Fferm Solar Larnog

Environmental Statement

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1. Carbon Balance Assessment

1.1. Introduction

1.1.1. WSP UK was commissioned by Trydan Gwyrdd Cymru (the 'Applicant') to undertake a Carbon Balance Assessment for the proposed Larnog Solar Farm in Lavernock, Wales (hereafter the 'Proposed Development').

1.1.2. Climate change effects were scoped out of the Environmental Impact Assessment (EIA) on the basis that construction and decommissioning impacts are expected to be temporary and minor, and that the operational phase would provide an overall beneficial effect through the generation of renewable electricity. However, the Proposed Development will generate greenhouse gas (GHG) emissions throughout its lifecycle, particularly during construction. As such, a Carbon Balance Assessment has been undertaken to quantify both the carbon emissions and carbon savings associated with the Proposed Development.

1.1.3. The assessment considers lifecycle emissions associated with the construction, operation and decommissioning of the solar photovoltaic (PV) array and Battery Energy Storage System (BESS), alongside the avoided emissions resulting from renewable electricity generation. The purpose of the assessment is to assess the net carbon benefit of the Proposed Development and its contribution towards Welsh and UK decarbonisation objectives.

1.2. Climate Change Resilience

1.2.1. As agreed with the Vale of Glamorgan Council through the Scoping Opinion (**Appendix 1C: EIA Scoping Opinion**), a standalone assessment of Climate Change Resilience (CCR) has not been completed as part of the EIA. The projected impacts of climate change on the Proposed Development are considered in relevant sections of the following ES chapters:

- **Chapter 5: Project Description**;
- **Chapter 6: Landscape and Visual**;
- **Chapter 7: Biodiversity**; and
- **Chapter 11: Other Environmental Effects**.

1.2.2. The vulnerability of the Proposed Development to climate change and relevant embedded measures are summarised in **Section 1.7** of this appendix.

1.3. Renewable Energy Policy Context

1.3.1. The carbon balance assessment has been completed in alignment with the relevant UK wide and Welsh legislative and policy framework for the development of renewable energy schemes. This includes consideration of:

- **Environment (Wales) Act 2016** - establishes Welsh-specific emissions reduction targets and a carbon budgeting framework reinforcing the importance of assessing GHG emissions at a project level to support delivery of Wales' statutory climate ambitions[1];
- **Climate Change Act 2008 (2050 Target Amendment) Order 2019** - sets a legally binding target for the UK to achieve net zero GHG emissions by 2050. It underpins the need to quantify and assess project emissions to understand their contribution to, or alignment with, this national target[2]; and
- **Carbon Budgets Orders (Carbon Budgets Order 2026)** - sets legally binding limits on UK GHG emissions over successive five-year periods and provides a framework against which the carbon performance of developments can be considered[3].

1.3.2. The approach taken by the UK and Welsh Governments in addressing climate change has been shaped and informed by a range of international agreements and climate change obligations including the Kyoto protocol[4], the Paris Agreement[5] and the 2021 Glasgow Climate Compact[6] reflecting the UK's role as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC).

1.3.3. UK Government action on climate change is therefore based on its net zero target which requires the UK to reduce GHG emissions by 100% below 1990 levels by 2050. UK carbon budgets, set in law, support the achievement of the net zero target by limiting aggregate emissions permissible in 5-year periods in line with the rate of reduction required to meet the net zero target. In the same manner, Wales is committed to achieving net zero GHG emissions by 2050, with interim targets set for 2030 and 2040, supported by a series of legally binding five-year carbon budgets.

[1] UK Government. (2016) Environment (Wales) Act 2016. Available at: https://www.legislation.gov.uk/anaw/2016/3/contents (Accessed: September 2026).
[2] UK Government. (2019) The Climate Change Act 2008 (2050 Target Amendment) Order 2019. Available at: https://www.legislation.gov.uk/uksi/2019/1056/contents/made (Accessed: September 2026).
[3] UK Government. (2026) The Carbon Budget Order 2026. Available at: https://www.legislation.gov.uk/ukdsi/2026/9780348283815 (Accessed: September 2026).
[4] UNFCC (1998). Kyoto Protocol. Available at: https://unfccc.int/resource/docs/convkp/kpeng.pdf (Accessed: September 2026).
[5] UNFCC (2015). Paris Agreement. Available at: https://unfccc.int/sites/default/files/english_paris_agreement.pdf (Accessed: September 2026).
[6] UNFCC (2021). Glasgow Climate Pact [online]. Available at: https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf (Accessed: September 2026).

1.4. Methodology

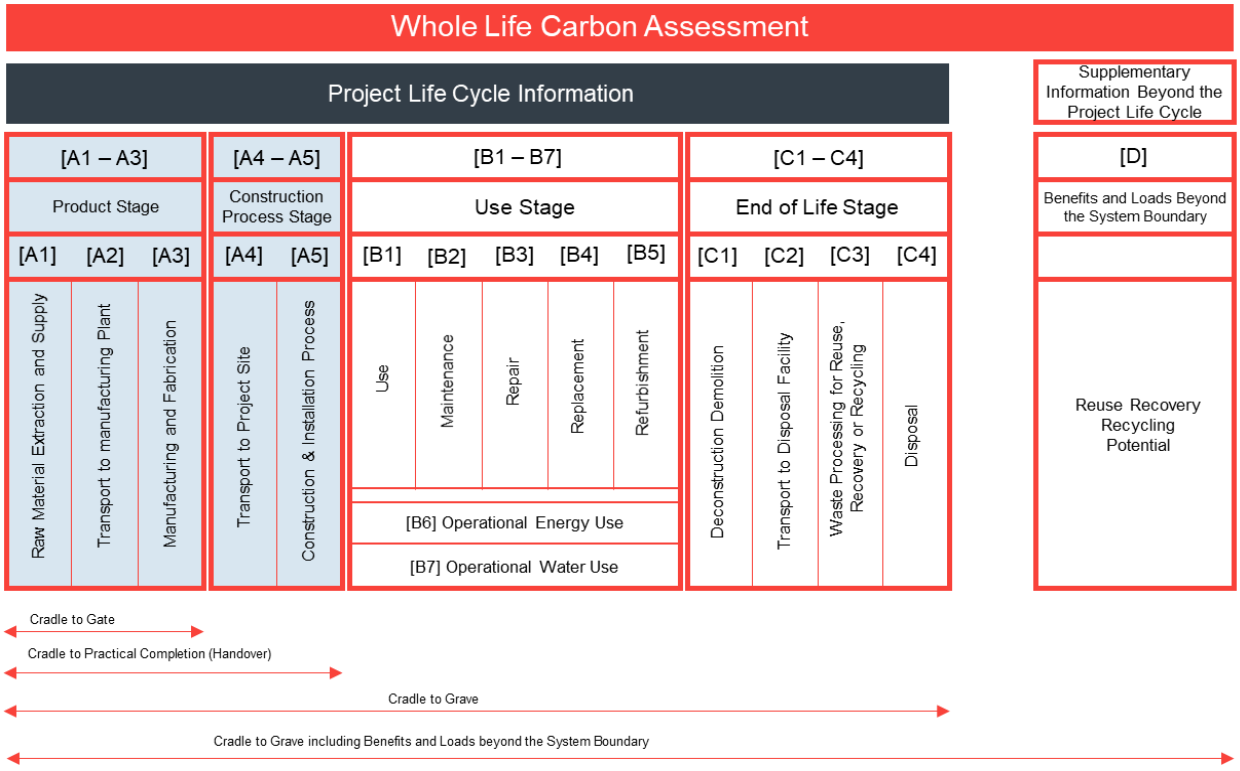
Assessment Scope

1.4.1. This carbon balance assessment quantifies an initial assessment of the total carbon emissions associated with the Proposed Development.

1.4.2. Total carbon emissions encompasses all GHG emissions arising throughout the asset lifecycle, including the production of materials, construction activities, operation and maintenance, component replacement, and end-of-life activities. Emissions are reported as tonnes of carbon dioxide equivalent (tCO_2e).

1.4.3. Potential emissions sources have been reviewed in line with best practice, as set out by the Institute of Sustainability and Environmental Professionals (ISEP)[7], Royal Institution of Chartered Surveyors (RICS)[8] and PAS 2080[9], and in accordance with British Standard

Plate 1-1: Carbon Lifecycle Stages



[7] Institute of Sustainability and Environmental Professionals (ISEP 2026). Assessing greenhouse gas emissions and evaluating their significance with supplementary guidance (Edition 2.1). Available online at: https://www.isepglobal.org/resources/blogs/2026/april/defining-significance-in-a-net-zero-era-the-next-step-for-greenhouse-gas-emissions-assessment-in-environmental-impact-assessment/

[8] Royal Institution of Chartered Surveyors (RICS), (2024). Whole Life Carbon Assessment for the Built Environment. Available online at: https://www.rics.org/content/dam/ricsglobal/documents/standards/Whole_life_carbon_assessment_PS_Sept23.pdf

[9] British Standards Institution, (2023). PAS 2080:2023 – Carbon Management in Buildings and Infrastructure. Available online at: https://www.bsigroup.com/en-GB/standards/pas-2080/

(BS) EN 17472:2022[10] lifecycle stages of the Proposed Development (**Plate 1-1**), to determine materiality for the carbon balance calculations (i.e. some negligible sources of potential GHG emissions have been scoped out of the assessment).

1.4.4. Of these lifecycle stages, those scoped into the assessment are outlined in **Table 1.1**.

Table 1.1 - Lifecycle stages scoped into the carbon balance

Lifecycle Module	Description
Product Stage (A1-A3)	Emissions associated with raw material extraction, processing, manufacturing and fabrication of construction products.
Construction Stage (A4-A5)	Emissions arising from the transport of materials to site and construction and installation activities, including waste management and site energy use. A5.1 (pre-construction demolition) is excluded from this assessment as there are no plans for demolition or removal of existing buildings or structures prior to construction.
Use Stage (B2 – B4)	Emissions associated with operation, maintenance, repair, and replacement throughout the operational life of the Proposed Development.
End-of-life stage (C1-C4)	Emissions associated with decommissioning, demolition, transport, waste processing and disposal of materials.
Benefits and loads beyond the system boundary (D2)	Potential benefits and loads from exported utilities exiting the system boundary.

Calculation Methodology

Assessment Data

1.4.5. The Carbon Balance Assessment has been undertaken at an early stage of project development when a detailed Bill of Quantities (BoQ) is not available. Consequently, the assessment has been informed by available design information as detailed within **Chapter 5: Project Description** and associated plans. These documents were reviewed to identify the principal components of the Proposed Development and to derive dimensions, capacities and quantities where practicable.

1.4.6. Where data was unavailable, reasonable assumptions were applied based on the available design information and industry standard references.

[10] British Standards Institution (BSI), (2022). BS EN 17472: Sustainability of construction works – Sustainability assessment of civil engineering works – Calculation methods. Available online at: https://knowledge.bsigroup.com/products/sustainability-of-construction-works-sustainability-assessment-of-civil-engineering-works-calculation-methods

1.4.7. The Proposed Development is assumed to be operational for 40 years before decommissioning.

Carbon Emissions Calculation Logic

1.4.8. The assessment presented in this report uses commercial software tool 'OneClick LCA' (OCL) and RICS[8] (2nd edition) methodology for all calculations. OCL is an online software tool for undertaking Lifecycle Assessment (LCA) studies of building and infrastructure assets. It focuses on calculating the Global Warming Potential (GWP) of assets by assessing all lifecycle stages, from pre-construction activities through construction, use, and demolition.

1.4.9. WSP inputted design information into OCL to support the calculation of carbon emissions and organisation into the lifecycle stages noted in **Plate 1-1**. There were no supplier-specific Environmental Product Declarations (EPDs) available, so EPDs available within OCL were selected based on professional judgement and reference to design information. RICS-aligned[8] assumptions were used regarding transport distances and the service life of materials. The most significant of these assumptions are detailed in **Table 1.3**.

1.4.10. A5 (Construction and installation processes) and B2 (Maintenance) emissions have been calculated outside of OneClick, by scaling proxy data from similar scale solar farm developments.

Avoided Carbon Calculation Logic

1.4.11. Carbon savings associated with the Proposed Development have been estimated by comparing the forecast renewable electricity generation against the carbon intensity of electricity generated from non-renewable sources.

1.4.12. The assessment uses the estimated annual electricity generation of the Proposed Development (39.2 GWh/year), derived from project design information and energy yield assumptions. This renewable generation is assumed to displace electricity that would otherwise be supplied by non-renewable generation sources on the UK grid.

1.4.13. Carbon savings are calculated by multiplying the estimated annual electricity generation (GWh/year) by the carbon dioxide intensity factor for electricity supplied from non-renewable fuels, as reported in the UK Government's Digest of UK Energy Statistics (DUKES)[11].

[11] DUKES (2026). Estimated carbon dioxide intensity of electricity supplied (DUKES 5.14) [online]. Available at: https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes [Accessed 22 September 2026].

Assumptions

1.4.14. Relevant assumptions associated with this assessment are summarised in **Table 1.2** and **Table 1.3**.

Table 1.2 - Lifecycle Stage Assumptions

Lifecycle Stage	Calculation method	Data Source for materials/ activities	Assumptions
A1-A3: Product stage	OCL	Project description and design drawings.	All EPD choices within OneClick have been assumed based on professional judgement and available design information. Further details on the main materials used are provided in **Table 1.3**.
A4: Transport to site	OCL	RICS Guidance[8]	Further details on the main materials used are provided in **Table 1.3**.
A5: Construction and installation	WSP Excel Model	Proxy data	Construction activities will be similar in nature to those for similar scale solar arrays.
B2-B4: Use stage	OCL and WSP Excel Model	Project description and design drawings.	OCL default scenario for replacement and repair of materials and products. For maintenance (B2), it is assumed maintenance activities will be similar in nature to those for similar scale solar arrays.
C1-C4: End of Life	OCL	RICS Guidance[8]	OCL default end-of-life assumptions used for C2-C4. C1 carbon emissions are assumed to be the same as A5 as a worst-case position.
D: Benefits	WSP Excel Model	DUKES[5]	40-year operating lifetime and annual electricity generation of 39.2 GWh/year.

Materials, Products and Transport Assumptions

1.4.15. A summary of the assumptions related to the main materials used in the assessment is provided in **Table 1.3**. This includes assumed transportation distance of products from the manufacturing facility to construction site. The transport carbon impacts are based on the default modes of transportation and default distances of transportation associated with the RICS guidance[8]. For materials with an expected service life shorter

than the operational lifetime of the Proposed Development, it has been assumed these materials would need to be replaced. However, it is likely that the certain components could continue to operate effectively beyond their expected service life through maintenance, repair and refurbishment. Therefore, components would only be replaced where required to ensure safe and efficient operation of the Proposed Development.

Table 1.3 - Material Assumptions

Material	Design element	EPD Name	Manufacturing Facility	Transport distance (km)	Service Life (Years)
PV Modules	Solar PV	Bifacial photovoltaic module, 755 Wp, 37.06 kg/unit, 3.106 m^2, 11.93 kg/m^2, 243 Wp/m^2, TWMNF66HDxxx (Tongwei Co., Ltd.)	Asia	500 (Road); 10,000 (Sea)	25
Steel tables	Mounting structure for PV panels	Solar panel mounting system for mounting solar panels, 10.278 kg/unit (PanelClaw)	UK	120	60
Steel beams	Piling Foundations for PV panels	Steel foundation piles from recycled steel (SSAB Europe Oy)	UK	120 (Road)	60
String inverter	Solar PV	String power inverters for large scale solar power plants, 124.5 kg/unit, 1080 V, 254 A, 3 phases, SG350HX (Sungrow Power Supply Co)	China	500 (Road); 10,000 (Sea)	10
Battery storage units	BESS	Energy storage system with lithium iron	China	500 (Road);	15

Material	Design element	EPD Name	Manufacturing Facility	Transport distance (km)	Service Life (Years)
		phosphate battery, 51.2 V, 50 kg/unit, AZZURRO HV ZBT 5K (Zucchetti Centro Sistemi SpA)"		10,000 (Sea)	
Current Transformers	Substation compound	Oil-immersed current transformer, 330 kV operating voltage, 50/60 Hz nominal frequency, 1200 kg/unit (One Click LCA)	Europe (non-UK)	1,500 (Road); 100 (Sea)	40
Voltage transformers	Substation compound	Voltage transformer, up to 40.5 kV, 50/60 Hz, plug-in design, 770 kg/unit (One Click LCA)	Europe (non-UK)	1,500 (Road); 100 (Sea)	40
Inverter Duty transformers	Substation compound	Voltage transformer, up to 40.5 kV, 50/60 Hz, plug-in design, 770 kg/unit (One Click LCA)	Europe (non-UK)	1,500 (Road); 100 (Sea)	40
Earthing transformer	Substation compound	Voltage transformer, up to 40.5 kV, 50/60 Hz, plug-in design, 770 kg/unit (One Click LCA)	Europe (non-UK)	1,500 (Road); 100 (Sea)	40
Grid transformer	Substation compound	Voltage transformer, up to 40.5 kV, 50/60	Europe (non-UK)	1,500 (Road); 100 (Sea)	40

Material	Design element	EPD Name	Manufacturing Facility	Transport distance (km)	Service Life (Years)
		Hz, plug-in design, 770 kg/unit (One Click LCA)			
Concrete	Transformer and substation compound foundations	Ready-mix concrete, in-situ, UK average, C40/50 (IStructE (2025))	UK	20 (Road)	60

1.5. Results

Carbon Emissions

1.5.1. The total expected carbon emissions associated with the Proposed Development are estimated to be 19,727 tCO_2e, excluding the carbon savings. The largest contribution arises from the Product Stage (A1-A3), accounting for 49% (9,627 tCO_2e) of total lifecycle emissions. This reflects the embodied carbon associated with the manufacture of the solar PV modules, BESS, mounting structures, electrical infrastructure and ancillary components.

1.5.2. Emissions associated with the Construction Stage (A4-A5) amount to 420 tCO_2e, representing 2% of total emissions. These emissions are primarily attributable to the transportation of materials to site and construction activities.

1.5.3. Operational emissions associated with maintenance and component replacement during the asset lifetime (B2-B4) are estimated at 8,477 tCO_2e, representing 42% of total emissions. This is due to components with relatively high embodied carbon needing to be replaced one or more times during the operational lifetime, such as the solar PV modules, BESS, and inverters. **Table 1.3** shows the expected service life for the main materials used in the assessment.

1.5.4. End-of-life activities (C1-C4) contribute 1,203 tCO_2e (6% of total emissions). The majority of these emissions relate to the management of waste taken off-site for re-use, recycling or recovery.

1.5.5. Potential benefits and loads from exported utilities exiting the system boundary (D) are expected to be substantial (661,696 tCO_2e), reflecting the avoided GHG emissions associated with the export of renewable electricity to the Grid.

1.5.6. Over the 40-year operational lifetime of the Proposed Development, these avoided emissions are anticipated to exceed the carbon emissions associated with the manufacture, construction, operation and decommissioning of the solar farm and BESS, resulting in a net carbon benefit as detailed within **Table 1.4**.

1.5.7. As a sensitivity, a 15% contingency factor has been applied to the results for all A-C life cycle modules due to the early stage of design. The results following this uplift are provided within **Table 1.4**.

1.5.8. Overall, the results demonstrate that embodied carbon emissions associated with the manufacture of project components are the dominant source of lifecycle emissions. This is consistent with solar and battery storage developments, where the majority of emissions occur upfront during material production, while operational emissions remain relatively low over the lifetime of the asset. The carbon emissions will be offset through the generation of renewable electricity, with the resulting carbon balance and carbon payback period presented in the next section.

Table 1.4 - Total carbon emissions by lifecycle modules

Lifecycle Module	tCO_2e*	tCO_2e (with 15% contingency) *
A1-A3: Materials and Products	9,627	11,071
A4: Transport to site	414	477
A5: Construction	6	7
SUBTOTAL [A1-A5]	**10,047**	**11,555**
B2: Maintenance impacts	50	58
B3: Repair impacts	81	93
B4: Replacement impacts	8,346	9,598
SUBTOTAL [B2-B4]	**8,477**	**9,749**
C1: Deconstruction and demolition impacts	6	7
C2: Transport impacts	209	240
C3: Waste processing for reuse, recycling or other recovery	988	1,136
C4: Disposal impacts	0.5	1
SUBTOTAL [C1-C4]	**1,204**	**1,384**
D: Potential benefits and loads from exported utilities exiting the system boundary	- 661,696	- 661,696**
TOTAL [A, B, C]	**19,727**	**22,688**
TOTAL [A, B, C, D]	**-641,969**	**- 639,008**

**tCO2e values exclude sequestered carbon and reflect the non-decarbonised scenario provided in OneClick LCA*

***contingency not applied to module D*

Carbon Balance

1.5.9. As shown in **Table 1.4**, it is expected that the carbon emissions associated with the Proposed Development will be 19,727 tCO_2e; whereas the avoided carbon emissions associated with the displacement of non-renewable generation benefit over the 40-year life of the solar farm is expected to be 661,696 tCO_2e[12]. This avoided emissions estimate is based on the solar farm generating 39.2 GWh/year for 40 years and replacing non-renewable electricity sources. In sum, this indicates an expected carbon payback period of 1.2 years[13], revealing the significant benefit that the Proposed Development will have on climate change mitigation.

1.5.10. As a sensitivity, a 15% contingency factor has been applied to the results for all A-C life cycle modules due to the early stage of design. This results in 22,688 tCO_2e associated with the Proposed Development and alters the payback period to 1.4 years[13].

1.5.11. In both scenarios, this assessment indicates that the Proposed Development will provide a significant net carbon benefit.

1.5.12. This net carbon benefit will contribute to wider electricity sector decarbonisation in support of both Welsh and UK Government net zero ambitions.

1.6. Limitations

1.6.1. This assessment has been undertaken using the information available at the current design stage. A detailed BoQ was not available; therefore, quantities have estimated from available design documentation, including drawings and associated specifications. Component dimensions and characteristics, such as lengths, widths, and material types, were derived from these documents to inform the assessment. Project-specific EPDs were not available and, as such, datasets from the OCL database have been used. Consequently, the results should be considered robust but indicative and may be refined as the design develops and more detailed project information becomes available.

[12] Calculation is: 422 tCO_2/GWh (Non-renewable fuel carbon dioxide intensity per DUKES) x 39.2 GWh/yr (Estimated annual generation) x 40 years (Operating lifetime) = 661,696 tCO_2e
[13] Calculation is: (Carbon emissions total / avoided emissions total) x 40 years (operating lifetime) = payback period

1.7. Climate Resilience

1.7.1. According to the latest State of the UK Climate Report[14], the UK's climate is changing. In general, climate change in the UK is project to lead to:

- Hotter drier summers with increased frequency and duration of heatwaves and droughts;
- Warmer, wetter winters with reduced frequence of snow and ice, however such events and extreme cold snaps remain a risk; and
- Increased frequency of extreme events such as heavy rainfall, resultant flooding, high winds and, potentially, lighting strikes.

1.7.2. The vulnerability of the Proposed Development to climate change has been considered in the design and other relevant topic chapters listed in **Section 1.2**. The environmental measures identified in topic assessments related to improving the CCR of the Proposed Development have been reproduced in **Table 1.5**.

Table 1.5 - Embedded measures improving climate change resilience (CCR)

Chapter/Technical Report	Environmental measure	Relevance for CCR
Chapter 5: Project Description	The Project Substation Compound (including substation equipment and BESS) has been located outside of areas at risk of surface water flooding.	This reduces the vulnerability of the infrastructure to future increases in surface water flood risk.
	The requirement for lightning protection associated with the Project Substation and associated electrical infrastructure will be assessed during the detailed design stage. Where required, lightning protection measures will be incorporated into the final design in accordance with the relevant engineering standards and operational safety requirements.	These measures increase the resilience of the substation components to increasing lightning strikes that may be experienced associated with climate change.

[14] Met Office (2026). State of the UK Climate. Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/about/state-of-climate (Accessed: October 2026).

Chapter/Technical Report	Environmental measure	Relevance for CCR
	Maintenance activities during operation would include vegetation management, routine inspection, maintenance and servicing of equipment and infrastructure, and the replacement of equipment or components where necessary.	Routine maintenance would help identify any impacts to the access tracks (deterioration of surfacing), substation and solar arrays from extreme weather associated with climate change, allowing for repairs, replacement or upgrades, if required.
	Fire safety and operational resilience of the BESS are considered within **Appendix 5D: Outline Battery Fire Safety Management Plan** (oBFSMP). The oBFSMP sets out the design principles and operational measures that will be incorporated within the detailed design of the BESS to manage fire risk and maintain safe operation under a range of environmental conditions.	Enhances the resilience of the BESS through thermal management, monitoring, protection systems and operational controls, supporting safe and reliable operation under future climatic conditions.
	The substation and associated electrical infrastructure would be designed and constructed in accordance with relevant industry standards, guidance and manufacturer specifications to ensure durability, reliability and safe operation throughout the operational lifetime of the Proposed Development	This would increase the resilience of Project Substation to future climate changes (i.e. increased temperatures, wind speeds, storm events, etc.).

Chapter/Technical Report	Environmental measure	Relevance for CCR
Chapter 6: Landscape and Visual/Chapter 7: Biodiversity	Existing woodland, trees, hedgerows and other environmentally sensitive features have been retained wherever practicable. Management proposals for the replacement or enhancement planting are set out within **Appendix 6G: Outline Landscape and Ecological Management Plan** (oLEMP), which will be secured as a planning condition. This will be undertaken over the lifetime of the development.	Management proposals would help the replacement or enhancement planting to succeed in response to changing climatic conditions i.e., drought conditions or increasing temperatures. The management regime will be reviewed at five yearly intervals to ensure it remains suitable and effective. This will include any alterations needed to mitigate for a changing climate.
	The planting proposals set out within **Appendix 6G: oLEMP** include native and locally appropriate species.	Planting proposals using native and locally appropriate species improves the likelihood of successful establishment and long-term resilience under changing climate conditions.
Chapter 11: Other Environmental Effects/Appendix 11E: Flood Consequences Assessment and Outline Drainage Strategy	Climate change allowances in line with Natural Resources Wales guidance have been applied to the hydrological modelling inputs to minimise vulnerability and provide resilience to the impacts of climate change.	Ensures that future increases in rainfall intensity have been considered in the design of the Outline Drainage Strategy for the Site, ensuring flood resilience is built into the design.
	Solar PV panels would be mounted on piled support structures rather than extensive concrete foundations.	Minimises disturbance of the soil, maintains the existing drainage pathways, and reduces the vulnerability of the Proposed Development to increased rainfall and surface water flooding events.