17 CLIMATE CHANGE

17.1 Introduction

17.1.1 This Chapter, prepared by Wardell Armstrong LLP, reports the likely significant effects of the Proposed Development in terms of climate change and risk mitigation in the context of the Site, surrounding area and the wider environment, recognising that climate change is a global issue.

17.1.2 This climate change chapter will cover the following:

- **Assessment of Impacts:** A conventional impact assessment that will focus on the potential effects of the Proposed Development (i.e., greenhouse gas (GHG) emissions on the climate). This will include an overview of how the Proposed Development aids in the mitigation of climate change; and
- **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 will include a qualitative discussion of the vulnerability and sensitivity of the Proposed Development to climate change impacts, with an assessment of the magnitude of effects.

17.1.3 This Chapter (and its associated appendices) is not intended to be read as a standalone assessment and reference should be made to the front end of this ES (Chapters 1 – 6), as well as the final chapters, 'Summary of Residual and Cumulative Effects' and 'Conclusions' (Chapters 21 - 22).

17.2 Legislation, Policy and Guidance

17.2.1 The relevant legislation, policy and guidance are listed below, with further details of legislation and planning policy provided in Appendix 17.1.

Legislative Framework

17.2.2 The applicable legislative framework is summarised as follows:

- Climate Change Act 2008 (2050 Target Amendment, Order 2019);
- Town and Country Planning (Environmental Impact Assessment) (Wales) Regulations (2017); and
- Building Regulations (Part L and Part F).

Planning Policy

17.2.3 The applicable planning policy is summarised as follows:

- Planning Policy Wales, Edition 11 (2021);
- Future Wales – The National Plan 2040;
- Cardiff Local Development Plan 2006 – 2026;
- Cardiff Replacement Local Development Plan 2021 to 2036;
- South East Wales Regional Waste Group Regional Waste Plan 1st Review (2008);
- One Planet Cardiff Strategy 2030;
- Cardiff Council Climate Action Plan.

Guidance

17.2.4 The applicable guidance is summarised as follows:

- The Institute of Environmental Management and Assessment (IEMA), 'Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance' (2017);
- IEMA and European Commission, 'Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment' (2013);
- BSI - PAS 2080:2016 'Carbon Management in Infrastructure';
- European Investment Bank (EIB) 'EIB Project Carbon Footprint Methodologies. Methodologies for the Assessment of Project GHG Emissions and Emission Variations' (2020);
- IEMA 'Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation' (2020);
- Royal Institution of Charted Surveyors (RICS), 'Whole life carbon assessment for the built environment' (2017); and
- National House Building Council and European Commission reports and the UK Climate Change Risk Assessment (2017).

17.2.5 Although not specifically designed for EIA purposes, the European Investment Bank guidance sets out a credible and viable definition for the baseline scenario in terms of

climate change, as this differs to the definition of a baseline scenario in other sections of the ES. This methodological approach is recommended by the European Commission in its guidance document; Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment (2013).

17.2.6 In summary, the baseline scenario does not consider a *"do nothing scenario"*. It assumes that there is demand for the development and supply is required for development targets to be met. Therefore, the assessment baseline scenario can be considered to be a 'typical' development which:

- Delivers the same outputs as the Proposed Development;
- Is built to standard building regulations using normal construction practices; and
- Is constructed in a nominal location.

17.2.7 A 2019 technical note from European Bank for Reconstruction and Development (EBRD) 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.

17.2.8 This differs from the IEMA guidance published in 'Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance' that suggests that all emissions are significant and therefore, unless a project is removing as much carbon from the atmosphere as it is emitting, its impacts will be considered significant. However, the IEMA method does not enable the scale of effect to be identified, and for which measurable mitigation measures can be identified that reduce the residual effects to within an acceptable level.

PART 1: ASSESSMENT OF IMPACTS

17.3 Assessment Methodology and Significance Criteria

Scope of the Assessment

17.3.1 Greenhouse gas (GHG) emissions are divided into three Scopes according to the GHG Protocol. Scope 1 (Direct) and Scope 2 (Indirect) emissions will be assessed. These are quantifiable and within the Joint Applicant's reasonable control. In this instance, these emissions are taken to be that associated with the combustion of fossil fuels (such as

natural gas in building heating systems) and the use of electricity (associated with lighting and ventilation) during the operational phase of the built development.

17.3.2 Construction emissions associated with the Proposed Development include the emissions associated with on-site machinery, plant equipment and welfare facilities, typically being the emissions associated with diesel fuel combustion. In the absence of project-specific information relating to all on and off-site construction activities, a high-level quantification of construction emissions for the Proposed Development has been undertaken based on the average figure for building construction site emissions supplied in the RICS guidance (2017).

17.3.3 Decommissioning emissions include those associated with the removal, transportation and disposal of waste materials either in landfill or to sites for recycling/re-use at the end of the project's operational lifetime. This is likely to be at least 80 years in the future and the modes of transport and decommissioning techniques and disposal/recycling methods could be very different and considerably less carbon intensive by that time. However, a high-level quantification of site deconstruction and demolition emissions for the Proposed Development has been undertaken based on the average rate from aggregated data supplied in the RICS guidance (2017). In this context, deconstruction refers to the disassembly of building components to recover the maximum amount of reusable and recyclable materials in a safe, environmentally responsible, cost-effective manner. This can apply to both the enabling works to prepare the existing site for the new development, as well as to decommissioning of the Proposed Development at the end of the implied operational lifetime.

Effects Not Considered within the Scope

17.3.4 Not included in the assessment are those emissions associated with the transport movements of occupants, goods and services, workers, supply chain, and visitors to site once the Proposed Development becomes operational. These are classed as Scope 3 (Indirect) emissions and are largely tied to actions outside the Joint Applicant's control.

17.3.5 Different greenhouse gases have different levels of impact on the climate. The assessment considers carbon dioxide equivalent (CO_2e) emissions. This is a 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 Carbon Dioxide (CO_2) with the same GWP. In practice this is limited to consideration of CO_2 and Nitrous Oxide (N_2O) only. It is understood that there are other emissions that contribute to climate change, such as those found in refrigerants e.g., chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). These emissions are considered to be minimal in volume by comparison to the operational CO_2e emissions and have therefore not been considered in the analysis.

17.3.6 Where possible, materials for construction will be sourced locally and sustainably-sourced materials will be selected preferentially. Although the embodied carbon in the materials has not been assessed in detail, this is expected to be a relatively minor component of the development's lifetime emissions. The use of sustainably-grown timber will provide a carbon store within the Proposed Development and whilst this will not offset other embodied carbon it will help to reduce the impact.

Extent of the Study Area

17.3.7 The assessment focusses on the impact of an external factor (climate change) on the scheme, as well as the global impact of the scheme on climate change through carbon emissions. This is very different to impacts arising from other EIA topics which consider spatially defined receptors within a limited geographical location.

Consultation Undertaken to Date

17.3.8 No additional consultation activities were undertaken in support of the preparation of this ES Chapter.

Assessment Methodology

17.3.9 The method of baseline data collection and assessment has been presented during the EIA Scoping exercise with Cardiff City Council and is in accordance with current guidance and industry best practice. Full details are provided in Appendix 17.2.

17.3.10 The assessment of GHG emissions is based on the accompanying Energy Strategy for the Proposed Development which has been produced separately to the ES.

17.3.11 The impacts of both the detailed and outline elements of the hybrid application are considered in this assessment of climate change.

Significance Criteria

17.3.12 For the purpose of this assessment, effects that are deemed to be significant are those described as minor, moderate or major in adverse scenarios, and in beneficial

scenarios that exceed the local policy. This goes beyond the standard EIA practice and represents a strict and conservative approach, which aligns with the magnitude of climate change as an issue, and local policy targets to reduce carbon emissions beyond Building Regulations. The significance criteria are provided in Table 17.1.

Table 17.1: Significance Criteria – Assessment of Greenhouse Gas Impacts

Criteria	Impact	Significance
Relative CO_2e emissions are greater than in the baseline scenario	Negative	Significant
Relative CO_2e emissions are no different to the baseline scenario	Neutral	Not Significant
Relative CO_2e emissions are over 5% less than the baseline scenario	Positive	Significant

17.3.13 All emissions that have an adverse impact are significant because this outcome would indicate that the Proposed Development will fail to meet the minimum requirements set out in Building Regulations. Emissions from a proposed development that fall below the baseline can be classed as beneficial as this would indicate that building efficiency and energy use exceeds statutory regulation requirements.

17.3.14 To avoid misinterpretation, it is important to understand the justification and the limitation behind the use of this significance criteria. It leads to a robust method for comparing likely emissions arising from the proposed development, relative to the baseline of a similar 'typical' development. For planning purposes, where it is important to weigh the benefits of one development against another, this is a useful and practical approach.

17.3.15 The alternative approach, which holds to a stricter interpretation of the absolute effects of the proposed development, is to take the baseline to be the 'do nothing' scenario. If the 'do nothing' approach were to be adopted, then almost any form of development would result in increased levels of GHG emissions and would be considered to deliver significantly adverse impacts.

17.3.16 The downside with this approach is that because all developments would deliver significant adverse impacts, it would be much more difficult to identify whether a developer was making a genuine attempt to reduce GHG emissions beyond the requirements of standard regulatory policy.

17.4 Baseline Conditions

17.4.1 The baseline operational energy demands have been modelled based on the maximum potential parameters defined in the Energy Strategy which has been produced separately to accompany the hybrid planning application.

17.4.2 The total annual energy demands have been projected for the baseline development. These are subsequently converted into CO_2e emissions in line with the baseline methodology described within Appendix 17.2.

17.4.3 A summary of the total annual energy and CO_2e emissions data for the Arena Quarter (Arena and Hotel) is provided in Table 17.2.

Table 17.2: Estimated baseline annual energy and emissions for the Arena Quarter

	Energy (GWh / year)		**Emissions (tCO_2e)**	
	Regulated	Unregulated	Regulated	Unregulated
HOTEL	1.28	0.13	259.83	30.37
ARENA	2.22	1.02	452.65	237.45

17.4.4 A Business as Usual assessment is provided based on using conventional gas boilers for heat and power supplied directly from the national grid. This is used as the baseline for the annual energy demand for the Atlantic Wharf, Butetown Masterplan, and is summarised in Table 17.3.

Table 17.3: Estimated baseline annual energy and emissions for the Masterplan

	Energy (MWh / year)		**Emissions (tCO_2e)**	
	Natural Gas	**Electricity**	**Natural Gas**	**Electricity**
MASTERPLAN	29,656	11,486	6.04	2.68

17.4.5 The total baseline energy demand for the 80-year operational lifespan of the Proposed Development has been modelled which takes into account the projected decarbonisation of the national grid, as summarised in Table 17.4. It is noted that the Proposed Development does not have a predetermined end of life or demolition plan, however, for the purpose of the assessment a defined time period has been selected. This is a standard timeframe which Wardell Armstrong uses to allow a realistic estimate of emissions over time.

Table 17.4: Baseline energy demand and emissions over 80-year operational lifespan

	Total Energy (GWh)	**Total Emissions (tCO_2e)**

Arena & Hotel	381	55,240
Masterplan	3,374	473,258

17.4.6 It is assumed that the baseline conditions for emissions arising from decommissioning and construction will be the same as those estimated for the Proposed Development.

Sensitive Receptors

17.4.7 When considering the effects of the Proposed Development on climate, unlike other technical areas, assessment of individual receptors is not strictly applicable. Climate change is a global phenomenon and highly localised impacts as a direct result of emissions associated with this development are extremely unlikely.

17.4.8 It is understood that certain regions, populations and species are more sensitive to climate change than others, but it would not be reasonable to provide an assessment of the Proposed Development's potential impact on these receptors as any single development would have an indiscernible impact on global climate change overall.

17.4.9 However, it is still important to undertake the assessment to ensure the Proposed Development does not emit unacceptable levels of emissions not only in an effort to reduce future climate change impacts, but to contribute towards local and national emission targets.

Limitations

Energy

17.4.10 Unregulated energy use could vary substantially when the Proposed Development is operational, but it is not possible to accurately predict this energy use and a reasonable allowance has been made to account for this.

17.4.11 There are currently limited resources available to give the annual energy demand of given building types and uses with improvements made in their energy efficiency. Therefore, this assessment models an increase in energy efficiency of the Proposed Development based upon Wardell Armstrong's experience of what is sensible and achievable.

Decommissioning Emissions

17.4.12 Decommissioning emissions include those from plant use and site facilities. There are also many off-site sources of emissions during the decommissioning process which vary depending on the amount of materials being recycled, sent to landfill or

incineration. A high-level overview of the potential emissions from the deconstruction phase has been provided in paragraph 17.5.7 based on information supplied by the Joint Applicant.

17.4.13 The emissions resulting from decommissioning are deemed to be negligible when compared to the emissions resulting from the operational energy use of the Proposed Development. However, the level of impact has been assessed so that appropriate mitigation can be implemented wherever possible.

Construction Emissions

17.4.14 A high-level overview of the potential emissions from the construction process has been provided in paragraph 17.5.7 based on information supplied by the Joint Applicant. During the construction process there will be emissions resulting from on-site machinery, plant equipment and site facilities. There will also be emissions resulting from the waste generated through the construction process and its treatment and disposal.

17.4.15 The emissions resulting from construction are deemed to be negligible when compared to the emissions resulting from the operational energy use of the Proposed Development. However, the level of impact has been assessed so that appropriate mitigation can be implemented wherever possible.

Embodied Carbon Emissions

17.4.16 Embodied emissions (also referred to as embodied carbon or embodied energy) are the emissions associated with the manufacture and transportation of all materials and products, including those used in construction. The embodied emissions within the materials used at the Site can make up a large proportion of the total emissions relating to the Proposed Development. This includes Scope 3 emissions, for instance, those emitted during the manufacturing process of materials such as concrete and steel which are used to construct the buildings.

17.4.17 The RICS guidance indicates that for a typical warehouse shed with office space and an operational life of 60 years, embodied emissions from the materials and on-site construction can make up 47% of the overall carbon emissions. For a residential block with basic internal fit out with an operational life of 60 years, embodied emissions from the materials and on-site construction can make up 51% of the overall carbon

emissions. This highlights the importance of reducing the embodied carbon of the materials used wherever possible.

17.4.18 A high-level indicative assessment of the embodied carbon within the materials being considered for the construction of the Proposed Development of the Arena Quarter is provided, based on information available at the time of assessment, and using the RICS guidance for default values for materials commonly used in construction and the Inventory of Carbon and Energy (ICE) Database. Insufficient information is available to enable an assessment of the embodied carbon within the materials to be used in the masterplan as it is an illustrative masterplan in the outline planning stages.

17.5 Assessment of Effects

Design Solutions and Assumptions

17.5.1 The assessment considers the operational CO_2e emissions over an 80-year period, which is assumed to be representative of the development's 'lifetime'. It is not possible to fully understand, at this time, how energy use and emissions will vary within buildings during this period, but it has been assumed that energy use will remain the same, year on year, throughout the assessment period.

Embedded Mitigation

17.5.2 Embedded mitigation has been considered in the assessment as the Joint Applicant wishes to be policy compliant with their approach. To achieve the minimum target of 37% emissions reductions planned by the Future Buildings Standard which is currently under consultation in Wales, the Proposed Development will incorporate improved building fabrics and various renewable and low carbon technologies.

17.5.3 The Arena is targeting high standards and a BREEAM rating of 'Excellent'. The masterplan aims to be climate neutral with net zero impact on the global atmosphere.

17.5.4 The models are, therefore, based on the assumption that the Proposed Development will deploy solar PV and install Air Source heat pumps for day to day space heating. Connection to the District Heating Network and future Energy from Waste Network is also considered in line with the requirements of local planning policy.

17.5.5 Full details of the embedded mitigation can be found in the Energy Strategy for the Proposed Development which accompanies the hybrid planning application.

Assessment of Effects

Effects from Decommissioning and Construction Phase

17.5.6 The estimated emissions arising from decommissioning and construction are summarised in Table 17.5. It has been assumed that decommissioning at end of life will be a reverse of the construction processes. However, this presents a worse-case scenario as it does not account for potential decarbonisation of transportation methods.

Table 17.5: Estimated Emissions from Decommissioning and Construction		
	Arena Quarter (tCO_2e)	**Atlantic Wharf Masterplan (tCO_2e)**
Construction	444	7,280
Decommissioning	1,979	7,541
TOTAL	**2,423**	**14,821**

17.5.7 Based on information supplied by the Joint Applicant, the total emissions arising from the deconstruction and construction phases for the Arena Quarter have been estimated at 2,423 tCO_2e and at 14,821 tCO_2e for the masterplan.

17.5.8 The combined level of effect from the decommissioning and construction phase, without mitigation, is deemed to be moderate adverse and significant in the short-term.

Effects from Operational Phase

17.5.9 A high-level assessment of the energy demand of the illustrative masterplan together with more detailed assessment of the energy demand of the detailed application for the Arena and the Hotel was completed by Arup and Sonas Energy. The assessment of effects for the operational phase is based on these energy strategies.

Arena Quarter

17.5.10 The total projected energy demand for the 80-year operational lifespan has been modelled with the embedded mitigation for the Arena Quarter (Arena and Hotel), as summarised in Table 17.6.

Table 17.6: Projected energy and emissions for the Arena Quarter over 80 year operational lifespan		
	Energy Demand (MWh/year)	**Emissions (tCO_2e)**
Arena & Hotel	329,425	49,133

17.5.11 The relative emissions over the 80-year project lifetime for the Arena Quarter, with embedded mitigation, are minus 6,107 tCO_2e. This is 89% below the baseline which equates to a positive beneficial impact over the long-term which is significant. This means that there are emissions savings or costs associated with the Arena Quarter (Arena and Hotel) achieved through Building Regulations and the additional low carbon measures proposed. Without mitigation, the Proposed Development would closely resemble a typical development that has met Building Regulations but has not actively pursued additional efforts to reduce climate change impacts.

17.5.12 The result of a positive beneficial impact should not be interpreted as the Arena Quarter (Arena and Hotel) having no contribution towards climate change. It is purely in relation to the Joint Applicant exceeding Building Regulations, meeting emissions targets within policy, and pursuing further action and commitment to sustainable development.

Solar Photovoltaics

17.5.13 The Proposed Development intends to deploy roof-mounted Solar Photovoltaic (PV) arrays at the Site which will be used to offset the projected energy demand for the Arena. It is estimated that active PV technology will cover around 1500m^2 of roof space and generate approximately 356MWh of electrical energy per year, saving 83 Tco_2e over the 80-year operational lifespan.

Air Source Heat Pumps

17.5.14 Air Source Heat Pumps (ASHP) are being considered for the Proposed Development. ASHP are expected to provide a considerable saving in CO_2e emissions to support the general day to day, non-event loads for the Arena. It is envisaged that peak loads on event days will be met by a natural gas supply or potentially from the heat network.

Atlantic Wharf, Butetown Masterplan

17.5.15 The first scenario for masterplan is modelled based on an all-electric solution to assess the standalone power demands assuming the heat demand is supplied by local heat pumps. The second scenario assumes the heating demand is supplied from the wider area heat network.

17.5.16 A summary of the projected energy demand and associated emissions over the 80 year operational lifetime for both scenarios is presented in Table 17.7.

Table 17.7: Projected energy and emissions for the Atlantic Wharf, Butetown Masterplan over 80 year operational lifespan

	Energy Demand (MWh/year)	Emissions (Tco_2e)
All Electric	1,680,098	56,414
Heat Network	3,008,826	407,004

17.5.17 Modelling indicates that there will be an 86% reduction in emissions for the All Electric scenario, and a 12% reduction in emissions for the scenario with connection to the heat network.

17.5.18 The level of effect from the operational phase with the embedded mitigation proposed is deemed to be beneficial in the long-term for the scenario with connection to the heat network. There is still a reliance on the combustion of fossil fuel to meet the majority of the required energy demand.

17.5.19 If the All Electric scenario is implemented, then the Proposed Development will result in a major beneficial impact which is Significant in the long term. The shift to all electric to meet the energy demands for the masterplan will also benefit from the decarbonisation of the national grid. The Proposed Development aims to be climate neutral, with a net zero impact on global emissions. Therefore, it is assumed that this will be the preferred option at outline, and as far as is reasonably practicable following detailed design.

17.5.20 This means that in both scenarios, there are emissions savings or costs associated with the Proposed Development achieved through Building Regulations and the additional low carbon measures proposed. Without mitigation, the Proposed Development would closely resemble a typical development that has met Building Regulations but has not actively pursued additional efforts to reduce climate change impacts.

17.5.21 The level of impact for both scenarios should not be interpreted as the Proposed Development having no contribution towards climate change. It is purely in relation to the Joint Applicant meeting Building Regulations and emissions targets within policy, and pursuing some further action and commitment to sustainable development.

Embodied Carbon

17.5.22 The embodied carbon emissions within construction materials can make up a large proportion of the total emissions relating to the Proposed Development. However, the materials to be used at the Site are indicative at the time of this assessment.

17.5.23 The total embodied carbon emissions within these indicative materials, for both elements of the hybrid application, have been estimated to be approximately 110.81 Mt CO_2e. This could be considered high but is proportionate to the scale of the Proposed Development and includes a high volume of steel and concrete. These materials are known to be more carbon intensive to produce than other materials. Alternatives could be considered during detailed design of the masterplan.

17.5.24 Embodied carbon emissions for the Proposed Development should be re-evaluated at the detailed design stage for the masterplan when more accurate information is available regarding specific construction materials and processes.

17.6 Mitigation

17.6.1 There is scientific agreement that carbon emissions resulting from human activities must be reduced to mitigate the risks associated with the more severe long-term impacts of climate change. Renewables are projected to need to supply 70-85% of electricity in 2050 to achieve targets of limiting global warming to 1.5°C. Average annual investment in low carbon energy technology and energy efficiency needs to be upscaled by a factor of five by 2050, compared to 2015. The potential risks associated with climate change will increase if these technologies are not implemented and the national grid is not decarbonised as far as possible.

Construction Phase

17.6.2 There are numerous standards that a contractor is expected to commit to during the construction phase, such as Common Minimum Standards (CMS), Construction (Design and Management) Regulations (CDM), or the Considerate Constructors Scheme (CCS). Prior to construction commencing, a Construction Environmental Management Plan (CEMP) and Site Waste Management Plan can be implemented which brings together these standards with site specific prescriptions. A CEMP for the enabling works will be submitted as part of the hybrid planning application. This can reduce the impacts on the environment during the construction and operation

processes and ensure the design allows capacity for effective waste management for the site.

Operational Phase

17.6.3 In addition to the embedded mitigation, there are additional measures that could be implemented or pursued in the design and construction of the Proposed Development to further reduce impacts on climate change during the operational phase. These include, but are not limited to:

- Incorporating improvements in fabric efficiency above Building Regulations;
- Utilising wastewater heat recovery technology;
- Use of energy efficient materials for construction, lighting, appliances, and production equipment;
- Minimised use of building materials with high lifecycle CO_2 emissions, most notably concrete, steel and cement;
- Reuse and recycling of materials on-site e.g., topsoil;
- Optimising solar gain and natural daylight;
- Installing a high level of insulation;
- Minimising the chance of cold bridging;
- Increasing air tightness; and
- Increasing the opportunity for natural ventilation.

17.6.4 It is anticipated these measures could be considered for the design development of those buildings within the illustrative masterplan, which would be developed as part of future reserved matters applications.

17.6.5 Energy efficient design is being considered for the Proposed Development. The Arena is targeting high standards and a BREEAM 'Excellent' rating.

17.6.6 Overall, the Proposed Development has been modelled to meet local policy requirements.

17.7 Residual Effects

17.7.1 The Proposed Development will result in the emission of GHGs, which is a long term and permanent effect contributing to global warming and climate change. If mitigation

measures are implemented in the form of energy efficient build standards and renewable energy sources, then the magnitude of this effect is minimised.

17.7.2 As noted in paragraph 17.3.4, this assessment has not included quantification of emissions from site users and visitors to the Proposed Development once it becomes operational. These will have a residual effect, but these emissions are deemed to be largely outside of the Joint Applicant's control.

17.7.3 There will be GHG emissions arising from the decommissioning and construction of the Proposed Development. The combined high-level estimated figure of 17,244 tCO_2e for construction and decommissioning of the Proposed Development in its entirety, will have an immediate impact on the local area and is deemed significant. The Proposed Development should actively seek to reduce the level of residual impact from the decommissioning and construction phases by reusing or recycling materials onsite wherever possible and employing good construction methods.

PART 2: ASSESSMENT OF CLIMATE RESILIANCE

17.8 Assessment of Vulnerability

17.8.1 The EIA regulations not only require an assessment of the potential impacts of a Proposed Development on climate change, but also an assessment of a Proposed Development's vulnerability to potential impacts of climate change. This will ensure that the risk of the Proposed Development to climate change effects are identified and mitigated if required.

17.9 Assessment Methodology and Significance Criteria

17.9.1 Assessing the impacts of climate change on a scheme varies from the assessment of impacts arising from the scheme in other EIA topics, since it focusses on the global impact of an external factor (climate change) on the scheme, rather than the local impact of the scheme on receptors in a confined geographical location. The resilience of the Proposed Development to climate change is assessed based on the susceptibility and vulnerability of a range on different receptors. The magnitude of the effects is deemed to be significant based on a matrix of likelihood and consequence. Full details of the methodology can be found within Appendix 17.2.

Limitations

17.9.2 The IEMA guidance (2020) explains how our 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 in order to assess the resilience of new developments to any future changes in climate.

17.10 Baseline Conditions

17.10.1 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. The average temperature in all months will be below 22°C and there is not an identifiable dry/wet season i.e., precipitation rates are similar year-round. The city of Cardiff experiences a significant amount of precipitation throughout the year, even in the driest month of March which receives an average of 72 millimetres (mm). The average annual rainfall is 1071 mm. The average temperature in Cardiff is 10.4°C, dropping as low as 5.1°C in February and rising to an average of 16.4°C in the hottest month of July.

Global Climate Change Projections

17.10.2 Global probabilistic projections provide a wider sampling of uncertainty and are useful for considering the wider context of future changes in climate. Table 17.8 highlights the main projected global climate change issues.

Table 17.8: Projected Global Impacts of Climate Change

Climate Change Issue	Projected Global Impacts
Solar Radiation	Long term projected changes in surface solar radiation, as a result 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. This is considered to be anthropogenic strengthening of "natural" decadal variability in irradiance, known as global dimming and brightening, which is influenced by synoptic weather patterns, cloud variations and atmospheric aerosols.
Heat Waves	The Intergovernmental Panel on Climate Change (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.

Table 17.8: Projected Global Impacts of Climate Change	
Climate Change Issue	**Projected Global Impacts**
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 the northern parts of the UK will experience overall increases of up to 10%, whilst southern areas may experience decreases of up to 5%. Overall, the UK is expected to see a general increase in precipitation trends up to the year 2100.
Rising Sea Levels	The most recent modelling indicates global sea level rise of 0.26-0.77m by 2100, under a 1.5°C warming scenario. Risk is amplified on small islands and in low lying coastal areas and deltas.
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 m s-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.
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

17.10.3 Climate change will have both direct (operational and performance-based) and indirect (securing of supplies and rising energy costs) impacts on operations at the Site. To study the regional impacts of climate change on the Proposed Development, the Climate Change Projections for the UK (UKCP18) are used. Regional and Local projections represent small scale climate changes through a narrower sampling of

uncertainty and provide the detail needed to inform local decision-making regarding adaptation.

17.10.4 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 in Cardiff Bay. The following graphs are based on the four Representative Concentration Pathways (RCP) and show how the climate in the region could change up to the year 2100, compared to a 1982-2000 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.

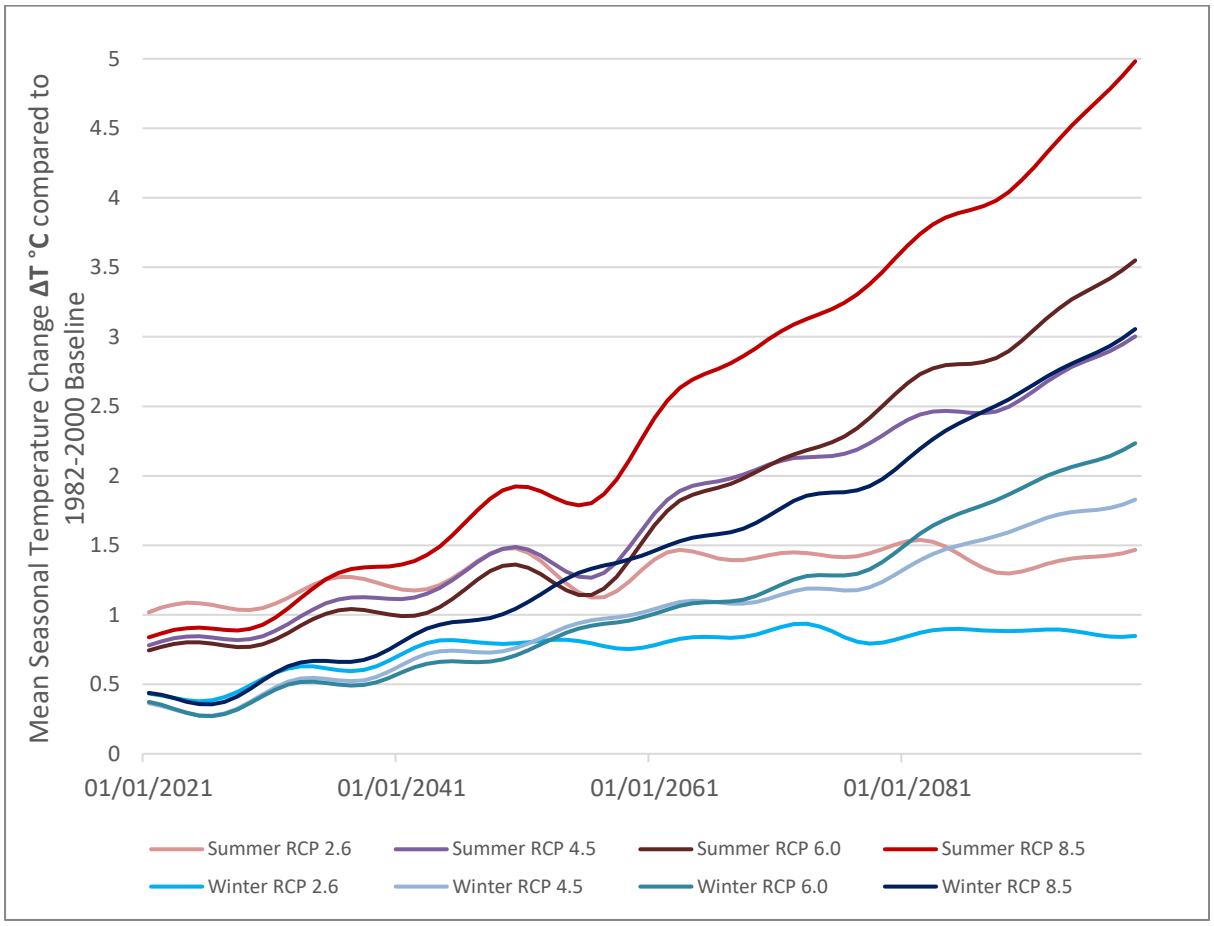

Figure 17.1: Projected changes in seasonal Mean Air Temperature across four RCP scenarios, from 2021-2099 compared to the 1981-2000 baseline, using the probabilistic projections (50th percentile) for a 25km grid around Cardiff, Wales.

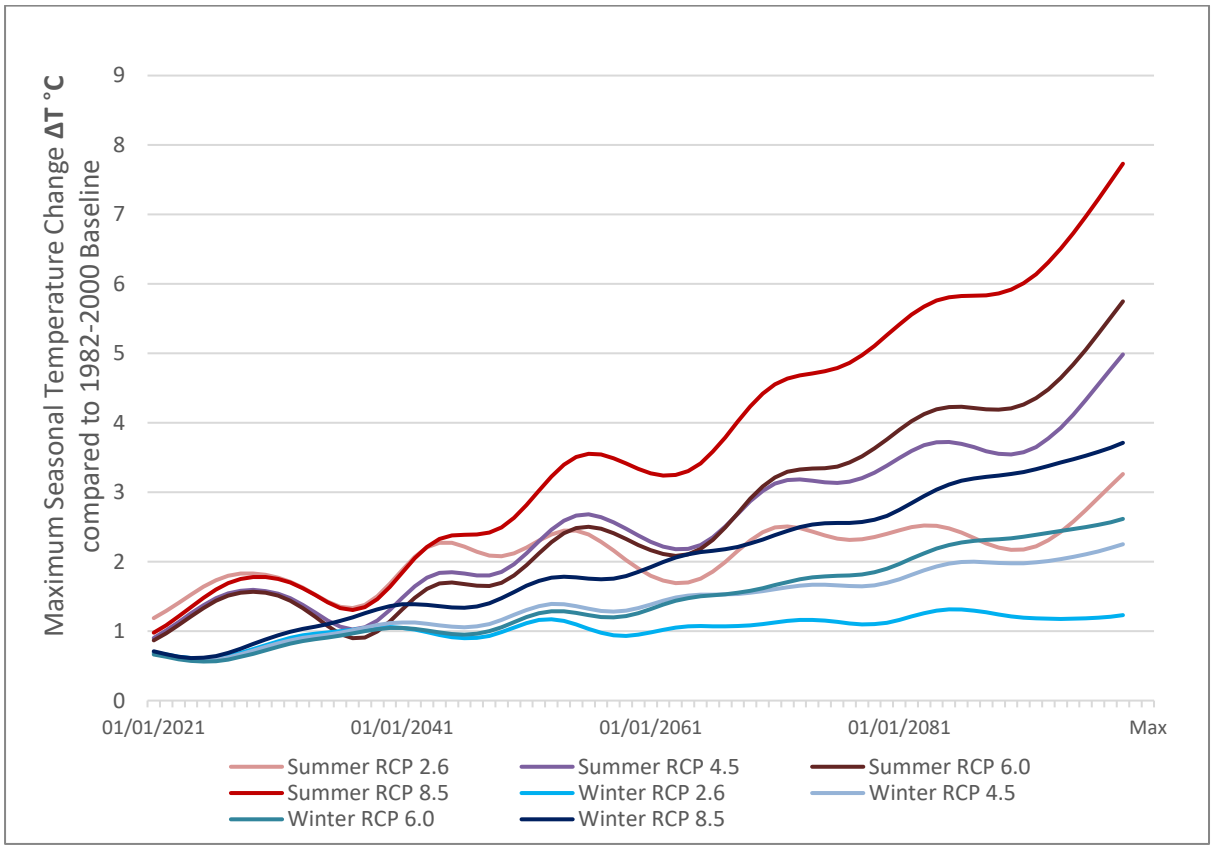

Figure 17.2: Projected changes in seasonal Maximum Air Temperature across four RCP scenarios, from 2021-2099 compared to the 1981-2000 baseline, using the probabilistic projections (50th percentile) for a 25km grid around Cardiff, Wales.

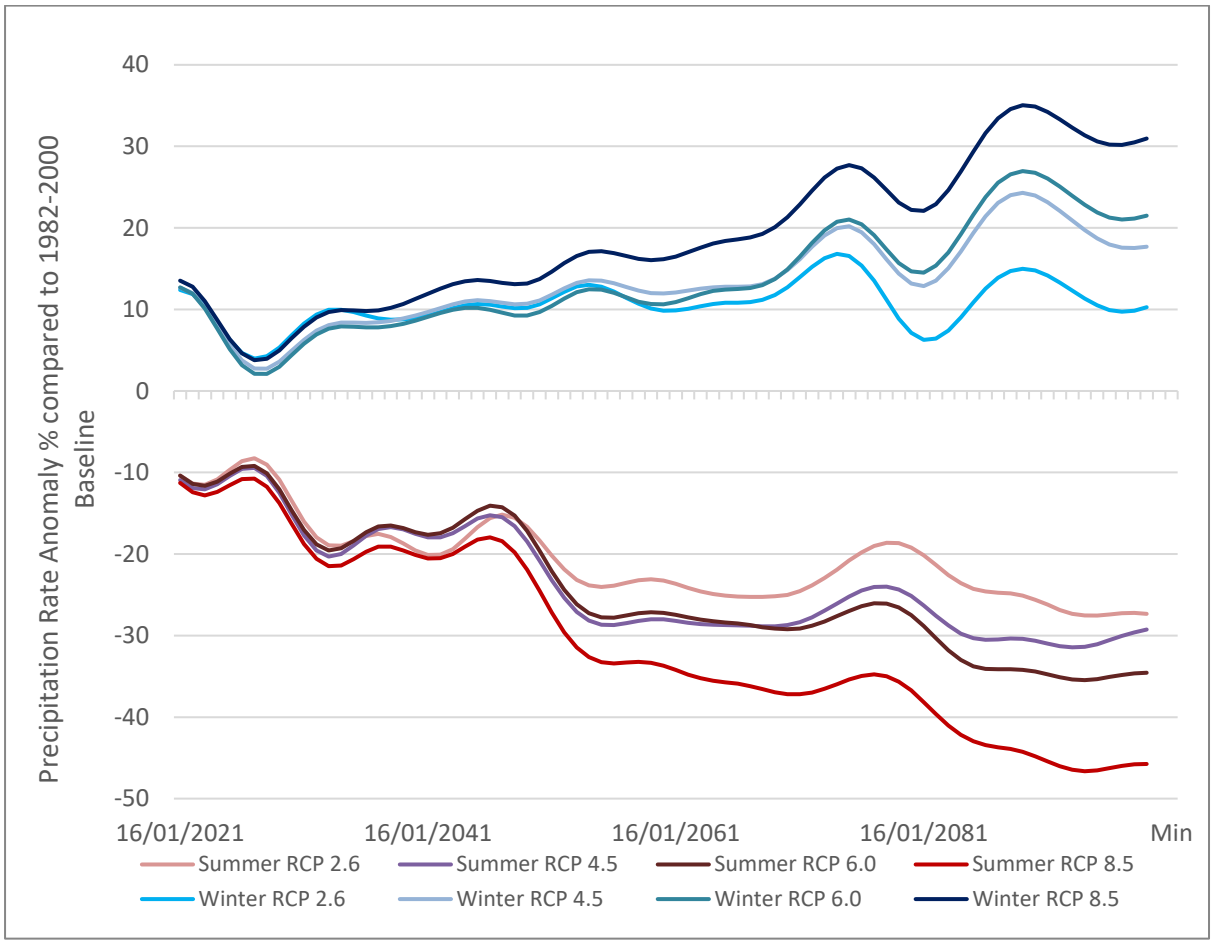

Figure 17.3: Seasonal average Precipitation rate anomaly (%) for 2021-2099 compared to the 1981-2000 baseline for all RCP scenarios using probabilistic projections (50th percentile) for a 25km grid around Cardiff, Wales.

17.10.5 Figure 17.1 and Figure 17.2 show that temperature is set to rise in summer and winter, even in a best-case scenario (RCP2.6), over the assumed 80-year lifetime of the project. The average temperature rise could be between 1.5°C and 5.0°C in the summer and 0.9°C and 3.1°C in the winter. Maximum temperatures could range between 3.3°C and 7.7°C in the summer and 1.3°C and 3.7°C in the winter.

17.10.6 Figure 17.3 shows that summer precipitation rates are reducing over the assumed 80-year lifetime of the project from between -27.54mm to -46.64mm. Climate projections suggest that winter precipitation rates are increasing from between 16.81mm to 35.04mm by 2100.

Climate Scenarios and Timelines Considered

17.10.7 Climate projections for the 2030s, 2050s, 2070s and 2090s time periods were selected to correspond with the proposed timescales for the Proposed Development's construction and operational phases.

17.10.8 The conservative approach recommended as best practice by the IEMA guidance (2020) 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. This assessment considers the regional variations in Glamorgan during these periods. A reference range is provided for possible outcomes and their relative likelihoods, using the 10% probability level as a lower limit and the 90% probability level as an upper limit.

17.10.9 These scenarios and probability levels were used to provide credible projected changes to climate variables including an indicative level of uncertainty for the future climate baseline (Table 17.9).

Future Climate Baseline

17.10.10 Table 17.9 provides a summary of a range of projected changes to climate variables. This can be used to build up a holistic view of future climate and assess potential impacts to determine a future climate baseline, using RCP8.5 as a conservative approach. 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.

17.10.11 The worst-case scenario indicates an increase in mean temperature in both summer and winter which corresponds with seasonal precipitation increasing in winter and decreasing in summer. This highlights the need for the Proposed Development to be able to deal with the potential risks for both increased flooding and increased heatwaves.

Table 17.9: Quantitative summary of the future baseline for key climatic variables in Cardiff, UK

Season	Variable	Time period*	Projected change at				
			Lower Probability		Median	Higher Probability	
			5th percentile	10th percentile	50th percentile	90th percentile	95th percentile

Winter	**Mean Temperature (ºC)**	2030s	-1.15	-0.77	0.53	1.83	2.20
		2050s	-0.73	-0.33	1.08	2.51	2.92
		2070s	-0.53	-0.03	1.70	3.48	3.99
		2090s	0.00	0.57	2.58	4.68	5.28
	Mean Precipitation (%)	2030s	-38.4	-28.0	8.6	43.7	53.9
		2050s	-38.1	-26.3	14.5	54.9	66.8
		2070s	-32.3	-21.1	21.6	68.0	81.1
		2090s	-30.8	-17.2	30.1	80.2	94.9
Summer	**Mean Temperature (ºC)**	2030s	-0.96	-0.52	1.04	2.63	3.08
		2050s	-0.51	-0.02	1.73	3.57	4.11
		2070s	0.17	0.76	2.93	5.24	5.91
		2090s	0.83	1.56	4.20	7.06	7.88
	Mean Precipitation (%)	2030s	-72.5	-61.0	-16.0	44.3	59.3
		2050s	-79.2	-68.3	-25.4	48.2	59.7
		2070s	-91.2	-80.1	-35.7	49.7	60.9
		2090s	-99.7	-90.5	-43.8	55.1	68.6

*UKCP18 provides 20-year time slices, hence averages taken for: 2030s (2020-2039), 2050s (2040-2059), 2070s (2060-2079), 2090s (2080-2099) under RCP 8.5.

17.11 Assessment of Effects

Climate Change Vulnerability

17.11.1 The Design of Future Climate Report published in 2010 identified three broad risk categories to buildings from future climate change in the UK, which are:

- **risk to comfort and energy performance:** warmer winters will reduce heating requirements, however the increased use of cooling systems in the summer will present a challenge to energy consumption and carbon emissions;
- **risk to construction:** resistance to extreme conditions, detailing, and the behaviour of materials; and
- **risk to water management:** management of water during both flooding and drought events, and changes in soil composition.

17.11.2 Combined, these categories can be considered climate change threats that could result in increased energy demands, economic losses and loss of life.

17.11.3 Climate change may result in variations in approach to general building design and construction in order to offer a higher degree of protection against the identified risks. Many of these improvements will be brought about using existing off-the shelf

components that are in common use in other places around the world but may not previously have been considered necessary in parts of the UK.

17.11.4 As well as seeking improvements in the construction techniques for the Proposed Development, there will also be a need to improve various aspects of the operational performance to provide more resilience against climate change.

17.11.5 At more localised levels the effects themselves 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 a resilience and a 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 months.

17.11.6 Table 17.10 highlights the impact on the Proposed Development that could arise from climatic effects, reproduced from data in the National House Building Council and European Commission reports and the UK Climate Change Risk Assessment Report. The level of reduction in global emissions will alter the likelihood of these effects as the climatic conditions will vary, this is shown within the range of temperatures and precipitation levels seen across the RCPs in Table 17.9. The climatic projections shown in the above figures are seasonal averages and therefore there is potential for even higher temperatures within that season.

17.11.7 The UK Climate Change Risk Assessment Evidence Report identifies flooding and high temperatures as posing the greatest risks to the built environment. In the interest of completeness, and to account for potential irregular, adverse extreme weather, this section will also cover reducing risk to snow and ice. However, projections suggest that overall these will become a decreasing risk with climate change.

Table 17.10: Potential Impacts on Proposed Development

Climatic Factor	General Impact	Component/Sub Structure Impact
Soil Drying	Increase will affect water tables and could affect foundations in clay soils.	Increased risk of basement heave or subsidence, water ingress, consequential damage to finishes and stored items. Ground shrinkage can lead to failure of electrical, gas

Table 17.10: Potential Impacts on Proposed Development		
Climatic Factor	**General Impact**	**Component/Sub Structure Impact**
		and water pipes, foundations and sub-structures.
Temperature	Maximum and minimum changes will affect heating and cooling. Frequency of cycling through freezing point will affect durability. Daily maximum and minimum temperature will affect thermal air movement. Increased temperatures may cause an increase in leachate gases.	Overheating of mechanical and electrical equipment effecting lifespan, reliability and potential health and safety issues. Plastic materials will have a reduced lifespan. Structure/cladding/roofing membranes, sealants, pavements and roads have increased risk of cracking. Reduced capacity of overheated power lines. Building overheating (due to increased fabric efficiency and incorrect implementation). Solar PV modules work slightly less efficiently at high temperatures and some studies[1] have shown that high temperatures can age at a faster rate. Decreased labour productivity.
Relative Humidity	Increase will affect condensation and associated damage or mould growth.	Increase in respiratory diseases amongst site workers.
Precipitation	Increase and decrease will affect water tables; cleaning costs will be increased in winter, with associated redecoration requirements; durability and risk of water ingress will be affected by combination of precipitation increase and gales.	Increased damage to capping system and higher risk of failure, increased chances of flooding. Structure/cladding/roofing membranes and sealants have increased risk of cracking due to different moisture movements. Damage to foundations and basements. Delays in construction and increased costs. Increased risk of subsistence.
Gales, Storms, Extreme Weather	Increase will affect need for weather tightness, risk of water ingress, effectiveness of air	Increased damage to roofing and higher risk of failure.

[1] Patt, A., Pfenninger, S. and Lilliestam, J., (2013). Vulnerability of solar energy infrastructure and output to climate change. Climate Change 121 pp93-102

Table 17.10: Potential Impacts on Proposed Development		
Climatic Factor	**General Impact**	**Component/Sub Structure Impact**
	conditioning, energy use, risk of roof failures.	
Solar Radiation	Increase may affect need for solar glare control.	Window specification and glare control requirement.
Cloud Cover	Increase/decrease in seasonal lighting needs.	Changes in lighting systems and glare control requirement.

Sensitivity of Receptors

17.11.8 The sensitivity of receptors has been determined through an assessment of the susceptibility and vulnerability of the Site to future climate changes. Full details of the definitions used to determine susceptibility and vulnerability can be found within Appendix 17.2.

17.11.9 The results of the assessment of the susceptibility and vulnerability of receptors are given in Table 17.11 below. The level of likelihood for the climate change issue was also identified in Table 17.11 according to the future climate baseline outlined in Table 17.9. The future baseline shows that at certain points in the Site's lifetime certain impacts are more likely than others.

Table 17.11: Assessment of Susceptibility and Vulnerability of the Proposed Development to Future Climate Baseline				
Climate Change Issue	**Receptors Impacted**	**Susceptibility** *(Low/Medium/High)*	**Vulnerability** *(Low/Medium/High)*	**Likelihood** *(Low/Medium/High)*
Soil Drying	Building Structure, Species and Habitats	Medium	Low	Medium
Increased Temperature	Site Workers, Structure,	Medium	Medium	High

Table 17.11: Assessment of Susceptibility and Vulnerability of the Proposed Development to Future Climate Baseline				
Climate Change Issue	**Receptors Impacted**	**Susceptibility** *(Low/Medium/High)*	**Vulnerability** *(Low/Medium/High)*	**Likelihood** *(Low/Medium/High)*
	Species and Habitats			
Relative Humidity	Site Workers	Medium	Medium	Medium
Precipitation Changes and Water Availability	Site Workers, Structure, Species and Habitats	Medium	Medium	High
Snow and Ice	Site Workers, Structure	Low	Low	Low
Gales, Storms, Extreme Weather	Structure, Species and Habitats	Medium	Medium	High
Solar Radiation	Site Workers, Structure	Medium	Medium	Medium
Cloud Cover	Site Workers	Low	Low	Low

Magnitude of Effects

17.11.10 A qualitative assessment has been undertaken based on the data from UKCP18 identified in Table 17.9 to assess the magnitude of the effects of climate change (see Appendix 17.2 for full details). In line with the IEMA guidance, a combination of probability and consequence is used to reach a reasoned conclusion on the magnitude of the effect of climate change on the Proposed Development (see Table 17.12). The

guidance indicates that the greater the probability of an effect, the more likely it is to occur, and the higher significance it will have on the Proposed Development if these projected changes in climate are not considered at the outset of the project.

Table 17.12: Assessment of Magnitude of Effects on Proposed Development from Future Climate Baseline

Climate Change Issue	Likelihood	Consequence	Magnitude of Effects
Soil Drying	Medium	Minor Adverse	Minor Adverse
Temperature	High	Moderate Adverse	Moderate Adverse
Relative Humidity	Medium	Moderate Adverse	Moderate Adverse
Precipitation	High	Moderate Adverse	Moderate Adverse
Snow and Ice	Low	Minor Adverse	Minor Adverse
Gales, Storms and Extreme Weather	High	Moderate Adverse	Moderate Adverse
Solar Radiation	Medium	Moderate Adverse	Moderate Adverse
Cloud Cover	Low	Minor Adverse	Minor Adverse

17.11.11 The impact of changes to the future climate baseline for the Proposed Development (summarised in Table 17.12) has been assessed to be within the medium to high likelihood and have moderate consequences if not mitigated against. Taking into account the control mechanisms and mitigation measures in place through Building Regulations, which the Proposed Development would be expected to comply with as a minimum standard, the overall magnitude of effects is considered to be relatively low for the 80-year lifetime of the project.

Significance Assessment

17.11.12 The significance of the magnitude of effects on the Proposed Development has been determined using the Significance Matrix for Climate Resilience (see Appendix 17.2). This is summarised in Table 17.13.

Table 17.13: Assessment of Significance

Climate Change Issue	Magnitude of Effect	Significance

Soil Drying	Minor Adverse	Not Significant
Temperature	Moderate Adverse	Significant
Relative Humidity	Moderate Adverse	Significant
Precipitation	Moderate Adverse	Significant
Snow and Ice	Minor Adverse	Not Significant
Gales, Storms and Extreme Weather	Moderate Adverse	Significant
Solar Radiation	Moderate Adverse	Significant
Cloud Cover	Minor Adverse	Not Significant

17.11.13 The significance of the magnitude of effects on the Proposed Development is assessed in conjunction with the Significance Criteria for determining the impact of the Proposed Development on climate change. The overall significance of future climate change on the Proposed Development prior to mitigation is deemed to be significant (refer to Appendix 17.2). This assessment is based on the reasonable assumption that the Proposed Development will meet the minimum standards required by Building Regulations. The Proposed Development should implement mitigation measures to further reduce GHG emissions and build in resilience to future changes in climate.

17.12 Mitigation

17.12.1 Key points are noted below regarding potential mitigation measures that could be considered for each receptor and climate variable as assessed. This is not an exhaustive list. It is anticipated that these aspects will be considered in more detail during the next stage of planning.

Temperature, Relative Humidity, Solar Radiation

17.12.2 Following the IPCC Fifth Assessment on Climate Change Report series, key findings for the building sector were summarised into a briefing called Climate Change: Implications for Buildings. It found that increased temperatures, precipitation and weather extremes pose a direct threat to building construction through delays, changes to building seasons and the increased likelihood of rebuilding and repair work. The Carbon Trust found that energy costs and associated CO_2 emissions are 30% higher in an air-conditioned building compared to natural ventilation, on top of

increased capital and maintenance costs. The UK Climate Change Risk Assessment 2017 states that buildings will need to be carefully designed to reduce heat loss during winter, reduce solar gain during summer, and maximise the effectiveness of natural ventilation.

17.12.3 The increasing number of heatwaves associated with an increase in temperature could result in periods of dry environments, where the fire risk will increase significantly. The Proposed Development will be built to current Building Standards which will include for fire safety measures. All materials used in the linings, materials and finishes of buildings will limit heat release through strict compliance with national fire regulations. The use of fire and smoke alarms in all buildings is mandatory and the implementation of basic fire preparation and response plans will significantly reduce the risks to human life. The Proposed Development will also incorporate good design and technologies to reduce the risk of solar radiation exposure for site workers and visitors to the Site.

17.12.4 The overall residual risk associated with building overheating cannot be fully determined without full building specifications, which have not been available at the time of this assessment.

Precipitation and Water Availability

17.12.5 The Site is located wholly within Flood Zone B, defined as an area that is known to have flooded in the past. Changes to precipitation levels as a result of climate change is set to increase the risk of flooding events across the UK, but also in the vicinity of the Site in Cardiff Bay.

17.12.6 The assessment of Water Resources (Chapter 8) assumes that construction will be undertaken in accordance with industry best practice, and that a Construction Environmental Management Plan (CEMP), or equivalent, will be developed, adopted, and adhered to throughout the construction phase of the Proposed Development.

17.12.7 Mitigation of effects upon flow rates and volumes of watercourses within the surface water catchments during the operational phase would be achieved through design of a suitable sustainable surface water drainage scheme for the Proposed Development, which takes into account climate change (1 in 100 years plus climate change event).

17.12.8 Water resources availability also presents a challenge that is expected to be exacerbated by a changing climate. Water efficiency measures can reduce stresses on the water network overall and improve the networks overall resilience.

17.12.9 The Proposed Development will be required to meet all the environmental requirements set out by Welsh Water and comply with appropriate standards. It is proposed for the water demand of the Proposed Development to be reduced through the provision of a water storage system within the Arena building. This is a proven solution for buildings with high peak demands that cannot be provided from the mains water network.

17.12.10 Measures that can improve water efficiency for the masterplan should be finalised at the detailed design stage when building services are specified.

Extreme Weather, Storms and Gales

17.12.11 It is difficult to attribute human induced climate change to any particular extreme weather event. In the absence of observed trends, there have been no Met Office studies so far providing a link between UK storminess and climate change. However, UKCP18 projects an increase in near surface wind speed in the second half of the 21st century during winter, although the increase in wind speed is modest compared to monthly and seasonal variability. Storm damage will typically involve the damage or removal of roof coverings or potentially the whole roof structure.

17.12.12 Wind loading can apply significant lateral forces to buildings and modelling to ensure that adequate bracing is in place to deal with these forces will be necessary. Eaves and roof structures that overhang external walls may be particularly susceptible to the effects of wind loading and sufficient consideration will be required to ensure that problems are avoided. It is not possible to quantify precisely future impacts of climate change vulnerability as insufficient data is available. However, a suitable margin of error should be used within the loading calculations to ensure the roof materials remain fixed in position during extremely severe wind conditions.

17.12.13 The Wind Microclimate assessment (Chapter 19) concluded that wind mitigation measures consisting of landscaping elements (7-10m tall), or pedestrian level mitigation (porous screens or art) are recommended to be included within the Arena area to improve the local windiness to 'Standing' or lower 'Strolling' levels, as required for queueing or mild walking activities. Windiness levels in other areas around the

Arena and Hotel are expected to remain suitable for intended pedestrian activities and no additional mitigation measures have been recommended around these plots.

17.12.14 Windiness levels around the illustrative masterplan plots which form the Waterfront Quarter, the Bute East Dock Quarter, the Car Parking Quarter, the Cultural Quarter, and Mixed Use Quarter are generally expected to remain suitable for general public access. Additional wind mitigation measures such as additional landscaping canopies or other external measures may be required within some of the most exposed areas around the outline plots. Specifics of required mitigation would be established once the details of building massing, entrance locations and uses of outdoor areas are fully defined.

17.12.15 Although projections suggest an overall decrease in cold spells, it is still important to consider risk mitigation in the event of adverse extreme weather. Appropriate design measures to reduce the risk to human health should be considered for the Proposed Development during the finalised building designs.

Air Quality and Transport

17.12.16 The relationship between air quality and climate change is highly complex but is an important consideration due to the direct risk to human health. For example, when atmospheric pressure increases pollutants are concentrated to the ground, resulting in increased respiratory health issues. Climate variations across regions will affect air quality differently. Increased precipitation aids the clearing of pollutants from air, whilst warmer, drier conditions stalls air that is saturated in pollutants e.g., smog.

17.12.17 The impact of the Proposed Development on local transport infrastructure likely to be affected has been assessed in Chapter 7 (Traffic and Transport). It states:

"the residual effects on severance, accidents and safety and hazardous loads would be unaffected by climate change. The large majority of movements will be undertaken by pedestrians walking, cycling or using public transport and therefore the impacts of climate change are unlikely to have a direct impact on them. Road surfaces may change due to the increases in summer temperatures and therefore could potentially

impact vehicles or cyclists using the local roads; however, this is expected to be a negligible issue in the short or medium term."

17.12.18 A Transport Assessment (TA) has been completed by WSP to support the hybrid planning application for the development of part of the masterplan area. The key design principles set by the development proposals include:

- Provision of new key pedestrian links and a new bus corridor, linking the Site to the surrounding area;
- Implementation of sustainable travel corridors, linking the Site to the wider existing transport network;
- Development and implementation of a Travel Plan to promote sustainable travel choices to, from, and around the vicinity of the Site;
- Provision of a permeable design to facilitate movement through the Site; and
- Provision of leisure and recreational opportunities that reduce vehicle emissions.

17.12.19 The Air Quality assessment (Chapter 11) has assessed emissions from both the construction phase and operational phase, taking into consideration baseline pollutant concentrations of NO_2, PM_{10} and $PM_{2.5}$. This includes dust and particulate matter generation during the construction phase and emissions from development-generated traffic in the operational phase. The assessment concluded that best practice mitigation measures such as electric vehicle charging points and low-NO_x boilers for heating in residential properties could be implemented to further reduce the impact of the Proposed Development.

Landscape and Biodiversity

17.12.20 Impacts on biodiversity can include but are not limited to mortality, biome shifts, ecosystem change, water scarcity/flooding, pest exacerbation and ecosystem feedback capabilities, including carbon sequestration. In the establishment of landscapes and ecological habitats the Proposed Development will need to consider the climate resilience of enhancements that are used. Key aspects suggested for consideration when designing climate resilient landscaping are:

- Species selection: Drought tolerant species e.g., enzymic resilience to warmer temperatures;
- Sensitivity to watering e.g., induced root hypoxia and rot from oversaturation;
- Growth inhibition e.g., pollution tolerance;

- Wind tolerance e.g., strong, deep root structures;
- Year-round ecosystem services e.g., forage and shelter capability during difficult seasons to continually support ecology and human needs;
- Avoiding fragmentation of green spaces, landscapes and ecological habitats where possible; and,
- Control use and ongoing spread of invasive and alien species that may impede native species ability to adapt or be in competition for resources during times of decreased availability e.g., as a response of extreme weather.

17.12.21 Landscape planting proposed as part of the Proposed Development will compensate for losses to the habitats and will serve to enhance and improve biodiversity at the Site post construction. Those native plant species that have the best tolerance to changeable climate and a possible increase in extreme weather events will be selected. This will ensure that the trees and other plants have the best chance of reaching maturity and increase the Proposed Development's resilience to changes in climate variables.

17.12.22 The masterplan is being designed as an integrated multi-functional space. Design measures are being incorporated into the wider development to reduce the urban heat island effect. This includes planting native deciduous trees and increasing the availability of green and blue spaces. The use of nearby water features and vegetation to improve landscaping can provide a cooling effect as well as providing insects, invertebrates, small mammals and humans shading from the elements.

17.13 Residual Effects

17.13.1 The Proposed Development should implement mitigation measures to reduce GHG emissions and build in resilience to future changes in climate, which would then result in the residual effects being deemed not significant.

17.13.2 According to the IPCC's 2018 Special Report on Global Warming of 1.5°C , there is high confidence that climate-related risks for natural and human systems depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options.

17.13.3 The report states *"Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and*

infrastructure (including transport and buildings), and industrial systems (high confidence). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (medium confidence).”

17.13.4 The Joint 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. However, the uncertainties associated with probabilistic climate projections are outside of the Joint Applicant’s control and cannot be fully mitigated against.

17.13.5 It is assumed that with the mitigation each individual discipline throughout the ES has suggested, there will not be a significant impact on the development as a result of climate change in the long-term.

17.14 Assessment of Cumulative Effects

Inter-Cumulative Effects

17.14.1 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 to reduce carbon emissions across the board and each and every development has a duty to minimise its own emissions as far as technically viable.

17.14.2 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:

- The emissions from other developments fall under Scope 3, which do not form part of the assessment under the methodology outlined;
- 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 Joint Applicant's control.

Intra-Cumulative Effects

17.14.3 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, for example air quality and water resources (and these have been assessed within the relative chapters of this ES), 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.

17.15 Conclusion

Assessment of Impacts from Emissions

17.15.1 The Proposed Development's absolute emissions with embedded mitigation were modelled to be below the baseline emissions for the Arena Quarter (Arena and Hotel). This represents a minor positive beneficial impact. The emission saving achieved over the 80-year project lifetime was reduced when taking into account the decarbonisation of the national grid which negates any additional savings over a longer timeframe. The Joint Applicant is considering measures that exceed the minimum standards required by Building Regulations as well as meeting the Future Buildings Standard. Overall, this represents a positive beneficial impact which is significant.

17.15.2 The Proposed Development's absolute emissions with embedded mitigation were modelled to be below the baseline emissions for both scenarios being considered for the masterplan. This represents a minor positive beneficial impact, although the All Electric scenario will have greater benefits as the grid decarbonises.

17.15.3 These results should not be interpreted as the Proposed Development having no impact on climate change through greenhouse gas emissions. It signifies that the Proposed Development is taking measures that will improve the overall impact above

a development of the same size, with comparable facilities, constructed to Building Regulations.

17.15.4 It is recommended that the assessment of GHG emissions for the illustrative masterplan element of the Proposed Development should be updated during Reserved Matters once more detailed information is available, to ensure that the modelled emissions for the masterplan are accurate.

Assessment of Climate Resilience

17.15.5 The overall significance of future climate change on the Proposed Development is deemed to be not significant. This assessment is based on the reasonable assumption that the Proposed Development will meet the minimum standards required by Building Regulations in place at the time of construction and will implement mitigation measures to reduce GHG emissions and build in resilience to future changes in climate.

17.15.6 It will not be possible to eliminate every risk associated with climate change but through intelligent design, preparation and responsible construction, these risks will be minimised. Discussion and recommendations have detailed reducing these risks in key areas such as overheating, flooding and extreme weather, which has taken into consideration not only the health and safety of the users of the Proposed Development, but the resilience of the Proposed Development itself. It is assumed that with the mitigation each individual discipline throughout the ES has suggested, there will not be a significant impact on the development as a result of climate change in the long-term.