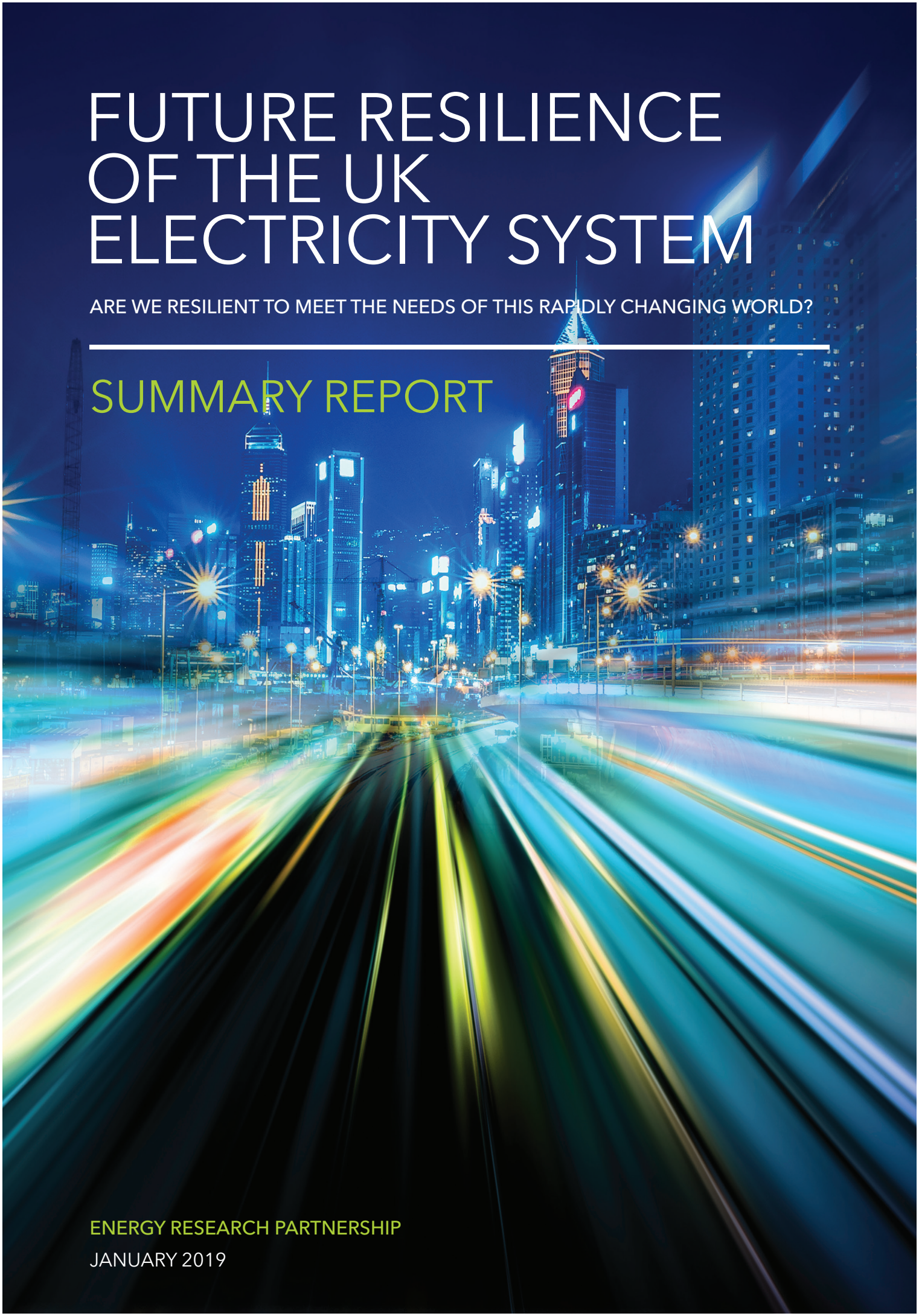
FUTURE RESILIENCE OF THE UK ELECTRICITY SYSTEM

ARE WE RESILIENT TO MEET THE NEEDS OF THIS RAPIDLY CHANGING WORLD?

SUMMARY REPORT



ENERGY RESEARCH PARTNERSHIP

JANUARY 2019

ABOUT THE ENERGY RESEARCH PARTNERSHIP

The Energy Research Partnership (ERP) is a high-level forum that brings together senior-level funders and stakeholders of energy research, development, demonstration and deployment across Government, industry and academia, plus other interested bodies. It is a partnership between public and private sector organisations providing reciprocal benefits to industry and Government members alike. Its primary purpose is to offer a consultative forum as an independent, not for profit organisation whose activities are funded by Member contributions.

By bringing together a diverse range of participants from across the sector, the ERP aims to accelerate innovation in the energy sector through enhanced dialogue and communication across industry and Government to build the public-private consensus on energy innovation.

The ERP is intended to provide high-level leadership and aims to identify recommendations to help shape future policies and regulations that benefit the UK economy and society. The ERP also supports UK trade and investment through identification of areas for export of British expertise.

On the topic of resilience, the broad spectrum within the ERP Membership, Working Group and Project Advisors (non-ERP members invited to bring specialist knowledge to the project) ensure the report represents a balanced view of the challenges that face the industry in the future and proposes recommendations that will seek to maintain and enhance system resilience going forwards.

The project scope was developed with support from Working Group Members (ERP members and Project Advisors). This report is based on information provided by each Working Group Member that set out their organisation's view on the UK electricity system resilience, and the potential future impact of the changing energy landscape. All working group members discussed and shared findings at a workshop held at the Department for Business, Energy and Industrial Strategy on 11th June 2018. The industry views from the responses submitted and expressed at the workshop are represented in this report. This report does not represent the full views of the organisations involved in the work, nor does it represent government policy. Individual organisations may have policies and ongoing work regarding resilience which may vary from the opinions set out in this report. However, all organisations, via Energy Research Partnership governance, support the broad consensus view expressed within this report.

WORKING GROUP

ERP Members

- ABB
- Arup
- Atkins, member of SNC-Lavalin Group
- Department for Business, Energy and Industrial Strategy
- EDF Energy
- Environment Agency
- Energy Systems Catapult
- National Grid Electricity Transmission
- National Infrastructure Commission
- Welsh Government

Project Advisors

- Energy Networks Association
- Electricity North West Ltd
- Northern Power Grid
- Scottish Power Energy Networks
- UK Power Networks
- Scottish and Southern Electricity
- University of Manchester

Other ERP Members

- Bosch Thermotechnology
- University of Cambridge
- The Carbon Trust
- Committee on Climate Change
- Energy Saving Trust
- Engineering and Physical Science Research Council
- Hitachi
- Origami Energy
- Scottish Enterprise
- Department for Transport
- Turquoise International
- UK Energy Research Centre

EXECUTIVE SUMMARY

The electricity system[1] has seen significant change over the last decade with a trend towards decentralisation of generation, a rapid increase in intermittent renewable generation, and an increased electrification of other critical infrastructures and sectors. There is a growing trend of society and business becoming increasingly reliant upon new technology, broadband and communications; all requiring electrical energy and ultimately leading to an increased interdependency between sectors. Furthermore, the world is changing; from climate change inducing extreme weather events, through to an increase in malicious intent to affect networks.

The UK electricity system has enjoyed high levels of resilience historically and remains resilient today[2], providing a high degree of confidence to businesses and consumers that power will be available 24 hours a day, 7 days a week, 365 days per year. However, a reliable electricity system is not necessarily a resilient electricity system. Reliable day-to-day operation during normal circumstances is expected, however we must be able to respond to the more severe, less frequent events to ensure power supplies are maintained or restored quickly following such an event. Therefore, we consider a reasonable definition of resilience to be:

'the ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such events'[3].

Looking forward, we should anticipate further change to ensure that any new infrastructure is built with the resilience required to meet future needs. The decarbonisation of heat and transport will introduce further complexity to the electricity system by increasing dependencies on electricity across many infrastructure sectors, and new energy vectors such as hydrogen will present new interactions and challenges. In addition to this, we should expect the rapid increase in the number of assets and different owners in the electricity system (including domestic power generation, such as roof-top solar panels) to continue.

Society's dependence upon electricity is far greater than when the current electricity system was established, and this is continuing to grow with each new technology introduced. So, in the future an external effect on the electricity system will impact a wide range of technologies dependent on power, which in turn is likely to have a much larger impact on society than in the past (Figure 1).

With these factors in mind, it is time to take a fresh look at how we ensure the UK has a resilient and robust electricity system in the future. The aim of this Energy Research Partnership led project is to identify and assess energy landscape changes that are likely to impact the future resilience of the electricity system and deduce the key focus areas for recommendations and proposed outcomes. The project has identified four key factors that will affect the future state of resilience in the electricity system, notably a growing economic importance of metropolitan centres, growing reliance upon technology and networks, growing complex interdependencies between networks and growing threats to network infrastructure.

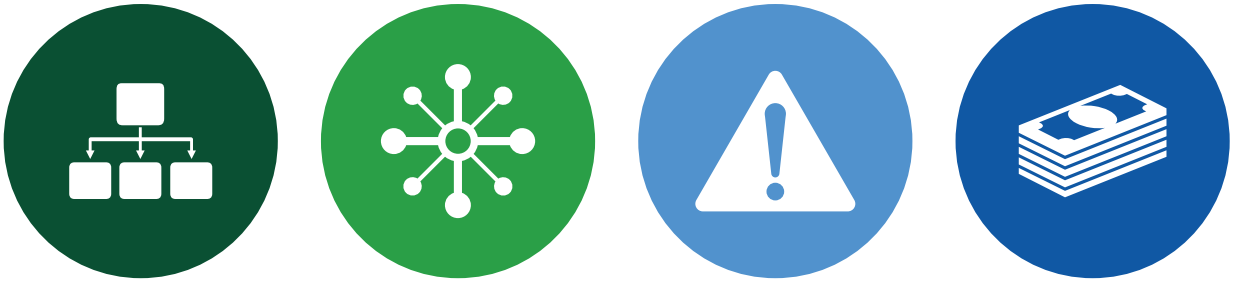
[1] Electricity System is defined as the assets, businesses, services and supply chain that facilitate the transport of electricity from the point of generation to the point of consumption; and the political, societal, economic and technological environment in which they operate.
[2] House of Lords (2014) The Resilience of the Electricity System. Oral and Written Evidence. (Science and Technology Select Committee) [pdf] Available at: https://www.parliament.uk/documents/lords-committees/science-technology/Resilienceofelectricityinfrasrtucture/Resilienceofelectricityinfrastructureevidence.pdf
[3] FERC (2018) *Grid Reliability and Resilience Pricing (Document No. RM18-1-000)*, and *Grid Resilience in Regional Transmission Organizations and Independent System Operations (Document No. AD18-7-000)*. [pdf] Available at: https://www.ferc.gov/CalendarFiles/20180108161614-RM18-1-000.pdf

POTENTIAL IMPACTS

Figure 1: Potential impacts from loss of electricity over varying outage durations

FOUR KEY EMERGING TRENDS

This ERP report has benefitted from a significant level of industry engagement – an indication of the importance of electricity system resilience and its future development. The project has identified four key factors that are expected to affect the resilience of the electricity system in the future:



RELIANCE UPON TECHNOLOGY AND NETWORKS

COMPLEX INTERDEPENDENCIES BETWEEN NETWORKS

THREATS TO NETWORK INFRASTRUCTURE

ECONOMIC IMPORTANCE OF METROPOLITAN CENTRES

The project has focussed on the electricity system, however these factors are likely to be applicable to the wider energy sector and potentially other sectors, such as transport and communications.

The UK population and economic activity is concentrating in metropolitan centres, which in turn increases the criticality of future electricity requirements at these centres. Moreover, large urban centres are likely to see further optimisation of transport systems and services through deployment of automation and technology, which in turn is likely to see increased requirements for resilience in these locations.

This report identifies that electricity use has changed significantly since the majority of the current electricity infrastructure was put in place (Figure 2). This trend is anticipated to continue with further electrification of sectors such as transport and heat, leading to a greater reliance upon electricity in the future. It is expected that for a given power disruption today, the impact on society and business will be higher for a similar event in the future.

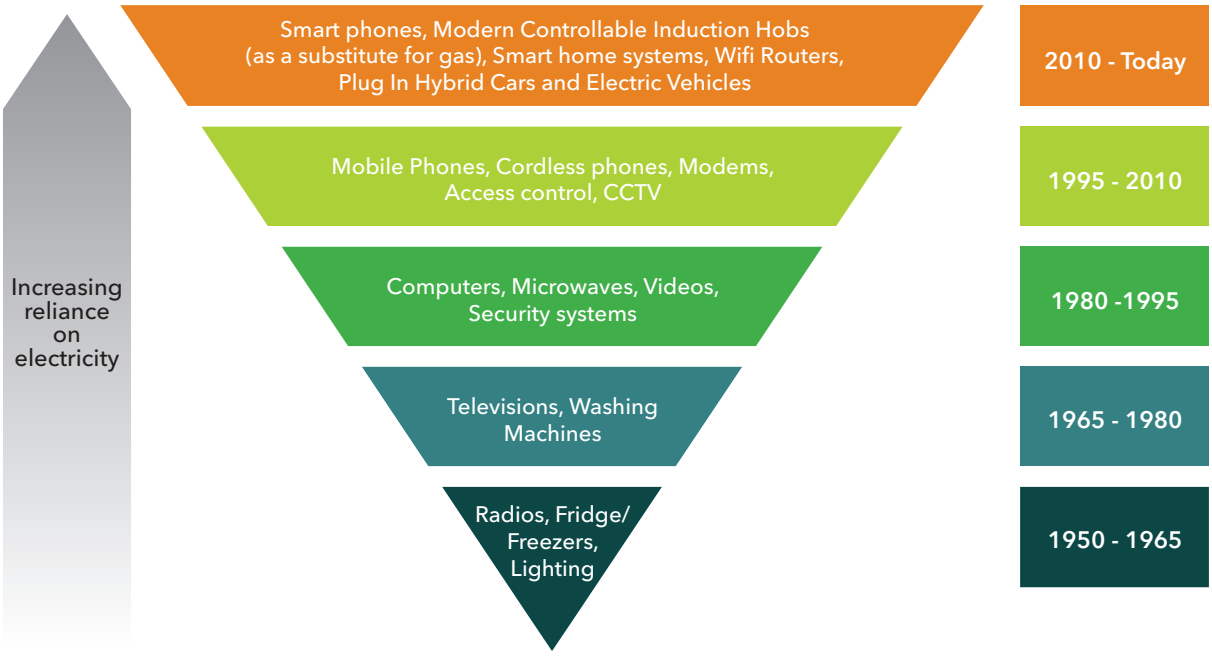


Figure 2: The increasing reliance upon electricity over the last 70 years

With further reliance on technology and networks, the interdependencies between sectors will increase, with most sectors having a level of dependency on communications and electricity (Figure 3). A holistic approach to managing resilience across sectors will offer greater visibility of the state of resilience and enable system wide solutions to be prescribed.

A key driver for change in the electricity system is the recognition of the variation in threats to future network infrastructure. The electricity system needs to be physically resilient to severe weather patterns attributable to climate change. At the same time, it must be resilient and adaptable to the new technologies that are being employed to decarbonise the electricity system, which are leading to a more decentralised topology. The increase in deploying new and smarter technologies reflects the need for future resilience to maintain a focus on cyber security.

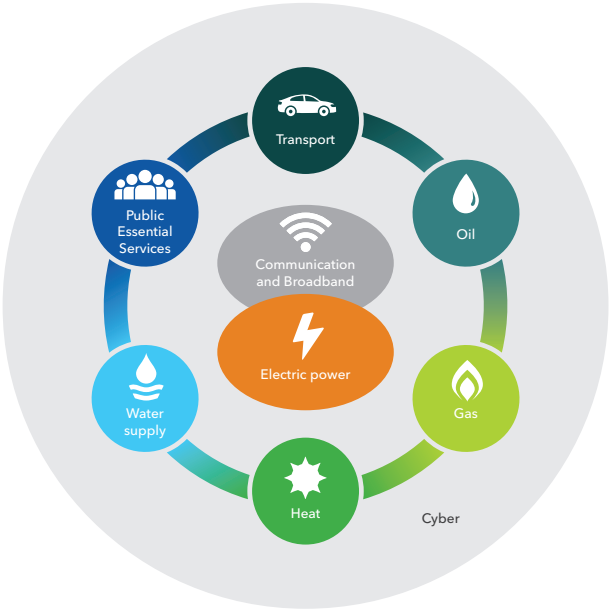


Figure 3: Key systems dependent on electricity

ECONOMIC IMPORTANCE OF METROPOLITAN CENTRES

- Today's society and business are gravitating towards large metropolitan centres. These centres often contain the new hi-tech, service, financial and retail industries that drive the economy today.
- The future resilience needs of these large urban centres will have to be increased in line with their economic importance, and proportion of population, if significant impacts to the economy and society are to be mitigated.

RELIANCE UPON TECHNOLOGY AND NETWORKS

- Today's society and businesses use of electricity is changing, with availability of electricity required for communication/broadband, lighting, heating/cooling, cooking, electronic payment systems and power for integrated technology.
- Further electrification of transport, the de-carbonisation of heat, and integration and automation of systems (inc. road transport) suggest a further reliance upon electricity. We should ensure our networks and systems are resilient to meet this future need.

COMPLEX INTERDEPENDENCIES BETWEEN NETWORKS

- Today's infrastructure networks depend heavily on each other - electricity and communications are a common dependency for most systems. This places them at the heart of the resilience debate.
- Complex interdependencies are expected to increase further with the fast pace of technology development and adoption of electrical powered smart devices. Electricity and Communications could become points of common failure, for multiple infrastructure networks.

THREATS TO NETWORK INFRASTRUCTURE

- Today's electricity system is under greater threat than ever, at the same time as we are more reliant on electricity. Whether these threats are from climate change, malicious cyber attacks or physical threats, they are also occuring in a time of growing international political instability.
- With more States investing heavily in cyber warfare and growing availability of information about networks available online, cyber enabled and physical threats will continue to increase, having the potential to disrupt our ever more complex and interdependent networks.

RECOMMENDATIONS

The electricity system currently undertakes extensive programmes of work to meet today's resilience requirements. To build upon the work currently being developed in the industry, through the collaboration led by the Energy Research Partnership, this report has identified a number of opportunities to further enhance future electricity system resilience to meet the growing challenges. This project has identified there is currently no common industry approach to managing resilience; further research and analysis could inform a whole-system view of a definition of resilience and strategies to manage cross sector resilience. This report has differentiated itself from other industry resilience work by strongly focusing on the future technologies and their place in a changing energy landscape. This will change the way we need to consider electricity resilience going forward, and the recommendations are suggested to build on the resilience work currently being done within the industry and Government.

The ERP expects this report to be a catalyst to initiate debate about how resilience is considered and managed within cross-sector infrastructure industry, Government and regulators.

The report's recommendations are summarised as follows, with Recommendation 1 serving as an overarching recommendation for four further recommendations:

RECOMMENDATION 1: RESILIENCE MEASURES

Investigate resilience measures which can be used cross-sector to establish acceptable levels of resilience to meet future needs.

Resilience measures can be defined in many ways, and there is currently no common methodology adopted within the electricity industry. Firm commitments are required to investigate development of a suitable measure, which could support understanding of the electricity industry's readiness and capability to meet society and business' expectations, as well as aligning with Government policy. Suitable measures, that gain support for implementation, will set clear standards for the electricity industry to achieve.

Proposed outcomes:

2020

Organisations across the sector to investigate applicable resilience measures, and share best practice via a regular industry and cross-sector forum.

2025

Common cross-sector measures of resilience agreed, ensuring regulated sectors are delivering resilience levels required by society and business.

2030

Resilience measures being refined to reflect changes in threats and learning from world-wide incidents. Continuing to demonstrate value to consumers.

RECOMMENDATION 2: ENGAGE SOCIETY AND BUSINESS

Engage a diverse set of views across society and business to establish future resilience requirements for the UK Electricity system.

With growing reliance on electricity, society and business should be engaged to understand their needs, and expectations for service provision following an exceptional event. The period society can tolerate loss of power, and the value placed on power-dependent amenities, would set the levels of resilience needed in the future. This in turn will influence Government resilience policy, balanced against constraints and National priorities.

Proposed outcomes:

2020

Relevant stakeholders to engage Society and Business in a meaningful way, to understand their future expectations and needs.

2025

Understand resilience requirements for different geographical and societal needs, consulting stakeholders and setting policies.

2030

All new infrastructure designed and constructed to meet future resilience policies. Networks meet resilience expectations of society and business.

RECOMMENDATION 3: GOVERNMENT AND POLICY

Government should work with cross-sector infrastructure parties to establish holistic resilience policies for the future.

Given the increasing interdependencies between systems, a holistic view of resilience is imperative to its management. Government needs to continue to take a lead on developing policies that enhance resilience, reflecting the future impacts of the rapidly changing world. Clear policies are required to ensure that the resilience needs of society and business are met in the right timescales. A task force comprising of senior leaders across sectors, working with Government, would be best placed to deliver the direction set in policy.

Proposed outcomes:

2020

Cross-sector task force, with senior industry leaders established by government to develop resilience policies.

2025

Cross-sector government policies for resilience developed, ready for consultation and implementation.

2030

Policy continuously reviewed to meet ongoing future needs.

RECOMMENDATION 4: REGULATION AND MARKETS

Infrastructure regulators to make resilience a central consideration of review periods. It should also stimulate markets to ensure relevant sectors provide resilience in their products and services.
Resilience should be a core topic of regulatory reviews for the electricity industry, and a strong market driver in future power-dependent sectors, such as transport. A measure would support regulatory outputs, to ensure the industry is delivering resilience levels society and business expect, whilst providing value for the consumer.

Proposed outcomes:

2020
Cross-sector task force identifies interdependencies and future technology impacts, supporting cross-sector regulatory consistency.

2025
Regulatory review periods have resilience as a core defined topic across all regulated sectors, allowing Government resilience policies to be met.

2030
Regulatory outputs and measures for resilience are demonstrating value to consumers and businesses. Market is providing resilience in non-regulated products and services.

RECOMMENDATION 5: CYBER SECURITY

Organisations to build their cyber security skills and capabilities, to address growing threats, and ensure secure network resilience during technology integration.
Cyber security should continue to be considered as a separate output in the resilience policy to physical security. The Networks and Information Systems Directive (known as the NIS Directive), being applied to the UK, ensures there is a national framework to support and promote the security of network and information systems.

Proposed outcomes:

2020
Electricity organisations meeting NIS directive on cyber security.

2025
UK companies achieving robust, world leading standards in cyber security.

2030
Robust cyber resilience ensures new technologies benefit society, through optimisation of our infrastructure networks securely.

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