential to reduce the volume of storage available within the floodplain. However, the assessment notes that any such ground raising would be very small scale and localised and located within a significant expanse of floodplain.

13.4.79 Proposed mitigation measures for the construction phase include best practice methods to avoid water pollution/silt laden run-off and adverse effects on the surface water drainage regime and, where required, the laying of cables at sufficient depth beneath watercourses/drains to avoid causing damage to the integrity of flood embankments. An **Outline Construction Environmental Management Plan (oCEMP)** (document reference 7.7) outlines many of these proposed measures, with the CEMP being finalised prior to construction.

13.4.80 Given the mitigation measures outlined above, it is considered unlikely that a climate effect will occur during the construction phase. The consequences of a climate effect are considered to be medium. Therefore, a **minor and not significant** in-combination climate effect is predicted for Hydrology, Hydrogeology, Flood Risk and Drainage during the construction phase.

13.4.81 Proposed mitigation measures for the operational phase include the design of surface water management infrastructure such that the surface water run-off regime replicates that existing prior to development, implementation of SuDS and the use of elevated floor levels and flood resilient construction measures as required.

13.4.82 Given the mitigation measures outlined above, it is considered unlikely that a climate effect will occur during the operational phase. The consequences of a climate effect are considered to be medium. Therefore, a **minor and not significant** in-combination climate effect is predicted for Hydrology, Hydrogeology, Flood Risk and Drainage during the operational phase.

<u>Ecology and Ornithology</u>

13.4.83 Increased rainfall and flooding events, coupled with rising temperatures, may modify UK flora and fauna over time, with shifts in species' ranges. Natural England's 'Climate Change Risk Assessment and Adaptation Plan' sets out the risks and threats posed by current climate change projections. In association with the RSPB, Natural England has also published a Climate Change Adaptation Manual which details the potential effects of climate change on different habitat types.

13.4.84 **Chapter 8: Ecology and Ornithology** (document reference 6.1.8) explains that projected increases in summer temperatures over the life span of the project (40 years) are likely to lead to lower water levels in the drains within the Energy Park site during the summer months which may have a negative effect on aquatic plants within the ditches. The predicted increase in summer temperature and potentially increased abundance in flying invertebrates may benefit insectivore birds and may benefit bats present and foraging with the area. Badgers' primary food source is various species of worms therefore increased summer temperature and longer periods of dry ground may degrade the quality of suitable foraging habitat for badgers. Young European Hare (leverets) which are left by their mothers in small depressions above ground from birth may benefit from warmer dryer spring and summer weather result in higher survival rates to adult.

13.4.85 An increase in heavy spring and summer rainstorms could have a negative effect on some species particularly ground nesting birds and potentially leverets in open fields. Increased winter rainfall may increase water level with ditches which may result in inundation of a number of the outlying badger setts where the entrance is below the top of the ditch banks.

13.4.86 The chapter concludes that there will be an overall significant residual, locally, beneficial effect on biodiversity in the area of the Proposed Development. No significant adverse residual effects are predicted on habitats, protected species, or sites designated for nature conservation interest, including the Wash Special Protection Area (SPA) during the construction and operational phase.

13.4.87 Significant beneficial residual effects are predicted at a local level for certain receptors, such as grasslands, boundary habitat, brown hare, badgers and invertebrates. Whilst acknowledging that a small area of plantation woodland and grassland may need to be cleared for the facilitation of the Additional Works, the ecological enhancements within the Proposed Development include the creation of over 60 hectares of species rich grassland, 2 hectares of traditional orchard and the conversion of 440 hectares of arable land to sheep pasture, using drought resistant seed mixes. This will increase resilience to the ecological effects of climate change through the provision of habitats of high ecological value and/or those which provide a clear ecosystem service such as carbon storage through tree planting and improvements in relation to water and soil erosion through the provision of attenuation measures. The enhancement measures will also improve ecological connectivity within the Energy Park site therefore increasing the ability of species to move and adapt.

13.4.88 Given the duration of the construction period, it is unlikely that a significant shift in species range will occur during this time period. Therefore, the likelihood of an in-combination climate effect occurring is considered unlikely. The consequence is considered to be low. Therefore, a **negligible and not significant** in-combination climate effect is predicted for Ecology and Ornithology during the construction phase of the development.

13.4.89 The likelihood of an in-combination climate effect occurring during the operational phase of the development is considered possible, with the consequence of a climate effect considered to be low. Therefore, a **minor and not significant** in-combination climate effect is predicted for Ecology and Ornithology during the operational phase of the development.

<u>Noise (included at the request of the Planning Inspectorate).</u>

13.4.90 Changes in rainfall are projected. However, as the assessment of noise effects, included in **Chapter 12: Noise** (document reference 6.1.12), has been considered against a baseline environment in the absence of rainfall, this would not affect the outcome of the assessment.

13.4.91 Chapter 12 concludes that whilst there is the potential for significant (moderate to major) adverse noise effects on residential and educational receptors during construction, under worse case scenarios, and with no mitigation, this can be reduced to non- significant (negligible to minor) adverse effects with the provision of suitable mitigation. This includes consideration of noise effects at the detailed design and selection of electrical/mechanical plant stage, with further attenuation and/or screening/temporary re-housing measures as required to achieve suitable noise limits. The extent of trenchless work will also be minimised, particularly for night-time drilling. Operational and decommissioning effects are not considered to be significant.

13.4.92 As a result of higher temperatures, any building services equipment that provides cooling for components of the Proposed Development will also be required to operate at a higher intensity and for longer periods in the future, resulting in increased noise emissions. Increased temperatures would affect the need for plant to operate ancillary cooling equipment. However, the assessment has been undertaken based on all plant (including cooling) operating at full duty during the night-time and therefore this accounts for future temperature increases.

13.4.93 Based on the above assessment assumptions and mitigation considerations, the likelihood of an in-combination effect is considered to be possible with the consequences assessed as negligible. Therefore, a **negligible and not significant** in-combination effect is predicted for Noise during the operational phase.

Project Resilience

13.4.94 In general, and taking account of design and additional mitigation measures proposed, it is not considered that the project could be affected by climate change to such an extent that the construction and/or operation of the Proposed Development could potentially become unviable. Further details are provided below.

13.4.95 The UKCP18 projections show a general trend towards drier summers and wetter winters, with more extreme weather events. Solar modules and inverters are designed to be used globally, including places with much higher ambient temperatures. The modules will typically operate from -40 to +85 degrees but derate at higher temperatures. The inverters will operate up to about 50 or 60 degrees and again will derate or shut down under very high temperatures.

13.4.96 Whilst it is possible that there would be slightly lower than expected generation with consistently higher temperatures, it is likely that this would be more than offset by less moisture in the air, and in any case, it would only be a reduction in low single digit percentages so generation would not be materially affected. A study from 2014 also suggested that climate change could lead to a mean increase in the UK's solar resource, although with greater seasonable variability and discrepancy between geographical regions (Burnett, 2014). This could actually increase the energy output of the Proposed Development, accepting that there is a high degree of uncertainty in this projection.

13.4.97 Whilst UK near surface wind speeds are expected to increase in the second half of the 21st century, with winter months in particular experiencing more significant impacts of winds, the Proposed Development will be designed to deal with the maximum wind loading expected (this applies to both fixed and tracking solar PV systems). This will include both the provision of new hedgerows and the enhancing of existing hedgerows to fill in gaps where necessary, helping filter and slow wind speeds throughout the Proposed Development. Solar PV modules selected for installation will also be certified to withstand other severe environmental conditions through their design. This will include antireflective and anti-soiling surfaces to minimise power loss from dirt and dust, in addition to resistance mechanisms to offer protection against snow load and severe salt mist and ammonia. The system will also be designed to deal with the maximum wind loading expected. As such, it is not considered likely that the solar PV modules will be affected by extreme weather events.

13.4.98 The high voltage parts of the Energy Park site will also have additional flood protection, as required, either through bunding or the use of elevated bases.

13.4.99 The UKCP18 projections show a general trend towards warmer winters and hotter, drier summers. This has been taken into consideration when designing the landscaping strategy for the Proposed Development, including to ensure that the species selected for planting on the site are resilient to wild fires.

13.4.100 As temperatures are projected to increase, in addition to the frequency and intensity of winter storms, there is an increased risk of discomfort, particularly for construction workers and the limited number of permanent employees working at the Proposed Development during its operational life[30]. To avoid employee discomfort, for example during periods of extreme temperatures or increased precipitation, construction and operational activities will be managed so that the hottest or wettest/coldest parts of the day are avoided to ensure worker safety, although it is noted that this may not always be possible during the construction phase. The design, orientation and positioning of welfare facilities for staff will also be carefully considered. Additionally, the risk of

[30] Those employed in operations and maintenance and a shepherd.

overheating/hypothermia will be incorporated into the site risk assessment and the Proposed Development will comply with all relevant UK legislation related to the work environment including The Health and Safety at Work etc. Act 1974 and The Management of Health and Safety at Work Regulations 1999 (as amended). For example, this may include measures such as ensuring appropriate personal protective equipment (PPE) is worn for the site conditions and adequate water supplies are available to ensure staff stay hydrated during hotter weather.

13.4.101 Whilst the consequence of a climate effect occurring would be high in the event of a wild fire, high winds or storm occurring, or high-medium for flood risk and employee discomfort, when the mitigation outlined above is taken into account, it is considered unlikely that these effects will occur. Therefore, **minor and not significant** effects are predicted in relation to the Proposed Development's resilience to climate change.

Mitigation and Enhancement

13.4.102 No additional mitigation measures to those identified above are proposed.

Assessment of Residual Significant Effects

13.4.103 The effects remain as reported above. There are no significant in-combination climate effects and no significant effects in relation to project resilience.

Cumulative Effects

13.4.104 With respect to climate change adaptation, this is a project specific consideration, namely the resilience of the project in question to climate change and the extent to which projected climate change could alter other predicted impact judgements. More widely, in relation to potential interactions with other developments, and following the same logic with respect to required compliance with regulatory standards and accepted good practice mitigation measures, **no significant cumulative effects** are anticipated.

13.5 SUMMARY FOR EMISSIONS REDUCTION

Introduction

13.5.1 To reflect the requirements of the 2017 EIA Regulations, an assessment has been undertaken of the potential effects of the Proposed Development on greenhouse gas (GHG) emissions reduction, in accordance with recognised guidance.

Baseline Conditions

13.5.2 The land within the site consists mainly of agricultural land and trees. The baseline conditions include the existing carbon stock (e.g. carbon sequestered within vegetation present) and sources of GHG emissions (e.g. from agricultural vehicles and machinery) from the existing activities on-site. Whilst the growing of crops will sequester carbon in the short term for the duration of a growing cycle, this carbon would be subsequently released in a relatively short cycle during the agricultural practices of management, harvesting and consumption.

Likely Significant Effects

13.5.3 The greatest volume of GHG emissions during the construction phase is as a result of the embodied carbon in construction materials which accounts for over 96% of the total emissions. The remaining emissions relate to the transportation of materials, land use change, waste and workers. Total GHG emissions from the construction phase are estimated to equate to 275,000 tCO_2e, which when compared to applicable national carbon budgets, in line with accepted guidance, equates to an effect that is not significant.

13.5.4 The greatest volume of GHG emissions during the operational phase is as a result of maintenance activities, associated with embodied carbon and the transport of replacement parts and equipment, which account for 93.6% of the total emissions. Total operational GHG emissions equate to 316,000 tCO_2e over the 40-year design life. Emissions associated with the land use change from intensive arable to solar energy generation have been calculated on the basis of the carbon footprint that would arise from the necessary transport and import of food and crops from elsewhere, which could otherwise have been grown on this land.

13.5.5 The average operational GHG intensity of both the Proposed Development (including Energy Storage aspects) and just the Energy Park (excluding Energy Storage aspects) have been calculated by dividing the corresponding total operational GHG emissions (outlined above) by the total energy generation of the Energy Park. When considering the Proposed Development as a whole, this gives an average operational GHG intensity of 22.5 grams of CO_2 equivalent per kWh (gCO_2e/kWh). This operational GHG intensity is well below the 2022 GHG intensity of the grid (136 gCO_2e/kWh), as published by BEIS (BEIS, 2021). When considering only the aspects relating to the solar energy generation from the Energy Park, this gives an average operational GHG intensity of 7.9 grams of CO_2 equivalent per kWh (gCO_2e/kWh). Importantly, without low-carbon energy generation projects such as the Proposed Development, the average grid GHG intensity will not fully decrease as projected, which would also adversely affect the UK's ability to meet its carbon reduction targets. Therefore, the Proposed Development is considered to have a significant beneficial effect on emissions reductions during its operational phase.

13.5.6 GHG emissions from decommissioning activities are estimated to equate to 3,110 tCO_2e and are associated with the transportation of materials, waste and workers. Whilst these emissions cannot be compared to a relevant national carbon budget as these do not yet extend to cover the date of likely decommissioning, these are considerably lower than construction related emissions, and are considered to equate to an effect that is not significant.

Mitigation and Enhancement

13.5.7 Whilst mitigation measures will be included such as designing to reduce waste and maximise the use of materials with lower embodied carbon, effects will remain as outlined above, i.e., not significant.

Cumulative and In-combination Effects

13.5.8 When considering the generation capacities of other planned solar energy projects within Lincolnshire County Council area (where known), these collectively represent an estimated 2,450MW of solar energy generation. This is also considered to have a significant beneficial effect on emissions reductions during their corresponding operational phases.

13.5.9 In-combination effects are considered below under 'climate change adaptation'.

Conclusion

13.5.10 No significant adverse effects have been predicted with respect to GHG emissions during the construction and decommissioning phases. A significant beneficial effect has been predicted during the operational phase both for the Proposed Development in isolation and cumulatively.

13.5.11 **Table 13.19** provides a summary of effects, mitigation and residual effects.

Table 13.19: Summary of Effects, Mitigation and Residual Effects

Receptor / Receiving Environment	Description of Effect	Nature of Effect	Sensitivity Value	Magnitude of Effect	Geographical Importance	Significance of Effects	Mitigation / Enhancement Measures	Residual Effects
Construction								
Global atmosphere	GHG emissions as a consequence of construction activities	Permanent*	High	Expressed as the change in mass of GHG emissions, in units of tonnes of carbon dioxide equivalent (tCO2e)	International	Negligible to Minor Adverse	No further mitigation required above the mitigation measures already proposed	Negligible to Minor Adverse **(not significant)**
Operation								
Global atmosphere	Net GHG emissions as a consequence of operation of the Proposed Development	Permanent	High	As above	International	Moderate Beneficial	No further mitigation required above the mitigation measures already proposed	Moderate Beneficial **(significant)**
Decommissioning								
Global atmosphere	GHG emissions as a consequence of decommissioning activities	Permanent	High	As above	International	Negligible to Minor Adverse	No further mitigation required above the mitigation measures already proposed	Negligible to Minor Adverse **(not significant)**

Cumulative (In-combination considered below)								
Global atmosphere	Net GHG emissions as a consequence of operation of the Proposed Development in addition to other solar schemes considered	Permanent	High	As above.	International	Moderate Beneficial	No further mitigation required above the mitigation measures already proposed	Moderate Beneficial **(significant)**

*Selected as the IPCC estimates that CO_2 remains in the atmosphere for 50-200 years.

13.6 SUMMARY FOR CLIMATE CHANGE ADAPTATION

Introduction

13.6.1 To reflect the requirements of the 2017 EIA Regulations, an assessment has been undertaken of the potential effects of the Proposed Development on climate change adaptation. In accordance with recognised guidance, this has included both the vulnerability of the Proposed Development to climate change and also any implications of climate change for the predicted effects of the project, as assessed by the other topic specialists ('in-combination climate effects').

Baseline Conditions

13.6.2 Baseline conditions have been determined with respect to average maximum and minimum summer and winter temperatures, average summer and winter sunshine hours and average summer and winter wind speeds.

13.6.3 With respect to future baseline conditions, the assessment uses the UKCP18 climate projections for the 2080s which suggest that, in future, the site and its surroundings will experience warmer, drier summers and milder wetter winters. Whilst heavy rain days are likely to increase throughout the year, there is still considerable uncertainty with respect to likely changes in both wind speed and storm frequency/intensity. All other ES topic area authors were provided with a summary of the climate change projections and were asked to consider the relevance of this for their baseline descriptions. Whilst some possible changes were noted, it was not felt that baseline conditions would be materially altered to such an extent that this would need to be reflected in the subsequent assessments of effects.

Likely Significant Effects

13.6.4 With respect to the vulnerability of the Proposed Development, it is not considered that the project could be affected by climate change to such an extent that the construction and/or operation of the Proposed Development could potentially become unviable. Therefore, no significant adverse effects are predicted.

13.6.5 With respect to 'in-combination climate effects', the assessment considered the projected climate change projections in more detail in relation to landscape and visual amenity (operational phase), cultural heritage (construction phase) flooding and drainage (construction and operational phase), ecology (construction and operational phase) and noise (operational phase). No new significant effects were identified for these topic areas as a consequence of projected climate change.

Mitigation and Enhancement

13.6.6 Whilst a number of mitigation measures will be included to ensure project resilience, effects will remain as outlined above.

13.6.7 No additional mitigation is required in relation to in-combination climate effects. Effects will remain as outlined above.

Cumulative and In-combination Effects

13.6.8 With respect to climate change adaptation, this is a project specific consideration, namely the resilience of the project in question to climate change and the extent to which projected climate change could alter other predicted impact judgements. More widely, in relation to potential interactions with other developments, and following the same logic with respect to required compliance with regulatory standards and accepted good practice mitigation measures, no significant cumulative effects are anticipated.

Conclusion

13.6.9 No significant effects have been predicted in relation to climate change adaptation, either for the Proposed Development in isolation or cumulatively.

13.6.10 **Table 13.20** provides a summary of effects, mitigation and residual effects.

Table 13.20: Summary of Effects, Mitigation and Residual Effects

Receptor/ Receiving Environment	Description of Effect	Nature of Effect	Probability	Conseq-uence	Geographical Importance	Significance of Effects	Mitigation/ Enhancement Measures	Residual Effects
Construction and Decommissioning								
Proposed Development	Extreme weather conditions	Temporary	Unlikely	Medium	Regional	Minor	Mitigation through solar PV module design	Minor **(not significant)**
Proposed Development	High winds/storms	Temporary	Unlikely	High	Regional	Minor	The planting of new and filling in of current hedgerows to filter and slow wind speeds	Minor **(not significant)**
Proposed Development	Employee discomfort	Temporary	Unlikely	Medium	Local	Minor	Health and Safety Training Risk Assessments Staggered working to avoid adverse climatic conditions, where possible	Minor **(not significant)**
Cultural Heritage	Changes in temperature and rainfall patterns can affect above and below ground heritage assets	Permanent	Unlikely	Low	Local to Regional	Negligible	No mitigation measures are considered necessary	Negligible **(not significant)**
Flooding and Drainage	Flood risk, drying out of watercourses, reduced flow rates	Temporary /Permanent	Unlikely	Medium	Local to Borough/ District	Minor	Best practice methods employed to avoid surface water run-off	Minor **(not significant)**

Receptor/ Receiving Environment	Description of Effect	Nature of Effect	Probability	Conseq-uence	Geographical Importance	Significance of Effects	Mitigation/ Enhancement Measures	Residual Effects
Ecology and Ornithology	Modifications of UK flora and fauna over time, with shifts in species' ranges	Permanent	Unlikely	Low	Local, with the exception of the Wash SPA/ Ramsar Site which is of international importance	Negligible	Awareness of invasive species risk	
Operation								
Proposed Development	Extreme weather Conditions	Temporary	Unlikely	Medium	Regional	Minor	Mitigation through solar PV module design	Minor **(not significant)**
Proposed Development	High winds/storms	Temporary	Unlikely	High	Regional	Minor	The planting of new and filling in of current hedgerows to filter and slow wind speeds	Minor **(not significant)**
Proposed Development	Wildfires	Temporary	Unlikely	High	Regional	Minor	Planting of suitably resilient plant and tree species, with reference to updated Natural England Guidance	Minor **(not significant)**
Proposed Development	Employee discomfort	Temporary	Unlikely	Medium	Local	Minor	Health and Safety Training Risk Assessments Staggered working to avoid adverse climatic conditions, where possible	Minor **(not significant)**

Receptor/ Receiving Environment	Description of Effect	Nature of Effect	Probability	Conseq-uence	Geographical Importance	Significance of Effects	Mitigation/ Enhancement Measures	Residual Effects
Landscape and Visual Amenity	Changes in average temperatures, precipitation and extreme weather events will have an effect on the landscape	Permanent	Possible	Low	Borough/ District to Regional	Minor	Use of native species in planting to increase the resilience of vegetation	Minor **(not significant)**
Flooding and Drainage	Flood risk, drying out of watercourses, reduced flow rates	Temporary /Permanent	Unlikely	Medium	Local to Borough/ District	Minor	Design of surface water management infrastructure such that the surface water run-off regime replicates that existing prior to development, implementation of SuDS and the use of elevated floor levels and flood resilient construction measures as required	Minor **(not significant)**
Ecology	Modifications of UK flora and fauna over time, with shifts in species' ranges	Permanent	Possible	Low	Local, with the exception of the Wash SPA/ Ramsar Site which is of international importance	Minor	Various enhancement measures which will improve ecological resilience and connectivity within the site therefore increasing the	Minor **(not significant)**

Receptor/ Receiving Environment	Description of Effect	Nature of Effect	Probability	Conseq-uence	Geographical Importance	Significance of Effects	Mitigation/ Enhancement Measures	Residual Effects
							ability of species to move and adapt	
Noise	Building services equipment that provides cooling will be required to operate at a higher intensity and for longer periods in the future, resulting in increased noise emissions.	Permanent	Possible	Negligible	Local	Negligible	The assessment has been undertaken on the basis of all plant (including cooling) operating at full duty during the night-time and therefore this accounts for future temperature increases.	Negligible **(not significant)**
Cumulative effects not considered further as effects are largely project specific								