Appendix: Climate Change

Annex 1: Trium Climate Change Technical Note

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Climate Change

Technical Note

Contents

1. Introduction

1.1 This technical note describes a future climate scenario which has been developed using the future climate projections data published by the Met Office (UKCP18) in November 2018. UKCP18 projections consider the climate effects arising from a series of 'Representative Concentration Pathways' (RCP) emissions scenarios.

1.2 The purpose of this technical note is to present projection data for the future climate and to provide guidance to the EIA technical team on how to consider whether the effects of the Proposed Development (defined under the current climate conditions) may alter under the future climate scenario. In the context of the future climate condition, consideration needs to be given to:

- The change in the magnitude of impact of the Proposed Development;
- Receptor vulnerability;
- Vulnerability of the Proposed Development; and
- Resilience of the Proposed Development.

Climate Projections

1.3 UKCP18 gives probabilistic projections[1] for a number of atmospheric variables, with different temporal and spatial averaging, for several future time periods, under four different future RCP emissions scenarios.

1.4 In general, the longer the lifetime of a development, the greater the uncertainty about the impact of climate change over time. Uncertainty is dealt with by presenting projections which are probabilistic in nature, and which give the probability of different climate outcomes.

1.5 To make use of the probabilistic projections, an emissions scenario and percentile outcome (i.e. the likelihood of the change in climate occurring) needs to be identified.

1.6 The emissions scenario and probabilistic projection are detailed within this document and have been used by all technical disciplines contributing to the Environmental Impact Assessment (EIA), to ensure consistency in approach.

Emission Scenarios

1.7 The RCP emission scenarios represent four distinct Representative Concentration Pathways (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) available in the UKCP18 climate projections. These are named according to the concentration of greenhouse gas modelled to occur in the atmosphere in 2100. The RCPs have been developed for long-term and near-term climate modelling and provide time-dependant projections of atmospheric greenhouse gas concentrations. These pathways were developed based on a literature review of current climate modelling research and have been chosen to represent the full range of climate outcomes presented within the literature.

1.8 The emission scenarios represent assumptions in terms of climate policy, land use and technological development, with RCP2.6 representing the 'optimum' emission scenario (i.e. measures aimed at achieving the maximum reduction in GHG emissions).

1.9 RCP 8.5 is the most conservative, highest emission, and highest-impact scenario. It assumes that technological development will slow and that there will be little to no decarbonisation of world power from new technology. It also assumes that no further climate mitigation or regulations to reduce climate change or air pollution will be implemented.

1.10 More information on the RCPs can be found in the UKCP18 Guidance: Representative Concentration Pathways[2].

[1] Probabilistic projections give a range of possible climate change outcomes and their relative likelihoods i.e. unlikely, likely or very likely ranging across 10th to 90th percentiles.

[2] UKCP18 Guidance: Representative Concentration Pathways https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/ukcp18-guidance-rcp.pdf

Adopted Emissions Scenario: RCP8.5

1.11 RCP8.5 has been used in the climate projections presented in this technical note as it represents a suitably conservative emissions scenario with regards to climate policy, land use, and technological development. This is in accordance with the Institute of Environmental Management and Assessment's (IEMA's) Climate Change Resilience and Adaptation guidance[3], which states that *"Recommended best practice is to use the higher emissions scenario (RCP 8.5 in the latest UKCP18 projections) at the 50th percentile, for the 2080s timelines, unless a substantiated case can be made for not doing this (e.g. anticipated lifespan of the project is shorter than 2080s)"*.

1.12 The use of RCP8.5 is also in accordance with *"the National Policy Statement on National Networks, which states that developments should use the UKCP09 high emissions scenario at the 50% probability level"*[3]; therefore, this RCP has been identified as the most reasonable conservative emissions scenario for identifying future climate change projections.

[3] Institute of Environmental Management and Assessment, (2020); Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation.

2. Approach to Assessment

1.13 These steps provide a guide to assessing climate change within the EIA. More information and guidance can be found in references listed in Appendix C.

Step 1: Define the Future Climate Condition

1.14 Within the "Climate Change" section of the chapter, firstly identify the climate variables that are relevant to the assessment. So, for example, the variables of relevance might be 'wind', 'temperature', 'humidity' etc.

1.15 The next stage is to determine how these variables change under the future climate scenario based on the information presented in appendix A. The future climate condition should be discussed in terms of the 50% probability level, but also acknowledge the predicted extremes at the 10% and 90% probability levels.

1.16 This stage defines the future climate condition that is relevant to your assessment.

Step 2: Define Receptor Vulnerability

1.17 Receptors that have been identified for inclusion within the technical assessment need to be considered in terms of their vulnerability[4] (i.e. susceptibility or resilience) to changes in the future climate. The vulnerability of the resource / receptors (including identifying individual receptors / sub-groups) should be defined using the definitions provided below.

1.18 Vulnerability of a receptor should generally be defined as follows and presented in tabular format:

- **High vulnerability**: the receptor is directly dependent on existing and/or prevailing climatic factors, and reliant on these specific existing climate conditions continuing in future (e.g. river flows and groundwater level); or only able to tolerate a very limited variation in climate conditions.
- **Moderate vulnerability**: the receptor is dependent on some climatic factors, but able to tolerate a range of conditions (e.g. a species which has a wide geographic range across the entire UK).
- **Low vulnerability**: climatic factors have little influence on receptors.

1.19 Table 1 provides an example of receptor sensitivity and vulnerability presented within a table.

[4] Please note that 'receptor sensitivity' is different to the consideration of 'vulnerability'. Reference to **sensitivity** of a resource / receptor in the EIA assessment reflects the receptor's **value** in terms of its quality or condition, and expresses its **proneness** to being potentially impacted through a change in the existing environment (i.e. existing climate conditions) in which is resides, as a result of the implementation of a Proposed Development.
Vulnerability is defined as a receptor's **susceptibility** or **resilience** to a change in climate (i.e. change in the existing environment).
By way of an example to highlight this difference, a highly sensitive receptor does not mean that it is highly vulnerable to climate change, while conversely a low sensitive receptor may be highly vulnerable to climate change.
Taking account of receptor vulnerability within the assessment requires consideration of whether climate change will alter the existing environment (i.e. existing climate conditions) within which the resource / receptor resides, and as a result, making a judgement as to whether climate change will alter the magnitude of the impact (defined under the current climate conditions) experienced by the resource / receptor (based on its vulnerability) because of the implementation of the Proposed Development. The higher the vulnerability of an individual resource / receptor to climate change, the greater the change in the magnitude of the impact.
For example, climate change alters the environment and for a high vulnerability receptor, results in amplifying the impact (of the Proposed Development) experienced by the receptor.
Conversely, an individual resource / receptor with a greater resilience (low vulnerability) to changes in the existing climate conditions is not likely to experience a change in the impact experienced as a result of the Proposed Development (i.e. no change in the magnitude of impact).
Please also note that there may be instances when a broad description of a resource / receptor group may comprise of sub-groups which may vary in their vulnerability to climate change. Where relevant, individual resource / receptors may need to be identified and considered as part of the climate change assessment.

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Table 1. Summary of Receptor Sensitivity and Vulnerability for Assessment

Resource / Receptor *(include as groups or as individual receptors as relevant)*	Sensitivity *(as per standard EIA criteria)*	Vulnerability *(as per the criteria cited above)*

Step 3: Magnitude of Impact, Nature and Scale of Effects and Effect Significance

1.20 Consider whether the magnitude of impact and resultant nature and scale of the effects of the Proposed Development (as defined earlier on in the chapter) during the operational phase will be worse or improved under the future climate conditions, and whether the changes alter the overall significance of effects identified for the Proposed Development, without climate change.

1.21 In most cases, there is likely to be an absence of published, accepted quantifiable methods for considering climate change effects for technical topics.

1.22 Therefore, this 'assessment' is likely to be qualitative and based on professional opinion which draws on the information available and acknowledges the level of uncertainty surrounding climate change projections.

1.23 Present the assessment as a narrative. Tables and supporting figures can be presented if helpful but are not essential. Appendix B gives examples of calculating the effect.

Step 4: Identify any Mitigation Needed

1.24 If any adverse significant effects are identified (as a result of the impact of climate change), appropriate mitigation will need to be identified.

1.25 When considering the adoption of mitigation to address any significant effects arising from changes in climate, consideration should be given to when the mitigation might be most usefully implemented over the duration of the scheme.

1.26 Mitigation measures include identifying appropriate resilience and adaptive management measures.

1.27 Resilience measures include design features (e.g. habitable rooms within residential units located above the flood level which accounts for climate change) and construction materials (e.g. materials resistant to increases in temperature), to provide an appropriate resilience to changes in the existing climatic conditions, as well as occurrences of extreme weather.

1.28 Adaptive management measures allow for the uncertainty surrounding climate change and its impact to be accounted for. Consideration should be given as to whether there are opportunities to introduce mitigation measures later into the project when there is more certainty over future climate projections. These measures could be secured through a commitment to prepare a management plan / strategy (or equivalent) which would periodically review the need for such measures and their integration into the scheme if / when required.

1.29 Where mitigation is proposed, consideration of the effectiveness of the measures should be taken into account, with reference to the resulting magnitude of impact and the resulting residual effect and its significance.

3. The Future Climate Condition for EIA

1.30 A summary of the future climate projections based on RCP8.5 is presented in Appendix A and described below for the climatic variables temperature, precipitation, and total cloud cover. Table 2 provides a breakdown of the data provided for each climatic variable in appendix A. UKCP18 data for wind is not yet available, so UKCP09 data has been presented.

Table 2. Climatic Variables for which Future Climate Projection Data is Provided

Climatic Variable	Climate Projection	Variable	Temporal Average
Temperature	**UKCP18 RCP8.5**	Mean	Annual
			Seasonal
		Mean Daily Max	Annual
			Seasonal
		Mean Daily Min	Annual
			Seasonal
Precipitation	**UKCP18 RCP8.5**	Mean	Annual
			Seasonal
Wind*	**UKCP09 A1B**	Mean	Annual
			Seasonal
Total Cloud	**UKCP18 RCP8.5**	Mean	Annual
			Seasonal

***Note**: UKCP18 probabilistic data for wind is not available, nor any RCP8.5 data for wind through alternative projections. For this reason, UKCP09 wind data has been presented for the A1B scenario, as it is comparable to RCP8.5.

Future London Climate Condition

1.31 The following description provides a high level overview of the future climate in London in 2100 under the UKCP18 using RCP8.5. Appendix A provides the data underlying this description.

Temperature[5]

1.32 Changes in temperature can have implications for the built and natural environment, built infrastructure, and human health. Increases in temperature can lead to impacts on human health, especially in urban areas such as London, where buildings can retain heat, leading to increased night-time temperatures. This is of particular interest when assessing developments within London, with its urbanised character and high population density.

1.33 The projected trends of climate changes in the 21st century indicate a move towards warmer, wetter winters and hotter, drier summers. Probabilistic projections show that there will be more warming in the summer than in the winter.

1.34 In summer, there is a pronounced north / south contrast when considering temperature changes, with greater increases in maximum summer temperatures over the southern UK compared to northern Scotland.

Precipitation[6]

1.35 Precipitation can have significant socio-economic impacts on various timescales, and can have implications related to pluvial or surface flooding, as surface run-off inundates the urban landscape. Flooding is one of the most socially and economically disruptive hazards within the UK, and has impacts on energy supply, transport and infrastructure.

[5] UKCP18 Factsheet: Temperature (2018) https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/ukcp18-factsheet-temperature.pdf

[6] UKCP18 Factsheet: Precipitation (2018) https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/ukcp18-factsheet-precipitation.pdf

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1.36 Year to year, a high level of variability in precipitation has been observed, with a slight overall increase in UK winter precipitation over the last few decades.

1.37 Probabilistic projections show that while the probability of dry summers increases, the probability of wet summers reduces only slightly. Trends indicate drier summers, with reductions in rainfall, are largest in the south of England.

Wind [7]

1.38 Wind data is not available for RCP8.5, nor probabilistic projections for any of the RCP emissions scenarios. UKCP09 A1B data has been presented in Appendix A.

1.39 UKCP18 guidance reports no significant trends in 'storminess', which is determined by maximum gust speeds, from the UK over the last four decades. Global projections over the UK suggest an increase in near surface wind speeds for the second half of the 21st century during the winter season. An increase in frequency of winter storms is also predicted. Though, it should be noted that the increase in wind speeds is modest compared to the variability observed.

Summary

1.40 This note provides a future climate condition for the technical assessment of the Proposed Development in relation to climate change. It has been developed to ensure consistency across the technical topics covered in the EIA.

1.41 The data provided within this technical note is up to date 3 August 2020 2020. It is acknowledged that more information will become available on the UKCP18 interface over time, and revisions of this note shall be provided as appropriate.

[7] UKCP18 Factsheet: Wind https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/ukcp18-factsheet-wind.pdf

Appendix A: Future Climate Projection Data

Table 3. UKCP18 Future Climate Projections: RCP8.5 Emissions Scenario

Climate Variable	Predicted Change from Baseline 2080s			Absolute Values 2080s		
	10th Percentile	50th Percentile	90th Percentile	10th Percentile	50th Percentile	90th Percentile
Mean Air Temperature	°C	°C	°C	°C	°C	°C
Annual Average	2.41	4.11	5.98	12.86	14.56	16.43
Winter Average	1.45	3.47	5.65	6.07	8.09	10.27
Spring Average	1.44	2.92	4.57	10.63	12.11	13.76
Summer Average	2.73	5.41	8.15	19.41	22.09	24.83
Autumn Average	2.26	4.29	6.56	13.47	15.50	17.77
Maximum Air Temperature	°C	°C	°C	°C	°C	°C
Annual Average	2.44	4.33	6.38	16.55	18.44	20.49
Winter Average	1.59	3.30	5.25	8.91	10.62	12.57
Spring Average	1.44	3.35	5.44	14.63	16.54	18.63
Summer Average	2.79	6.04	9.52	23.97	27.22	30.70
Autumn Average	1.80	4.48	7.44	16.64	19.32	22.28
Minimum Air Temperature	°C	°C	°C	°C	°C	°C
Annual Average	2.17	3.96	6.07	8.79	10.58	12.69
Winter Average	1.31	3.50	6.19	3.13	5.32	8.01
Spring Average	1.43	3.01	4.94	6.48	8.06	9.99
Summer Average	2.74	4.96	7.5	14.67	16.89	19.43
Autumn Average	1.98	4.36	6.91	9.55	11.93	14.48
Precipitation	%	%	%	mm / day	mm / day	mm / day
Annual Average	-13.00	-1.79	9.66	1.52	1.72	1.92
Winter Average	-3.04	21.46	52.25	1.68	2.11	2.64
Spring Average	-23.42	-8.27	8.41	1.25	1.50	1.78
Summer Average	-71.24	-35.57	3.62	0.49	1.10	1.77
Autumn Average	-12.05	5.75	24.61	1.68	2.02	2.38
Total Cloud Anomaly	%	%	%	(0-1)	(0-1)	(0-1)
Annual Average	-16.47	-8.15	-0.28	0.57	0.63	0.68
Winter Average	-3.78	0.25	4.24	0.70	0.73	0.76
Spring Average	-17.25	-6.24	4.67	0.56	0.64	0.71
Summer Average	-39.02	-19.02	1.03	0.40	0.53	0.66
Autumn Average	-16.89	-7.27	1.50	0.55	0.62	0.68

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Table 4. UKCP09 Future Climate Projections for Wind: A1B Emissions Scenario

Climate Variable	Predicted Change from Baseline 2080s			Absolute Values 2080s		
	10th Percentile	50th Percentile	90th Percentile	10th Percentile	50th Percentile	90th Percentile
Wind	n/a	M s-1^2	n/a	n/a	n/a	n/a
Annual Average	n/a	-0.065	n/a	n/a	n/a	n/a
Winter Average	n/a	-0.052	n/a	n/a	n/a	n/a
Spring Average	n/a	-0.154	n/a	n/a	n/a	n/a
Summer Average	n/a	-0.01	n/a	n/a	n/a	n/a
Autumn Average	n/a	-0.044	n/a	n/a	n/a	n/a

Appendix B: Examples of Defining Effect 'Scale within an EIA

Receptor Sensitivity	Magnitude of Impact			
	High	Medium	Low	Very Low
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible
Very Low	Minor	Negligible	Negligible	Negligible

Example 1

'Normal EIA'
Receptor A = High Sensitive
Magnitude of Impact = Low
Resultant Effect = Moderate

Climate Change
Receptor A = High Sensitive
Vulnerability = Low
(*climate change has little influence on receptor as resilient to changes in existing environment / climate, so climate change unlikely to alter the magnitude of impact*)
Magnitude of Impact = Low
Resultant Effect = Moderate

Example 2

'Normal EIA'
Receptor A = High Sensitive
Magnitude of Impact = Low
Resultant Effect = Moderate

Climate Change
Receptor A = High Sensitive
Vulnerability = High
(*receptor directly dependent on existing environment / climate, so change is likely to alter the magnitude of impact, i.e. change in the environment as a result of the Proposed Development)*
Magnitude of Impact = High
(*qualitative judgement*)
Resultant Effect = Major

Example 3

‘Normal EIA’	Climate Change
Receptor A = Low Sensitive	Receptor A = Low Sensitive
Magnitude of Impact = Low	Vulnerability = Low
Resultant Effect = Negligible	(*climate change has little influence on receptor as resilient to changes in existing environment / climate, so climate change unlikely to alter the magnitude of impact*)
	Magnitude of Impact = Low
	Resultant Effect = Negligible

Example 4

‘Normal EIA’	Climate Change
Receptor A = Low Sensitive	Receptor A = Low Sensitive
Magnitude of Impact = Low	Vulnerability = High
Resultant Effect = Negligible	(*receptor directly dependent on existing environment / climate, so change is likely to alter the magnitude of impact, i.e. change in the environment as a result of the Proposed Development)*
	Magnitude of Impact = High
	(*qualitative judgement*)
	Resultant Effect = Moderate

Appendix C: Policy and Guidance

Policy and Guidance

- EU Guidance on Integrating Climate Change and Biodiversity into the Environmental Impact Assessment (2013)[8]
- IEMA Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation (Nov 2015)[9]
- UK Climate Change Risk Assessment Evidence Report (2017)[10]
- 2017 EIA Regulations[11]

[8] EU Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessments http://ec.europa.eu/environment/eia/pdf/EIA%20Guidance.pdf
[9] IEMA EIA Guide to Climate Change Resilience and Adaptation https://www.iema.net/assets/templates/documents/iema_guidance_documents_eia_climate_change_resilience_and_adaptation%20(1).pdf
[10] UK Climate Change Risk Assessment (2017) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/584281/uk-climate-change-risk-assess-2017.pdf
[11] EIA 2017 Regulations http://www.legislation.gov.uk/uksi/2017/571/introduction/made