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Response to the National Infrastructure Commission Resilience Study Scoping Report September 2019

Dear Sir/Madam

Thank you for the opportunity to respond to the consultation on the National Infrastructure Commission's Resilience Study scope report. This response is provided on behalf of National Grid Electricity System Operator (ESO) and is not confidential.

ESO is principally responsible for operating the GB electricity transmission system. Whilst we do not own the physical electricity transmission infrastructure the ever-growing dependence of society for reliable electricity supplies places equal importance on the resilience of our systems, data, and processes as placed on physical and digital resilience of other organisations within the electricity industry.

We welcome the work of the Commission identified within this scoping report to identify common challenges to resilience and to understand how these challenges may evolve over time. The concept of a resilience framework, as proposed, with sufficient flexibility to work across a number of sectors is welcomed providing associated benefits can be identified and measured. Subsequent policy recommendations to improve resilience during the period when this framework is being developed would also be of benefit and we look forward to reading the findings from the final report.

We have chosen to respond to those questions (in Appendix 1) where we believe it is appropriate for us to comment. If you would like to discuss our response further, please contact Vitor Soares at vitor.soares@nationalgrideso.com in the first instance.

Yours sincerely

[via email]

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Appendix 1

As the electricity system operator for Great Britain (GB), National Grid ESO moves electricity safely, reliably and efficiently through the electricity transmission system. Infrastructure resilience at all levels is therefore a key requirement of the networks, data, system and processes to enable ESO to perform this important role.

Systemic issues that make infrastructure vulnerable to current shocks and future changes

Britain's electricity is generated from a wide range of sources, such as renewable energy like solar and wind, and more traditional power stations run on nuclear or gas. We share electricity with our neighbours from abroad, using interconnectors – technology which can transfer energy back and forth between countries.

National Grid ESO does not own or run power stations or energy providers, but can ask these providers and generators to make more power available to meet demand or to reduce output if there is excess power at any time. The ESO then operates the electricity system, balancing supply and demand, second by second, 24/7. The ESO has visibility and controllability of transmission system connected users.

Distribution Network Operators take electricity from the transmission system and move it through their own network of power lines and underground cables, taking it to homes and businesses. As they do this, they convert the high voltage electricity that's in the network to the lower voltage electricity that people need.

In terms of issues impacting on infrastructure, the ESO does not have visibility and controllability of users connected in the distribution networks which could impact ESO's assessment of the impact of its actions beyond the transmission system.

Physical components of the digital network in relation to systemic vulnerabilities

When considering digital networks, we believe that from a high-level approach there are two key areas for consideration:

Core network equipment / technology, including both hardware and software.

Increased diversity of both equipment types and suppliers should be utilised to ensure no single vulnerability affects large scale assets across the industry.

Network routes and data centres should be utilised to ensure network resilience, not just for one company, but across industries and sectors.

As with core network equipment an increased diversity of routes, locations and site supplies should be sought to minimise the impact of a type-failure across the industry.

What future changes to infrastructure policy, supply and demand and systems' physical architecture need to be tested to develop a holistic understanding of future system vulnerabilities?

The ESO's responsibilities are predominantly set out in its license and industry codes and standards, in particular the Connection and use of System Code (CUSC)[1], Grid Code[2], and the Security and Quality of Supply Standard[3] (SQSS). The SQSS sets frequency and voltage control performance standards. The Grid Code specifies the voltage and frequency ranges that customers connecting to the transmission system will experience. The Grid Code also contains procedures that the ESO use to provide assurance that transmission network users, including generators, can meet specific requirements of the Grid Code.

We believe a wider review of policy, processes or procedures may be appropriate, this includes:

- A review of the security standards (SQSS) to determine whether it would be appropriate to provide for higher levels of resilience in the electricity system. This should be done in a structured way to ensure a proper balancing of risks and costs;
- Assessing whether it would be appropriate to establish standards for critical infrastructure and services (e.g. hospitals, transport, emergency services) setting out the range of events and conditions on the electricity system that their internal systems should be designed to cater for;
- A review of the timescales for delivery of the Accelerated Loss of Mains Change Programme to reduce the risk of inadvertent tripping and disconnection of embedded generation, as GB moves to ever increasing levels of embedded generation.

How have the current approaches to infrastructure resilience changed over time in order to become more effective?

The ESO sets out possible outlooks of future generation and demand patterns annually through is publication of Future Energy Scenarios[4] (FES). FES is built each year with extensive industry stakeholder involvement and provides a basis for future planning and operation of the electricity transmission system.

Through publications such as Operability Strategy Report[5], Summer Outlook[6], Winter Outlook[7], and the System Operability Framework[8], the ESO regularly reviews current and new transmission system operability issues.

The ESO has been carrying out a wide range of innovation activities to better understand the operational implications of changing demand and generation outlooks. List of innovation activities is available on our website. Some notable projects are:

- Power Potential[9]: this initiative aims to create a new reactive power market for distributed energy resources (DER) and generate additional capacity on the network.
- The Enhanced Frequency Control Capability[10]: Facing the challenge of maintaining the 50 Hz frequency stability on the transmission system as new generation technologies come online, such as solar and wind.

The outcomes of all innovation activities are shared with the wider industry. The learnings also form basis of improvements to current ESO processes and activities.

The ESO also publishes Electricity Ten Year Statement[11] (ETYS) annually to highlight where transmission system investment is needed. This forms part of an annual Network Options Assessment[12] (NOA) process.

NOA describes the major projects considered to meet the future needs of GB's electricity transmission system as outlined in the ETYS 2018, and recommends which investments in the year ahead would best manage the capability of the GB transmission networks against the uncertainty of the future. The purpose of the NOA process is to facilitate the development of an efficient, coordinated and economical system of electricity transmission consistent with the National Electricity Transmission System SQSS and the development of efficient interconnection capacity. It is important to note that whilst the ESO recommends progressing options in order to meet system needs, any investment decisions remain with the Transmission Owners (TOs) or other relevant parties as appropriate.

The current NOA process is heavily focused on Transmission Owner solutions assessment. The ESO is looking at expansion of the NOA to:

- enable network and non-network solutions across the transmission and distribution systems to compete to meet transmission network needs;
- assess the needs of the system over the whole year to a greater extent;
- carry out more focused, regional, NOAs which consider how regional voltage issues can be more efficiently managed;
- investigate the value and feasibility of expanding the NOA approach to system stability in the longer term, which will include challenges such as dynamic voltage, fault levels and inertia; and
- communicate our transmission system needs and the recommended options for meeting them in a way a wider audience can understand.

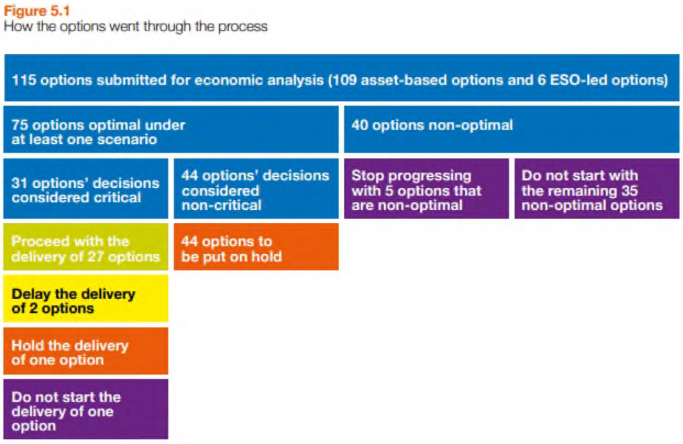
These plans are complex and ambitious and involve a large range of potential stakeholders. The ESO is working closely with industry, in particular the Electricity Networks Associate (ENA) Open Networks[13] project and taking a learning by doing approach, implementing the changes through a number of pathfinding projects. More information pathfinding projects can be found on our website.

Public acceptability of infrastructure services – balancing costs, benefits and public expectations

We publish the NOA as part of our ESO role. NOA methodology describes how the ESO, working with the Transmission Owners (TOs), carries out these activities. NOA recommendations are based on cost benefit analysis of additional network investment against the short-term market solutions. The methodology 1.21 The Network Options Assessment (NOA) process set out in Electricity Transmission Standard License Condition C27 facilitates the development of an efficient, coordinated and economical system of electricity transmission and the development of efficient interconnection capacity.

The Joint Regulators Group on behalf of the UK's economic and competition regulators recommend discounting all costs (including financing costs as calculated based on a weighted average cost of capital or WACC) and benefits at HM Treasury's social time preference rate (STPR). This is known as the Spackman approach and is used for all our reinforcements.

Example from NOA 2018/19 publication:



Should a consistent approach be used to set levels of service in different sectors? If so, what principles could be used to ensure that different sectors take a consistent approach which reflects the expectations of citizens?

Yes. The development of strategic whole system objectives will assist current and future challenges across sectors.

Principles:

- Flexibility: a continuous evolving landscape across sectors demand agile answers to new challenges.
- Simplicity: the complexity of bringing together different sectors is a challenge by itself, let alone set levels of service across sectors.
- Replicability: different sectors own/operate similar equipment. Where applicable there is no reason not to standardise activities.
- Improvement: pursue it continuously to deliver value for money.
- Engagement: work collaboratively, benchmarking, be open to change and challenge.

As outlined in the ESO's Forward Plan, the end goal should be the delivery of value with a smart, flexible whole system.

How does the public respond to infrastructure disruptions and what is its appetite for making different sectors more resilient?

The resilience of supply for electricity is becoming even more relevant in a society which is increasingly reliant upon new technology, broadband and communications. That, along with the need to tackle climate change and the pursue of sustainable future, presents a challenge: how to ensure a reliable, secure system operation to deliver electricity when customers need it?

Recent research[14][15] demonstrates shows that society has very low tolerance to (energy) infrastructure disruptions and there is strong appetite to for making different sectors more resilient. A good example for increased standardised resilience across the energy sector is demonstrated in the EU Network Code on Emergency and Restoration[16]

ESO carries out continual engagement with our stakeholders and society, to help us influence the future of electricity infrastructure. Examples of these can be found in our online consultations (e.g. RIIO-2 draft Business Plan, Future Energy Scenarios, Whole Electricity System), through promotion of industry forums and discussions (e.g. ESO's Operational Forum) or contribution in Industry Wide Workgroups (e.g. E3C and associated Electricity, Communications and Black Start Task Groups).

Another good example demonstrating the appetite for investing in resilient systems is the creation of the National Infrastructure Committee itself.

Resilience governance and decision making

The impact of national level decisions can be presented in two dimensions (applicable to both normal operating conditions and emergencies):

- The regulatory framework: This is crucial as it translates the decisions made at "Policy & Strategy" level. When formal legislation is put in place and targets for levels of infrastructure services are regulated they are effectively setting the standard for services delivered across sectors. A relevant part of it is the incentives;

- Finding Better Ways: continuous support to R&D (technology) and training (people) is vital to deliver world-class results.

The ESO is responsible for the operation of the National Electricity Transmission System (NETS) and real time balancing of electricity generation with demand. Any imbalance between generation input and demand will result in perturbations around the nominal system frequency of 50Hz. Changes in network configuration and the feeds to and from it, either in normal operation or due to equipment faults, will result in changes to system voltage.

Managing Frequency

The SQSS specifies the limits of frequency deviations as a result of an event (loss of output from a single generating unit). The specified limits are:

- Normal Infeed Loss Risk: maximum frequency deviation should not exceed 0.5Hz;
- Infrequent Infeed Loss Risk Frequency should not deviate outside the range 49.5Hz to 50.5Hz for more than 60 seconds.

The level of the normal infeed loss covered depends on the configuration of the system at the time (typically it is c. 1,000W). The current normal infrequent infeed maximum loss risk is 1,260MW for when the largest generator on the system operates at full load. For a larger generation loss than the Infrequent Infeed Loss Risk or a large generation deficit in an importing power island following a sudden system split, the National Low Frequency Demand Disconnection (LFDD) scheme (as described in Grid Code OC6.6) is designed to automatically disconnect demand using low frequency relays to contain the incident and prevent a total or partial shutdown of the GB electricity system.

In the event of a partial/full shutdown (blackout), the most extreme event, the ESO has contingency arrangements in place to ensure electricity supplies can be restored in a timely and orderly way. Relevant stakeholders assisting restoration:

- Black Start (BS) Service Providers (Generators and/or Interconnectors), by having the capability to re-start without reliance on external supplies;
- Non-BS Service Providers (Generators and/or Interconnectors), by being able to support long-term restoration;
- Transmission Owners & Distribution Network Operators, by making available restoration routes between generation & demand as well as supporting communications;
- Communication Service Providers, by enabling communications between relevant stakeholders under a BS event.

ESO for the future

At Infrastructure Operator level the ESO will, as outlined in the RIIO-2 draft Business Plan / Theme 1[17], in brief terms:

- Re-design our control centre architecture to enable more market participants and transparency and enhance our balancing capability;
- Ensure our control engineers have the right training and simulation capabilities to operate the energy system of the future;
- Develop new tools to assist/enhance restoration, should the need ever arise.

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1 https://www.nationalgrideso.com/codes/connection-and-use-system-code-cusc
2 https://www.nationalgrideso.com/codes/grid-code?code-documents=&page=0&search=
3 https://www.nationalgrideso.com/codes/security-and-quality-supply-standards
4 http://fes.nationalgrid.com/
5 https://www.nationalgrideso.com/insights/system-operability-framework-sof
6 https://www.nationalgrideso.com/insights/summer-outlook
7 https://www.nationalgrideso.com/publications/winter-outlook
8 https://www.nationalgrideso.com/insights/system-operability-framework-sof
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11 https://www.nationalgrideso.com/insights/electricity-ten-year-statement-etys
12 https://www.nationalgrideso.com/insights/network-options-assessment-noa
13 http://www.energynetworks.org/electricity/futures/open-networks-project/
14 Future Resilience of the UK Electricity System –Energy Research Partnership UK 2018
15 Living without electricity, Royal Academy of Engineering, IET, Lancaster University https://www.raeng.org.uk/publications/reports/living-without-electricity
16 https://www.entsoe.eu/network_codes/er/
17 https://www.nationalgrideso.com/about-us/business-planning-riio/riio-2-draft-business-plan