

How can UK energy systems be made more resilient to the impacts of climate change?

What changes are needed in the UK electricity generation, transmission and distribution systems to address the dual challenges of reducing vulnerability to the impacts of climate change while decarbonising the energy system?



National and regional policies seek to ensure that resilient infrastructure systems are in place to meet future energy needs in the face of a changing climate while also contributing to the UK's carbon emission reduction targets. Fulfilling both objectives poses challenges. The use of low carbon, renewable energy technologies, such as wind turbines and hydropower, is expected to increase. However, the power supply from these technologies may be periodic and/or irregular. At the same time many emission pathways suggest a switch from the use of fossil fuels to low carbon electricity for powering vehicles and heating to meet carbon reduction targets.

What are the implications of decarbonising the UK energy supply?

The goal of decarbonising the UK energy system will have impacts upon the resilience of supply systems:

- Increasing levels of intermittent supply from renewable resources located across the UK, will alter the way the electricity grid is designed and operated.
- Uncertainty remains over how a different generation portfolio will meet new peak loads emanating from new demand-side technologies.
- Driven by rapid increases in electricity demand, the shift to renewables and the addition of new generating plants, the grid will need to grow significantly and have the capability to respond to increased amounts of intermittent generation if the UK is to make the changes necessary to deliver on its 2°C commitments.
- The electrification of heating as well as road transport, in order to reduce carbon emissions, will place substantial new loads on the grid. For example if 45% of households were to install heat pumps to replace fossil fuel heating, without significant efficiency measures, an additional demand of approx 26TWh could be created.
- Increasing electrification and ever more reliance on electricity for convenience, comfort and connectivity (ie laptops, entertainment and security systems) further increase sensitivity of consumers to supply disruption.

Will the changing climate impact upon the UK's ability to generate energy from renewable sources?

Climate projections to 2050 suggest:

- A slight overall increase in solar energy output but with significant regional differences – greater increases in the south and smaller in the north. Seasonal changes will also mean a slight decrease in the winter and an increase in the summer.
- A slight increase in overall annual output from hydropower resources, but marked seasonal differences. There is slight increase in winter output (c 6%) and a more marked decrease in summer output (c -13%); however because more power is generated in the winter period this results in the small net increase.
- That adaptation to hydropower schemes to capitalise on changes in rainfall patterns may enable a significant increase (c 25%) in capacity, but the measures would make individual schemes more expensive to construct (c +20%) due to their larger size.
- Only limited changes to the supply of wind and wave energy.

How resilient is the energy system in response to climate change?

Current evidence indicates that:

- The physical infrastructure of the national grid is likely to remain able to withstand extreme weather conditions arising from climate change over the coming twenty years, assuming that electricity demand does not increase significantly during that period.
- Transmission system assets are vulnerable to increases in temperature that result from climate change, particularly where the urban heat island effect is strong. Overhead lines may see a reduction in rating (the amount of power they can carry) of 27%, cable ratings may be reduced by 10% and transformers by 17%. In some cases, these reductions in ratings can be easily mitigated but designers should already consider the impact of climate change as they choose equipment to be installed.
- Equipment may age more quickly as air temperatures increase. This is particularly the case for transmission system transformers.
- Robust systems that are less vulnerable to extreme weather events will be required in the longer term. This will give additional benefit in comparison to building in extra redundancy/decreasing repair times.
- The widespread adoption of air conditioning or comfort cooling within the commercial and domestic sectors, coupled with increasing temperatures associated with climate change, could lead to a significant increase in summer electricity demand.
- Increased cooling demand has the potential to move peak energy demand from the winter to the summer, dependent on the evolution of the market in the domestic sector and improvements in the efficiency of domestic (and non-domestic) cooling systems and strategies. Such changes would need to be factored into grid operation and maintenance.

How can new methods of modelling UK energy demand help?

The RESNET electricity demand scenario tool has been developed to quantify plausible energy use scenarios which can be used to test the UK energy system resilience against extreme events such as flooding and severe storms:

- Systematic bottom-up modelling of energy demand can be used as part of an appraisal of the impacts of climate change on electricity generation and transmission systems.
- The probabilistic nature of future climate projections allow a climate-based risk analysis to be carried out on the likelihood of defined system thresholds being exceeded. This can aid the design of resilience into energy networks that are serving future demand.

What action do decision makers need to take?

Polymakers will need to

- Take account of the technological and behavioural change arising from efforts to decarbonise and their impacts on electricity demand, eg how householders use heat pump technologies and when and where they may charge electric vehicles.
- Take account of the impacts of climate change on energy demand, eg its effects on the demand for comfort cooling.
- Monitor electricity demand in relation to the capacity of the physical infrastructure of the UK grid.
- Ensure that information is made available to the public about how climate change may affect the UK energy system and the supply to their homes and workplaces.

Energy companies will need to:

- Upgrade certain assets to increase system resilience, eg install larger cables to increase rating, and upgrade some transformers.
- Consider resilience at multiple scales to reflect the differing needs of different consumer groups, eg large industrial consumers, critical users (eg hospitals) and private consumers.
- Make appropriate advice available to differing consumers and consumer groups as to the types of measures that they can take to enhance their own resilience.

Further information

This Policy and Practice Note was written by Professor Ian Cotton and Dr Ruth Wood on behalf of the RESNET project team and Professor Gareth Harrison, Professor Phil Banfill and Dr David Jenkins on behalf of the ARIES Project Team. Thanks go to Jamie McWilliam, Head of Futures, Energy Networks Association, for comments on the text.

Useful resources:

ARCC <http://www.arcc-network.org.uk/>

RESNET: <http://www.mace.manchester.ac.uk/our-research/centres-institutes/tyndall-manchester/major-research-projects/completed-projects/resnet/>

ARIES: <http://www.arcc-network.org.uk/project-summaries/aries/#.VyN7l4f2bs0>

Fu, G., Wilkinson, S. & Dawson, R. 2014 'A Spatial Model for Infrastructure Network Generation and Evolution' in Sanayei, A., Rössler, O.E. & Zelinka, I. (eds) Proceedings of 2014 Interdisciplinary Symposium on Complex Systems, 365-371

Wood FR, Calverley D; Glynn S; Mander S; Walsh C; Kuriakose J; Hill F; Roeder M, 2015 The impacts of climate change on UK energy demand Infrastructure Asset Management Volume 2 Issue 3, 107-119

Panteli, M, Pierluigi, M, 2015 The Grid: Stronger, Bigger, Smarter?: Presenting a Conceptual Framework of Power System Resilience IEEE Power and Energy Magazine vol 13, issue 3 58-66

Panteli M, Pierluigi, M, 2015 Influence of extreme weather and climate change on the resilience of power systems: Impacts and possible mitigation strategies Electric Power Systems Research Volume 127, 259-270 doi:10.1016/j.epsr.2015.06.012

Ghanem, DA, Mander, S, Gough, C 2016 "I think we need to get a better generator": Household resilience to disruption to power supply during storm events Energy Policy Volume 92, 171-180 <http://www.sciencedirect.com/science/article/pii/S0301421516300453>

Contact: Ian Cotton, Manchester University

email: ian.cotton@manchester.ac.uk

Series editor: Anne Liddon, Newcastle University

Series coordinator: Jeremy Phillipson, Newcastle University