Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Environmental Statement Chapter 18: Climate Change

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18.1 Introduction

18.1.1 This chapter of the Environmental Statement provides the context, baseline data, methodology and approach, assessment results and mitigation measures for the three assessments under the climate change topics:

a) Greenhouse gas (GHG) emissions assessment;

b) Climate change resilience (CCR) assessment, and

c) In-combination climate change impact (ICCI) assessment.

18.1.2 The **GHG emissions assessment** quantifies the potential GHG emissions associated with the construction and operation of the proposed development and identifies mitigation measures to reduce these emissions.

18.1.3 The **CCR assessment** evaluates the effectiveness and feasibility of adaptation measures integrated into the proposed development to avoid or reduce hazards and/or increase resilience of the proposed development to climate change impacts.

18.1.4 The **ICCI assessment** evaluates the combined effect of the proposed development and potential climate change impacts on the receiving environment during construction and operation.

18.1.5 Consideration of the three related but separate climate change assessments within this chapter provides a holistic assessment of climate change aspects related to the proposed development.

18.2 Legislation, policy context and guidance

18.2.1 The climate change assessment has been undertaken in line with the relevant legislation, policies and guidance documents, as outlined below.

Paris Agreement

18.2.2 Adopted in 2015 and entered into force in November 2016, the Paris Agreement is an international climate agreement aiming to limit global temperature increase this century to less than 2 degrees Celsius above pre-industrial levels. It additionally establishes a goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing

vulnerability to climate change. During the 24th Conference of the Parties to the United Nations Convention on Climate Change, held in Katowice in December 2018, nearly 200 countries signed up to a 156-page rulebook. This rulebook acts as a set of guidelines for implementing the Paris Climate Change Agreement.

EIA Directive 2014/52/EU

18.2.3 The Directive 2014/52/EU states that EIAs shall identify, describe and assess the direct and indirect significant effects of climate change relevant to the project. The regulations implementing this directive were transposed into UK legislation in May 2017.

Climate Change Act 2008

18.2.4 The Climate Change Act 2008 committed the UK to its first statutory carbon reduction target to reduce carbon emissions by at least 80% from 1990 levels by 2050. It also requires that five-yearly carbon budgets are set and not exceeded. It also established a requirement to undertake a climate change risk assessment every five years and develop a programme for adaptation action in response to the risks identified.

Well-being of Future Generations (Wales) Act 2015

18.2.5 The Well-being of Future Generations (Wales) Act 2015 requires public bodies to carry out sustainable development, which is the process of improving the economic, social, environmental and cultural well-being of Wales by taking action aimed at achieving the well-being goals. The Act establishes seven well-being goals, which specifically reference acting on climate change. As such, the Act requires all public bodies to embed climate change into their decision-making.

Environment (Wales) Act 2016

18.2.6 The Environment (Wales) Act 2015 requires Welsh Ministers to meet greenhouse gas reduction targets for Wales and establishes a 2050 emission target of 80% reduction in net emissions from the baseline year (1990 or 1995 depending in the specific greenhouse gas). Progress to this target is supported by interim emissions targets set for every ten years until 2050 and carbon budgets established for five-yearly periods.

Planning (Wales) Act 2015

18.2.7 The Planning (Wales) Act 2015 emphasises that national, strategic and

local planning must be carried out in accordance with the sustainable development definition and principle as per the Well-being of Future Generations (Wales) Act 2015.

Clean Growth Strategy (UK)

18.2.8 Published in October 2017, the Clean Growth Strategy outlines the UK government's proposals to decarbonising all sectors of the UK economy though the 2020s.

Climate Change Strategy for Wales

18.2.9 Published in October 2010, the Climate Change Strategy for Wales establishes a target to reduce greenhouse gas emissions by 3% per year from 2011 in areas of devolved competence, against a baseline of average emissions between 2006 and 2010. It is supported by the actions set out in the Delivery Plans for emission reduction and adaptation.

UK Climate Change Risk Assessment

18.2.10 The second UK climate change risk assessment was published in 2017, as required under the Climate Change Act 2008. It establishes the six priority risk areas for action over the following five years. It is based on the independent evidence report published by the Committee on Climate Change.

Pembrokeshire County Council Local Development Plan (2013-2021)

18.2.11 Strategic Objective A in the LDP is mitigating and responding to the challenge of climate change. It is supported by Strategic Policy 1 – Sustainable Development and General Policy GN.2 Sustainable Design, on the basis that climate change is a key long term environmental challenge and the need to reduce emissions and use resources more efficiently is essential.

Carmarthenshire County Council Local Development Plan

18.2.12 The LDP includes several policies and objectives relating to sustainable development. Of particular relevance is Strategic Objective 5 – to make a significant contribution towards tackling the cause and effect of climate change by promoting the efficient use and safeguarding of

resources.

Carmarthenshire County Council Local Flood Risk Management Strategy

18.2.13 Carmarthenshire County Council (CCC) are a designated Lead Local Flood Authority (LLFA) under the Flood and Water Management Act (the Act) 2010 and are required to produce a Local Flood Risk Management Strategy.

Pembrokeshire Local Flood Risk Management Strategy 2012

18.2.14 Pembrokeshire County Council has responsibility for 'local flood risks', which includes the risk of flooding from ordinary watercourses, surface runoff and groundwater. The Council have published a draft Flood Risk Management Strategy that details responsibilities, measures, objectives and assessments of flood risk.

Guidance

Institute of Environmental Management and Assessment (IEMA) (2015) Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation

18.2.15 This guidance provides a framework for the consideration of climate change resilience and adaptation in the EIA process, in line with Directive 2014/52/EU.

IEMA (2017) Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance

18.2.16 This guidance aims to assist EIA practitioners with addressing greenhouse gas emissions assessment and mitigation. It outlines the process for undertaking the carbon assessment as it relates to the EIA stages.

PAS 2080:2016 Carbon management in infrastructure

18.2.17 PAS 2080 provides a framework on how to manage whole life carbon[1] when delivering infrastructure assets and programmes of work. This assessment broadly follows the principles set out in PAS 2080 for the quantification of greenhouse gas emissions.

[1] Carbon is used throughout this report as shorthand for emissions of all greenhouse gases, measured in units of carbon dioxide equivalent (CO_2e).

18.3 Scoping and consultation

18.3.1 The purpose of the EIA screening and scoping exercise is to determine the topics to be included in the EIA. As a consequence of the delays to the project in early 2018, the decision was made to update the Screening Report, Scoping Report and the full Environmental Statement (ES) to take account of the most recent 2014 Directive (as amended) 2014/52/EU. Following the introduction of the regulations implementing EIA Directive 2014/52/EU in May 2017, the climate change chapter has been introduced into the EIA as a standalone topic chapter.

18.3.2 No consultation has been undertaken in the preparation of this chapter.

18.4 Assessment Methodology

GHG emissions assessment

Capital carbon

18.4.1 The scope of the capital carbon assessment covers the following:

a) **Materials** – The total amount of carbon produced during resource extraction, transportation, manufacturing and fabrication, to bring a product to its existing state;

b) **Plant** – The carbon produced from the combustion of fuel or consumption of energy by machinery, plant and vehicles used on site, including vehicles used for moving fill within the alignment, and

c) **Transport** – The carbon produced from the combustion of fuel or consumption of energy by the transportation of materials, plant and people to and from site.

18.4.2 The method applied used the Scheme material quantities, derived from the highways design model and drawings, which were then converted into CO_2e through the application of documented emission conversion factors.

18.4.3 The emission conversion factors used in the assessment are from the following sources:

a) 'Inventory of Carbon and Energy (ICE) Version 2.0' developed in 2008 and updated in 2011 by the University of Bath: Sustainable Energy Research Team;

b) 'Greenhouse gas reporting: conversion factors 2017', published in August 2017 by the UK Department of Business, Energy and Industrial Strategy (BEIS);

c) 'Environmental Product Declarations (EPDs)' – specifically for methacrylate resin products[2], and

d) 'Updated Energy and Emissions Projections: 2017', published in 2018 by the Department for Business, Energy and Industrial Strategy[3].

18.4.4 Volume 3 Appendix 18.1 summarises the emissions factors used in the carbon assessment.

Operational carbon

18.4.5 The scope of the operational carbon covers the emissions resulting from consumption of energy in all network assets. In this assessment, it includes:

a) **Maintenance** – This includes carbon emissions that result from activities such as the wearing course, road markings, railings and fences, grass cutting or gritting for example. As outlined in the assumptions below, the quantification of maintenance emissions in this assessment is limited to the embodied material emissions associated with resurfacing the road.

b) **Street lighting** – Emissions from electricity consumed by street lighting along the road alignment.

18.4.6 As outlined in PAS 2080, other sources of operational carbon can include energy for control and automation systems, signage, signalling and other energy related emissions and operational processes necessary for the operation and management of transport assets. The Scheme does not have any energy-consuming control and automation systems, signage or signalling, so these were excluded from the assessment.

User carbon

18.4.7 Changes in user carbon as a result of the Scheme were assessed. The assessment was undertaken following the principles set out in WebTAG guidance[4] for the assessment of greenhouse gases, which is predominantly used for option appraisal and monetisation of impacts to feed into the economic appraisal of a scheme.

18.4.8 The study area of the assessment was taken to be the entirety of the traffic model network area, to ensure all potential impacts resulting from changes to traffic were captured. The study area is shown in Figure 18.1.

[2] Bauder, EPD for MMA resin products, https://www.bauder.co.uk/assets/e/n/environmental-product-declaration-mma-resin-products-liquitec.pdf [Accessed November 2017]
[3] BEIS, Updated Energy and Emissions Projections: 2017, 2018, https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017 [Accessed March 2019].
[4] Department for Transport, TAG Unit A3, Environmental Impact Appraisal, December 2015

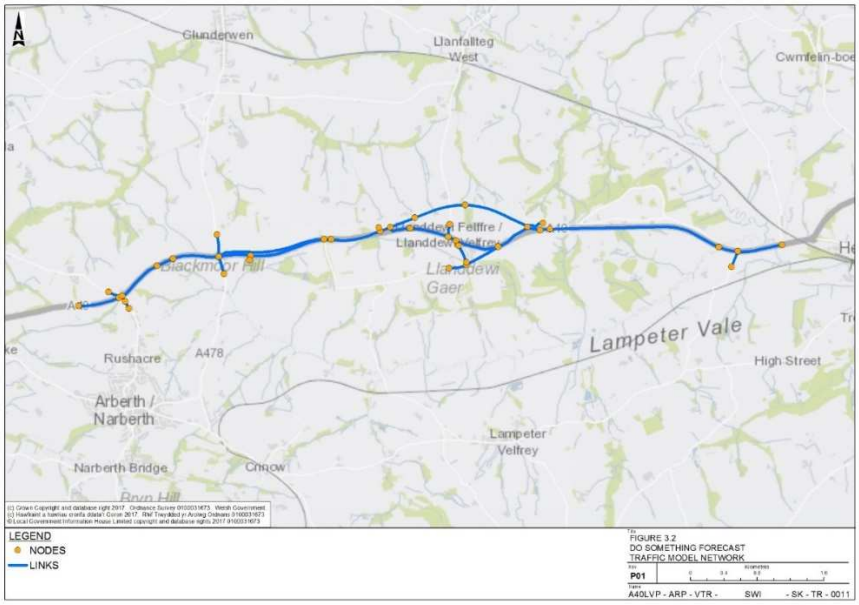

Figure 18.1 Assessment study area for user vehicle emissions

18.4.9 Total carbon emissions for all road links in the study area were calculated for the Do Minimum (without Scheme) and Do Something (with Scheme) scenarios for an opening (2021), forecast (2036) and future (2051) year. Emissions were calculated using the Defra Emission Factor Toolkit[5] (EFT v8.0.1). The EFT makes an estimate of future vehicle fleet mix in the UK and provides predicted emission rates for all years up to 2030. Therefore, for the forecast and future year scenarios, emission rates and predicted fleet mix were held constant at 2030 levels.

18.4.10 The change in carbon emissions as a result of the Scheme were calculated for every year over the 60-year appraisal period. A linear interpolation was applied to the change between the opening and forecast year and forecast and future year to provide the yearly change in emissions in both Do Minimum and Do Something scenarios. It should be noted that carbon emissions were held constant for 2051 onwards due to uncertainties regarding future traffic growth beyond this point.

Assumptions

18.4.11 The carbon assessment was undertaken based on the information available at the time of the assessment.

18.4.12 Specifically, the assessment of embodied carbon in materials was undertaken based on high-level material quantities, which were

[5] DEFRA, Emission Factor Toolkit (v8.0.1), https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html [Accessed November 2018]

calculated prior to construction. It provides bulk estimates of materials and fuel quantities, however does not provide specific information relating to their use in individual structures. The reported emissions by activity type are based on estimates of the proportion of materials and fuel used.

18.4.13 This assessment is based on the assumptions outlined in Table 18.1

Table 18.1 Carbon assessment assumptions

Carbon component	Assumption
Capital	
Materials Plant	The quantities of materials and fuel for plant were based on initial Scheme material quantity calculations. Subsequent design changes were generally not reflected in the carbon assessment; however, these were expected to be small.
	Emissions factors for materials and fuel for plant were based on the closest emissions factor available for the material type. UK typical values were used where more specific information is not available.
Transport	Worker transport is calculated based on number of days worked derived from overall labour costs, assuming an 8-hour work day.
	All worker transport to site would be by single occupancy car (assuming average car).
	Daily travel distance by workers is estimated to be in the following proportions: 10km - 20% 20km - 25% 50km - 10% 100km - 20% 200km - 10%
	Transport distances for materials are based on distances to likely sources (suppliers or manufacturers) of each material type. Distances are provided in Table 18.4.
	Land transport is assumed to be in a rigid truck, while sea transport is assumed to be by container ship.
	Emissions from transport of waste are not included in the assessment. Transport of waste from the site will be minimal as a cut-fill balance is achieved by the design. It is assumed that topsoil excess will be reused around the Scheme or in the local area, negligible transport required.
Maintenance	Maintenance emissions are based on the embodied emissions in the pavement materials used to replace 30mm of pavement surface every 10 years over the life of the Scheme. For the detrunked section of the existing A40, surface replacement is assumed to occur every 20 years.

Carbon component	Assumption
	Maintenance, operation and user emissions are calculated over a 60-year appraisal period. This appraisal period has been selected for consistency with the WebTAG assessment.
Other	The impact of vegetation removal as a lost carbon sink has not been quantified in the carbon assessment as all vegetation removed in the construction phase of the Scheme will be replaced.
Operation	
Street lighting	Street lighting operation hours are estimated to be 15 hours/day for winter use (half year), and 7 hours/day for summer use (half year).
	Emissions from the UK electricity grid are reduced in line with the 2017 BEIS Energy and Emissions Projections.
	The majority of street lighting that already exists along the alignment (road to be detrunked) is expected to be retained when the proposed Scheme is operational.
User	
Vehicle emissions	Future vehicle use of the road has been predicted using the traffic model produced for the Scheme.
	Vehicle fleet mix and emission rates for future scenarios are based on predictions included in the Defra Emission Factor Toolkit.
	The emissions are calculated based on average speeds and daily use along modelled sections of the road, which do not account for the following factors which may influence emissions: Road gradient and curvature; Changes in user numbers along the road due to induced demand, and Changes in speed within modelled sections of road, for example acceleration and deceleration due to intersections and/or congestion.
	A linear interpolation has been assumed between the opening and forecast year and the forecast and future year.
	The assessment has assumed no further traffic growth post 2051.

Significance criteria

18.4.14 The IEMA guide to assessing greenhouse gas (GHG) emissions and evaluating their significance[6] publishes the over-arching principle:

[6] IEMA, 2017, Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance

"The GHG emissions from all projects will contribute to climate change; the largest inter-related cumulative environmental effects…as such any GHG emissions or reductions from a project might be considered to be significant…"

18.4.15 In accordance with this guidance, any carbon emissions associated with the Scheme can be deemed significant. Accordingly, initiatives to mitigate emissions were integrated into the design where possible, as outlined in Section 18.7.

18.4.16 To provide an indication of the relative scale of the emissions from the Scheme they can be compared to the carbon emissions from road transport on all purpose roads (commonly referred to as A roads) in Pembrokeshire, which were 124 $ktCO_2e$ in 2012[7].

CCR assessment

18.4.17 The approach and methodology for the climate change resilience assessment is based on UKCP09[8] and is as follows:

a) analysis of relevant climate change and weather data, emissions scenarios and probability levels;

b) assessment of climate hazards;

c) identification of potential risks from these climate hazards to the assets and occupants of the proposed A40 Scheme;

d) consideration of the resilience of the proposed Scheme within the context of any incorporated mitigation measures, including resilience measures which are embedded within the design due to regulations and design guidelines, and

e) identification of need for any further resilience measures to protect the proposed Scheme against the effects of climate change.

18.4.18 For the CCR and ICCI assessments, the timeframes for the risk assessment were selected to align with the start and end of the appraisal period.

18.4.19 Due to the short temporal phase of construction, it is unlikely that climate change would affect the before-use stage. This phase is therefore not considered in the CCR and ICCI assessments.

18.4.20 In the case of flood risk, detailed planning requirements and design

[7] UK Government, Local Authority Emissions Estimates, https://www.gov.uk/government/statistics/local-authority-emissions-estimates [Accessed November 2017]
[8] At the time of assessment in October 2018, UKCP18 had not yet been released. The trends in climate variables in the UKCP18 projections are broadly consistent with the UKCP09 projections and would not materially affect the CCR and ICCI assessment results reported in this chapter. Further detail on the UKCP18 projections is available at Met Office, 2018, UKCP18 Headline Findings, https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/ukcp18-headline-findings.pdf, [Accessed March 2019]

guidance relating to climate change exist. Therefore, an assessment of climate change impacts on flood risk is carried out within ES Chapter 7 Road Drainage and the Water Environment, taking into account current Environment Agency climate change allowances for increases in peak river flow and rainfall intensity.

Significance criteria

18.4.21 The significance of the risks identified in the CCR assessment is based on the likelihood of a hazard having an impact on the proposed development, and the consequence of the impact. The potential likelihood and consequence of impacts to the proposed development were assessed using a qualitative five-point scale as defined in Appendix 18.2.

ICCI assessment

18.4.22 The approach and methodology for the ICCI assessment is as follows:

a) analysis of relevant climate change and weather data, emissions scenarios and probability levels;

b) consideration of potential climate change impacts for all environmental topics;

c) assessment of each environmental topic's respective significant effects and the corresponding mitigation measures identified by each topic;

d) assessment of any potential in-combination climate change impacts and effects given existing mitigation measures (i.e. mitigation measures identified by each environmental topic);

e) assessment of whether there are any significant in-combination climate change effects, based upon whether potential in-combination climate change impacts are assessed to be 'likely' or 'high' consequence;

f) consideration of additional mitigation measures to address significant in-combination climate change effects, beyond those existing mitigation measures identified by other environmental topics, and

g) inclusion of allowances for future mitigation measures and monitoring, to ensure continued resilience of receiving environment.

Significance criteria

18.4.23 The outcomes of the ICCI assessment will be the categorisation of each environmental topic based on the following significance criteria:

1. many potential in-combination climate change impacts with high consequences;
2. some potential in-combination climate change impacts with high consequences;
3. some potential in-combination climate change impacts with low consequences, and
4. no potential in-combination climate change impacts.

18.5 Baseline Conditions

GHG emissions assessment

18.5.1 User GHG emissions from vehicles using the existing road have been quantified. Total carbon emissions for all road links in the study area were determined for the Do Minimum (without Scheme) scenario for every year over the 60-year appraisal period.

18.5.2 In the opening year of the Scheme (2021) user emissions are modelled to contribute 6.3 $ktCO_2e$, increasing to 7.8 $ktCO_2e$ per year by 2051. This is based on the traffic models of the Scheme, as per Section 0. The cumulative emissions from road users are 446 $ktCO_2e$ over the 60-year appraisal period.

CCR and ICCI assessments

18.5.3 The baseline environment for the CCR and ICCI assessments include consideration of:

a) Current climate conditions; and

b) Projected future climate conditions.

18.5.4 The **current climate conditions** were established for a range of climate variables based on the long-term average of historical weather data for 1961 – 1990. This data was taken from the UK Climate Projections (UKCP09) gridded observations. The projections used for the Scheme are based on the $25km^2$ grid area where the proposed Scheme is located. These values are presented in Figure 18.3 as a baseline for comparison with the projected future climate conditions.

18.5.5 The future climate conditions are also presented in Figure 18.3, based on projections of different probability levels and emissions scenarios. These are presented over two timescales; 'the 2020s' (which is defined by the Met Office as the period 2010-2039) and 'the 2070s' (which is defined as the period 2060-2089). These periods were selected as they align with the construction and operational phases of the proposed

development, based on the 60-year design life.

18.5.6 In Figure 18.3 the future climate conditions are given for both a medium emissions and high emissions scenario at the 50% probability level. A reference range is also provided in each case, using the 10% probability level medium scenario as a lower limit and the 90% probability level high scenario as an upper limit.

18.5.7 An indication of the directional trend for each of the climate variables is also included in Figure 18.3. Overall, the trends in climate variables are summarised as:

a) **High temperatures** – Increase in mean daily temperatures in the summer and winter, increase in the number of hot days (days when daily mean temperature is >25°C) and increased insolation;

b) **Low temperatures** – Decrease in the number of frost days (days when daily minimum temperature <0°C);

c) **High precipitation** – Increase in mean daily rainfall in the winter, increase in the number of days with heavy rain;

d) **Low precipitation** – Decrease in mean daily rainfall in the summer, increase in the annual number of dry spells;

e) **Extreme wind** – Increase in extreme wind events[9], and

f) **Lightning** – Increase in the number of lighting days, particularly in Autumn[10].

[9] IPCC (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, https://ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap23_FINAL.pdf [Accessed December 2017] page 1279

[10] Future changes in lightning from the UKCP09 ensemble of regional climate model projections, http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87950&filetype=pdf [Accessed December 2017]

Table 18.2 UKCP09 historical climate data (1961-1990) and climate change projections for the Scheme

Parameter		**Long-term average (1961-1990)**	**2020s (2010 – 2039)**			**2070s (2060 – 2089)**			**Trend**
			Medium emissions scenario	*High emissions scenario*	*Range*[11]	*Medium emissions scenario*	*High emissions scenario*	*Range*	
Temperature	Mean summer daily temperature [°C]	14.9	16.4	16.3	15.4 - 17.3	18.2	18.9	16.6 - 21.4	↑
	Mean winter daily temperature [°C]	4.5	5.7	5.7	5.1 - 6.5	7.1	7.4	5.98 - 9	↑
	Mean daily summer maximum temperature [°C]	18.9	20.8	20.7	19.4 - 22.1	23.1	24.1	20.6 - 27.9	↑
	Mean daily summer minimum temperature [°C]	10.9	12.3	12.3	11.4 - 13.3	14.1	14.9	12.4 - 17.7	↑
	Mean daily winter maximum temperature [°C]	7.2	8.4	8.4	7.7 - 9.3	9.7	10.0	8.2 - 12.1	↑
	Mean daily winter minimum temperature [°C]	1.7	3.2	3.2	2.3 - 4.1	4.7	5.2	3 - 7.5	↑
Precipitation	Annual mean daily precipitation [mm/day]	3.9	4.0	3.9	3.7 - 4.2	3.9	4.0	3.6 - 4.4	↕
	Winter mean daily precipitation [mm/day]	4.7	5.1	5.1	4.6 - 5.7	5.9	6.2	5 - 8.2	↑

[11] Range is from 10% probability level at the medium emissions scenario to 90% probability level at the high emissions scenario, for both timescales

Parameter		**Long-term average (1961-1990)**	**2020s (2010 – 2039)**			**2070s (2060 – 2089)**			**Trend**
			Medium emissions scenario	*High emissions scenario*	*Range*[11]	*Medium emissions scenario*	*High emissions scenario*	*Range*	
	Summer mean daily precipitation [mm/day]	3.1	2.9	3.0	2.4 - 3.6	2.5	2.4	1.8 - 3.4	↓
Cloud	Annual cloud cover [%]	70.9% (1423.5 sunshine hours per year)	69.7%	69.7%	67.9% - 71.4%	68.3%	67.9%	65.6% - 70.8%	↓
Extreme weather events	Annual number of hot days (daily mean temperature is >25°C)	0	0.2	0.2	0 - 0.48	2.4	4.8	0 - 14.08	↑
	Annual number of frost days (daily minimum temperature <0°C)	44.0	19.2	20.6	12.8 - 27.3	9.6	9.0	2.0 - 16.7	↓
	Annual number of days per year when precipitation is greater than 25mm per day (Met Office definition of 'heavy rain')	4.0	4.8	4.7	3.6 - 5.8	6.2	7.0	4.5 - 9.4	↑
	Annual number of dry spells (10+ day with no precipitation)	2.7	3.2	3.1	2.4 - 4.0	3.7	4.1	2.6 - 5.3	↑

18.6 Assessment of Environmental Effects

GHG emissions assessment

18.6.1 This section outlines the results of the carbon assessment. Overall, the current design of the Scheme has a carbon footprint of 486 $ktCO_2e$ over the 60-year appraisal period. Table 18.3 summarises the results for each component of the assessment scope.

Table 18.3 Carbon assessment results[12]

Carbon component	Do nothing scenario (tCO_2e)	Scheme emissions (tCO_2e)
Capital		10,000
Materials		*4,600*
Plant		*4,600*
Transport		*830*
Operation	2,400	3,200
Maintenance	*2,100*	*2,900*
Street lighting	*200*	*300*
User	446,000	472,000
Total	**448,000**	**486,000**

Capital carbon

18.6.2 The capital carbon emissions account for 2.1% of the emissions over the 60-year appraisal period. The two largest sources of emissions during the construction phase are the embodied carbon in construction materials, and direct emissions on site from fuel consumption in site plant, equipment and vehicles (referred to as 'plant').

18.6.3 Emissions associated with the transport of waste around the site are included in the plant carbon component as earthworks movements. It is assumed that topsoil will be reused around the Scheme or in the local area, negligible transport required.

18.6.4 The assumed distances travelled by different materials to the sites are summarised in Table 18.4.

[12] Note that values reported in the table do not add to the total due to rounding.

Table 18.4 Assumed material transport distances

Material	Source	Transport distance (km)
Aggregates	Local quarries	15
Concrete	In-situ concrete - local batching plants	20
Concrete	PC concrete - Swansea	70
Concrete	PC concrete - Ireland	400
Fuel	Swansea	70
Steel	Newport	150
Steel	Kent + Midlands	350
Bitumen	Swansea	70
Timber	Swansea	70
Timber	Hereford	180
Bricks	Swansea	70
Mortar	Swansea	70
Iron	Swansea	70
Iron	Midlands	300
Aluminium	Midlands	300
Plastic	Swansea	70

18.6.5 Figure 18.2 shows the emissions from these two largest sources by activity type. The emissions from plant are calculated based on the estimated fuel quantities during construction and are estimated for each activity based on the proportion of fuel consumed by that activity.

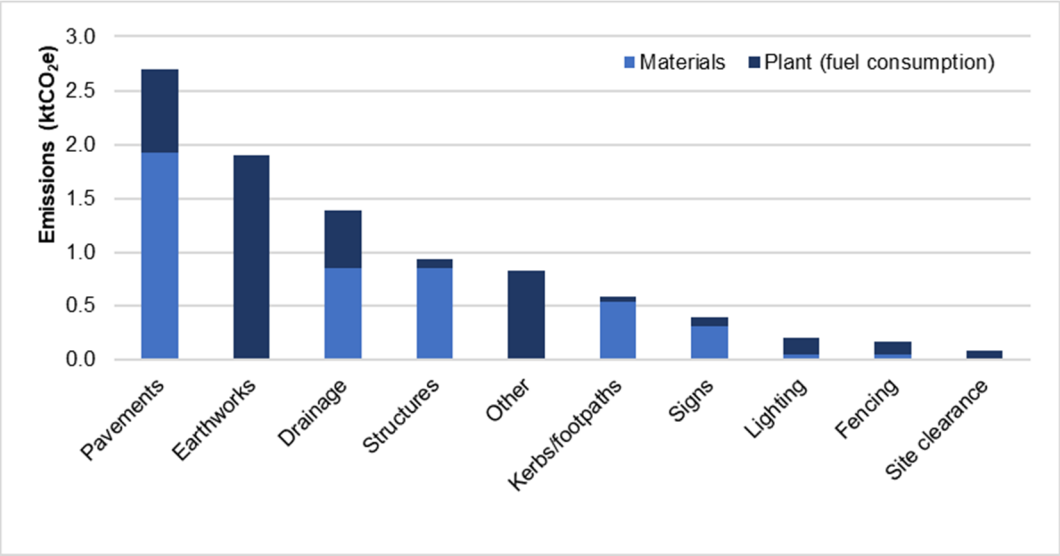

Figure 18.2 Emissions from materials and plant sources ($ktCO_2e$), by activity type

Operational carbon

18.6.6 During the operational phase, street lighting is estimated to consume 95MWh per year. Over the 60-year appraisal period this results in operational emissions of 0.3$ktCO_2e$, making up far less than 1% of the overall Scheme emissions.

18.6.7 The embodied carbon impacts associated with replacing the road surface during maintenance resulted in emissions of 2.9 $ktCO_2e$ over the project life.

User carbon

18.6.8 Emissions from vehicles using the road account for the vast majority of emissions over the project life (97.3%). In the opening year of the Scheme (2021) user emissions are modelled to contribute 6.7 $ktCO_2e$, increasing to 8.2 $ktCO_2e$ per year by 2051. This is based on the traffic models of the Scheme, as per Section 0.

18.6.9 Annual user emissions in the Do Something scenario are greater than in the Do Minimum scenario for all years assessed, by between 5% to 6%. Over the appraisal period, the impact of the additional road use will increase emissions by 27 $ktCO_2e$ compared to the Do Minimum scenario. The cumulative emissions from road users are shown for the Do Minimum and Do Something scenarios in Figure 18.3.

18.6.10 The increase in emissions is due to an increase in average speeds, based on the traffic forecast models, and also a very slight increase in vehicle kilometres travelled due to the alignment of the proposed road.

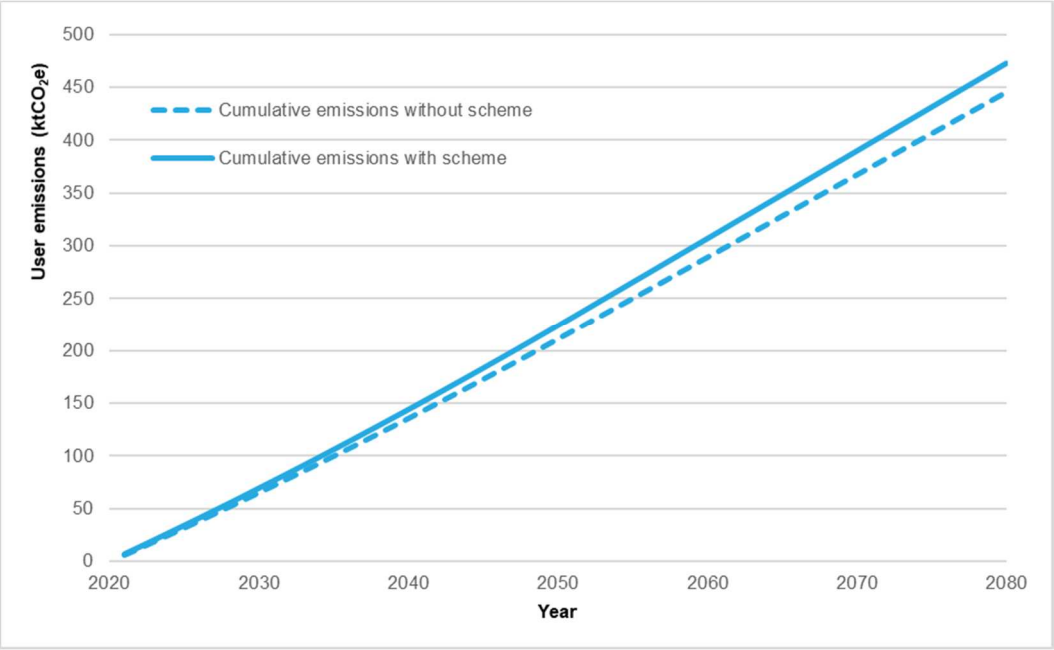

Figure 18.3 Cumulative user carbon emissions ($ktCO_2e$), Do Minimum (without Scheme) and Do Something (with Scheme) scenarios

18.6.11 The Scheme includes an additional roundabout (compared to the Do Minimum scenario), which is likely to increase emissions as vehicles must decelerate to pass through the roundabout and accelerate again. This impact has not been quantified in the traffic model used to calculate the user emissions, as it is based on average daily trip data; however the impact will be minimal compared to the factors outlined in 18.6.10 above.

18.6.12 The user emissions in both scenarios are based on conservative projections of improvements in vehicle fuel efficiency, and do not allow for the emissions reductions that could be achieved with increased penetration of electric vehicles in the fleet[13]. However, any improvements in fuel efficiency will impact both scenarios and user emissions will remain greater in the Do Something scenario.

18.6.13 User emissions from the Scheme account for the vast majority of impacts from the Scheme and can be used as a comparator on an annualised basis. In the opening year of the Scheme (2021) user emissions are modelled to contribute 6.7 $ktCO_2e$. This is equivalent to 5.4% of overall annual emissions from road transport on A roads in Pembrokeshire. At approximately 10 km, the length of the modelled length of the A40 is about 3.6% of the length of all A roads in

[13] The predicted fleet mix used in the emission Factor Toolkit is taken from the National Atmospheric Emission Inventory (NAEI) Vehicle Fleet Composition Projections, http://naei.beis.gov.uk/data/ef-transport, [Accessed November 2017]

Pembrokeshire (280 km)[14].

18.6.14 This comparison shows that the emissions from this section of road in the Do Something scenario are disproportionately high compared to its length (which is also the case in the Do Minimum scenario, with user emissions of 6.3 $ktCO_2e$ in 2021). Overall, this indicates that this length of road is already well used compared to other 'A roads' in Pembrokeshire, and as a result is a comparatively significant source of user carbon emissions.

18.6.15 Another reference for comparison is the emissions from the transport sector in Wales. According to the most recently published greenhouse gas emissions inventory, the transport sector in Wales accounted for 6.0 $MtCO_2e$ in 2015, or 13% of the total national emissions[15]. In the first year of Scheme operation, user emissions would be equivalent to approximately 0.1% of the current annual emissions from the transport sector in Wales.

CCR assessment

Assessment of effects in construction

18.6.16 The construction works are to be completed by 2021, thus the associated changes in climate are expected to be relatively small compared to the current baseline. Therefore, it has been assumed that sufficient mitigation measures are already in place during the construction programme to ensure resilience under current climate conditions.

Assessment of effects in operation

18.6.17 Over the near term (the 2020s), the risks identified in the CCR assessment have a 'Low' or 'Very low' risk rating due to the mitigation measures embedded in design.

18.6.18 Over the long term (the 2070s), while most risk are low or very low, one risk identified has a 'Medium' risk rating. This is risks associated with flooding as a result of extreme rainfall events. No risks identified in the CCR assessment were classified as significant. The results of the CCR assessment are included in Volume 3 Appendix 18.2.

[14] StatsWales, 2017, Road length (Km), by type of road and local authority, Wales https://statswales.gov.wales/Catalogue/Transport/Roads/Lengths-and-Conditions/roadlength-by-typeofroad-localauthority-year [Accessed November 2017]
[15] National Atmospheric Emissions Inventory, 2017, http://naei.beis.gov.uk/reports/reports?report_id=932 [Accessed November 2017]

ICCI assessment

Assessment of effects in construction

18.6.19 The construction works are to be completed by 2021, thus the associated changes in climate are expected to be relatively small compared to the current baseline. Therefore, it has been assumed that sufficient mitigation measures are already in place during the construction programme to ensure resilience under current climate conditions.

Assessment of effects in operation

18.6.20 No risks identified in the ICCI assessment were classified as significant. The results of the ICCI assessment are included in Volume 3 Appendix 18.3.

18.7 Mitigation Measures

GHG emissions assessment

18.7.1 The GHG emissions assessment provides an indication of the emissions associated with the construction and operation phases of the proposed development. As all emissions from the development are considered significant under the definition in the methodology, mitigation actions should be implemented to reduce GHG emissions from the development.

18.7.2 PAS 2080 provides a framework for the management of carbon in projects in the built environment. The use of PAS 2080 to guide the approach to reducing GHG emissions associated with the proposed Scheme is recommended.

Scheme Design considerations

18.7.3 This section considers the elements of the design development that have resulted in capital and operational carbon reduction on the Scheme relative to 'business-as-usual' design. The reductions are already included in the carbon footprint presented in the assessment results.

18.7.4 The **lighting** strategy is to minimise the extents of lighting in order to reduce operation and maintenance costs, ecological and landscape impacts and reduce carbon. Only the two roundabouts proposed at either end of the Scheme are proposed to be lit. The extents of the lighting of the approaches to the roundabouts were reviewed and minimised, requiring a Departure from Standard.

18.7.5 The highway alignment has been developed to provide an **earthworks balance**. This means that the excavated material that is exported as waste to landfill has been minimised and the majority will be reused in the construction of embankments, landscaping and in the road build-up, therefore reducing the carbon impact.

18.7.6 The **pavement design** has considered the traffic forecast data, with a view to minimise the thickness of material required. Pavement materials are carbon intensive, so the pavement thicknesses were minimised as far as practicable without impacting durability.

18.7.7 Alternative junction arrangements to the additional roundabout were considered in order to reduce the carbon impact of stop-start conditions. These were not adopted in the current design due to a range of considerations, including improved safety by reducing the likelihood of a high-speed collision.

Future mitigation opportunities

18.7.8 In recognition of the significance of any carbon emissions associated with the Scheme, further mitigation opportunities will be identified, assessed and integrated as the project progresses. In line with the carbon emissions reduction hierarchy outlined in PAS 2080, in the context of the current design stage, these opportunities will broadly include:

a) *Build clever – considering the use of low carbon solutions (including technologies, materials and products) to minimise resource consumption during all project phases*

b) *Build efficiently – using techniques (e.g. construction, operational) that reduce resource consumption during the construction and operation phases.*

18.7.9 Where practicable, local suppliers of resource and material will be used. This will minimise the journey distances to the project site, therefore reducing the carbon impact required to transport materials to site. These will be identified at a later stage of design and construction of this project.

18.7.10 There is also an opportunity to explore strategies to reduce emissions within the local community as part of the project, for example through

provision of decarbonised energy infrastructure. This type of initiative would offset the carbon impact of the project, by reducing carbon emissions elsewhere in the community.

CCR assessment

Mitigation of effects from operation

18.7.11 Mitigation measures currently included within the design are:

a) The drainage design includes allowance for climate change as design for ponds and culverts includes an allowance for a 1 in 100-year flood occurrence with an added 30% allowance.

b) Overland flow analysis has been in included for a 1 in 100-year flood occurrence plus a 30% allowance to see how water moved in the event of a flood however no impact on third party land was shown.

c) The structures have been designed to Eurocode standards to allow for expansion and contraction, to provide resilience to extreme temperatures.

18.7.12 Further measures are not currently recommended to address the risks identified in the CCR assessment as they are not classified as significant.

18.7.13 Due to the uncertainties involved in adapting to future climate change, a pathways approach is recommended for monitoring and managing climate risks into the future. Further measures to reduce climate risks over the long term are not currently recommended for implementation as they may result in maladaptive outcomes that limit future adaptation options.

ICCI assessment

Mitigation of effects from operation

18.7.14 Further measures are not currently recommended to address the risks identified in the ICCI assessment as they are not classified as significant.

18.8 Summary

18.8.1 The climate change assessment addresses the potential effects of the Scheme on greenhouse gas (GHG) emissions; the resilience to the consequences of climate change (CCR); and the in-combination climate change impact (ICCI), which evaluates the combined effect of the

proposed development and potential climate change impacts on the receiving environment during construction and operation.

18.8.2 The GHG assessment identified that over the whole life of the Scheme there will be an increase in emissions associated with the Scheme, with the majority (97.3%) due to vehicles using the road during operation. The increase in user emissions is due to an increase in average speeds and a slight increase in distance travelled due to the alignment of the roads. There are also emissions associated with the construction and operation of the Scheme. Over the 60-year appraisal period, the total emissions from the construction, operation and use of the road are expected to increase by 8.4% compared to the Do Minimum scenario.

18.8.3 The CCR and ICCI assessments did not identify any significant risks associated with climate change. Potential risks associated with flooding are addressed by mitigation measures in design.