Written evidence submitted by Civil Engineering at Newcastle University

Newcastle University is a Russell Group University with over 20,000 undergraduate students and 600 post graduate students. The school of Civil Engineering was ranked 3rd in the UK for Civil Engineering research power (REF 2014). Two of our major research areas are 1) climate change and climate change impacts, and the 2) resilience of critical infrastructure. This submission is from the civil engineering discipline based in the School of Engineering at Newcastle University. Based on our expertise, we make the following submission to the topics requested:

Key vulnerabilities and levels of preparedness of UK CNI to extreme weather events and other effects of climate change, including:

- The possible compound effects of such events;
- The interdependencies between different aspects of UK CNI;
- Supply chain vulnerabilities; and
- Recent 'near miss' scenarios ;

Many of the key climate variables that affect CNI have not been well accounted for in previous climate models (e.g. wind and lightning). This has prevented CNI owners and operators from making all but the highest-level assessments of the vulnerability of their systems to some future extreme events. The situation has improved with the recent release of UKCP18 climate projections; however, quantified risk assessments for some climate variables are absent from CCRA 3rd round reports. New research on future changes in hazardous weather

New Met Office convection-permitting climate simulations for the UK and Europe are providing new information on changing hazards from extreme weather in the UK. Results presented suggest significant increases in high impact events by the end of the century under the high RCP8.5 emissions scenario, as follows:

Precipitation Extremes:

CNI has been shown to be particularly vulnerable to flooding, and significant increases in hourly and daily precipitation extremes are expected (Chan et al., 2020 and in review). On average across the UK, the 30-year return level of 1h and 24h precipitation is projected to increase by 30% and 20% (central estimate) by 2070 under RCP8.5. The high estimate of change is 45% and 40%, respectively.

The increases tend to be somewhat higher over the north of the UK. For example, central estimates to the future changes for 30-year return level for 1h and 24h precipitation over Western Highlands and Northern Ireland are +35% and +25% respectively. This is in contrast somewhat lower increases over the south (+20% for 1hr Pr, 30-yr return level). These variations are potentially important to local adaptation planning.

Climate model uncertainties are large. For shorter return periods (< 30 years), UK-mean projected changes have model uncertainty that is comparable to the uncertainty in the extreme value estimates per ensemble member, highlighting the importance of conducting multi-ensemble simulations.

Increasing precipitation from large organised convective systems (MCSs) (Chan et al, in review). For the British Isles in summer (autumn), the contribution of MCSs to total precipitation increases substantially, almost tripling from 156% (20-25%) to 30-445% (30-55%) by 2100 according to the projections by Met Office and Swiss ETH-Zurich climate simulations.

These increases show extreme-producing events are becoming more unequally distributed in time and space. Since mean rainfall is projected to decrease by both models (especially during summer), this is suggesting both flood and drought risks are increasing at the same time.

Projected increase in slow-moving storms in Met Office model (Kahraman et al., 2021). 14x increase in the number of quasi-stationary storms with the potential for high precipitation accumulations over land across Europe by 2100. More research is required on this climate hazard.

Lightning

Increases in lightning in summer. For the UK, preliminary analysis is showing that lightning is projected to increase more than 2x in July and August by 2100 under RCP8.5. Decreases are projected in autumn despite an extension of the convective season. This is particularly relevant to electricity infrastructure as this is one of the biggest climate related faults experienced by these networks. More research is required on this climate hazard.

Hail

The potential for severe hail is likely to remain low into the future. Preliminary results suggest a decrease in the potential for severe hail across continental Europe, but more work is needed to assess changes in extreme hailstorms (hail diameter larger than 5 cm), which might indicate changes in either direction.

Windstorms

Windstorms are the biggest climate hazard to electricity distribution networks. Preliminary work shows large increases in the frequency of extreme windstorms found over the UK in the UKCP18 ensemble. For the UK, windstorms that occur typically once every 20 years in the 1990s are projected to occur once every 10 years in the 2070s, under RCP8.5. More research is required on this climate hazard.

Large increases are found in the frequency of intense windstorms over Europe at the end of the 21st century in single realisation 10-year climate simulations (Manning et al., 2021).

In both studies, a large proportion of the future increase in the most extreme windstorms is associated with storms that develop sting jets. Wind speeds driven by sting jets are also underestimated by coarser resolution simulations (Manning et al., 2021).

Some of the above hazards are caused by the same meteorological phenomena. Short-duration extreme rainfall is caused by thunderstorms which also causes lightning, meaning risks to vulnerable CNI and public health (like pluvial flooding of roadways, damages to transmission towers, power stations, and substations, and sewage overflows) would be correlated. Like in August 2019, multiple lightning strike events at different locations leading to large-scale power outages across the UK (Ofgem System and Network Team 2020). Windstorms are somewhat different. They could be generated by convective event, or be associated with extra-tropical cyclones (like sting jets). For the former, severe winds can occur with individual or clusters of thunderstorms, but large-scale windstorms associated with extra-tropical cyclone are of particular importance to the UK. These extra-tropical cyclones could occur in any season. They can also have flash flood and lightning producing thunderstorms (especially if they occur in the warm season), but hazards from these cyclones would include wind and longer-duration precipitation extremes. One still has correlated risks but to different assets – like damages to overhead powerlines and off-shore/coastal assets, and fluvial flooding. A good example of this is February 2014 event in which flooding occurs in the Somerset Levels and collapse of the Dawlish Sea Wall is caused by the same extratropical cyclone, leading to the destruction of coastal flooding defences and extended disruption of railway service to the South West (Kendon and McCarthy 2015).

Windstorms and large-scale winter flooding are both caused by extra-tropical cyclones though they are correlated over different time scales. Flooding occurs due to successive winter storms that causes soil moisture and river levels to gradually build while damages due to winds arise from single events. Their combined influence on impacts has not yet been quantified though it is likely that their combined effect will lead to larger insured losses in a given season than when either occurs alone. The insurance industry currently treats these hazards as independent which may lead to an underestimation of risk of extreme impacts, particularly in a future climate where we expect a larger frequency of compound events due to projected increases in rainfall and windstorm intensities. We have undertaken research, with the Energy Networks Association and District Network Operators (DNOs), to relate weather forecasts (focusing on wind speeds) to likely asset damage, allowing us to form probable estimates of consequences of failure (i.e. consumers without power) for a given weather event (i.e. wind storm).

Interdependencies between different CNI is well recognized, but little work has been done to couple models together except for a few specific case studies. Further work is required to quantify cascading failures between CNI sectors

What might constitute an ‘acceptable’ level of resilience to climate change within UK CNI, both to near-term risks and longer-term uncertainties or ‘tipping points’, and the obstacles to achieving it;

No comment

the effectiveness of Government policy, legislation and implementation frameworks for managing national security risks arising from climate change, including those emerging within the private sector;

No comment

Allocation of roles and responsibilities at the national, devolved and local level, and the connections between them;

No comment

The role of the Government’s forthcoming National Resilience Strategy, particularly in addressing opportunities for (and obstacles to) improved resilience among CNI providers;

No comment

The extent and effectiveness of UK-wide monitoring and early warning systems;

Early warning for flooding is provided by the EA. Recent work is improving these systems, but there is still a lot more to do for CNI. Proof of concept early warning system that estimates damage to electricity networks due to approaching storms is presented (Wilkinson et al.). This framework is applicable to all types of CNI and climate hazard provided the data is available. CNI operators generally have asset and fault data that can be used to set up these systems, but the quality of this data varies between sectors.

The opportunities presented by technological solutions (such as AI and digital twins) for anticipating and managing the implications of climate change for CNI.

Research from the NERC funded project (NE/N012992/1) incorporating a simple digital twin to manage the climate risk to CNI for current climate has recently been published (Wilkinson et al.). This work is now being extended to include projected risks due to climate change in the BEIS funded project CS-NOW. The UK is in a strong position to use this approach to make both tactical interventions (early warning systems) as well as longer term strategic investments (climate impact and consequence assessments). Met office weather forecast models, observations and climate projections can be coupled with asset databases and damage/interruption information maintained by infrastructure owners and operators to both "train" models, make short-term tactical forecasts or longer term strategic risk assessments to inform investments. This approach is currently being applied to electricity networks, as the datasets for this application are good (Ofgem require district network operators to report faults and interruption via a consistent collection and recording system known as the National Fault Interruption and Reporting Scheme). All infrastructure operators will collect similar information; however, the quality (in terms of resolution, precision and accuracy) can be quite different. UKCP18 projection now numerically resolve most of the parameters that affect infrastructure networks and so can be credibly applied to make risk assessment for future climate, although the uncertainty is likely to remain high. Other models that translate climate variables (such as precipitation) to environmental loadings (such as flood depth) are also improving in speed and accuracy and therefore can start to be used in digital twins. City-scale models at the resolution of metres are now available

Digital twins are data driven and therefore require access to large amounts of data. The UK has some good data collecting facilities and some good data sets and while in general the owners of these datasets are willing to share, this is not always the case, or it is not always easy to know and find the relevant datasets. There are also issues around the quality and consistency of the data in different sectors or the ability of models to be used interoperably. This is an issue when it comes to modelling interdependencies. Met-office data is not always freely available for private sector.

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