Final report

Climate Change Committee

UK projections of climate risks and effectiveness of adaptation measures for water scarcity

Appendix E - Acute Water Stress Power Sector Case Study

October 2025

2024UK258755-Project Report-P04 – Appendix E

Appendix E

Acute Water Stress Power Sector Case Study

Appendix E – Acute water stress detailed results (Power Sector Case Study)

Impact of climate

England

Table E-1 shows the mean of the worst ten weather-driven unmet demand 3-month events by region, as a proportion of total demand for the region, for Scenarios 3 and 7 to compare a 1.3ºC and 2.0ºC world with no growth in water demand assumed so the climate signal can be identified. At this regional scale, only small differences are apparent between the weather-driven unmet demand under these warming levels. This reflects the relatively modest level of warming (only 0.7ºC between the two) compared to natural climate variability within the models. When considering more extreme, lower probability events, the challenge of distinguishing a climate change signal from natural climate variability becomes more difficult. It is notable that in a number of areas of the UK no drought event in the UK has surpassed the severity of that experienced during the 1970s for multiple sectors, despite over 1 ºC of warming since then.

Table E-1 : The mean of the 10 worst 3-month weather-driven unmet demand events are show as a proportion of the total demand for the region for each start month to show the difference between a 1.3ºC and 2.0ºC world with no growth. All sub-sectors are summed.

	1.3ºC world with no growth				2.0ºC world with no growth			
Region	January	April	July	October	January	April	July	October
WCWR	1%	2%	5%	2%	1%	2%	8%	2%
WRE	0%	3%	11%	3%	0%	4%	14%	3%
WRN	0%	0%	0%	0%	0%	0%	0%	0%
WRSE	2%	3%	4%	4%	4%	4%	4%	4%
WRW	0%	1%	4%	1%	0%	2%	5%	1%

There are differences between sub-sectors in terms of the response to low flows. Figure 4.2 and Figure 4.3 illustrate the difference in weather driven unmet demand in a 1.3ºC and 2.0ºC world for hydropower in the WCWR region and fossil fuels sub-sector in WRSE region.

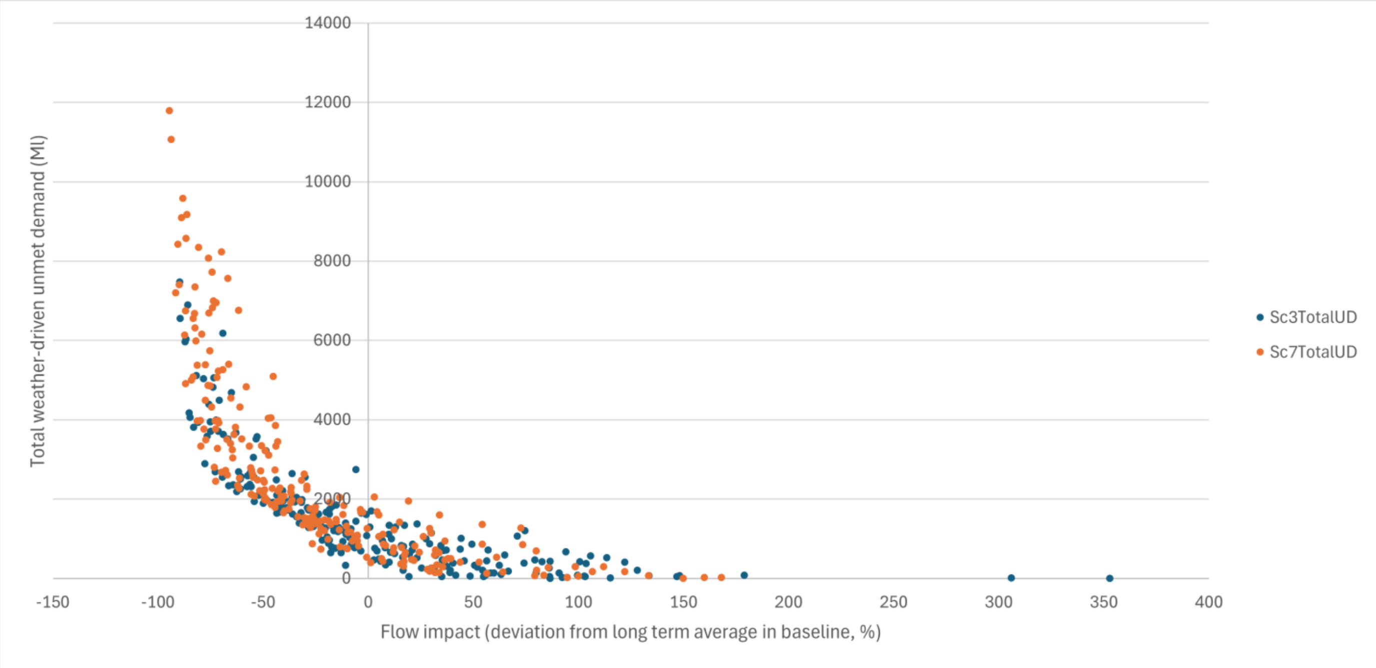

Figure E-1 : Difference in weather-driven unmet demand for selected hydropower sites with hands-off flow licence constraints, in WCWR region. Comparison between a 1.3ºC and 2.0ºC world with no growth in water demand.

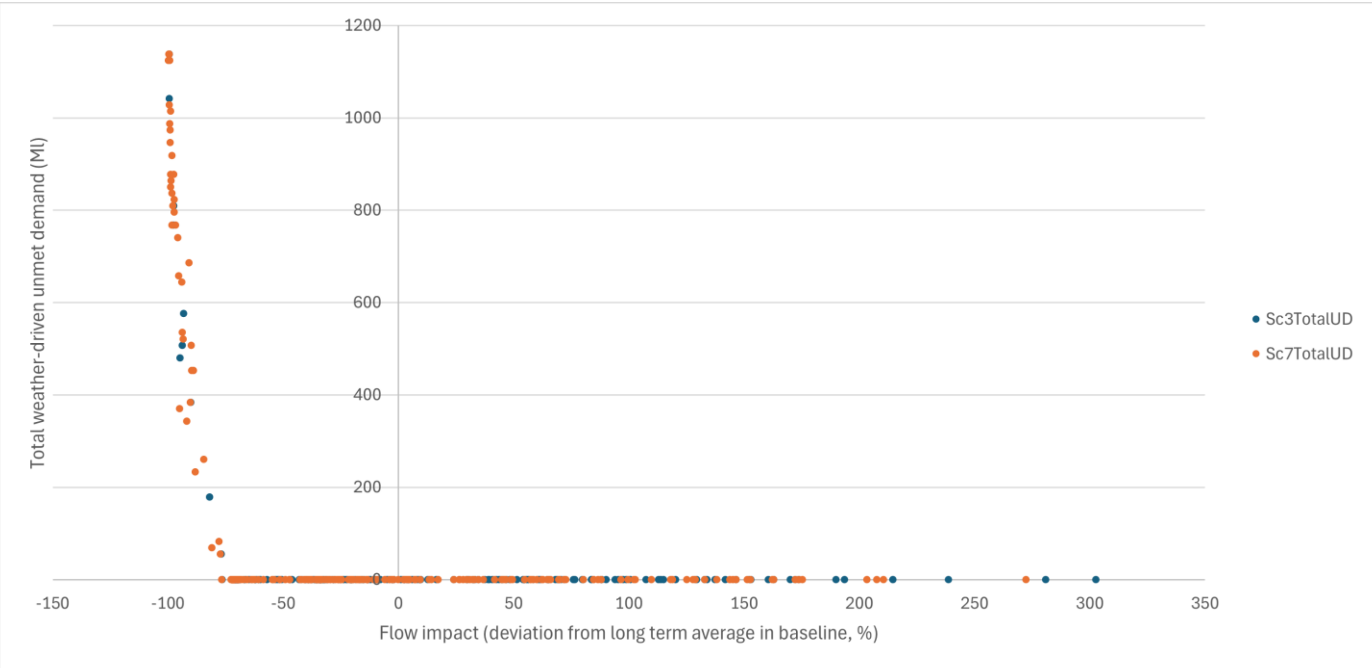

Figure E-2 : Difference in weather-driven unmet demand for selected fossil fuel and nuclear sites with hands-off flow licence constraints, in WRSE region. Comparison between a 1.3ºC and 2.0ºC world with no growth in water demand.

Figure E-1 and Figure E-2 show a very different response to changing flow impact; a more gradual increase in severity is shown in Figure E-1 compared to Figure E-2 which appears to hit a threshold, above which, weather-driven unmet demand increases rapidly with increasing flow deficit. There are fewer reference sites contributing to the graph in Figure E-2 compared to Figure E-1. The fossil fuels sites are also quite close to the coast, so whilst they technically abstract from waterbodies classified as freshwater surface waterbodies, their water sources may in fact be significantly influenced by the sea. By contrast, the hydropower sites that contribute to the results in Figure E-1 are at a variety of locations across the region. Such differences may contribute to the responses to flow in the figures.

A further consideration is the granularity of data underpinning the assessment, particularly temporally. This is thought to be a significant issue for hydropower and unclassified power sub-sectors. The data on these licences does not reflect the variation in operation over the year yet, the licenced volumes at many of these sites is of a magnitude such that it would be impossible for those abstraction volumes to be operational for much of the year. As a result, accurate estimates of vulnerability to flow cannot be made.

In contrast to the illustrative examples shown in Figure E-1 and Figure E-2, nearly all of the sites in Water Resources North show no weather-driven unmet demand in the baseline, scenario 3 or scenario 7. Although for security reasons, vulnerability of any particular selected site cannot be presented to water-related issues, at a local level, the weather-driven unmet demand impacts can vary widely within the same region, including reference sites with no impact at all through any of the scenarios tested. This finding is supported by the engagement with the power sector during this project who were unaware of any dry weather event negatively impacting the UK power sector in living memory. The diversification and geographic spread of power production, and the historic decisions to locate critical infrastructure close to plentiful water supplies being the most likely reasons why their resilience appears to be high.

Table E-2 shows the increase in frequency of events in which the weather-driven unmet demand is equal to or greater than the maximum value in the baseline (scenario 3) compared with a 2.0ºC world. The table shows events of 3-month duration only, for all sub-sectors added together. The average of events starting in all months is shown.

Table E-2 : Increase in frequency of events equal to or greater than the baseline maximum unmet demand. Event of interest, 3-months duration, average of all start months. Comparison between a 1.3ºC and 2.0ºC world with no growth in water use for England and Wales

Region	Multiplier
WCWR	4.8
WREast	3.9
WRNorth	N/A
WRSE	1.8
WRWest	2.4

Scotland, Wales and Northern Ireland

Weather-driven unmet demand results have only been presented for England. After interrogating the unmet demand results for Scotland, Wales and Northern Ireland, the decision was taken to remove these results from this assessment by HR Wallingford during their quality assurance process. The licence information contained within the WRGIS15 and WRGIS-lite tools, are not sufficiently detailed (particularly temporally) enough to appropriately measure the risk to hydropower abstractors at a water body scale which dominate these countries, for subsequent aggregation and presentation in this assessment. As a minimum the water bodies impacted by hydropower abstractors needs to be reviewed, including in particular, any seasonal operation of the sites and consumption of water (for example, where flows are abstracted from one waterbody and discharged into another) before any such similar assessment could be undertaken with confidence in the results. As a result of this decision, impacts on the flows in close proximity to the abstractor sites selected is presented as a proxy for the scale of potential impacts from climate- related flow deficits on this sector in Scotland, Wales and Northern Ireland.

Figure E-3 and Figure E-4 shows flow deficit comparison of a 1.3ºC and 2.0ºC worlds. Flow deficit is measured using flow anomaly for 3-month events starting in July and October respectively. The flow anomaly is the deviation of the flow from the baseline (Scenario 2, 1.3ºC warming) long term average, measured as a percentage change i.e. how does a three month period of flow, starting in July change from the baseline to a 2.0ºC world. The results for each region are a sum of several sites, selected for their proximity to hydropower abstractors. The flows at each site were calculated for each regional climate model so the flow values are across all of the climate models. Despite using all the available regional models, this is still a very small ensemble size for exploring events that could cause systemic issues in the power sector. The regional climate model producing the lowest flows in a 1.3ºC world may be different to the regional climate model producing the lowest flows in a 2.0ºC world. All regional climate models are considered to be equally likely versions of the future climate.

The results show a worsening of flows in the summer and into autumn. These are consistent with other studies that demonstrate an increase in the duration of drought periods in the future (Parry et al., 2024) that in effect appears as a lengthening of the driest period over summer, into the autumn.

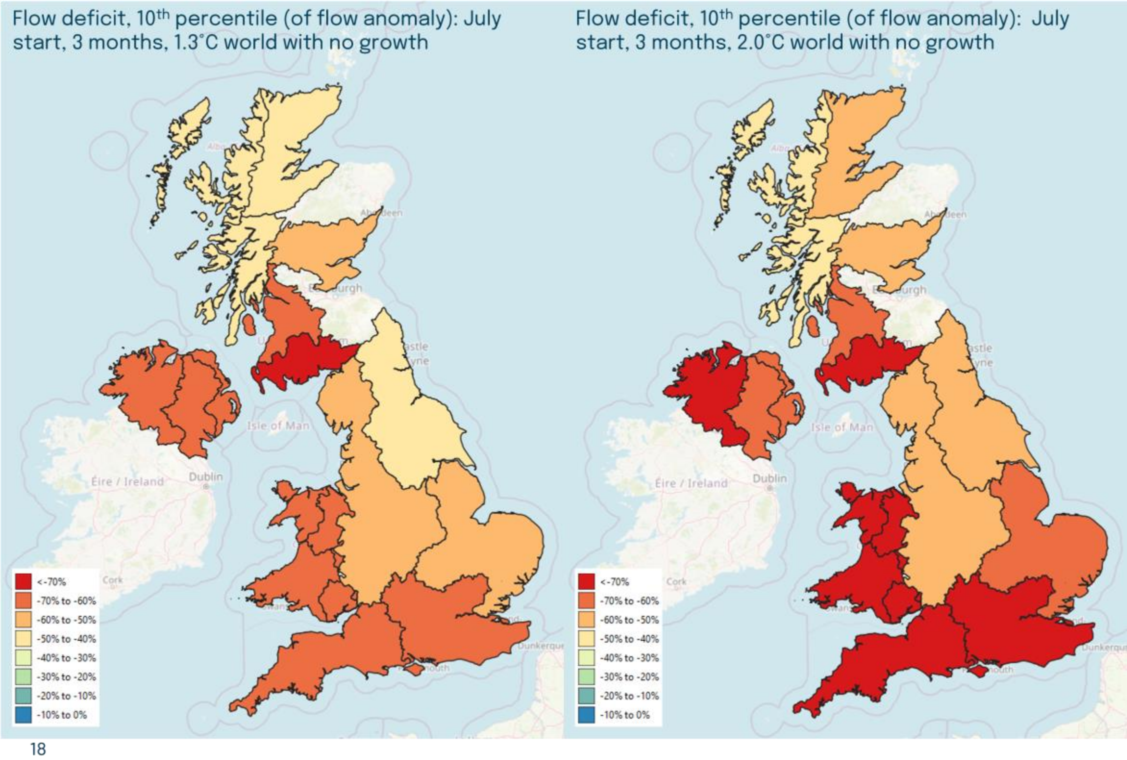

Figure E-3 : Flow deficits comparison of a 1.3ºC and 2.0ºC world. Flow deficit is measured using flow anomaly for 3-month events starting in July (i.e. deviation from the long term average, measured as a percentage). The 10th percentile of the flow anomaly is presented to represent low flows.

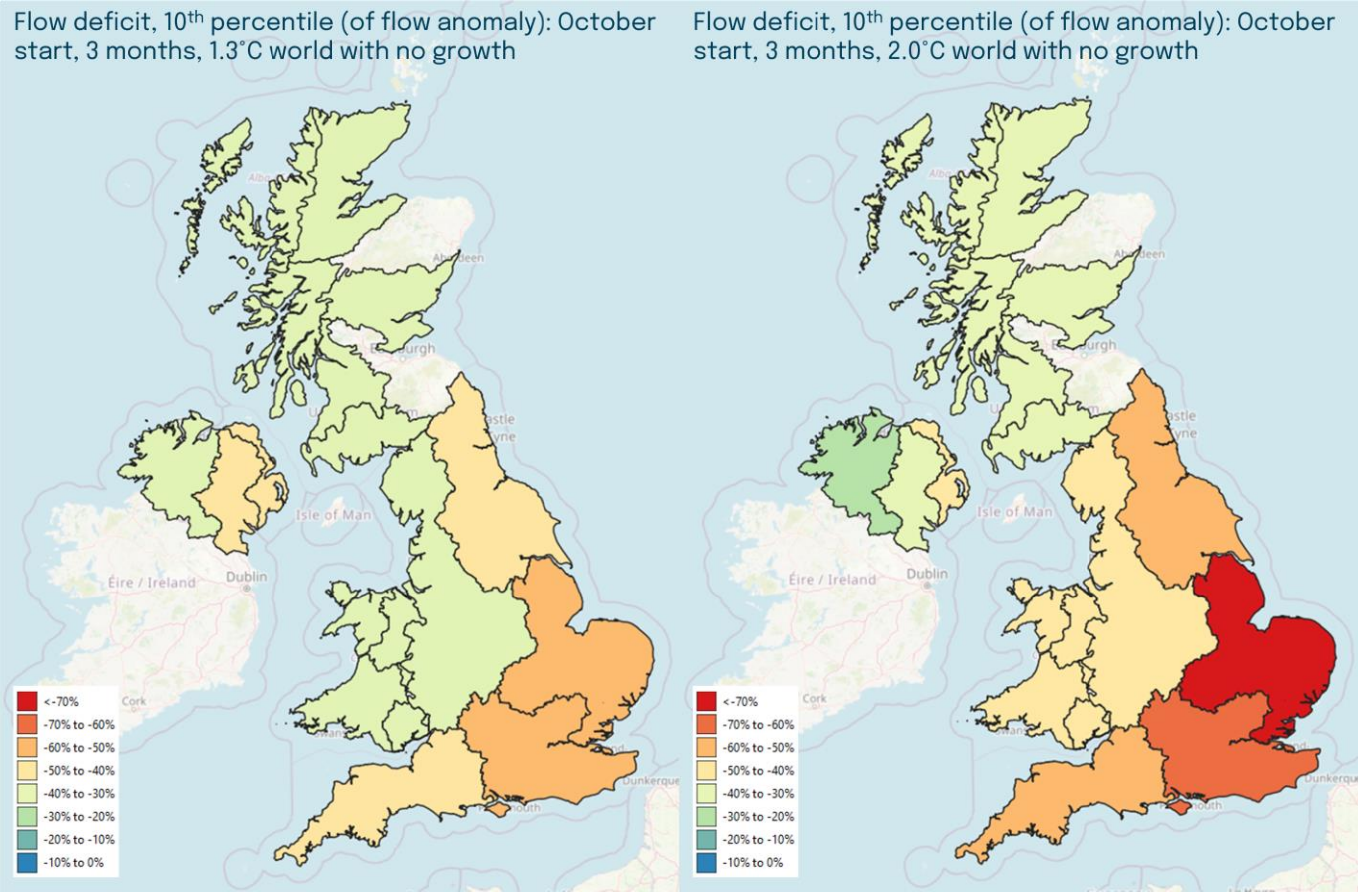

Figure E-4 : Flow deficits comparison of a 1.3ºC and 2.0ºC world. Flow deficit is measured using flow anomaly for 3-month events starting in July (i.e. deviation from the long term average, measured as a percentage). The 10th percentile of the flow anomaly is presented.

Figure E-5 provides an illustrative example of the natural variability present in the projections of flows. For each year shown on the x-axis, the sum of the deviation of flow from the long-term average (the average of scenario 1, the baseline) is presented for periods starting in October and lasting 3-months for each RCM. The region shown is Neagh Bann in Northern Ireland. Other regions are presented in Appendix D. It is difficult to discern any pattern of change in the flows due to climate change signal. There is considerable variability from year to year of the flows in the 3-month periods.

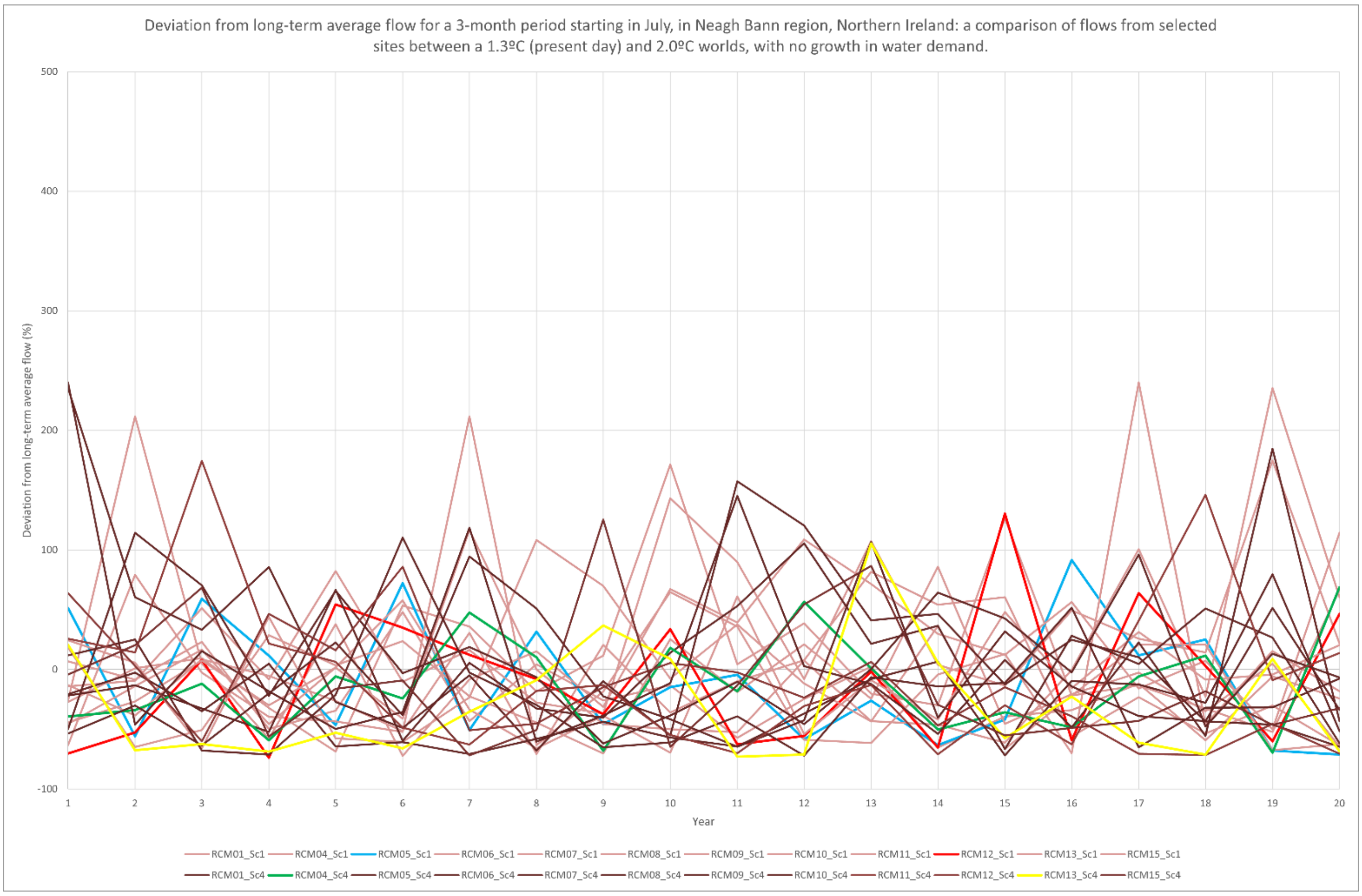

Figure E-5 : Deviation from long-term average flow for a 3-month period starting in July, in Neagh Bann region, Northern Ireland: a comparison of flows from reference sites between a 1.3ºC (present day) and 2.0ºC worlds, with no growth in water demand.

Source: "Present day" projections are shown as solid pink lines, future projections are shown as dark red lines. The median RCM selected in the economic analysis for this project to represent the 'typical' impacts is shown in blue for present day and green for the future. The high sensitivity RCM are shown in red for the present day and yellow for the future.

Impact of growth

Growth is the greatest driver of change in unmet demand generally as well as for the most acute water stress, when compared to the central and high global warming levels, environmental destination scenarios tested or actions from the public water supply sector.

The growth assumptions used in this assessment are defined by the Environment Agency's assumptions within the NMF2.0. Their assumption for the power sector, in the absence of better information, is that existing abstractors will switch from using their recent actual volume of water (usually an average of the last 6 years) to their fully licenced volume. The increase in water use between the baseline and 2050s scenarios are shown in Table E-3 below. Across the UK, this table shows that existing abstractors could try to abstract nearly 3 times the volume they currently abstract, on average, and still be within their allowable limit according to the present licencing regime.

Table E-3 : Increase in water demand between the present day and 2050s scenarios

Sub-sector	England (%)	Wales (%)	Scotland (%)	Northern Ireland (%)
Hydropower	2.4	2.1	4.1	3.4
Fossil fuels and nuclear	4.9	1.0	na	na
Energy from waste	0.9	na	3.0	na
Biomass / fossil fuel co-fired	5.0	na	na	na
Unclassified power	6.9	1.6	na	na
Average increase	3.0	1.6	3.5	3.4

It is not clear from the abstraction licence data available, whether it is likely that abstractors in the power sector would increase their demand to their fully licenced volumes, even in a net zero future. However, it should be noted that these abstractors are currently permitted to at least attempt to take these volumes. Increasing the demand for water dwarfs all other drivers but as it is unclear as to whether this water would ever actually be required in these locations, there is an opportunity to better understand the water requirements of key power producing sites to better understand their needs and the available water at a local scale to understand whether such assumptions that are integrated into water resources planning are actually realistic.

wsp.com