15 INTRODUCTION

15.1 Introduction

15.1.1 This Chapter reports the preliminary assessment of the likely significant effects of the Proposed Development on climate and the vulnerability of the Proposed Development to climate change (together, "Climate Change"). The report will consider the likely significant effects of greenhouse gas (GHG) emissions on the global climate and the impacts of climate change on the Proposed Development.

15.1.2 This chapter is presented in two parts to cover the following:

- Part A – Assessment of impacts on climate: An impact assessment that focuses on the potential effects of the Proposed Development (i.e. greenhouse gas emissions (GHG) on the climate through an assessment of whole life carbon). This includes an overview of how the Proposed Development aids in the mitigation of climate change.
- Part B – Assessment of climate resilience: A review of the resilience of the Proposed Development to the potential effects arising from projected changes in future climate. This includes a qualitative discussion of the vulnerability and sensitivity of the Proposed Development to climate change impacts, with an assessment of the magnitude of potential effects.

15.1.3 This Chapter (and its associated figures and appendices) is not intended to be read as a standalone assessment and reference should be made to the whole Environmental Impact Assessment (EIA) Report.

15.1.4 This chapter is intended to inform consultees (both specialist and non-specialist) about the likely environmental effects of the Proposed Development, helping to inform their consultation responses.

15.2 Legislation, policy context and guidance

15.2.1 The following legislation, policy and guidance considered in this chapter is relevant to the assessment of climate change, with further details provided in Appendix 15.1.

National

- The Infrastructure Planning (Environmental Impact Assessment) Regulations (2017)
- The Climate Change Act 2008 (2050 Target Amendment) Order 2019

- The National Development Framework – Future Wales – The National Plan 2040 (2021)
- Planning Policy Wales Edition 11 (2021)
- Net Zero Strategy: Build Back Greener (2021)
- Climate Change Committee: Delivering a reliable decarbonisation power system (2023)
- Powering Up Britian: Net Zero Growth Plan (2023)

Local

- Caerphilly County Borough Council Local Development Plan (2010)

Guidance

15.2.2 The climate change impact assessment is based on the latest EIA guidance published by the Institute of Environmental Management and Assessment (IEMA).

15.2.3 Part A of the assessment primarily follows the 'Environmental Impact Assessment: Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance' (2022). This is the most recent guidance available and is applicable to the UK. It is also considered to be the most holistic method of assessing GHG emissions as it applies a whole lifecycle methodology, incorporating not just the construction and operational phase of development, but also the decommissioning/end of life and beyond asset lifecycle stages. The whole lifecycle methodology allows for a more robust 'worst case scenario' to be applied which is proportionate to the nature and scale of the scheme.

15.2.4 Several guidance publications have been produced containing suggested methods for establishing an GHG emissions baseline and limited advice on techniques for applying significance thresholds. The EIB Project Carbon Footprint Methodologies (2023) guidance is used to expand upon the IEMA guidance to establish the baseline scenarios for the assessment. This goes into greater detail in terms of a baseline methodology and allows for easier comparison of impacts where there is no prior development in an area.

15.2.5 Guidance on the whole life carbon emissions of the BaU alternative baseline, in this case natural gas, is described through the UNECE assessment 'Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources' (2022).

15.2.6 Part B of the climate change assessment applies the IEMA 'Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation' (2020) guidance as this is the most recent available and is applicable to the UK.

15.2.7 The following guidance documents have also been used to inform both parts of the assessment:

- European Commission, 'Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment' (2013);
- Royal Institution of Charted Surveyors (RICS), 'Whole life carbon assessment for the built environment' (2nd Edition, Version 2, 2023); and
- BSI - PAS 2080:2023 'Carbon Management in Buildings and Infrastructure.

15.3 Consultation undertaken to date

15.3.1 As part of the scoping process the opinions of relevant statutory consultees have been sought, with South Wales Fire and Rescue Service providing comment on climate resilience aspects, as per below in Table 15-2.

Table 15-1: Summary of Consultations undertaken to date

Organisation	Summary	How is it addressed in this chapter?
South Wales Fire and Rescue Service	Advise a precautionary approach of positive avoidance of constructing developments in areas that could be affected by flooding from the sea or rivers. Second point relates to the threat of wildfires particularly in populated areas adjoining green spaces. Where the development is in an area at risk of wildfires, consideration should be given on how to mitigate the spread of wildfires. For example, sustainable land management could assist with prevention measures.	As reported in the Flood Consequences Assessment, to reduce the potential increase in flood risk posed by the Proposed Development, it is proposed to manage and disperse surface water runoff within the proposed development with no discharge off site. Sufficient attenuation will be provided within the site for 1 in 100 year storm events including appropriate allowances for climate change.

15.4 Scope of the Assessment

15.4.1 The assessment is intended to assess the greenhouse gas emissions associated with all aspects of the proposed development, o determine the extent to which it can provide benefits in mitigating or avoiding emissions from other sources to reduce future climate change impacts and contribute towards local, national, and global emission reduction targets.

15.4.2 The Proposed Development is a renewable energy project and therefore, provided it is well designed, it should offset (through the displacement of fossil fuel generation) far more emissions over its lifetime than it emits. The time to pay back carbon has been calculated for the Proposed Development as 1.11 years.

15.4.3 The resilience of the Proposed Development to future changes in climate is also assessed using probabilistic climate projections for the region.

Characterisation of Impacts

15.4.4 The categorisation of these assessments in relation to key determining criteria are explained below:

- **Positive or Negative** - The impact overall for this type of development can only be negative due to the release of GHG emissions. However, the purpose of this assessment is to consider the efforts of the Project to minimise the negative impact. Only projects that actively reverse (rather than reducing) the risk of severe climate change can be judged as having a beneficial effect.

- **Extent** - The release of GHGs may occur locally, however, the associated impact i.e., contribution to global warming and climate change, is a global issue.
- **Magnitude** - Whilst any single scheme has an infinitesimal impact on global climate change overall, it is still important to assess the Proposed Development's contribution to local and national targets. Additionally, the assessment considers magnitude in the context of emission reduction compared to baseline scenarios. For the purposes of determining the magnitude of effects of climatic variables on the Proposed Development, a combination of the probability and consequence of likely events are used.
- **Probability** - This takes into account the chance of the climatic effect occurring over the relevant time period (e.g., lifespan) of the development and the likely impact of this if the risk is not mitigated.
- **Consequence** - This reflects the geographical extent of the climatic 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.
- **Duration and Timing** - The duration and timing of a future climatic event will also affect resilience.
- **Frequency** - When assessing the resilience of the Proposed Development to future climate, the frequency of projected events is used to determine the likelihood and consequence of impacts.
- **Reversibility** - Once emitted into the atmosphere, GHGs are circulated and interact with different processes and reactions to create different molecules, with varying lifespans and effects. This process is irreversible. However, it is possible to take actions which can limit the emissions released. It is also possible to sequester certain gases and remove them from the atmosphere, such as through the use of green and blue infrastructure.
- **Likelihood** - Any form of activity or process will result in the release of GHGs to some degree. This includes activity associated with positive climate change action, such as the development of renewable energy or other low carbon technology. The likelihood of future climate risks is determined by the level of probability. This

assessment aims to consider how the inevitable impact of emissions is minimised and reduced, as well as how the resilience to future climate change is increased, in the design and planning of the Proposed Development.

15.4.5 Mitigation has taken a prominent position within EIA, with GHG emissions mitigation considered from the outset and throughout the project's lifetime.

PART A: ASSESSMENT OF IMPACTS ON CLIMATE CHANGE (GREENHOUSE GAS EMISSIONS)

15.5 Part A: Assessment Methodology and Significance Criteria

15.5.1 The climate change impact assessment is based on the latest guidance published by IEMA, EIB, and the UNECE as mentioned in section 15.2.

15.5.2 The scope of the climate change impact assessment is to assess activities associated with the Proposed Development that either directly or indirectly release GHG emissions that contribute to climate change effects, irrespective of their source, and across all relevant project lifecycle stages (whole life carbon emissions).

Extent of Study Area

15.5.3 The assessment considers the GHG emissions associated with the manufacture, construction, operation and maintenance and eventual decommissioning of the Proposed Development. The global climate is the receptor that is affected as GHG emissions are not geographically constrained. This study area differs from others generally listed within an EIA context as it is not at a distinct local scale, but a global one.

15.5.4 A system boundary and a temporal boundary is applied to the assessment to determine the Proposed Development's impact on climate change in relation to the release of GHG emissions associated with the project across the entire lifecycle.

System Boundary

15.5.5 British Standard (BS) EN15978 and the Royal Institution of Chartered Surveyors (RICS) Professional Statement (PS) set out four stages in the life of a typical project, described as lifecycle modules. These lifecycle modules have been simplified in the diagram in **Figure 15.1**, below, but include the following:

- Module A0 – A5 (Pre-construction, product sourcing and construction stage);
- Module B1 – B8 (Use stage);

- Module C1 – C4 (End of life stage); and
- Module D (Benefits and loads beyond the system boundary).

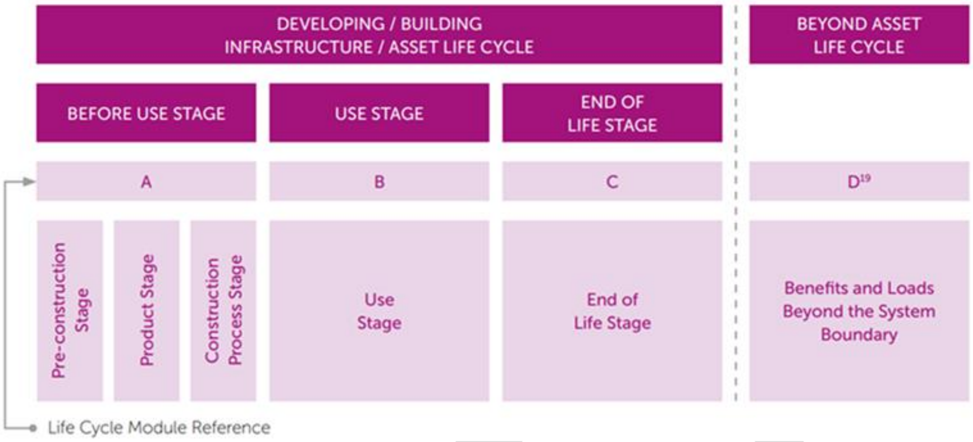

Figure 15.1: Simplified Diagram of Modular Approach of Lifecycle Stages and Modules for EIA GHG Emissions Assessment (Source: IEMA, 2022)

15.5.6 The system boundary applied for this assessment is Cradle-to-Grave and this is proportional to the nature and scale of the Proposed Development. It will cover the entirety of modules A1 (raw material extraction and supply) through to C4 (end of life stage), with the exception of modules A0 (pre-construction stage) and B8 (user activities not covered in B1-B7). Module D is also excluded from the assessment of impacts as justified under 'Effects not considered within the scope' section.

Temporal Boundary

15.5.7 The project will comprise construction, operational and decommissioning phases. Construction will last approximately 6-8months, the operational phase will last 30 years, and decommissioning and restoration is expected to take up to 6 months. This timeframe forms the temporal boundary for the assessment.

Whole Life Carbon Emissions

15.5.8 A sum total of all emissions associated with the project over the entire lifecycle, which includes operational emissions from day-to-day energy use, is provided in order to assess the impacts associated with the Proposed Development over the reference study period. Emission savings achieved from any incorporated low carbon technologies during operation (e.g., renewable energy/heat generation) are taken into consideration. The assessment includes embodied carbon emissions, which consists of:

- Material sourcing;
- Fabrication of components;
- Transportation of materials to/from Site;
- Construction;
- Maintenance, repair and replacement; and
- Demolition, dismantling, and disposal.

15.5.9 The assessment considers the whole life carbon emissions from cradle (raw material extraction and supply) to grave (end of functional life) for the solar and wind farm at Rhymney, Caerphilly, South Wales. The objective of the assessment is to measure the Proposed Development's whole life carbon emissions. The assessment will also demonstrate how the design of the Proposed Development will mitigate the impact it will have on climate change through the release of GHG emissions.

Effects not considered within the Scope

Emissions from land use change

15.5.10 Emissions relating to land use change and any vegetation clearance required during construction of the solar and wind development are assumed to be very low, therefore they have been excluded from the assessment. The approach of excluding these emissions is justified within the 2022 IEMA guidance, where it states that:

15.5.11 "*Activities that do not significantly change the result of the assessment can be excluded where expected emissions are less than 1% of total emissions and where all such exclusions total a maximum of 5% of total emissions; all exclusions should be clearly stated*".

15.5.12 The preliminary results from the soils assessment (Chapter 13) found no peat within the Site and the majority of soils will be retained.

Lifecycle Modules Excluded from Assessment

15.5.13 Lifecycle Module A0 (pre-construction stage) and Module D (benefits and loads beyond the system boundary) and Module B8 are excluded from the assessment of impacts. The purpose of this Whole Life Carbon (WLC) assessment is to consider the potential impacts of the Proposed Development within the context of UK legislation and planning policy, and it is therefore a partial WLC assessment using the RICS (2023) global industry framework as a guide. In this instance, Module A0, Module D and Module B8 are not deemed to be applicable. These have been excluded from the WLC assessment for the purposes of this Climate Change Impact and Risk Assessment.

Setting a baseline methodology

15.5.14 A baseline is a reference point against which the impact of a new project can be compared against (sometimes referred to as 'business as usual' (BaU)), where assumptions are made on current or future GHG emissions. The baseline can take the form of:

A. GHG emissions within the boundary of the GHG quantification[1], but without the proposed project ('Baseline A'); or

B. GHG emissions arising from an alternative project design and/or BaU for a project of this type ('Baseline B').

15.5.15 This assessment considers both forms of baseline represented by points A and B to provide a meaningful comparison of impacts associated with the project. As stated in the IEMA (2022) guidance, the goal of establishing a baseline is assessing and reporting the proposed project's net GHG impact.

Baseline A

15.5.16 In relation to Baseline A, there are limitations in estimating the GHG emissions associated with the current use as reliable data is unavailable. The IEMA guidance (2022) sets out that:

"It may not always be possible to report on current baseline emissions, particularly with projects situated in areas with no physical development or activity. In this instance there would be zero GHG emissions to report at a site level."

15.5.17 As such, in relation to Baseline A, the assessment will assume that the existing site is in equilibrium in relation to GHG emissions and the baseline emissions within the site boundary are zero. The IEMA (2022) guidance goes on to state that:

[1] This is not the same as the boundary of the Site. The boundary for emissions quantification includes both upstream and downstream emissions from manufacturing and electricity transmission, many of which will occur outside of the Site boundary.

15.5.18 *"…alternative baselines can be used to supplement the analysis and address uncertainty… a realistic worst-case baseline should still be used for assigning significance".*

Baseline B

15.5.19 Baseline B forms this alternative and is used for assigning significance as it provides a logical reference point in relation to legislative and policy-based climate commitments. In-line with industry best practice dictated by the IEMA guidance (2022), this baseline will capture all future emissions within the applied system boundary (Cradle-to-Grave).

15.5.20 The EIB (2023) provides further guidance on undertaking sectoral/BaU baseline assessments:

"By definition, emissions prior to developing on a greenfield site are zero. Hence, applying a simple ''before and after'' approach gives rise to a zero baseline. By contrast, the baseline scenario … (i.e. without a project scenario) places no weight on whether a development is greenfield, brownfield or a partial replacement — the key issue is how the projected demand could otherwise have been met, which is not addressed in the "before and after" scenario.

If the project is designed to replace a life-expired asset, a ''before and after'' approach would use previous emissions as the baseline. However, this approach would lack credibility in many cases.

The project baseline scenario (or "without project" scenario) is defined as the expected alternative means to meet the output supplied by the proposed project...

…The baseline scenario must therefore propose the likely alternative to the proposed project which (i) in technical terms can meet required output; and (ii) is credible in terms of economic and regulatory requirements. The choice of baseline should normally be approached in the same way as the expected alternative scenario is determined for the project economic analysis."

15.5.21 The 2023 EIB guidance further states that, first, a baseline scenario should be identified that is able to meet the demands of the Proposed Development in technical terms, for instance the baseline must be able to technically meet the outputs of the Proposed Development. Secondly, that a baseline scenario is credible by meeting the following simplified tests:

Socio-economic test: The baseline scenario should be financially viable with similar financial rates of return to that of the Proposed Development.

Legal requirement test: The baseline emissions alternative scenario could not fail to comply with binding legal requirements.

Life-expired test: The baseline alternative could not assume continuing use of existing assets beyond their economic life.

15.5.22 The 2023 EIB guidance outlines how the Proposed Development will be compared to a standardised development, which will form the baseline BaU scenario for the assessment. The standardised development, on an alternate site, would produce the same deliverables and meet the legislated and policy requirements.

15.5.23 The approach to setting a credible baseline for this assessment is endorsed by a recent Technical Note published by European Bank for Reconstruction and Development (EBRD) in 2019. This Technical Note states that this type of baseline is appropriate since *"it is recognised that 'something' must be done"* and allows for a comparison of relative effect.

15.5.24 This assessment method for setting a baseline is a slightly different approach to other technical disciplines which describe a *'no development scenario'* as the future baseline for the assessment of impacts within the ES Chapters, however, it is still compliant with the requirements of the EIA legislation in the UK.

Estimating Emissions

15.5.25 The assessment is based on a combination of detailed information as supplied by the project design team, as well as UK default values for current industry standards and indicative material specifications for renewable energy products. The general equation for emission estimation is:

GHG emissions = Activity Data x Emission Factor

15.5.26 Activities where expected emissions are less than 1% of the total emissions can be excluded, but only where all exclusions total up to a maximum of 5% of total overall emissions associated with the Proposed Development across all project lifecycle modules within the applied system and temporal boundaries (the whole lifecycle carbon emissions).

15.5.27 Emissions are expressed in terms of tonnes of carbon dioxide equivalent (tCO_2e). This is a universal metric measure used to compare the emissions from various greenhouse gases on the basis of their global warming potential (GWP) by converting amounts of other gases to the equivalent amount of CO_2 with the same GWP.

Relative Emissions

15.5.28 The Proposed Development is assessed for its 'relative emissions' (Re) or net emissions, which is expressed as the difference between 'absolute emissions generated by the Proposed Development' (Ab) and the 'baseline emissions from the BaU scenario' (Be):

Relative Emissions (Re) = Absolute Emissions (Ab) – Baseline Emissions (Be)

15.5.29 The relative emissions are then used a reference point in combination with industry expertise on carbon reduction targets to evaluate the project against the significance criteria defined below.

Significance Criteria

15.5.30 Effects that are deemed to be 'Significant' for the purposes of this assessment are different to those associated with other technical ES chapters.

15.5.31 All sources of GHG emissions will contribute to global climate change. The atmospheric concentration of GHG emissions is defined by IEMA (2022) as being of High sensitivity to further emissions. Therefore, all emissions are considered to have an adverse and permanent impact on climate change in the long-term.

15.5.32 The significance of the impacts associated with the Proposed Development has been assessed in-line with the criteria set out within the 2022 IEMA guidance, as summarised in Table 15-2. Where GHG emissions cannot be avoided, the goal of the EIA process is to reduce the Proposed Development's residual emissions at all lifecycle stages within the applied system boundary.

Table 15-2: Significance Criteria for Assessment of Impacts from GHG Emissions

Criteria	Impact	Significance
The project's GHG impacts are not mitigated or are only compliant with do-minimum standards set through regulation, and do not provide further reductions required by existing local and national policy for projects of this type. A project with major adverse effects is locking in emissions and does not make a meaningful contribution to the UK's trajectory towards net zero.	Major adverse	Significant

Table 15-2: Significance Criteria for Assessment of Impacts from GHG Emissions		
Criteria	**Impact**	**Significance**
The project's GHG impacts are partially mitigated and may partially meet the applicable existing and emerging policy requirements but would not fully contribute to decarbonisation in line with local and national policy goals for projects of this type. A project with moderate adverse effects falls short of fully contributing to the UK's trajectory towards net zero.	Moderate adverse	Significant
The project's GHG impacts would be fully consistent with applicable existing and emerging policy requirements and good practice design standards for projects of this type. A project with minor adverse effects is fully in line with measures necessary to achieve the UK's trajectory towards net zero.	Minor adverse	Not Significant
The project's GHG impacts would be reduced through measures that go well beyond existing and emerging policy and design standards for projects of this type, such that radical decarbonisation or net zero is achieved well before 2050. A project with negligible effects provides GHG performance that is well 'ahead of the curve' for the trajectory towards net zero and has minimal residual emissions.	Negligible	Not Significant
The project's GHG impacts are below zero and it causes a reduction in atmospheric GHG concentration, whether directly or indirectly, compared to the without-project baseline. A project with beneficial effects substantially exceeds net zero requirements with a positive climate impact.	Beneficial	Significant

15.5.33 With consideration to the 2022 IEMA guidance, minor adverse and negligible effects are considered to be Not Significant (see Table 15-2 **and** Figure 15.2). However, impacts are only considered to be minor adverse if the project's GHG impacts are fully consistent with existing and emerging policy requirements and good practice. Impacts are only considered to be negligible if the development goes well beyond existing policy and design standards. It needs to be viewed as well 'ahead of the curve' for the net zero trajectory and have minimal residual emissions. Only projects that actively reverse (rather than only reduce) the risk of severe climate change can be judged as having a beneficial effect.

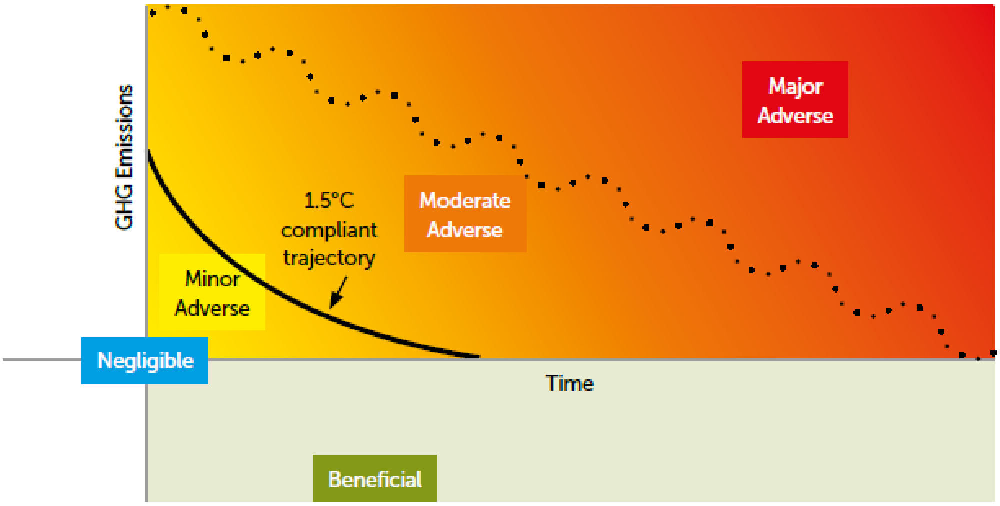

Figure 15.2: Extract from 2022 IEMA showing Significance vs UK Net Zero Trajectory

15.6 Baseline Conditions

Current Baseline Conditions (Baseline A)

15.6.1 The current baseline represents existing GHG emissions from the application site before the proposed project's construction and operation. This is Baseline A as described in 15.5.13.

15.6.2 Prior to development, the site comprises land classified as 'Grade 5 agricultural' land, currently used for farming activities such as grazing. The northwest parcel of land is made up of Grade 4 land. Agricultural land will typically release emissions in the form of methane (CH4) and nitrous oxide (N2O). Sources of emissions include from soils as land is farmed, from farm machinery, and from any livestock on Site. There are limitations to estimating the Site's potential for the soil and existing vegetation to sequester from the atmosphere due to data restrictions.

15.6.3 In the absence of a detailed assessment of the carbon balance of the agricultural system, which is likely to fluctuate dramatically from year to year depending on how much grazing occurs or whether the land is left fallow, a zero emissions baseline will be assumed.

Future (sectoral) Baseline Conditions (Baseline B)

15.6.4 For the purposes of the assessment, the absolute emissions (Ab) are compared to 'a sectoral future baseline' (Be) that has been developed to provide a credible comparison of relative effects, as recommended by the 2023 EIB guidance. The baseline BaU emissions scenario (Be) represents Baseline B. This is different to other Chapters, which describe a 'no development' scenario as the future baseline.

15.6.5 The baseline BaU emissions scenario assumes that the expected energy generation of an alternative development on the site of the proposed solar and wind farm is instead obtained from an alternative energy source, in this case fossil fuels (i.e. natural gas). Annual emissions and whole life carbon emissions have been calculated based on the method explained in 15.5**Error! Reference source not found.**. Lifetime covers project lifecycle stages A1 (raw material extraction and supply) through to C4 (end of functional life).

Natural Gas Generation

15.6.6 In comparing the Proposed Development against a baseline, it is not really feasible to contrast emissions against those associated with grid electricity (unless we are looking at the operational phase in isolation). This is because the published emissions factors for grid electric are derived based on the emissions per kWh of electricity supplied but do not include for the whole lifecycle emissions of all of the generating stock supplying the electricity to the grid. In order to define a suitable baseline for consideration of the whole life cycle emissions of the Proposed Development it makes more sense to compare to an alternative equivalent generating technology. In this instance, a Combine Cycle Gas Turbine (CCGT) using natural gas is used as the comparator as it is the cheapest alternative fossil fuel generation.

15.6.7 The efficiency of CCGT is estimated to be 55% and this represents the most common technology for gas generation in the UK. Generating 1 kWh of electricity will, therefore, require 1.82 kWh of gas to be fed into the turbine. Using the UK Government's GHG Conversion Factors for Company Reporting , a natural gas emission conversion factor of 0.20226 kgCO2e/kWh is used to estimate the emissions (net calorific value (CV)) that are produced by the combustion of gas in the turbine, representing the operational emissions. The whole life carbon emissions are calculated based on the United Nations Economic Commission for Europe (UNECE) assessment to generate benchmark carbon emission figures that are then multiplied by the equivalent energy generation from the Proposed Development.

15.6.8 The UNECE assessment calculates the whole life cycle impact of 1 kWh of natural gas power production (excluding carbon capture and storage) as 0.434 kgCO2e/kWh. It has been assumed that this figure covers lifecycle stages A1 (raw material extraction and supply) through to C4 (end of functional life) and is, therefore, representative of the system boundary applied for this assessment. This figure has been applied to estimate baseline BaU lifetime (whole life carbon emissions) for the reference study period for this assessment.

Future (Sectoral) Baseline Emissions Results

15.6.9 The Proposed Development has been modelled to generate 33,000 MWh per year. The baseline BaU emissions scenario (Be), as calculated based on the energy generation of the natural gas equivalent is indicated in Table 15.3. This will form part of the baseline for the assessment of impacts associated with the Proposed Development (Baseline B).

Table 15.3: Baseline BaU Emissions Scenario

Baseline B: Natural Gas Equivalent				
	No. Years	**Energy Generation (MWh)**	**Operational Emissions (tCO_2e) (Nat Gas Emissions Factor: 0.20226kgCO_2e/kWh)**	**Whole Lifecycle Carbon Emissions (tCO_2e) (Assuming 0.434kgCO_2e/kWh)**
Annual	1	33,000	12,136	-
Lifetime	30	990,000	364,068	429,660

15.6.10 The Baseline B scenario estimates emissions from the most likely alternative form of generation (natural gas) based on published studies, and includes the whole life carbon emissions associated with this technology. It has been derived from real - life experience recorded from actual generators. However, WLC figures are presented as average figures per unit energy generation, resulting in the implications set out below.

15.6.11 Figures per unit energy are most appropriate for a Combined Cycle Gas Turbine (CCGT), where the whole lifecycle emissions are heavily related to the operational phase and the combustion of fuel on a per hour basis. In such a case, the longer the gas turbine is operating, the higher its WLC emissions will be and emissions will increase with every MWh of generation.

15.6.12 However, for renewable energy technology, most of the emissions are embodied in its initial raw materials and construction processes. Only net carbon savings arise from the operational phase, and each MWh of electricity generated results in slightly lower lifecycle emissions. In this case, emissions are based on the installed capacity of the generator (i.e. per MW installed or per MWp) will be more appropriate and this figure is used in preference (where such an emission factor is available). Here, the longer the renewable generator is in place, the better. Such a figure has been used for the solar generation. It is noted as a limitation that, whilst a similar figure may be preferred for wind as well, the WLC emissions factor for wind is found to be expressed per MWh.

15.7 Assessment of Effects

Design Solutions and Assumptions

15.7.1 The assessment considers the operational CO_2e emissions over the 30-year operational lifetime period, including the embodied emissions. It has been assumed that energy generated will remain approximately the same, year on year, throughout the assessment period, ignoring the effect of any potential panel degradation or variation in the wind regime or insolation levels. The assessment has used an emissions calculation based on installed capacity of the solar panels, rather than the amount of energy per year that they generate. This is due to the vast majority of the lifecycle emissions for PV come from the 'before use' stage, in the manufacture and production of the panels.

15.7.2 For wind generation, as a reliable WLC emissions factor per MW installed has not been identified, a figure per MWh has been used as the best available alternative, but this represents a limitation in the assessment methodology. As a result, whole lifecycle emissions will appear to increase with a longer project lifetime rather than decreasing as would logically be the case with more fossil fuel generation being offset.

15.7.3 This comparison between the natural gas energy generation scenarios (Baseline B), that are the equivalent of the energy generated by the solar and wind farm, allows for the calculation of the emission saving potential of the solar array and wind turbines

15.7.4 It is acknowledged that approximately 4,000 MWh per year of generation from the solar and wind farm will be used directly at the Convatec manufacturing plant in Rhymney. A further 4,000 MWh per year of heat is used at the manufacturing site, which can also be met by the generated electricity. The use of locally generated renewable power at the Convatec manufacturing site will displace current fossil fuel heat and power, decarbonising operations, avoiding transmission and distribution losses, helping provide security of supply and insulating against price volatility, all of which provides operational security and future-proofing to the business and the jobs that it provides.

Embedded Mitigation

15.7.5 It is assumed that, as part of the embedded mitigation, a number of decisions will be incorporated into the design, construction operation and decommissioning of the Proposed Development. These may include:

- Consideration of embodied carbon during the procurement process;
- Minimisation of material use and avoidance of waste generation;
- Optimisation of transportation and construction efficiency and minimisation of fuel use;
- Reuse of materials onsite and recycling of waste materials;
- Landscape enhancement, planting and biodiversity net gain;
- Preferential use of low carbon site maintenance options, where possible/practicable;
- Reuse/recycling of applicable materials following decommissioning.

Absolute Emissions and Emissions Compared to Baseline B

15.7.6 The absolute emissions (Ab) of the Proposed Development will be zero or minor because it is assumed that the renewable energy "*will displace (at least in part) fossil fuels*" that are used to create grid electricity generation. Table 15.4 states the absolute emissions based on the energy generation of the solar PV farm. Table 15.5 states the absolute emissions based on the energy generation of the wind turbines. These two generators combined form the Ab which is stated in Table 15.6. This is based on a capacity of 5 MW for the solar farm.

15.7.7 It is relevant to note that the operational emissions are listed as zero since there are no emissions associated with the actual generation. There will be a small volume of emissions associated with routine maintenance and cleaning, but these have been assumed to be negligible for the purpose of the assessment.

Table 15.4: Absolute Emissions Scenario Solar PV
Ground Mount Solar PV

	No. Years	Energy Generation (MWh)	Operational Emissions (tCO_2e) Solar PV Emissions Factor: $0kgCO_2e/kWh$	Whole Lifecycle Carbon Emissions (tCO_2e) (Assuming $615kgCO_2e/kWp$)
Annual	1	5,000	0	-
Lifetime	30	150,000	0	3,075

Table 15.5: Absolute Emissions Scenario Wind Turbines

Wind Turbines				
	No. Years	Energy Generation (MWh)	Operation Emissions (tCO_2e) Onshore Wind Emissions Factor: $0kgCO_2e/kWh$	Whole Lifecycle Carbon Emissions (tCO_2e) Assuming $0.0124kg\ CO_2e/kWh$
Annual	1	28,000	0	-
Lifetime	30	840,000	0	10,416

Table 15.6: Absolute Emissions Scenario Solar Farm and Wind Turbines

Solar farm and Wind Turbines				
	No. Years	Energy Generation (MWh)	Operational Emissions (tCO_2e) total Emissions Factor: $0kgCO_2e/kWh$	Whole Lifecycle Carbon Emissions (tCO_2e) total
Annual	1	33,000	0	-
Lifetime	30	990,000	0	13,491

Impacts during Construction Phase

15.7.8 The construction phase spans the project lifecycle modules A1 through to A5. This includes the embodied carbon contained within the materials and components that form the solar array and wind turbines, from extraction of the raw material [A1] through to manufacturing of the end products [A2-A3], as well as transportation of materials to the Site [A4] and the construction and installation process [A5].

15.7.9 Embodied carbon emissions of a wind and solar farm development are emissions arising from upstream processes that include:

- Raw material extraction;
- Materials production;
- Turbine and module manufacture;
- System/plant component manufacture; and
- Installation and plant construction.

15.7.10 The embodied carbon of wind turbines, solar PV modules and infrastructure can vary considerably as it is dependent on various factors, such as country of manufacture and source of energy to extract and produce the materials.

15.7.11 Research published by Etude in 2021[2], based on the work by Louwen *et al.* (2016) and Pehl *et al.* (2017), found that embodied carbon of solar was around 615 $kgCO_2e/kWp$ of installed capacity. Kilowatt peak (kWp) is a unit of measurement that represents the maximum power output of a PV system under standardised test conditions.

15.7.12 The UNECE report provides a figure for the lifecycle GHG emissions of 0.0124kg CO_2e/kWh for onshore wind power production. The majority of the embodied carbon from onshore wind farms are from the foundation, tower, generator, hub and blades.

15.7.13 Using the 615kg/kWp embodied carbon figure for solar and the 0.0124kg/kWh for wind, the assumed total embodied carbon for the solar array and wind turbines is 13,491 tCO_2e as stated in Table 15.7. Based on the annual operational emission savings provided in Table 15.7, it will take approximately 1.11 years to pay back the embodied carbon of the Proposed Development.

Table 15.7: Estimated Embodied Carbon for the Proposed Development	
Solar Embodied carbon per unit (tCO_2e/kWp)	0.615
Solar Installed capacity (kWp)	5,000
Wind embodied carbon per unit (tCO_2e/MWh)	0.0124
Wind energy generation (MWh)	840,000
Sequestered carbon (tCO_2)	0
Total embodied carbon (tCO_2e)	**13,491**
Years to pay back carbon	**1.11**

15.7.14 As stated in the 2022 IEMA guidance "*GHG emissions have a combined environmental effect that is approaching a scientifically defined environmental limit ; as such any GHG emissions or reductions from a project might be considered to be significant*". It is, therefore, determined that all unmitigated construction emissions are individually adverse and Significant.

[2] Etude (2021). '*The (low) embodied carbon of solar PV*' [Online Article]. Available at: https://etude.co.uk/how-we-work/low-embodied-carbon-of-pv/ [Accessed 31 January 2024].

15.7.15 As efficiencies in the production of solar arrays are beginning to be realised, it is possible for the embodied carbon impacts to be further reduced. Etude (2021) propose that 20-34gCO_2/kWh is a reasonable range for embodied carbon within solar arrays at this time. The UNECE report states under European Union (EU) conditions, solar PV technologies shows lifecycle GHG emissions of about 37gCO_2e/kWh for ground and roof-mounted systems.

15.7.16 Although based on real life averages, attempting to forecast embodied carbon as a function of total energy generated means that figures are completely dependent on the lifetime of the solar farm, with the longer the solar farm lifetime, the higher the predicted embodied carbon. This cannot be correct as it would suggest a more long-lived solar farm has higher levels of embodied carbon. Since an estimated 99% of the embodied emissions for solar PV relate to the manufacturing process, the project lifetime is largely an independent variable. For this reason, the 615kg/kWp embodied carbon figure is used in this assessment to present a 'worst-case' scenario of impacts associated with the Proposed Development across all relevant project lifecycles.

15.7.17 Emissions released in the short-term during the construction phase will have a minor adverse impact on climate change that is not significant.

Impacts during Operational Phase

15.7.18 The operational phase spans the project lifecycle modules B1 (Use) through to B7 (operational water use) and includes the operational energy use [B6].

15.7.19 In relation to the operational water use [lifecycle module B7], there are currently few studies that have investigated the water use of solar PV electricity, which may be due to the low water demand of PV systems during operation. A recent study by the International Energy Agency (IEA)[3] assessed the water consumption and water withdrawal of electricity generated by PV systems by considering all life cycle stages for the manufacture of monocrystalline silicon (mono-Si) and cadmium telluride (CdTe) PV modules, and by taking account of country-level regional differences in water availability.

[3] P. Stolz, R. Frischknecht, G. Heath, K. Komoto, J. Macknick, P. Sinha, A. Wade, (2017), '*Water Footprint of European Rooftop Photovoltaic Electricity based on Regionalised Life Cycle Inventories*.' IEA PVPS Task 12, International Energy Agency (IEA) Power Systems Programme, Report IEA-PVPS T12-11:2017.

15.7.20 This research found that: "…*The water consumption of electricity generated by mono-Si and CdTe PV systems amounts to 1.5 and 0.25 L/kWh, respectively. …The electricity demand in the production of mono-Si and CdTe PV modules is an important driver of the total water stress impact. …The water stress impact of process or cooling water used directly in the manufacture of PV modules amounts to 16 % for the mono-Si and 3 % for the CdTe technology, whereas the input materials contribute 2 % and 20 % to the water stress impact, respectively. Water consumption during operation of the European rooftop mono-Si and CdTe PV systems is negligible (<1 %)*."

15.7.21 In-line with the EIB (2023) methodology, the absolute operational emissions of the development will be "*zero or minor absolute emissions except for hydropower with large reservoir storage*". This is in relation to the operational energy use [lifecycle module B6]. Solar power, through the production of low carbon electricity, reduces the exploitation of fossil fuel (coal and natural gas) by generating electricity from a renewable source. This development offsets the emissions associated with non-renewable methods of electricity generation and, therefore, mitigates the impact of climate change.

15.7.22 There will be no emissions associated with energy generation once the wind and solar farm are operational. Emissions released in the long-term during the operation phase from repair and maintenance activities are considered to have a negligible impact on climate change which is not significant.

Impacts during Decommissioning Phase

15.7.23 Emissions associated with decommissioning will largely be the equivalent to emissions associated with the construction phase, with broadly similar activities involved in removing the components from Site as required to install them. It is not possible to accurately predict the technological advancements that may occur before the decommissioning phase takes place; there could well be considerable decarbonisation of vehicles and processes before that time.

15.7.24 A level of significance has not been determined for the emissions released in the short-term during the decommissioning phase, however, these are expected to be approximately equivalent to the construction phase emissions which would have a minor adverse impact.

Relative Emissions

15.7.25 Compared to the natural gas baseline scenario, the relative emissions associated with the Proposed Development are negative, showing a net reduction in whole life carbon emissions. These negative emissions have been determined to have a beneficial impact on climate change in the long term.

15.7.26 The emissions savings from using solar PV and wind, instead of using natural gas over the lifetime of the project total approximately 416,169 tCO_2e, as shown in Table 15.8. This positive impact, derived from the negative Relative Emissions, demonstrates the substantial lifetime emission savings associated with energy generated from the Proposed Development, compared to the equivalent amount of electricity supplied from natural gas.

Table 15.8: Total emission savings of the Proposed Development compared to natural gas equivalent

Baseline Emissions (tCO_2e)	429,660
Absolute Emissions (tCO_2e)	13,491
Relative Emissions (tCO_2e)	**-416,169**
Total Emission Savings (tCO_2e)	**416,169**

15.8 Mitigation and Monitoring

15.8.1 Electricity production in the UK is a significant source of the UK's carbon emissions based on our current mix of technologies generating electricity at the utility scale. This development offsets the emissions associated with non-renewable methods of electricity generation and, therefore, mitigates the impact of climate change.

15.8.2 Emissions associated with the routine and periodic maintenance of the PV panels, turbines, electrical infrastructure and general site upkeep will be limited but should still be minimised where practical to do so.

15.8.3 No additional mitigation measures proposed at this stage.

15.9 Residual Effects

15.9.1 Residual effects are those effects of the Proposed Development that remain after any identified mitigation measures have been implemented.

Construction Phase

15.9.2 The Proposed Development will result in the short-term release of GHG emissions during construction (including embodied emissions), which has a long-term and permanent adverse effect contributing to global warming and climate change. The residual effects during construction are as assessed in Table 15.6, are quantified as the release of 13,491 tCO_2e during the construction phase of the Proposed Development. This is considered to be a moderate adverse effect that is significant.

Operational Phase

15.9.3 An emission saving of 416,169 tCO_2e is predicted, when the renewable electricity generation is compared with a natural gas equivalent, which is considered to be a beneficial effect that is significant, as shown in Table 15.8.

Decommissioning Phase

15.9.4 As with the construction phase, barring any leaps in technology prior to decommissioning, the Proposed Development will result in the short-term release of GHG emissions which have a long-term and permanent adverse effect. This is considered to be a moderate adverse effect that is significant.

Overall Project

15.9.5 The Relative Emissions associated with the overall project are assessed to be -416,169tCO_2e compared to the generation being supplied by gas turbine, which is undoubtedly a beneficial result in terms of reducing the risk of climate change.

15.9.6 Notwithstanding this, the guidance set out by IEMA suggests that for a project to be considered beneficial in climate terms, it must not only reduce emissions but actively reverse them, as per Figure 15.2. On this basis, overall, the Proposed Development is considered to have a negligible, not significant impact on climate change in that it exceeds the requirements of the UK net zero trajectory but does not contribute to carbon reduction in all development phases. The IEMA guidance recognises this as a high bar and that the project will help to ensure the UK remains on track to achieve net zero by 2050 and avoid the worst effects of climate change.

15.10 Assessment of Cumulative Effects

15.10.1 It is considered that there is potential for inter-cumulative Climate Change effects during the construction and operational phases of the Proposed Development, but a review of the other developments identified have been scoped out for the reasons as explained below.

Intra-Cumulative Effects

15.10.2 Intra-cumulative effects (i.e. climate change effects in combination with other environmental effects on a common receptor) are also unrealistic to appraise. Climate change effects manifest as effects considered within other environmental disciplines, but do not have a quantifiable direct effect on local receptors. The effects act on a global receptor, but the individual contribution from a single development of this scale is almost indistinguishable. It is the cumulative effects from all the combined development going on around the world that poses the potential catastrophic threat.

Inter-Cumulative Effects

15.10.3 In terms of climate change, which is a global issue, comprehensive consideration of inter-cumulative effects (i.e. effects of this Proposed Development in combination with other developments) would need to account for every other development and activity that generates carbon emissions or releases other greenhouse gas effects. As this encompasses, to varying degrees, most of the activity on the globe, it is not practical to consider inter-cumulative effects beyond recognising that it is necessary for each development to reduce carbon emissions as well as having a duty to minimise its own emissions as far as technically viable.

15.10.4 It is unreasonable for the purposes of a planning application to quantify all sources of emissions from other third-party developments for the following reasons:

- Large technical data requirements from other developments are not accessible;
- It would require a huge interlinking scope of assessment that would exceed that expected of a planning application for any one development;
- It is not feasible to undertake a high-level chemical assessment to analyse likely synergistic impacts between different emissions from varying developments; and
- Complicated, unpredictable chemical reactions driven by atmospheric, climatic and behavioural factors are beyond the Applicant’s control.

PART B: ASSESSMENT OF CLIMATE CHANGE RESILIENCE

15.11 Part B: Assessment Methodology and Significance Criteria

Extent of a Study Area

15.11.1 The impact of climate change on the proposed development is assessed based on global climate projections and regional climate projections for a 25 km grid surrounding the application site. The Proposed Development will also be affected by future changes to the climate.

Scope of the Assessment

15.11.2 The assessment methodology for Part B follows the guidance set out by IEMA, and the European Commission, as mentioned in section 15.2.

Climate Scenarios and Timelines Considered

15.11.3 Climate change projections for the UK (UKCP18) are based on global climate simulation models to explore regional responses to climate change. UKCP18 considers the effects arising from a series of emissions scenarios and Representative Concentration Pathways (RCP), which project how future climatic conditions in the UK are likely to change at a regional level, taking account of naturally occurring climate variations. The RCPs show how the climate could change up to the year 2100, compared to a 1981-2000 baseline. The RCPs are probabilistic projections and provide a range of possible climate change outcomes and their relative likelihoods (ranging from the 10th to 90th percentiles).

15.11.4 The Proposed Development was assessed against a high (RCP 8.5) emissions scenario to allow for comparisons between best and worst-case across the 30-year reference period, which encompasses the construction, operational and decommissioning periods.

15.11.5 It is anticipated that the Proposed Development would be constructed between 2024 and 2025 and decommissioned in the 2050s. The UKCP18 climate projections for the 2030s (2024-2039) and 2050s (2040-2059) time periods have been selected to correspond with the proposed timescales for the Proposed Development's construction, operational and demolition phases.

15.11.6 The conservative approach recommended as best practice by the 2020 IEMA guidance is to use the central estimate (50th percentile) for the high emissions scenario (RCP8.5) to establish the likely worst-case changes to climatic conditions.

Future Climate Baseline

15.11.7 This assessment considers the regional variations in Rhymney, Caerphilly, South Wales during the periods identified above. A reference range is provided in each case, using the 10% probability level as a lower limit and the 90% probability level as an upper limit. These scenarios and probability levels were used to provide credible projected changes including an indicative level of uncertainty.

15.11.8 A summary of a range of projected changes to climate variables will be provided, which can be used to build up a holistic view of future climate and assess potential impacts. According to UKCP18, relative probabilities for specific outcomes are typically much higher near the 50% cumulative probability level (median) of the distribution, than for outcomes lying either below the 10% cumulative probability level or above the 90% cumulative probability level.

Climate Vulnerability and Sensitivity of Receptors

15.11.9 The resilience of the Proposed Development to climate change is assessed based on the susceptibility and vulnerability of a range on different receptors. Potential receptors within elements of the project relevant to the location, nature and scale of the Proposed Development have been identified and receptor groups include:

- buildings and infrastructure receptors (including equipment and building operations);
- human health receptors (e.g. construction workers, site users, occupants);
- environmental receptors (e.g. habitats and species); and
- climatic systems.

15.11.10 The IEMA guidance (2020) describes the sensitivity of the receptor/receiving environment as "*the degree of response of a receiver to a change and a function of its capacity to accommodate and recover from a change if it is affected*." Therefore, in line with the IEMA guidance, the following factors have been considered to ascribe the sensitivity of receptors in relation to potential climate change effects:

- value or importance of receptor;
- susceptibility of the receptor (e.g. ability to be affected by a change); and
- vulnerability of the receptor (e.g. potential exposure to a change).

15.11.11 The susceptibility and vulnerability of the receptor is determined using the scales detailed in Table 15.9 and Table 15.10.

Table 15.9: Measure of receptor susceptibility to climatic impact

Scale	Susceptibility
Low	Receptor has the ability to withstand or not be altered much by the projected changes to the existing/prevailing climatic factors.
Medium	Receptor has some limited ability to withstand or not be altered by the projected changes to the existing/prevailing climatic conditions.
High	Receptor has no ability to withstand or not be substantially altered by the projected changes to the existing/prevailing climatic factors.

Table 15.10: Measure of receptor vulnerability to climatic impact

Scale	Vulnerability
Low	Climatic factors have little influence on the receptors.
Medium	Receptor is dependent on some climatic factors but able to tolerate a range of conditions.
High	Receptor is directly dependent on existing/prevailing climatic factors and reliant on these specific existing climate conditions continuing in future or only able to tolerate a very limited variation in climate conditions.

Magnitude of effects

15.11.12 The magnitude assigned to the impact considers control mechanisms that may already be in place (e.g. due to legislation and commonly occurring standards), which would reduce the probability or the consequence of the impact and, therefore, the overall level of effect.

15.11.13 In line with the IEMA guidance (2020), a combination of probability and consequence is used to reach a reasoned conclusion on the magnitude of the effects of climate change on the Proposed Development. The IEMA guidance states that magnitude is based on a combination of:

- probability, which takes into account the chance of the effect occurring over the lifespan of the development if the risk is not mitigated; and
- consequence, which reflects the geographical extent of the effects 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.

15.11.14 Definitions of likelihood and magnitude will vary between schemes and are tailored to the specific project. Project lifetime is considered to include demolition/construction and operational stages and a 'reference period' of 30 years has been taken for this assessment of climate risk.

15.11.15 A likelihood category is detailed in Table 15.11 which is based on the probability of the regional climate impact identified using the future climate baseline.

Table 15.11: Definitions of the likelihood of the climate impact effecting the receptors.

Likelihood Category	Description (Probability and Frequency of Occurrence)
Very High	The event occurs multiple times during the lifetime of the project (assumed 30 years), e.g. approximately annually, typically 30 events.
High	The event occurs several times during the lifetime of the project (30 years), e.g. approximately once every five years, typically 6 events.
Medium	The event occurs limited times during the lifetime of the project (30 years), e.g. approximately once every 15 years, typically 2 events.
Low	The event occurs during the lifetime of the project (30 years), e.g. once in 30 years.
Very Low	The event may occur once during the lifetime of the project (30 years).

15.11.16 From this the consequence of impact is determined as indicated in Table 15.12.

Table 15.12: Consequence of climatic impact and the description of varying consequence of impact on the receptor.

Consequence of Impact	Description of Impact
Extreme Adverse	National-level (or greater) disruption lasting more than 1 week.
Major Adverse	National-level disruption lasting more than 1 day but less than 1 week. Or Regional-level disruption lasting more than 1 week.
Moderate Adverse	Regional-level disruption lasting more than 1 day but less than 1 week.
Minor Adverse	Regional-level disruption lasting less than 1 day.
Negligible	Isolated disruption to the immediate locality lasting less than 1 day.

Significance Criteria

15.11.17 The IEMA (2020) guidance indicates that the greater the probability of a climatic effect, the more likely it is to occur, meaning that the consequence of impacts is likely to be high, and the magnitude of the effect(s) on the Proposed Development will be greater if these projected changes in climate are not considered at the outset of the project.

15.11.18 The magnitude of effects of climate change impacts on the Proposed Development is determined using the Significance Matrix for Assessing Climate Resilience (**Error! Reference source not found.**), and then an associated level of significance is applied for the Proposed Development as also indicated in Table 15.13, below.

Table 15.13: Significance Matrix for Assessing Climate Resilience.

Climate Resilience Significance Matrix		**Measure of Likelihood**				
		Very Low	**Low**	**Medium**	**High**	**Very High**
Measure of Consequence (Impact)	**Negligible**	Negligible (Not Significant)	Negligible (Not Significant)	Negligible (Not Significant)	Minor Adverse (Not Significant)	Minor Adverse (Not Significant)
	Minor	Negligible (Not Significant)	Minor Adverse (Not Significant)	Minor Adverse (Not Significant)	Moderate Adverse (Significant)	Moderate Adverse (Significant)
	Moderate	Minor (Adverse Not Significant)	Minor Adverse (Not Significant)	Moderate Adverse (Significant)	Moderate Adverse (Significant)	Moderate Adverse (Significant)
	Major	Minor Adverse (Not Significant)	Moderate Adverse (Significant)	Moderate Adverse (Significant)	Major Adverse (Significant)	Major Adverse (Significant)
	Extreme	Minor-Moderate Adverse (Not Significant)	Moderate Adverse (Significant)	Moderate-Major Adverse (Significant)	Major Adverse (Significant)	Major Adverse (Significant)

Assumptions and Limitations

15.11.19 Using data provided by UKCP18, the RCP8.5 scenario is modelled and changes to such climate factors as temperature and precipitation are projected and assumed to occur until the end of the century.

15.11.20 The 2020 IEMA guidance explains how the climate is changing, but there remain uncertainties in the magnitude, frequency and spatial occurrence, either as changes to average conditions or extreme conditions, which generally makes it difficult to assess the impacts of climate change in relation to a specific project. Therefore, scientific assumptions must be made to assess the resilience of new developments to any future changes in climate.

15.11.21 Whilst the Applicant can implement measures to reduce the impacts and increase climate resilience according to global and regional climate projections with relevance to the scale of the Proposed Development, uncertainties associated with probabilistic climate projections are outside of the Applicant's control and cannot be fully mitigated against.

15.11.22 This assessment relies on data provided by third parties with other technical disciplines providing information regarding the embedded mitigation to determine the development's resilience to climate change. Therefore, WA accepts no responsibility for inaccuracies carried forward from third party information.

15.11.23 Currently only climate projections are available to help understand the likely future weather conditions, and these follow a range of different scenarios. A current 'worst-case' scenario has been adopted for this assessment. This will be especially important in the event that there is any deviation from the projected patterns or increased volatility in the system that risks compromising the Proposed Development's climate resilience.

15.12 Baseline conditions

Existing baseline conditions

15.12.1 Wales is classified under Köppen Geiger as having a 'Cfb' climate, more commonly known as a 'temperate oceanic climate'. These are typically mid-latitude climates with warm summers and mild winters. In Wales, the average temperature in all months has been below 16.2°C and there is not an identifiable dry / wet season (i.e. precipitation rates are similar year-round). The mean average annual temperature in Wales is approximately 9.6°C[4]. Within the country, significant variations in temperature arise from the combined effects of proximity to the coast, topography and, to a lesser extent, urban development. The Proposed Development is within Rhymney, South Wales, where the average annual rainfall in Rhymney is around 1143mm and the average annual mean temperature is 8.5°C[5].

[4] Climate Data (2024) *Wales.* Available from: https://en.climate-data.org/europe/united-kingdom/england/wales-176888/ [Accessed 23 January 2024].
[5] Climate Data (2024) *Rhymney.* Available from: https://en.climate-data.org/search/?q=rhymney [Accessed 23 January 2024].

Future baseline

Global climate change projections

15.12.2 Global probabilistic projections provide a wider sampling of uncertainty and are useful for considering the wider context of future changes in climate. **Table 15.14** highlights the main projected global climate change issues.

Table 15.14: Projected Global Impacts of Climate Change

Climate Change Issue	Projected Global Impacts
Solar Radiation	Long-term projected changes in surface solar radiation, because of global warming, would suggest a decrease in available solar power due to a decrease in downwelling shortwave radiation, likely linked to the increase of water vapour and hence cloud presence. Anthropogenic strengthening of 'natural' decadal variability in irradiance, known as global dimming and brightening, is influenced by synoptic weather patterns, cloud variations and atmospheric aerosols.
Increased Global Mean Surface Temperature (GMST)	As stated within Intergovernmental Panel on Climate Change (IPCC) Special Report[6], *"The increase GMST, which reached 0.87°C in 2006–2015 relative to 1850–1900, has increased the frequency and magnitude of impacts".* This strengthens the evidence of how a 1.5°C increase or more, in GMST, could impact natural and human systems.
Heat Waves	The IPCC predict that temperature extremes will increase more rapidly than global mean surface temperature, with the number of hot days projected to increase in most land regions. In the 1.5°C warming scenario heat waves in mid latitudes could warm by up to 3°C.
Extreme Rainfall and Flooding	IPCC and Met Office both suggest a general uncertainty in the projection of changes in heavy precipitation for the UK due to position in the transition zone between north and south Europe's contrasting projected changes. It is generally agreed that Northern Europe is one of the regions that will experience the largest increase in heavy precipitation events for 1.5°C to 2°C warming. Overall, the UK is expected to see a general increase in precipitation trends up to the year 2100. With slightly wetter winters and drier summers expected to occur annually during the project lifetime.
Storms and Winds	Atmospheric circulations have large variability across interannual through to decadal time scales, which makes forming projections with any reasonable confidence very difficult. There is more robust evidence in the Northern Hemisphere that, since the 1970s, there has been a general poleward shift of storm tracks and jet streams and near-surface terrestrial wind speeds have been declining by approximately 0.1-0.14 ms^{-1} per decade across land. Despite anemometers being used for decades to measure near surface wind speed, the data has rarely been used to analyse trends and lacks important instrumentation meta data. In general, confidence is low in wind speed projections due to large uncertainties across global data sets.

[6] Intergovernmental Panel on Climate Change (IPCC). 2018. *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

Table 15.14: Projected Global Impacts of Climate Change	
Climate Change Issue	**Projected Global Impacts**
Cold Spells and Snow	It has been observed the spring snow cover has been continuing to decrease in extent in the Northern Hemisphere and that cold temperature extremes are projected to decrease along with the number of frost days.

Regional climate change projections

15.12.3 Climate change projections for the UK (UKCP18) are based on global climate simulation models to explore regional responses to climate change. UKCP18 considers the effects arising from a series of emissions scenarios and RCPs, which project how future climatic conditions in the UK are likely to change at a regional level, taking account of naturally occurring climate variations. Probabilistic projections provide a range of possible climate change outcomes and their relative likelihoods (ranging across 10th to 90th percentiles).

15.12.4 The UKCP18 dataset provides future climate change projections for land and marine regions, as well as observed climate data for the UK. Analysing time series plume data from UKCP18 provides an indication of climate projections for the regional 25km grid that encompasses the Site.

15.12.5 The following graphs are based on the four RCPs and show how the climate at Rhymney could change up to the year 2100, compared to a 1981-2000 baseline. The RCPs are used to analyse how different emission scenarios could affect climate projections. These range from RCP2.6 where atmospheric emission concentrations are strongly reduced through to the worst-case scenario, RCP8.5, where emission concentrations continue to rise unmitigated.

15.12.6 **Error! Reference source not found.** and **Error! Reference source not found.** show that the temperature is set to rise in summer and winter, even in a best-case scenario (RCP2.6), until the end of the century. Over the 30-year reference time period, the average temperature rise (**Error! Reference source not found.**) could be between 1.68°C (RCP2.6) and 2.47°C (RCP8.5) in the summer; and 0.95°C (RCP2.6) and 1.62°C (RCP8.5) in the winter. By 2054, maximum temperatures (**Error! Reference source not found.**) could increase between 1.93°C (RCP2.6) and 2.78°C (RCP8.5) in the summer; and 0.93°C (RCP2.6) and 1.60°C (RCP8.5) in the winter.

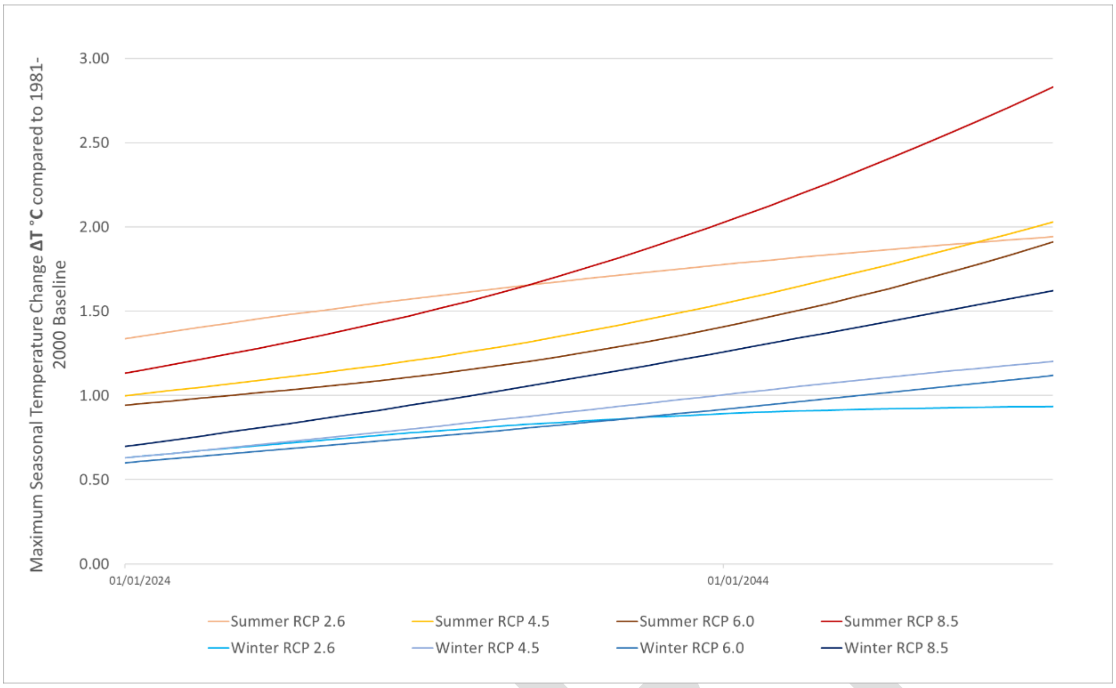

Figure 15.3: Projected changes in seasonal Maximum Air Temperature across four RCP scenarios, from 2024-2054 compared to the 1981-2000 baseline, using the probabilistic projections (50th percentile) for a 25km grid around Rhymney.

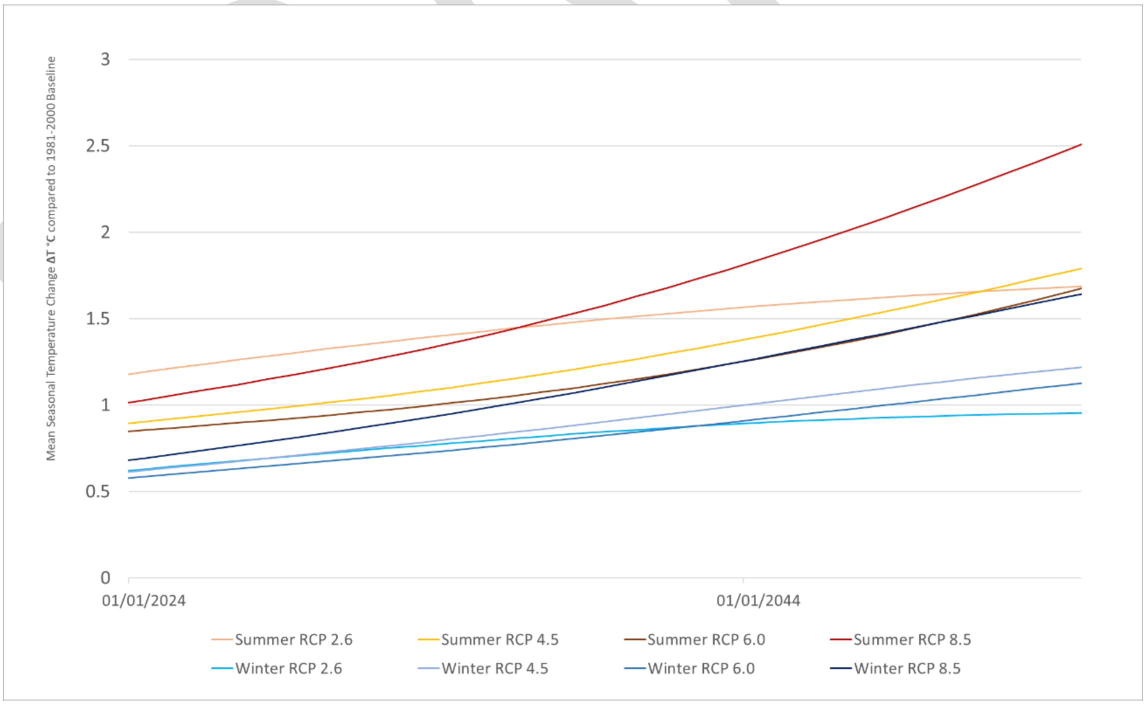

Figure 15.4: Projected changes in seasonal Mean Air Temperature across four RCP scenarios, from 2024-2054 compared to the 1981-2000 baseline, using the probabilistic projections (50th percentile) for a 25km grid around Rhymney.

15.12.7 **Error! Reference source not found.**, below, shows that summer precipitation rates are reducing over the 30-year reference time period, from between -21.70 mm (RCP2.6) to -26.23 mm (RCP8.5). Climate projections suggest that winter precipitation rates will increase from between 7.29mm (RCP2.6) to 11.23mm (RCP8.5) by 2054.

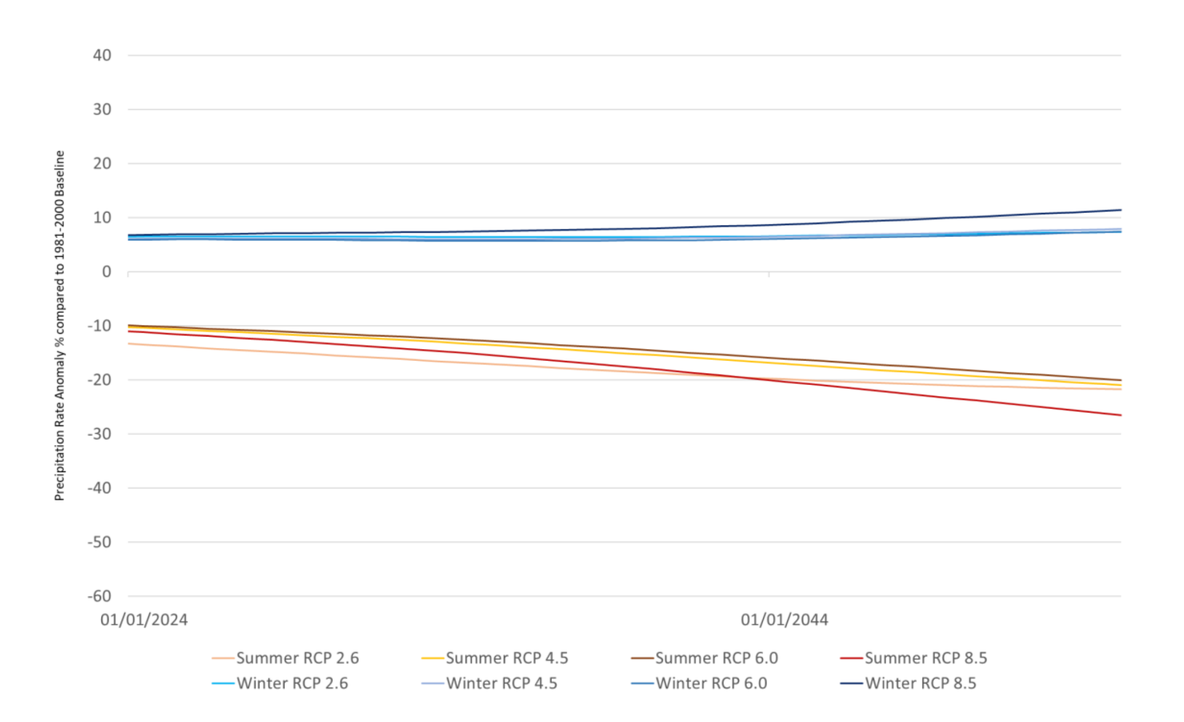

Figure 15.5: Seasonal average Precipitation rate anomaly (%) for 2024-2054 compared to the 1981-2000 baseline for all RCP scenarios using probabilistic (50th percentile) for a 25km grid around Rhymney.

Future climate baseline

15.12.8 A summary of climate projections for climate variable under RCP 8.5 for the 2030s and 2050s time periods is provided in **Table 15.15**. This can be used to build-up a holistic view of the future climate and assess potential impacts to determine a future climate baseline.

Table 15.15: Quantitative summary of the future baseline for key climatic variables at the Site.			
Season	**Variable**	**Time Period**	**Projected change at various probabilities**
			Median
			50th Percentile
Winter	**Mean Temperature (ºC)**	2030s	0.89
		2050s	1.47
	Mean Precipitation (%)	2030s	7.26
		2050s	10.15
Summer	**Mean Temperature (ºC)**	2030s	1.28
		2050s	2.19
	Mean Precipitation (%)	2030s	-14.1
		2050s	-23.6
**Averages taken for: 2030s (2024-2039) and 2050s (2040-2059) under RCP 8.5*			

15.12.9 **Error! Reference source not found.** shows precipitation is set to increase in the winter, increasing a risk or more severe and frequent flooding. Mean temperature is predicted to increase, whereas precipitation is set to decrease in the summer, causing hotter and drier summers.

15.12.10 **Table 15.16** discusses how the climatic factors will affect various receptors during the Proposed Development's operational phase.

Table 15.16: Potential Impacts on Proposed Development			
Climatic Factor	**General Impact**	**Receptors**	**Component/Sub Structure Impact**
Soil drying	Increase risk of soil drying will affect water tables and could affect foundations in clay soils.	Solar array, wind turbines	Damages to the structure. Ground shrinkage can lead to collapse of wind turbines and solar arrays, damage and failure to the underground wires and electrical equipment and sub-structures.

Increase in temperature	Increases in average and maximum annual temperature will affect efficiency of PV modules and potentially the operation of the Proposed Development.	Solar PV array, turbines, wires, electrical equipment and control rooms.	Higher temperatures may cause overheating of onsite electrical equipment affecting lifespan, reliability and potential maintenance and safety issues. Some studies have shown that high temperatures can impact solar output; “Solar cell output typically decreases by about 0.5% (most crystalline cells) for each temperature rise of 1°C”[7].
Extreme Rainfall and Flooding	Increase and decrease will affect water tables and durability of the PV system and substations. Flood risk for surrounding infrastructure / buildings.	Solar PV array	Maintenance costs may be increased in winter, with associated cleaning requirements. Durability and risk of water ingress will be affected by combination of precipitation increase and gales
		Wind turbines	Maintenance costs may be increased in winter, with associated cleaning requirements. Failure of the wind turbine during extreme flooding due to the softer soil and ground which may not hold a weight of a turbine. Increased erosion of turbine blades which leads to increased costs of repairing or replacing of the blades.
		Electrical equipment, sub-station and control rooms and wires.	Increased damage to wires, structure of the onsite factory and substations, and higher risk of failure of electrical equipment and wires, increased chances of flooding. Structure/cladding/roofing membranes and sealants have increased risk of cracking due to different moisture movements. Increased risk of subsidence.

[7] ADB. 2012. Climate Risk and Adaptation in the Electric Power Sector. Available at: Climate Risk and Adaptation in the Electric Power Sector (adb.org)

			Water may impact electrical elements of infrastructure.
Solar Radiation	Reduced amount of shortwave radiation received at the ground.	Solar PV modules.	Reduced amount of direct sunlight that the modules utilise for the provision of energy that is converted into electricity.
Snow and Ice	Increase will affect productivity of the PV system	Solar PV modules and turbines.	Solar farms are not especially vulnerable to cold temperatures although should snow cover the panels then generation would be reduced or prevented. The panels are mounted at a 15^{o} angle to the horizontal which would aid in snow sliding from the panels. Hail has the potential to damage the turbine blades, particularly the leading edge, causing erosion and a reduction in productivity. Snow and ice build up on turbine blades can cause a decrease in power production.
Gales, Storms, Extreme Weather	Increase will affect the stability and productivity of the array structure, may affect wind turbine blades and structure and surrounding electrical infrastructure, which will affect efficiency of the system.	Solar PV array structure, substations, and onsite electrical equipment and wind turbines.	Static loading calculations will be analysed for the site, including a margin for error, to ensure the framework and panels remain fixed in position during strong wind events. Gales and extreme weather events can cause damages to the solar array structure, the electrical infrastructure onsite and to the wind turbine blades. This may lead to increased and more frequent repairs and replacement of the components.
Cloud Cover	Increase/decrease in Solar PV efficiency	Solar PV modules	Clouds affect the number of sunshine hours and hence the amount of solar irradiance reaching the earth's

			surface which the PV modules utilise for the production of energy. Research[8] states that "during cloud cover, solar photovoltaic panel output can decrease by 40%–80% within a few seconds, increasing just as dramatically when the sky clears. For large arrays, this rapid fluctuation can cause localized voltage and power quality concerns because shading of one panel affects the entire array connected to a single inverter."
Wind Speed	Decrease will affect the productivity of the wind farm	Wind urbines	Turbines will be located to maximise productivity based on wind speed modelling for the site.

15.13 Embedded Mitigation

Inherent Designs

15.13.1 Research[9] findings suggest that climate change may enhance the weather variability and, therefore, increase the power intermittency generated from the solar PV system. Research states that future climate change (as modelled under the RCP4.5 scenario) will change the frequency of weather conditions and increase average temperatures, which may lead to very low PV power outputs. At the end of the 30-year reference time period, temperatures within the RCP8.5 scenario are projected to increase by 2.47°C.

15.13.2 Typically, the temperature coefficient of solar panels is around a 0.4% decrease per degree. With the projected 2.47°C increase of the RCP8.5 scenario, it can be expected that the power efficiency will reduce by a maximum of 0.99% by the end of the project lifetime. Therefore, the impact of increased temperature from the projected climatic changes of a RCP8.5 scenario on the efficiency of the panels is negligible.

[8] ADB. 2012. Climate Risk and Adaptation in the Electric Power Sector. Available at: [Climate Risk and Adaptation in the Electric Power Sector (adb.org).]

[9] Feron, S., Cordero, R. R., Damiani, A., and Jackson, R. B. 2021. Climate Change extremes and photovoltaic power output. *Nature Sustainability*. Vol 4, pp 270 276.

15.13.3 The panels are proposed to be a maximum of 0.8m above ground. This will allow for sufficient air flow beneath the mounted structure and reduce heat gain. This will reduce the impact of increasing temperature on output efficiency. With less than a 1% change in efficiency and sufficient air ventilation, the impact of increased temperature on Proposed Development is minor.

Flood Risk

15.13.4 The Flood Consequences Assessment considered surface water and small watercourse flooding. It found:

- The development proposals and climate change could result in increased surface water runoff rates and volumes, which could impact areas downstream of the site.
- To reduce the potential increase in flood risk posed by the Proposed Development, it is proposed to manage and disperse surface water runoff within the proposed development with no discharge off site. Sufficient attenuation will be provided within the site for 1 in 100 year storm events including appropriate allowances for climate change.
- There is always a possibility of a storm event that exceeds the design standards of the proposed flood risk management measures for new developments. Potential risks include the exceedance of the surface water attenuation facilities during extreme storm events.
- Surface water attenuation features within the site will be designed to provide sufficient attenuation for the 1 in 100 year (plus climate change) storm event. If the capacity of the attenuation features is exceeded by an extreme storm event, exceedance flows will follow the existing topography with no increased risk to areas previously unaffected by surface water runoff.
- A Surface Water Management Plan will demonstrate that on-site attenuation will incorporate the use of Sustainable Drainage Systems (SuDS) features to accommodate flows in exceedance of up to and including the 1 in 100 year storm event, including an appropriate allowance for climate change.

Extreme Weather

15.13.5 Key points are noted below regarding mitigation measures that have been designed into the Proposed Development for certain receptors and climate variables are outlined below:

- Structures are strong enough to withstand higher winds;
- Design improves passive airflow beneath PV mounting structures, reducing panel temperature and increasing power output; and
- Modules have heat-resistant PV cells and module materials designed to withstand short peaks of very high temperature.
- The turbines will be equipped with ice detection sensors to detect any ice build up to prevent turbines from shutting down in these circumstances.
- During construction all workers will be suitably hydrated for the conditions they are working in.

15.14 Assessment of Impacts

Construction Phase

15.14.1 At more localised levels, the effects of climate change can manifest in different ways and, therefore, the most appropriate strategies should be selected on a site-specific basis. A coastal village may be at most risk from sea-level rises and storm surges, while at inland locations, the threat of heat waves or high winds might be more significant. Adaptation involves developing resilience and preparedness to deal with the likely consequences of climate change. The Proposed Development needs to consider and mitigate against the likely impacts of increased overheating events in summer months and intense precipitation events in winter.

15.14.2 Overall, the impact of the proposed changes to climatic factors, as seen in the future climate baseline, for the construction phase of the Proposed Development is determined to be of very low likelihood and, therefore, Negligible (i.e. consequences for receptors within the construction phase). In this assessment, this refers to the impact of climatic effects on construction workers; the only receptor existing solely within the construction phase. The overall magnitude of the climatic impacts on receptors within the construction phase is Negligible and the effect would be Not Significant.

Operational Phase

15.14.3 The results of the assessment of the susceptibility and vulnerability of receptors existing within the operational phase, taking into account embedded mitigation, are given in **Table 15.18**.

Table 15.17: Assessment of Susceptibility and Vulnerability of the Proposed Development during the operational phase to Future Climate Baseline

Climatic Factor	Receptors Impacted	Susceptibility (Low / Medium / High)	Vulnerability (Low / Medium / High)	Likelihood
Increase in temperature	All receptors (Wind turbines, solar array, substation, control building and associated infrastructure)	Low	Low	Medium
Extreme Rainfall and Flooding		Medium	Low	Medium
Solar Radiation		Low	Medium	Low
Snow and Ice		Low	Low	Low
Gales, Storms, Extreme Weather		Medium	Low	Medium
Cloud Cover		Low	Low	Low

15.14.4 The level of likelihood for the climate change issue was also identified according to the future climate baseline outlined in Table 15.12. The proposed mitigation measures are considered within the analysis of magnitude.

Magnitude of Effects

15.14.5 The level of consequence considers the likelihood of the event occurring and both the value and sensitivity of the receptor to the climatic impact. The latter has been determined based on the susceptibility and vulnerability of the receptor to the various climatic impacts.

Table 15.18: Assessment of Magnitude of the Impact on the Proposed Development from Future Climate Baseline			
Climatic Factor	**Likelihood**	**Consequence**	**Magnitude of the effects**
Increase in temperature	Low	Minor Adverse	Minor Adverse
Extreme Rainfall and Flooding	Medium	Minor Adverse	Minor Adverse
Solar Radiation	Low	Minor Adverse	Minor Adverse
Snow and Ice	Low	Minor Adverse	Minor Adverse
Gales, Storms, Extreme Weather	Medium	Minor Adverse	Minor Adverse
Cloud Cover	Low	Minor Adverse	Minor adverse

15.14.6 The impact of changes to the future climate baseline for the Proposed Development during the operational phase summarised in **Table 15.18** has been assessed to be of low to medium likelihood with minor consequences.

Significance Matrix

15.14.7 In-line with the IEMA guidance, the significance matrix is used to reach a reasoned conclusion on the magnitude of the impact of climate change on the Proposed Development, as shown in **Table 15.19**. This based on a combination of the probability (which considers mitigation) and consequence (which considers the receptor sensitivity) of the climate change impact on the Proposed Development.

Table 15.19: Assessment of Significance		
Climate Change Issue	**Level of Effect**	**Significance**
Temperature	Minor Adverse	Not Significant
Precipitation	Minor Adverse	Not Significant
Snow and Ice	Minor Adverse	Not Significant
Gales, Storms and Extreme Weather	Minor Adverse	Not Significant
Solar Radiation	Minor Adverse	Not Significant
Cloud Cover	Minor Adverse	Not Significant

Decommissioning phase

15.14.8 Activities carried out during the decommissioning phase will likely mirror the construction phase but the climate may have altered substantially during the intervening period. Although weather during the decommissioning phase may be more erratic and volatile than during construction, the process will be short and temporary and, provided suitable planning is made to ensure site safety during this time, there are not expected to be any excessive risks. The overall magnitude of the climatic impacts on receptors within the decommissioning phase is Negligible and the effect would be Not Significant.

15.15 Mitigation and Monitoring

15.15.1 As the embedded mitigation measures demonstrate the level of effects as minor adverse and not significant, no additional mitigation measures are required.

15.16 Residual Effects

15.16.1 Over the 30-year operational lifetime of the Proposed Development, there is the potential to generate 990 GWh of renewable electricity, which saves 416,169 tCO_2e (after embodied carbon payback) from the equivalent energy sourced from the natural gas.

15.16.2 Solar and wind power, through the production of low carbon electricity, reduces the exploitation of fossil fuel (coal and natural gas) by generating electricity from a renewable source. This development offsets the emissions associated with non-renewable methods of electricity generation and therefore mitigates the impact of climate change.

15.16.3 The residual effects remain as per those identified in the assessment of effects sections above. Overall, the Proposed Development is considered to have a minor adverse and not significant impact on climate change when compared against the most realistic alternative of natural gas.

15.17 Summary and Conclusion

15.17.1 Over the 30-year operational lifetime of the Proposed Development, there is the potential to generate 990 GWh of renewable electricity, which saves 416,169 tCO2e (after embodied carbon payback) from the equivalent energy sourced from the natural gas.

15.17.2 The Proposed Development is considered to have a minor adverse (not significant) impact on climate change when compared against the most realistic alternative of natural gas.