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Submission to the House of Lords Select Committee on National Resilience
Inquiry into National and Local Preparedness and Resilience

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Introduction

1 We welcome the opportunity to submit evidence to the Inquiry into National and Local Preparedness and Resilience. As researchers in the Department of Electrical and Electronic Engineering at the University of Strathclyde, working in the University's specialisms of energy networks and communications research, we consider, that with the increasing complexity of modern infrastructure, the Committee's approach of considering the interconnectedness of risks across different threats and sectors is essential.

2 Given our background, we will focus our contribution on the interconnectedness of power and communications networks, and respond to Question 1. However, our research on resilience also allows us to include some recommendations in respect of Questions 5 and 6.

Risk Assessment Question 1: How far are national and international risks inter-connected, including across different sectors and across short-term and long-term risks, and what are the implications for the national approach towards preparedness and resilience?

3 Society has long relied on energy. In recent years, our dependence on electricity has grown as individuals, businesses and organisations become increasingly digital. The electrification of heat and transport to meet Net Zero goals will increase this dependency still further. This highlights the growing interconnectedness of critical national infrastructure systems, thereby heightening the complexity of resilient system design (Fig.1).

4 The scale and complexity of power networks means that, as they always have been, they are vulnerable to weather events, while the age of much of the infrastructure is also a factor. There is a wide range of possible causes of unplanned outages of equipment, which may be correlated. Depending on the design of the system, these may result in interruptions of supply of power to end users of electricity. A resilient system is one that can cope with unplanned disturbances to the system, not one that depends on them never happening. Therefore, our focus should be on collaborating cross-sector to design systems that prevent interruptions to power supply from happening within reason, limit the impact or minimise recovery time from an event.

5 Although the power system in Britain has not experienced a total system shutdown, the North Hyde substation fire in March 2025 and the major power disruption in August 2019 disrupted tens of thousands of consumers and critical infrastructure[1]. In Europe, once a point of no return had been reached, the Iberian Peninsula massive blackout in April 2025 disconnected Spain and Portugal from the wider European grid within seconds, overwhelming the mechanism designed to save the system from a collapse of system frequency[2]. These high impact incidents highlight that, despite provisions in Grid Codes

[1] North Hyde Review | National Energy System Operator; Ofgem 9 August 2019 Power Outage Report ; https://pureportal.strath.ac.uk/en/publications/an-analysis-of-the-august-9th-2019-gb-transmission-system-frequen/

[2] 28 April 2025 Iberian Peninsula Blackout

designed to enhance system resilience, cascading effects can overwhelm existing protection schemes.

6 Restoration of power supplies to end users following the Iberian peninsula collapse in April 2025 took around 12 hours in Portugal and 17 hours in Spain. A new standard is being introduced in Britain from January 1st 2027 that will oblige the National Energy System Operator (NESO) to be capable, following a GB-wide system collapse, of restoring 60% of demand in every region within 24 hours and 100% of GB-wide demand within 5 days[3]. The impact of such a widespread outage – no power anywhere for many hours – would be huge. Although a minimum standard for restoration can be seen as a good step forward, formal restoration targets may not alone guarantee an acceptable level of system wide resilience in the face of complex, cascading disturbances.

Power and Communications

7 A key dimension of CNI interdependence is the strong coupling between energy and communications systems. Power system control and protection depend on communications networks to transmit monitoring and control signals, while communications infrastructure itself relies on electricity from the power grid. Indeed, lack of stable power causes a quarter of communication network failures (Ofcom Connected Nations 2023). This mutual reliance creates significant challenges for the development of a highly resilient integrated infrastructure.

8 Such challenges have been highlighted by the analogue Public Switched Telephone Network (PSTN) switch-off, commonly referred to as the copper switch-off. Many PTSN lines remain embedded across power utility environments, including substations and wider grid infrastructure where legacy remote terminal units, dial-up modems, and alarm systems continue to rely on copper connections. In the event of power loss, analogue PTSN lines often remained operational. The switch-off requires a migration to digital voice and IP-based connectivity which rely on power[4]. Therefore, digital communications hubs are often provided with uninterruptible power supply (UPS) units. However, all intervening equipment in a long chain of infrastructure – e.g. Wi-Fi access points, routers, switches, mobile base stations, and core network equipment – between the end device and the destination needs to be similarly hardened. In other words, every network element along the communication route would need backup power and robust design to prevent communications failure in the event of a power outage. This is why communication outages are often cascading and widespread rather isolated to an endpoint outage.

9 The Iberian Peninsula outage also revealed that communications systems were less resilient than anticipated, even though expectations for their performance under such conditions were already relatively low[5]. Whilst labelled a 'black swan event', this case is not an isolated incident with Europe facing several large-scale power outages in recent decades[6]. In the UK, Storm Arwen took down 1,500 sites for one mobile operator, and 130 of these were down for 72 hours[7].

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[3] https://www.gov.uk/government/publications/introducing-a-new-electricity-system-restoration-standard/introducing-a-new-electricity-system-restoration-standard-policy-statement
[4] PSTN Cessation & Electricity Utilities: Protecting Vital Systems
[5] UKSPF: Enhanced Operational Telecommunications (OT) and the Energy Transition, JRC, October 2025
[6] *Social profiles and response patterns during the 2025 Iberian Peninsula power outage. The case of Spain
[7] Final report on the review into the networks' response to Storm Arwen, Ofgem, June 2022

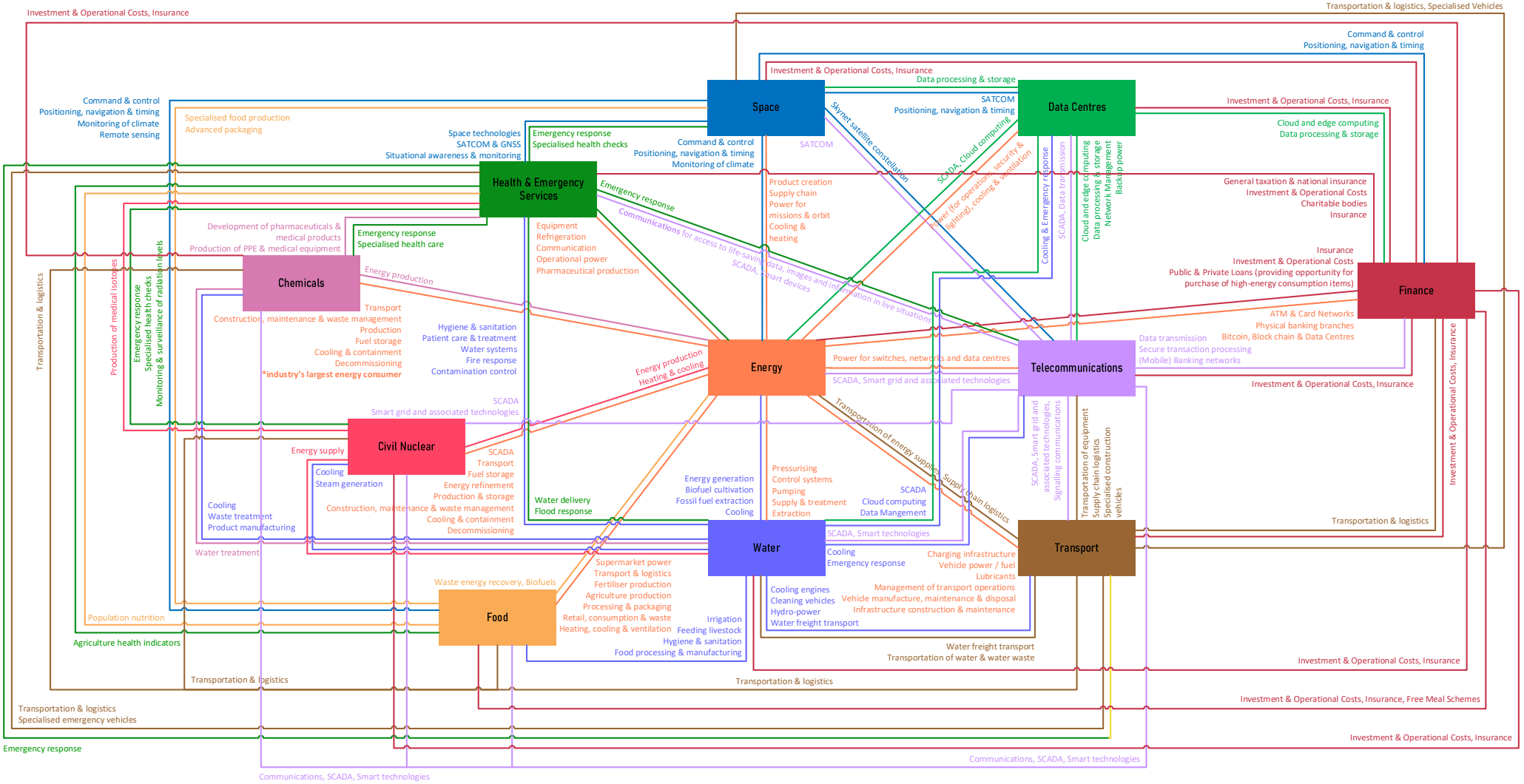

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Figure 1: Interdependency of Critical National Infrastructure Sectors

Grid Instability

10 "Grid instability" has always been a possibility. Over the years, it has led to system-wide or regional collapses in systems based on every kind of energy source. System operators have an obligation to keep the power system stable regardless of where the energy is coming from. They – and owners of generation – have an obligation to get the engineering right. At a first level, that obligation is defined in standards and codes.

11 Curtailment of wind output in GB has, for the most part, been to ensure that the transmission network would not be overloaded. That is, the system operator has done what it should. The question in that context is: has the cost of doing so been reasonable? It could be argued that it's been excessive because of (a) failure to build enough network capacity quickly enough, (b) excessive cost of gas generation to replace curtailed wind or (c) failure to plan the location of new wind generation in a way that takes account of both the cost of wind in different places and the cost of the network[8]. Looking to the future, replenishable energy storage becomes increasingly important. The Government has charged NESO with producing a Strategic Spatial Energy Plan but (a) that Plan is a year late in being delivered (late 2027 instead of 2026) and (b) it's not clear how the Plan will be put into effect.

Recommendations

Ownership

12 **Clear ownership needs to be defined.** This presents a challenge within the energy sector, as the disaggregation of systems leads to more fragmented responsibilities and increasingly diffuse accountability. The energy sector has a multitude of different actors with myriad market positions and regulatory requirements (Fig.2). For example, public electronics communication networks are designated Critical National Infrastructure (CNI), delivered by private companies. Policy is set by the Department for Science, Innovation and Technology (DSIT) and regulatory oversight is fulfilled by Ofcom[9].

13 Industry codes and standards are key to managing relationships and ensuring that different physical facilities and their owners interact in a way that does not threaten stable system operation. However, it has been continually argued that existing codes and standards are out of step with technological and market developments[10]. A revised approach is required to ensure that regulatory guidance can be updated in a timely and appropriate manner. This challenge is not confined to the energy sector.

[8] https://ukerc.ac.uk/news/transmission-network-unavailability-the-quiet-driving-force-behind-rising-curtailment-costs-in-great-britain/

[9] Progress in adapting to climate change: 2025 report to Parliament - Climate Change Committee

[10] UKERC response to BEIS/Ofgem consultation on energy industry codes | UKERC | The UK Energy Research Centre

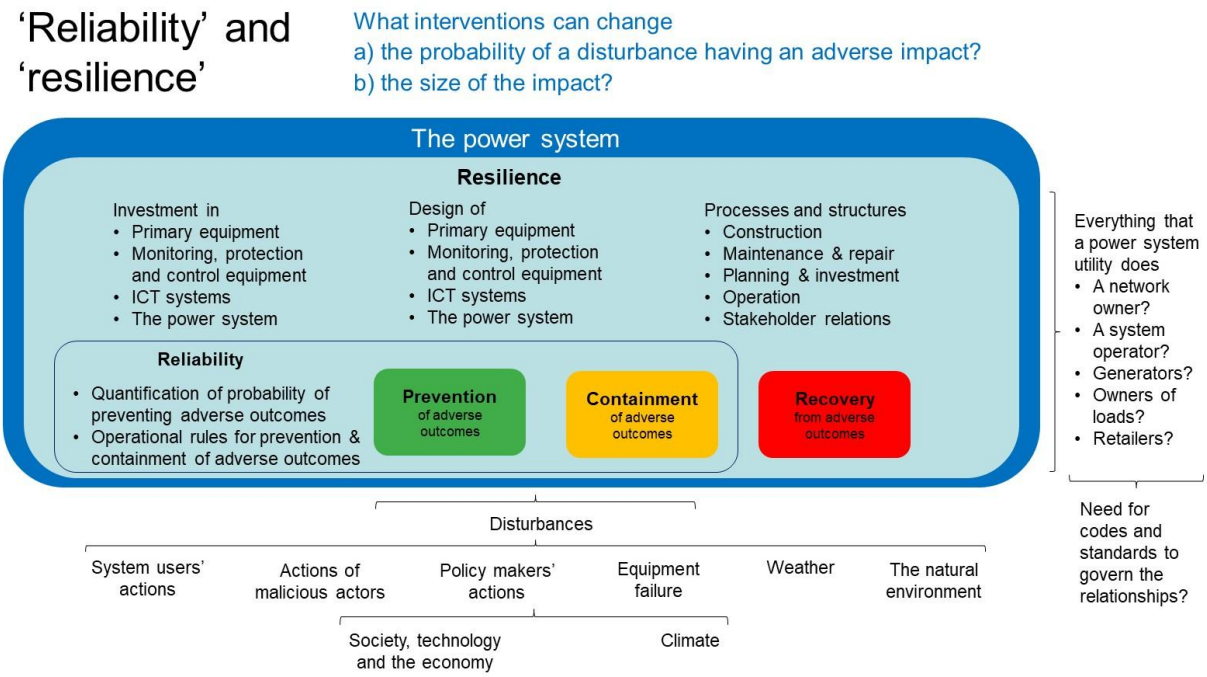

Figure 2: Considerations for Reliability and Resilience in the Power System

Cross-Collaboration

14 **Greater cross-sector collaboration is required**, particularly across standards development, regulation and exercising.

15 Standards are typically defined by industry working within their silos. 3GPP, the standardisation body responsible for mobile communication standards including 5G, has attempted to invite application sectors to get involved with limited success. This has tended to involve industry groups such as JRC[11]or EUTC[12] who lack the resources to get involved in standards Working Groups. This means that even where standards are developed to share information between networks, industry take up has been limited.

16 In terms of regulation, it is essential that sector regulators like Ofgem and Ofcom work better on cross-cutting issues. This is happening to an extent on issues like spectrum allocation for utilities[13], albeit the UK is now far behind other European countries in this regard.

17 The National Resilience Action Plan encouragingly states that system testing and exercising is essential. However, events never happen as planned. The effectiveness of exercising is constrained by the creativity and foresight of those designing them. Accordingly, diversity in approaches, participants, and system designers is essential, together with continuous and iterative testing to ensure that systems remain robust under a wide range of conditions and evolving risks.

[11] Joint Radio Company, a trade body in the UK for utility telecoms
[12] European Utilities Telecom Council
[13] Call for Input: Potential Spectrum Bands to Support Utilities Sector Transformation, Ofcom, June 2023

Whole of Society Question 5: How can a shared vision be developed to improve preparedness and resilience across the whole of society?

18 A shared language or understanding around resilience does not exist. Definitions of resilience are often not stated or shared between connected entities. Operators, dependents and supply chains should be encouraged to define what resilience means to their organisation and share with important stakeholders.

19 System behaviour emerges from the network of relationships between system components and stakeholders, within and across system boundaries. CNI operates in a complex stakeholder environment. It is often subject to third-party operational, policy and regulatory decisions that exert influence and unintended consequences on systems beyond their immediate boundaries. If these relationships are decoupled and siloed within technical, economic, social and institutional domains, we will likely miss signals of change that are identifiable from these system interactions.

20 Similarly, research suggests that there is an 'expectation gap' between CNI operators, and between consumers and CNI operators in relation to the provision of services in the event of a crisis. As highlighted following the North Hyde power outage, owners of CNI do not know what they were getting in respect of energy supplies nor, in some cases, know they are CNI. Networks owners and system operators have no particular responsibilities towards CNI.

21 Consumer expectations are typically framed around minimal downtime. However, governments and CNI operators increasingly expect responsibility to be shared, with consumers taking active roles in preparing for and managing the impacts of outages. It is therefore essential to provide users with clear and reliable information so that, where possible, they can make alternative arrangements for heating and hot food, and ensure that vulnerable family members or neighbours are properly supported[14].

Recommendations

22 **Organisations should have a clear, testable definition of resilience**.

23 Such definitions would simplify interactions between disparate organisations, limiting the need to understand the nuances of other sectors. For example, a specification that an organisation is 'resilient' is practically useless, but is a current regulatory requirement for UK CNI. In contrast, a specification that, for example, supply will be restored within 3 hours of interruption is clear and specific.

Whole of Society Question 6: How can understanding of preparedness and resilience be improved, with action encouraged at all levels of society so that these priorities are both seen as relevant and achievable in practice?

24 Resilience requires that businesses plan around what is now a more complex grid, but they often find it challenging to understand the risk and plan for it. The Heathrow incident is a good example of this, as the airport did not have a true understanding of the implications of its electricity network connection agreement, as arguably the power

[14] Ensuring resilience: Spain, Storms, North Hyde and What They Tell us About our Electricity Supply – Part 2 | UKERC | The UK Energy Research Centre

network met its resilience requirements of restoration within 3 hours, but the airport did not resume normal operations for 24 hours.

25 There is no regular review of existing standards and frameworks. Frameworks can be helpful to provide structure for theory and conceptual thinking but often become a "tick box" exercise to comply with regulation whereby action is taken for compliance. Such a "black box" approach fails to understand system operations, emerging causes of system vulnerability or society's changing expectations.

26 Many existing resilience frameworks and standards provide well-established theoretical principles and systematic methods for evaluating systems holistically. Applying these frameworks to CNI is complicated by the fact that oversight and influence are exercised by third-party regulatory authorities. This constrains organisational decision-making autonomy. As a result, these conceptual principles should be operationalised through measurable indicators and outputs. However, that is just a minimum. Organisations are incentivised to pursue a 'good enough' level of performance, oriented toward meeting the measurable criteria established by the regulatory authority rather than fully realising the underlying principles of resilience.

27 By reducing resilience to a specific set of measurable metrics, interdependencies, relationships and the influence of uncontrollable external factors are often overlooked. This produces imperfect information, thus limiting the accuracy and usefulness of resilience assessments.

Recommendations

28 **Organisations consider their system as part of an interconnected whole**, and anticipate and account for the factors considered above. This includes determining which suppliers, logistics partners and distribution channels are indispensable for sustaining minimum service levels and maintaining cash flow. In doing so, they can avoid becoming overly self-referential and ensure that resilience strategies reflect the broader context in which their system operates.

29 **Further research is needed into the purpose and objectives of resilience frameworks**, including whether they have demonstrably achieved their intended outcomes and why implementation remains limited. Addressing these questions may help inform the development of a shared vision and more effective pathways for action.

30 **Organisations must reflect on past resilience failures and regulators should ensure corrective actions are undertaken**. Memories fade and business as usual returns, and the lessons learned are often forgotten. For example, a number of Ofgem's recommendations from Storm Arwen have not yet been implemented[15]. Rural

[15] For example, "Action 1: We recommend that the E3C should review current network infrastructure standards and guidance, including those for vegetation management and overhead line designs, to identify economic and efficient improvements that could increase network resilience to severe weather events. This should be completed by 30 September 2022." In addition, "Action 4: We recommend that the E3C should put forward proposals for an outcome-focused resilience standard to set Government and public expectations on restoration times during widespread power disruptions. This action should be completed by 30 September 2022". (We assume Action 4 to relate directly to distribution networks and, therefore, to be separate from an "Electricity System Restoration Standard" that would apply in the event of a GB-wide electricity system shutdown). See https://www.ofgem.gov.uk/research/storm-arwen-report

communities seem to be more resilient to electricity supply interruptions than suburban or urban ones, in large part because they happen so often.

31 The Climate Change Committee has also previously highlighted the "lack of coordinated policy and planning from government on infrastructure interdependencies" and a "regulatory gap" resulting from the multiple stakeholders involved in CNI delivery, policy and oversight[16].

Our understanding is that, although some reviews may have been completed, no changes to standards have been implemented.

[16] Progress in adapting to climate change: 2025 report to Parliament - Climate Change Committee