UK Energy Research Centre

House of Lords Select Committee on Risk Assessment and Risk Planning

Risk assessment and risk planning in the context of disruptive national hazards

UK Energy Research Centre Response

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Introduction to UKERC

The UK Energy Research Centre (UKERC) carries out world-class, interdisciplinary research into sustainable future energy systems.

UKERC is a consortium of top universities and provides a focal point for UK energy research and a gateway between the UK and the international energy research communities.

Our whole systems research informs UK policy development and research strategy. UKERC is funded by the UK Research and Innovation Energy Programme.

Currently in its fourth phase running from 2019-2024, UKERC delivers an ambitious programme of research on the challenges and opportunities for delivering the transition to a net zero energy system and economy. The programme brings together engineers, natural scientists and social scientists to generate evidence that informs real-world decisions.

Introduction and overview

This response has been prepared by experts from the UK Energy Research Centre, UKERC. UKERC is a consortium of leading universities, funded by the UK Research Councils, with research focused on the transition to a low carbon energy system, in line with the targets set by the government under the Climate Change Act. The focus of our submission is on the risks of disruption to electricity supplies, or power outages, where UKERC research provides insights. [1,2]

Electricity supply in the UK is among the most reliable in the world. This has continued to be the case as the power systems in both Great Britain and on the island of Ireland have been progressively decarbonised with growth of wind and solar power, and a 50% reduction in the emissions intensity of electricity in Britain in less than 10 years. Indeed, by some metrics – 'customer interruptions' and 'customer minutes lost' – reliability has improved in that time.

Looking forward, the share of traditional fossil fuels in electricity supply will continue to decline and the use of electricity will increase as cars and home heating are electrified. Changes to electricity production technology, if not properly managed, may bring new risks while an increase in the dependence on electricity increases the impacts of outages (i.e. loss of power to homes or businesses). However, there is no particular reason why, given serious attention, we cannot improve system reliability and the ability to recover from disturbances compared with the present day. This will come in part from getting the engineering right and in part from better understanding of impacts that can help us to put measures in places to improve societal resilience.

Our response addresses questions 2, 4, 8, 9, 10 and 12, and covers the following issues:

- Changes to the electricity supply mix and their impacts on risk
- Changes to the use of electricity and how these affect resilience
- Regulatory and governance arrangements for ensuring reliable supplies
- Responses and contingency arrangements on the part of national and local government, and the role of individual households.

2. Are there types of risks to which the UK is particularly vulnerable or for which it is poorly prepared? What are the reasons for this?

Risks of interruption to electricity supplies

As the sources of electricity change it is important to consider the potential risk of a large disruption to electricity supply, something that UKERC research provides evidence about.[1,2] As the electricity system goes through this period of significant change, it is important to ensure that this risk is managed carefully in order that the very high standards of reliability that we have enjoyed historically, and still enjoy now, are not compromised. As we move to a higher share of renewable and other sources of low carbon energy, it is possible that we lose some inherent traditional sources of resilience (e.g. large synchronised rotating masses). Their role in reliability will need to be replaced with other sources, such as through new service contracts to make use of batteries or wind farms to help keep the system in balance. However, it is important to note that decreased dependency on fossil fuels also reduces some risks. Fossil fuel supplies can be interrupted for a variety of reasons both domestically and internationally. For example, the worst peacetime disruptions to power supplies in the UK were caused by the miners' strikes in the 1970s.

Exogenous risks to electricity systems are also increasing: extreme weather events are already responsible for the majority of long outages, and we can expect more extreme weather in future as a result of climate change. UK systems are particularly vulnerable to flooding, which can disrupt multiple infrastructures simultaneously, making it more difficult to get systems back up and running. Adapting to climate change impacts will require ensuring that physical assets are protected from extreme weather.

Overall, unanticipated shocks to energy supplies will never be completely avoidable; no electricity system can be 100% reliable and the nature of complex systems is that the outcome of a disturbance cannot always be foreseen and adverse impacts avoided. Thanks to well-established system design and operation procedures, experience from around the world is that major outages are uncommon. However, they can occur and, where they do, they often result from an unexpected combination of factors which are challenging to predict or avoid.[3] Therefore, as well as maintaining a reliable energy system, we also need to understand how to contain and recover from the disruptions which do occur.[4]

In spite of the challenges, major electricity supply disruptions in the UK are rare and the GB system has never experienced a whole system collapse. However, there is no cause for complacency. A large amount of new equipment and controls have been added to the electricity system in a very short space of time, on occasion causing some unexpected interactions and creating uncertainty over the precise vulnerabilities of the electricity system and the interlinked systems that depend on it.[5] An example of this is the outage of August 9, 2019, where around 1.1 million people lost power for around 40 minutes. Like many large disruptions, the outage was caused by an unexpected combination of events occurring simultaneously.[5,6] It was not caused by a lack of power generation or the variability of wind power. Rather, it concerned the ways in which resources are controlled and the system is operated. A lighting strike was the initial trigger and the event unfolded because of incorrect automatic control actions. These included large amounts of small-scale, 'Distributed Generation' dropping off the system in ways that the most recent version of connection standards are intended to forbid.[5] However, the largest impacts on citizens and the economy occurred not because of the loss of electricity per se, but because of the resulting disruption to the rail network, which itself was caused by unexpected vulnerabilities arising from a recent software upgrade.[6,7] The incident demonstrates the potential for incorrectly specified automated systems to increase our vulnerability to outages, particularly in the case of new systems with which operators are unfamiliar.

The incident also highlighted a critical infrastructure interdependency which might not have been apparent otherwise. There is a need to improve our understanding of interdependencies between critical infrastructures and the essential services that depend on them; electricity failure probably represents the greatest risk in terms of knock-on impacts to other sectors.[8] Many of the interdependencies are bi-directional: in other words, loss of electricity impacts other sectors such as communications and water supplies, which in turn can have knock-on effects back on the electricity system. The emergency plans of many organisations, including those responsible for critical infrastructures, rely on hired diesel generators. However, in the event of a large outage these would be severely oversubscribed: for example, in the West Scotland storms in 2013, the 30MW of mobile generation deployed included almost all large units north of London.[9]

The impact of electricity supply interruptions

A second key risk stems from the growing dependence on electricity, both for end-users such as households and businesses, and for utilities which use increasingly sophisticated ICT to manage their systems.[10] The shift to home working during the current Covid-19 pandemic means that organisations are now fundamentally reliant on reliable energy and communications services in people's homes, with behavioural data suggesting that this may continue after Covid-19.[11] During an electricity outage or other crisis, communication is vital for reducing impacts, by enabling people to plan and prepare and reducing anxiety.[12,13] However, increasingly people do not own radios or landline telephones, and are entirely reliant on the internet and social media for communication. During a major outage in Lancaster in 2015, during which 61,000 properties lost power for up to a week, mobile phones did not work at all, due to loss of power to the base stations powering the transmitters. Alongside this most domestic internet connections were also lost.[14] During a long disruption in the West of Scotland in March 2013, citizens commented that "the worst thing was not knowing what had happened" because of phone and internet failures.[9] Impacts of communication failures caused by electricity outages will have a particularly severe impact on young, urban populations, because they lack experience in dealing with poor mobile phone availability. Increasingly, information about what to do during an outage is only available online. We should not assume that people will be able to access the internet during an outage, due to congestion on mobile networks, loss of home broadband routers and limited battery life on devices.

Mobile phone networks in the UK are not regulated to provide any specific amount of backup power, which has been judged to be 'prohibitively expensive' (Ofcom, cited in RAEng, 2016). That said, regulation is not a silver bullet: in the US, mobile providers are required to provide eight hours of backup power, yet in practice they often fail to do this.[15] Overall, there is currently a large gap in knowledge about the extent to which mobile networks can be expected to operate in the event of an outage. This gap in knowledge is problematic because emergency plans often assume the use of mobile networks: for example, many organisations now rely on mobile platforms such as WhatsApp to communicate with their staff. These workers might be vital for getting systems and services back up and running. A priority should be to ensure that emergency planners and risk managers within critical infrastructure sectors are aware that the internet and mobile phones cannot be relied upon to work during a crisis, and have backup options in place.

4. Given the range of possible national risks, and the need to achieve a balance between efficiency and resilience, what level of assurance should the Government be seeking on the UK's resilience to hazards? What would effective national risk management achieve, and how could its success be measured?

Disturbances to the electricity system are inevitable, whether due to natural phenomena such as short circuit faults caused by lightning or high winds, or random equipment failures. The system should be, and is, designed to be resilient. It should be capable of preventing, containing and recovering from the adverse impact of disturbances, i.e. interruption of supply to energy users. This level of resilience is currently achieved for the electricity system through a combination of rules for the design and operation of the network, such as in the Security and Quality of Supply Standard, and minimum performance standards for equipment connected to the network.[16,17] However, the technologies used to generate and transmit electricity and enabling its use are very different now from when the main engineering standards were written. It is essential that reviews are carried out sufficiently frequently and standards are appropriately updated for system risks to be kept acceptably low.

In our view, reviews have not been done often enough or sufficiently rigorously. The major system incident in August 2019, described in our answer to question 2, while having a significant impact only on the rail system in the south-east of England, revealed important weaknesses in the institutional arrangements for managing the system.[6] In particular, Ofgem's investigation suggests that existing Grid Code rules and 'Engineering Recommendations' are not being enforced;[18] if they had, there is good reason to suppose that the initial disturbance that day would not have led to any interruptions to supply. Failure to update some existing conventions on system 'defence measures' – a key part of ensuring overall resilience – might have caused a more severe incident. Were the system to have collapsed – shown by incidents around the world to be a very real risk for a power system – the closure of thermal power plant over recent years and failure to develop alternative procedures would have presented significant challenges to the rapid re-starting of the system and restoration of supplies.

8. How well are national contingency plans communicated to and understood by those at a local level, including emergency responders? What could be changed to increase the capability of local responders to effectively plan for and respond to emergencies?

One issue highlighted in the investigation by the Energy Emergency Executive Committee (E3C) of the August 2019 event described above was the lack of a common definition of 'essential services'. According to the E3C report, "Impacts were further exacerbated by the ineffectiveness of essential services' business continuity plans" implying a lack of understanding of what sorts of electricity system disturbances their supplies might be vulnerable to.[19]

9. What is the role of the individual in relation to national crises? Are there potential benefits in increasing public involvement and transparency in emergency planning? What limitations are there to this? What lessons have been learnt or should have been learnt about the approach taken to risk assessment and risk planning in this country from the COVID-19 pandemic?

Individual actions taken in response to a problem on one system can cause knock-on impacts on other systems. For example, in cases of gas disruption, widespread use of electric heaters often puts strain on local electricity grids. Understanding behavioural responses to energy supply outages is therefore important.

During outages, the immediate needs of citizens involve finding information about what has happened and how long it can be expected to last. In many previous incidents (in the UK and elsewhere), people have gathered in hospitals in an attempt to find information, because these tend to have backup generators and are often the only place with heat, light, and power to charge phones.[14,20,21] This puts strain on hospitals, which simultaneously need to deal with a large increase in in-patients due to failures of home medical equipment.[22,23].

The burden on hospitals could be mitigated through better community provision, such as distributing oxygen, distributing lists of open pharmacies and doctors' surgeries, and publicising available transport options to take pressure off ambulances.[21,23] Ensuring that home carers and community health workers know what to do in the event of an outage can help to avoid hospital admissions arising from health workers not knowing where else to take their patient.[23] A 'low regrets' option for societal resilience, which could take the pressure off hospitals and police stations, could be to ensure that each community has a publicly-funded, shared building (e.g. a library) which is equipped with a backup generator and battery-operated radios for use in the event of an outage.

Our work on the role of individuals during energy crises[1] demonstrates that disruptions often create societal cohesion: people tend to cooperate and perform altruistic acts, and panic is unlikely. However, the response depends on the historical context, because disruptions tend to magnify existing vulnerabilities and tensions. In cases where the societal context at the time was one of poverty, inequality, cuts to public services, corruption or racial tension, then outages have been associated with disorder, violence and crime. Thus, minimising the risks from outages involves not only treating the risk itself, but also improving societal resilience during normal times. An equal, inclusive and cohesive society is less likely to experience panic and crime during an outage, as well as being better-placed to withstand other types of risk. Covid has demonstrated that we are only as safe as the most vulnerable among us, and it is therefore clear that support for the most vulnerable should be at the core of our everyday societal functioning, even after the disruption has passed.[24]

10. What challenges are there in developing resilience capability? Your answer could refer to critical infrastructure, but also to systems and networks beyond those elements. What is the role of exercising to test risk preparedness, and are these methods utilised effectively in risk assessment and risk planning in this country?

In our view, the greatest challenge to electricity system resilience comes not from the variability of wind or solar power for which it is possible to construct adequate forecasting tools, but from the replacement of long established electrical technology of which the Electricity System Operator has visibility and control through defined market arrangements. These are being replaced with technologies that behave very differently, present major modelling challenges and, very often, are connected to distribution networks and have lacked adequate monitoring and control.[25,26] These are, in many ways, more institutional and governance challenges than engineering problems, for example around the clear definition of responsibilities and the collection and exchange of data.

Accurate modelling of how the system and its various elements respond to disturbances is essential to ensuring resilience. Many aspects of this, governed by the Security and Quality of Supply Standard,[17] are carried out many times every day. However, there are potential equipment behaviours that the models currently used do not capture.

There is always a chance – very small but not zero – that a major regional or whole system collapse will occur.[2] Speedy restoration would then depend on well-managed interactions between, in particular, the Electricity System Operator, generators, the electricity transmission network owners and the Distribution Network Operators. Information on the frequency and rigour of practice exercises is, as far as we are aware, not publicly available.

12. What individual or economic behaviours would strengthen national resilience against hazards, and what mechanisms are open to the Government or society to incentivise these behaviours? How should we prioritise any changes required in approach, process or policy needed to improve risk mitigation and strengthen the UK's resilience to extreme risks and emergencies?

Regulatory and commercial arrangements already exist to address many aspects of electricity system resilience. Their success has arguably been demonstrated by the relative infrequency of major loss of supply incidents and by the reduction in the total number of 'customer interruptions' and total 'customer minutes lost' over the last 10 years or so.[27] However, in our opinion, adequate maintenance of electricity system resilience has been hampered by a lack of clarity regarding which party has responsibility. For example, the Electricity System Operator has, by convention, been responsible for maintenance of the Security and Quality of Supply Standard and Grid Code (though Ofgem has raised questions around the extent to which that responsibility has been adequately discharged[18]) but had no responsibility for equipment connected to the distribution networks, while the Distribution Network Operators have had no 'whole system' responsibility.[6] 'Whole system' responsibility should be clarified and minimum standards, e.g. for speed of system restoration following a major event, should be established.

It is possible for individuals to increase their own resilience to power outages by undertaking preparedness measures, such as stocking tinned goods and bottled water and keeping candles, batteries, radios, etc..[28] However, placing the onus on individual households to prepare in such a way is neither necessary nor desirable as an approach. Firstly, there is evidence that information campaigns may have very little impact on household preparedness for emergencies,[29] because encouraging people to prepare for low-probability, high-impact events is highly challenging. Urban populations in particular are unlikely to have preparedness measures in place, and are less likely to be willing to undertake them, even in response to a previous outage.[30]

Secondly, actions which focus on household-level resilience may be regressive. This is because people on low incomes are less likely to have the money to buy equipment or supplies, less likely to have alternative heating options such as wood fires, less likely to own useful camping equipment such as gas stoves, and less likely to have enough space to store bottled water or tinned goods.[1] Those in fuel poverty are particularly vulnerable during outages, because they are more likely to have underlying health conditions, more likely to have very young or very elderly members of the household, and more likely to have a poorly-insulated home which loses heat quickly.[31] The most vulnerable are not always easily-identified: Priority Service Registers are important but they are difficult to keep up-to-date, and outages may create less obvious vulnerabilities such as amongst young mobile adults who may be less likely to have social support in their immediate locality.[32]

Therefore, rather than focusing on maximising resilience through individual behaviours, the focus should be on maximising community and social resilience. Means of communication, discussed above, are the most crucial part of this. Civic responses could include ‘buddy’ systems, so that residents know who to look out for during a crisis. Some communities may already have similar systems of support, but these operate on an informal basis, and isolated individuals may not benefit. To be effective, systems such as this should be well-resourced and not reliant on volunteers, and they should be developed at local level with input from local community and religious leaders. Measures which aim to increase community cohesion are equally valuable during normal times.

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