# ANTICIPATE, REACT, RECOVER

## Annex: Call for Evidence responses

NATIONAL INFRASTRUCTURE COMMISSION

May 2020

# About this call for evidence

In October 2018, the then Chancellor asked the Commission to undertake a review of the resilience of UK economic infrastructure and how this can be improved. The full terms of reference for the study can be found **here**.

The Commission published a call for evidence alongside the resilience study **scoping report** in September 2019. This followed an initial consultation during the scoping phase of the study to gather stakeholder views on topics to consider throughout the study. A summary of responses to the first consultation can be found **here**.

The purpose of this second consultation exercise was to gather evidence to allow the Commission to answer three key questions from the scoping report:

1. **What are the systemic issues that make infrastructure vulnerable to current shocks and future changes and how could they be addressed?**
2. **What does the public expect of infrastructure services and how should their views be considered in decisions about resilience?**
3. **What changes to governance and decision making could improve current levels of resilience and ensure future challenges are addressed?**

The call for evidence was open for four weeks, closing on 18th October 2019. The Commission received submissions from 24 organisations, including operators, industry groups, consumer groups, local government, academia and consulting groups. The full list of respondents can be found in the acknowledgements in the **main report**.

All non-confidential responses are published in this annex. The evidence gathered was used to support the analysis and conclusions in the Commission's **final report**.

**From:** _____
**Sent:** 17 October 2019 10:56
**To:** _____
**Cc:** _____
**Subject:** NIC Resilience Study: Call for Evidence

Dear _____,

Many thanks for the really valuable discussion yesterday relating to the call for evidence for the Resilience Study being led by the National Infrastructure Commission.

To support the next phase of work, ahead of the final report and recommendation to government next Spring, please find the following documents which may be of assistance/interest to you (as discussed yesterday):

1. Greater Manchester Infrastructure Strategy
2. Greater Manchester Infrastructure Framework 2040
3. Resilient Places - Infrastructure, Building, and Environment (A synthesis of work completed by Arup in support of GM's Resilience Strategy)
4. Resilient Places - Infrastructure, Buildings, Environment (Establishing the current approaches of GM Primary Infrastructure Providers to Resilience)
5. Regional Aqueduct System: Resilience Considerations (Workshop Summary Report)
6. Greater Manchester Preliminary Resilience Assessment
7. Greater Manchester Digital Infrastructure Plan (currently being refreshed)
8. Greater Manchester Cyber Resilience Plan
9. Building Urban Resilience with Nature: 100RC and Earth Economic Report

Please let me know if you have any issues downloading any of the documents.

_____

I will keep you abreast of the development of the GM Resilience Strategy, and please keep in touch!

Best wishes

_____
Senior Policy Advisor
Mobile: _____

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# WSP Response – NIC Resilience Study

| | | | |
|---|---|---|---|
| **TO** | NIC Enquiries Team | **FROM** | _____, Head of Public Affairs WSP |
| **DATE** | **17 October 2019** | **CONFIDENTIALITY** | **Public** |
| **SUBJECT** | **WSP Response – NIC Resilience Study** | | |

## Introduction

WSP is delighted to submit its response to the National Infrastructure Commission's Scoping Report on Resilience. We agree with the Commission that more could be done to ensure the UK's economic infrastructure is resilient, both now and in future. And welcome the Commission's focus in the next phase of the study. In this document, we have looked to holistically address the following questions, which constitute the next phase of the NIC's study, and look forward to being involved in any follow-up conversations and workshops the Commission organises.

1. What are the systemic issues that make infrastructure vulnerable to current shocks and future changes and how could they be addressed?
2. What does the public expect of infrastructure services and how should their views be considered in decisions about resilience?
3. What changes to governance and decision making could improve current levels of resilience and ensure future challenges are addressed?

## Response

There are many definitions of resilience which differ in scope but all have a similar objective focussed on societal, economic and natural environment systems being able to resist, respond and recover from events and trends which have a tendency to overwhelm them. The IPCC AR5 definition states:

> "*Resilience - The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation."*

Whilst the lack of a formal and accepted definition is uncomfortable in a paradigm where we wish to allocate funds and effort only where we can measure an effect and value the effectiveness of our efforts and funds, we cannot stand still and wait for such a definition to arise; visible trends around population increases, socio-economic pressures and climate change impacts all align to create very near-term reliability and capacity issues in our supporting infrastructure which need addressing. We need to be Future Ready.

The US 4th National Climate Assessment (USGCRP, 2018) provides another way of looking at the problem. It is an extremely comprehensive analysis, and has had several assessment cycles. It provides some useful ideas on how to think about a challenging policy landscape, using a series of questions:

- What do we value? What is at risk?

- What outcomes do we wish to avoid with respect to these valued things?
- What do we expect to happen in the absence of adaptation action and/or mitigation of our greenhouse gas (GHG) emissions?
- How bad could things plausibly get?
- Are there important thresholds or tipping points in the unique context of a given region, sector, and so on?

The overarching question was “what should keep you up at night?” with a strong focus on:

- Impacts and losses on the economy;
- Extreme impacts (Impacts from changes in extreme statistics of key climate variables) that are currently less likely but have severe consequences;
- Communicating cascading effects among and within complex systems;
- Quantification of risks that could be avoided by taking action now.

We consider below some aspects in a partial response given that much of the required evidence is still slowly emerging. For example, we know that the NIC has recently commissioned a study to produce a conceptual model, using system mapping techniques (as per our CCC interacting risks project), to understand the critical interactions between policies, incentives, investments and other national-level decisions that have the most impact on the delivery of the UK infrastructure services (as a proxy for resilience). The insights from this project will be helpful in support of this understanding.

*A1) Usefully for now, our Interacting Risks project for the Committee on Climate Change (CCC) Adaptation Sub-Committee (ASC) has provided (through initial model runs only) some insights which support our understanding of sector vulnerability to climate change:*

- **Event cascades within sectors (eg Infrastructure, Natural Environment or Built Environment) appear more important than cascade pathways between these** - At the Devolved Administration level, intersectoral pathways appear less important than within-sector cascades in terms of affecting the overall level of risk.
- **The climate projection is a greater driver of risk than the cascading nature of impacts from single events** - Put simply, more frequent hazards (e.g. coastal flooding) result in larger impacts than the total damages caused by the cascading impacts from the hazardous event (e.g. coastal flooding leading to loss of power supplies, causing IT/comms. to be disrupted). This means that the overall level of risk is appreciably lower in a 2°C world than a 4°C world which further reiterates the importance of achieving net zero.
- **Impacts in the natural environment appear lower than other sectors** – Unlike infrastructure and the built environment, the natural environment has some ability to recover from events resulting in lower magnitude impacts. However, there is currently much less certainty over valuing natural environment impacts compared with other sectors and our future valuations of natural environments may alter this finding.

In a wider sense, as our population and the economy has become larger we need more access to what we see as basic infrastructure – water services, transportation systems, ITC networks, energy networks. Even in the absence of any change to how we invest in such infrastructure, the mere existence of more people being affected by any event, whether single or cascade, potentially raises the consequence of service failure.

As a simple example, the 1947 floods in the Thames Valley hit when the population of the UK was approximately 41M and when the 2013 flood struck the population of UK was nearer 66M – an increase of over 60%. The number of people affected by reduced transport access, loss of sewerage service and other

cascade effects was undoubtedly larger than in 1947 even if the actual number of houses flooded was reduced.

Systemic issues which affect the vulnerability of infrastructure include:

- Location
- Interconnectedness
- Investment decision making

## Location

Much of our current infrastructure serves population centres which have historically been located on the coast or near rivers, frequently in low lying areas that in times of flood provide flood plain storage. Our base load power generation, nuclear or thermal, has been located on rivers and on our coasts to allow access to cooling water. Roads, rail and power systems are densely provided at the population nodes/centres.
These economic centres are longstanding, and functionally immovable in the short to medium term. We therefore have locked-in vulnerabilities given the large number of people and economic activities dependent on reliable service provision.

## Interconnectedness

It is a fact of modern life that all economic and social activity requires infrastructure services and these have become deeply interconnected; roads, rail, trams, water supplies, energy supplies and IT and communications systems individually provide essential services but their interdependence, whether through energy provision, water supplies, flooding and/or landslide, is revealed when one or more of the contributing services fails.
We have seen many examples of cascade type events in recent years and we are familiar with these events; Dawlish, Beast from the East, 2013 floods, the August 9th 2019 power outage for example The direct and indirect effects of these types of events can be significant, even when not accounting in financial terms for the lost time and potential lost opportunities of citizens.
Referring back to the location factor, urban concentrations, which are promoted for their efficiency of operation, offer particular interconnection vulnerabilities due to population density, demand density on systems and access issues.

## Investment decision making

Benefit cost assessment has and remains the main decision tool for investment decision making. This is reasonable provided we are able to account fully and appropriately for the benefits and/or disbenefits of decisions, including any future missed or lost opportunities.

In addition, many of the services provided from our infrastructure are regulated, either directly through sector regulators such as Ofgem and Ofwat, or through Government policy and agencies. One of the main pillars of such regulation has been to maintain reasonable costs of service. As a political and economic aim this is rational and the approach has encouraged better, more cost effective, asset management; better understanding of asset lives and performance, closer management of operations, increased provision of standby and back-up services and improved contingency planning. As a result of the ability to manage more precisely and in the interests of keeping costs down, it is perhaps inevitable that headroom in supply versus demand has eroded over time, leading to an increase in interdependence hazard.
It is, however, only relatively recently that services providers have started to look more thoroughly at interdependencies and cascading failures, partly prompted by the reality of the risks and by regulation. Given

commercial sensitivities, it is likely that many vulnerabilities in systems are not as widely known as they could be, and/or that they have not yet been revealed by events.

It seems inevitable in an environment of close equivalence of supply and demand that new capacity will be needed – in storage, in delivery networks, in generation to name a few – and/or that per capita demand needs to reduce. It is encouraging to see that regulation and policy is moving in this direction, but the time required to address these issues of supply and demand – system inertia in a sense – whether due to planning constraints, availability of funding and/or willingness to pay may mean both a transition period where we remain vulnerable and a cost impact on citizens, which will need careful, political engagement.

*A2) The general public expects "always on" and low cost.*

Like infrastructure systems which are being run closer and closer to the bone, with less headroom, so are many people's lives quite finely balanced whether dominated by time, money and/or health/stress.

As such, individuals' plans are vulnerable to service failure from basic infrastructure; so whilst the general public does understand that significant events can happen (i.e. large storms, long heatwaves and/or power outages) their expectation is that the effects of these on them should be short and they want to be informed accurately and frequently about what has happened and when services will be restored so they too can reset their plans and recover their position.

Their expectation, supported by broad Government policy, is that the service providers should invest sufficiently to keep disturbance to a minimum and that when there is a failure they should be compensated for their loss. Certainly, the compensation aspect of failures has increased and broadened in recent years; the cost to businesses acts as a proxy for the disbenefits in a cost benefit assessment, provided it is set appropriately.

The views of the general public are highly relevant to decisions about resilience as they are both the consumers and the funders of the services. The issue remains that engaging with the public in any meaningful way is very difficult as in order to get valuable contributions many people must be engaged with and a significant effort is needed to inform the public about the issues in ways that are digestible. The water industry has made great strides but rarely do they manage both to engage with significant numbers AND provide high quality information.

*A3) The direction of Government policy seems generally correct; raising the debate around resilience and its socio-economic effects; requiring regulation to address reliability of service and to consider how individual service providers interact more broadly with customers and other businesses to provide reliable services.*

However, there appears at the moment to be limited or no requirement for either regulators or the regulated to work together to solve resilience issues jointly and most cost-effectively. The recent creation of RAPID in the water sector (Regulators Alliance for Progressing Infrastructure Development) is a welcome advance in that the water sector regulators have understood the need to reduce the potential for obstacles arising from their separate governance processes and will work together to support new storage and transmission capacity.

This does not directly address the issue of service providers working together cross sectorally to provide the best responses to resilience issues. There is no doubt more interaction on operational issues between service providers than we see, but in the absence of regulatory control or oversight it is likely that these "voluntary" actions are less integrated than might be.

The National Risk Register reports issued to date (2019 report is pending) deal with sector risks with little mention of inter-dependencies as a specific risk set. It will be interesting to see the extent to which these risks are recognised and commented upon in the next reporting round.

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EC4A 1AB.

18 October 2019

By email only to: resilience@nic.gov.uk

**National Infrastructure Commission (NIC): Resilience Study Consultation**

Dear Sir/Madam

Thank you for the opportunity to comment on the above consultation. Our response is on behalf of UK Power Networks' three distribution licence holding companies: Eastern Power Networks plc, London Power Networks plc, and South Eastern Power Networks plc. We are the UK's largest electricity Distribution Network Operator (DNO) group, dedicated to delivering a safe, secure and sustainable electricity supply to 8.3 million homes and businesses.

Mindful of the five page limit to the response we have set out brief answers to your questions in the appendix to this letter. We have also attached our response of Ofgem's open letter on RIIO-ED2 which was submitted earlier this week – in particular we draw your attention to our detailed responses to questions 24 to 27. We would welcome the opportunity to elaborate on any of the points raised in either our response or RIIO-ED2 document should this be of benefit to you.

If you have any questions please do not hesitate to get in touch with myself or a member of my team.

Yours faithfully

James Hope
Head of Regulation and Regulatory Finance
UK Power Networks

# Appendix

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

1. **What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?**
    a. **Examples of systemic vulnerabilities that originate from the structure of the network at a system level, including the physical and virtual connectivity of assets (but not individual assets themselves) within and between sectors.**

We have identified the following vulnerabilities that arise from network architecture: black start, communications failure and/or removal of provision, fuel shortages as all parties will be facing the same constraints and pandemic due to the loss of critical people to perform key roles.

2. **What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?**

It will be important to understand where the key locations for other sectors are so we can identify the electrical infrastructure that supports them. By way of an example, for a telecommunication provider, knowing the location of their key sites and from which substations and circuits the power to them is supplied. The underlying resilience of each key site is also important to understand, some sites might have a secondary electrical supply from the electricity distribution network and should be noted, others might have on site generation backup – in both cases this reduces the vulnerability of those sites.

3. **Aside from those included in the last National Infrastructure Assessment, 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?**

We believe that the following areas need to be considered to develop a holistic understanding of future system vulnerabilities:

- Whether assessment of strategic investment into national infrastructure adequately builds in and encourages infrastructure companies to consider wider system resilience
- Balance between current and future customers – ensuring a fair balance of costs across generations whilst delivering the best whole life solutions
- Balancing the need to make greater use of existing infrastructure (asset utilisation) with recognition of need for contingency – be that from non-network solutions as well as physical assets
- Ensuring that the increased number of smaller, decentralised generators are sufficiently resilient to credible scenarios and existing standards and arrangements recognise the evolving landscape from one of a small number of large generators to one with numerous small generators

The above points should be considered in the context of infrastructure including communications infrastructure) depending upon a reliable supply of electricity.

Many essential services, such as water and rail, are already reliant on a secure electricity supply. As we transition to a decarbonised future through the growth of EVs and electrification of heat, the public's reliance and value of electricity is only going to increase. This puts an even greater focus on the importance of providing a reliable and resilient distribution network. Similarly, in areas of significant UK economic activity such as London and Cambridge, these public expectations could be felt even more acutely.

It should be recognised that resilience goes beyond just simply physical interventions and strategy. As we move to a more decentralised and digitalised energy system, most industry observers expect the number of connected smart devices to rise exponentially. Whilst providing significant opportunities for new services for customers, they also represent new attack surfaces that could be used to disrupt electricity supplies. Furthermore, the effects of climate change have the ability to disrupt normal working practices and an ability for a company to recover quickly from a disruptive incident along with an adequately trained workforce are just as important as preventing incidents from occurring in the first place.

Therefore to support this, we have suggested that the forthcoming RIIO-ED2 price control could provide appropriately benchmarked ex-ante allowances to tackle resilience activities such as the hardening of both physical and virtual defences, asset management strategies, broader inspection and maintenance and workforce planning policies. Coupled with strong incentive arrangements companies should continue to be encouraged to deliver a level of resilience that meets customers' changing expectations whilst keeping any required increases in costs as low as possible.

It is widely recognised that the roles and responsibilities of electricity distribution companies will change over RIIO-ED2, not least in their transition to Distribution System Operators (DSOs). Achieving net zero will require the electrification of both heat and transport coupled with further increases in the deployment of both renewable generation and storage. We believe the biggest impact of this change will be experienced on the distribution networks and will require investment not only in physical network assets, but in people, processes and systems. Consequently, the operating model of DNOs will change and so will the risks that they are exposed to.

We recognise that at transmission level there has been a perceived conflict of interest, which has led to greater separation of the Electricity System Operator (ESO) from the Transmission Operator (TO). Due to the progress we and other DNOs are making on DSO, it is natural that similar questions are being raised about whether this is leading to fair competition and the best outcome for customers. We understand the importance of this debate. As a DSO that facilitates competition and network access, we recognise that we have a responsibility to provide assurances over our procurement processes, and to remove any perception that we are not neutral. However, without understanding the full-range of consequences, DNO and DSO separation would risk removing accountability for security of supply and would make co-optimising network based and market based options more difficult and costly than otherwise.

4. **How have the current approaches to infrastructure resilience changed over time in order to become more effective?**
    a. **Examples of good practice approaches to resilience that demonstrate how an organisation, or sector has responded to significant changes including, but not limited to; technology, disruptive events and/or changing user demands.**

We have set out below some examples of good practice in respect of meeting changing user demands:

- Creation of new industry technical recommendation documents (known as ETR documents) following major storms or events e.g. ETR 132 following 2002 power cuts relating to tree cutting and ETR 138 for flood resilience
- Tightening incentive targets and definition around exceptional events as part of everyday fault response and network investment planning
- Tougher guaranteed standards arrangements for the electricity industry (reduction from 18 hour standard to a 12 hour standard) and increases in compensation levels. Furthermore, these standards were extended to new areas such as rota disconnection

**Public acceptability of infrastructure services**

5. **How are costs, benefits and public expectations balanced when setting levels of service?**
    a. **Examples of how each of these factors have been considered when setting a desired level of service, either as a requirement or a target.**

The electricity industry has a mature regulatory model which considers the following elements as part of work to set minimum requirement targets or a desired level of service:

- Incentives – covering key attributes that matter to customers, with targets and incentives rates being rebased at successive price controls;
- Benchmarking – of relative performance, particularly in electricity distribution, where a relatively large number of companies provides a useful dataset for the regulator to drive performance levels;
- CBAs – common assessment frameworks to enable companies to put forward more stretching targets in return for additional allowances;
- Willingness to Pay (through both qualitative and quantitative surveys) – to determine the value to attribute to particular elements of the price control and facilitate more robust trade-offs and targeting of investment;
- As part of the DPCR5 price control review, Ofgem assessed submissions from a number of companies with respect to High Impact Low Probability (HILP) events. In the case of investment for the City of London, Ofgem was concerned about the overall risk assessment, the difficulties involved in carrying out a cost benefit analysis and the implied cross-subsidy between different groups of customers. Ofgem stated at that time that "It remains an option for Government to provide guidance to us in this matter".

6. **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?**

To set a consistent level of service across sectors would potentially mean needing to change the underlying levels of service that those sectors have successfully been working to. However, for common failures and/or co-located assets there may be an argument to increase resilience to that of the highest party. By way of an example, if we protect our main substations for a 1 in 100 flood but communications providers' hubs supplying an equivalent number of customers are not protected to the same level, should the communication providers be required to increase their resilience?

This also raises the question of relying on willingness to pay as means to calibrate performance levels, where this may differ significantly across sectors, or to apply "top down" valuations and how these may be derived. Additionally, any drive for consistency should also consider the differences between sectors, for example if it is cheaper in one sector to let things fail and then to fix it quickly, whereas in another sector it is all about preventing failure, then each sector should be allowed to follow their respective path.

7. **How does the public respond to infrastructure disruptions and what is its appetite for making different sectors more resilient?**
    a. **Please provide evidence from direct public engagement which demonstrates public tolerance of disruption and the appetite for resilience investment in the sectors covered by the study (energy, water, digital and transport). This includes, but is not limited to, outputs from willingness to pay surveys, focus groups and deliberative public engagement.**

In the electricity industry, customers receive a high level of service with power cuts being the exception and not the norm. However, we have not rested on our laurels and along with a drive to prevent power cuts and minimise their duration we have also conducted work with customer

groups to consider their resilience in the unlikely event of a disruption to their power supply. Three examples of this that UK Power Networks has conducted are:

- working with theatres in the West End of London
- working with business communities representing SMEs across our footprint
- working with care homes across our footprint

In all cases the aim was to educate and inform so customers are better prepared for any disruption. We are happy to provide more details on this on request.

**Resilience governance and decision making**

8. **What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?**

This is a complex question and we are happy to provide additional information on request but are mindful of the page limitation for this response. With this in mind we set out below some of the key elements that affect electricity distribution:

- Licence conditions that enshrine performance requirements, minimum standards and incentives such as:
  - Interruptions Incentive Scheme (IIS)
  - Guaranteed standards
  - Broad Measure
  - Design Standards (such as N-2)
- E3C/Ofgem energy incident reporting/BEIS major incident reporting in respect of significant events on or affecting the electricity network

9. **How does the infrastructure system respond to uncertainty?**
   a. **Examples of how uncertainty over a particular variable, such as the nature of an anticipated risk, has affected the level of resilience decision makers choose to build into a system.**

In the electricity industry, uncertainty is managed in a number of ways:

- Strategically through price control mechanisms such as reopeners which are triggered by material changes such as volume/cost increases or decreases
- Operationally through exemptions for severe weather such as those for the IIS
- Given demand growth uncertainty and a desire to avoid asset stranding, the electricity distribution companies have been encouraged to innovate in and find alternative means to deal with potential reinforcement needs. UK Power Networks has pioneered this work with flexibility tenders offering contracts for up to four years, thereby helping hold down current customers' bills and deferring the need for physical reinforcement until greater certainty over long-term needs are clearer.

10. **How have system wide resilience challenges been addressed effectively in the past?**
    a. **Examples of how different policies, incentives or decisions across a system have interacted effectively to address an identified cross sector vulnerability and improved the resilience of the system overall.**

The electricity industry has a mature structure to manage major events including resilience challenges. This includes the Energy Emergencies Executive Committee (E3C) and other fora with BEIS who look at improving resilience where cost effective. By way of example, following both the 2009 low frequency event and the winter 2013/14 storms, the industry has worked with Ofgem, BEIS and E3C to publish reports looking at the cause, impact and lessons learned. Included in these reports have been actions which have been delivered to improve future resilience.

# United Utilities response to NIC call for evidence "Resilience Scoping Report" – September/October 2019

United Utilities is the statutory water and wastewater service provider for the North West of England, responsible for planning, delivering, operating and maintaining vital water and wastewater infrastructure as well as providing water and wastewater services to more than 3 million households and businesses. Our response therefore predominantly refers to views from the perspective of water and wastewater networks, rather than other forms of national infrastructure.

## Theme 1 - Systemic issues that make infrastructure vulnerable to current shocks and future changes

**1. What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?**

The water service is still reliant on many inherited assets, built as dispersed, isolated systems. They have evolved to provide greater interconnectivity with a focus on fewer, larger sites. This evolution of network systems means that the risk from systematically vulnerable systems has been mitigated, rather than the networks having been designed as resilient in the first place. Systems may be more resilient as a result but there is often less redundancy, the constant drive for greater efficiency risks the erosion of headroom within the systems. The risk is not necessarily even across the entire network and this is unachievable due to the prohibitively high cost of completely replacing the network. Even greater inter-connectivity needs to be encouraged to share risk more effectively.[1]

For the sewerage service, inter-connectivity is not often a viable solution due to the large volumes of water involved so the reliance on smaller isolated systems remains. A large proportion of our network is a legacy of the Victorians built as a combined foul and surface water network which makes accommodating growth and climate change more costly. The original systems were built solely with public health, not environmental condition, in mind, the modern expectations of reducing discharges to sea and rivers are complex and costly to retrofit to systems that were not designed that way. Focus on tackling these issues takes funding from addressing other underlying issues such as replacing ageing assets.

Price controls, where the focus is on efficiency, encourages making the best of existing often ageing assets but maintaining the status quo does not necessarily fully support future requirements.[2] Historically regulatory regimes have not naturally incentivised enhancement in resilience – this may, in turn, have discouraged investment in UK infrastructure as there are better options elsewhere. More recent developments, such as Ofwat's resilience duty and its proposals for Direct Procurement and water trading, may better support future investment in improving the resilience of water networks. And for a time, improvements and innovations in operational and maintenance practice can deliver enhanced performance but this is not sustainable in the longer term. Reliance on past cost models risks encouraging the taking of more and more risk rather than thinking through long

[1] See Section 2.1 of our Business Plan supplementary "S4002 Resilience Case Studies" https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s4002_resilience_case_studies.pdf

[2] See our Business Plan supplementary "S4001 Asset Health Approach" https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s4001_asset_health_approach.pdf

term requirements and costs. Operating at lower and lower costs also has an impact on resourcing and knowledge and there is a risk that when maintenance requirements increase there will be a lack of skills to address the issue.

We are increasingly reliant on power to operate, to achieve high levels of environmental compliance and to improve the resilience of our water network. Digital is becoming as critical as we increase levels of monitoring, automation and control. Even small outages in power and digital have significant consequences for us. We question whether resilience standards in power and telecoms have kept pace with their increasing criticality to overall national infrastructure resilience.

We are also ever more closely interlinked with international supply chains and the global economy. Fluctuations in international trade have the potential to impact our resilience.

**2. What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?**

The adoption and embedment of digital technologies along with the wider business digital transformation introduces a new set of demands on resilience and security on not just the internal business infrastructure but across the wider Digital Ecosystem that is helping to support the growing digital business. The physical infrastructure components are no longer constrained to within the boundary of our operational environment, the demand for operational efficiency, performance data and customer satisfaction amongst others has necessitated the adoption of connected systems that expand outside the boundary of the conventional infrastructure.

This has placed reliance on systems that are often outside our control and are the provision of others. Historically this has been true of utilities such as power but in the move to digital we have new dependencies on infrastructure such as telecommunications, vital in ensuring the end to end digital integration of our systems and customers and solutions hosted externally on 3rd party cloud infrastructure. The move to grow our digital capability has seen the growth of 3rd party hosted solutions and capabilities that are externally hosted yet form an integral part of our operating model, there is a growing need to map these capabilities and fully understand the underlying infrastructure and dependencies that they have on their supply chain.

Whilst the list of physical components continues to expand from traditional Power and now communications infrastructure and 3rd party hosted systems we must also overlay the security aspects that are intrinsically embedded across all these technologies and ensure we understand the reliance we have of these systems and providers and that we trust them to ensure we are operating in a safe environment. Aligned to this there will be a high reliance on infrastructure that can provide capability in this security arena be it hosted internally or provided externally by others.

**3. Aside from those included in the last National Infrastructure Assessment, 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 NIC should consider the role of all parties in delivering water and sewerage resilience including that of government, regulators, developers, retailers and manufacturers in:

- promoting the importance of water saving – the policy on water metering needs to support this. We currently offer a Free Meter Option (FMO), which will be supported by our "lowest bill guarantee" where a customer will pay the lower of their measured and unmeasured bill. If this does not hit the required number of meter fits to deliver our Water Resources Management Plan we will consider other options such as installation of meters at change of

occupancy. If the impact of climate change is worse than forecast and the level of metering proposed does not impact demand for water in the expected way, we think it is worth considering changes to the legislative framework, for example, the definition of "area of serious water stress" in light of national challenges around water scarcity which are the only conditions under which compulsory metering can be considered. With metering, the support of vulnerable customers is a critical consideration in any change of policy.

- in the policies around water efficiency standards in new homes.
- in incentivising the promotion of water efficient appliances for the home and
- in promoting the use of Sustainable Drainage – the retention of the automatic right to connect surface water to public sewer is incompatible with the development of resilient sewerage infrastructure.

The NIC should consider what could be achieved by a more collaborative national effort. A more consistent national framework of policy and incentives could help nudge developers towards more sustainable building both in terms of water efficiency and the delivery of more sustainable drainage.

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

Risk Framework – Our risk management framework has continuously evolved to become a much more comprehensive, evidence led assessment, supported by better information and more sophisticated IT systems. This evolution will no doubt continue given the pace of technological change.[3]

Planning – Our resilience planning has also become more sophisticated, particularly in the area of water resources planning which has been greatly enhanced since the 1996/97 drought supported by computer modelling and enhanced by a high level of public consultation throughout the planning process.[4] The development of drainage and wastewater management plans to mimic this approach on the sewerage side is welcomed although due to the disparate ownership of drainage assets, dual service (foul and surface water) and fewer options to address deficiencies, the task is considerably more complex.

Operations - We have learned from previous incidents and developed new operational practices that have been highly beneficial in more recent events such as the "Beast from the East" freeze-thaw in March 2018. A systems thinking approach is at the core of our strategy with a centralised control centre using remote monitoring and modelling to predict, prepare and respond to events before customers are aware of them. We have made significant improvements in how we communicate with customers during events and how we quickly identify and support more vulnerable customers.[5] This and other innovations, like our integrated catchment approach, has helped us to enhance resilience at a lower overall cost. We recognise that resilience is not always about investment and

[3] See our Business Plan supplementary report "S4003 Corporate Risk Management Framework" https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s4003_corporate_risk_management_framework.pdf

[4] See our Final Water Resources Management Plan 2019 https://www.unitedutilities.com/globalassets/z_corporate-site/about-us-pdfs/wrmp-2019---2045/final-water-resources-management-plan-2019.pdf

[5] See Section 2.5 of our Business Plan supplementary report "S4002 Resilience Case Studies" https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s4002_resilience_case_studies.pdf

we will continue to look for opportunities to use technology and new thinking to deliver cost effective improvements.

Regulation – Recent changes to regulatory policy has the potential to deliver more resilient infrastructure including the greater involvement of markets that should drive greater participation, the direct procurement approach to funding large schemes has enabled significant resilience infrastructure such as Thames Tideway and our Manchester Resilience scheme to go ahead and the promotion of water trading should contribute to greater national resilience in the long term. Regulatory guidance such as Ofwat's "Resilience in the Round" have contributed to providing more direction on this complex topic.

## Theme 2 - Public acceptability of infrastructure services

**5. How are costs, benefits and public expectations balanced when setting levels of service?**

We have significantly enhanced our level of customer engagement when exploring the appropriate balance between cost and benefits in setting levels of service to the point where changes in committed service level will be always be subject to direct customer scrutiny. We seek views early in the planning process rather than seeking permission once levels of service have already been decided. This research allows us to prioritise and set incentives on performance appropriate to customer expectations.[6]

There is however a potential conflict between customer support for investing in resilience (and ensuring the cost of meeting future challenges does not unfairly burden future generations) and the cost and performance benchmarking and use of league tables based on lagging performance measures and past costs that form the basis for many regulatory regimes.

Risk understanding seems to be moving away from cost and benefit towards a binary intolerance of consequences. It is increasingly difficult to have a sensible discussion about the trade-off between cost and risk. The reaction from politicians, regulators and media after infrastructure disruption is often that "this must never happen again" and criticism of infrastructure providers far outweighs praise of those who handle the situation well. In this climate, the public come to expect zero consequences and this intolerance can lead to a situation whereby enhancement may be required, but customers are unwilling to pay for it. We need to be able to have better informed conversations about the trade-off between cost and risk if we are going to prioritise and invest appropriately.

**6. 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?**

A consistent approach could have benefits in easier public perception of service levels however over simplifying the message to say that all infrastructure providers provide the same levels of resilience is unhelpful if we are to have better conversations about the trade-offs between cost and risk. The NIC should promote the opportunity to improve public engagement so that they are better informed about the different cost and risk trade-offs in different sectors so that they are better informed about the level of resilience and give an informed opinion on how to get the greatest public benefit for any additional investment.

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[6] See Chapter 2 of our Business Plan "Voice of the customer: our approach to engagement" https://www.unitedutilities.com/link/1479f995501a467e89ad40b0ad7fb8d5.aspx, and https://www.unitedutilities.com/corporate/about-us/our-future-plans/listening-to-our-customers/

If a common approach is proposed it would need to be implemented carefully to ensure it doesn't disincentivise others from going beyond national standards. It would require customers to be well informed about risks to enable a debate around their tolerance of consequence and also their tolerance of costs to achieve any nationally consistent standard for the sector.

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

In the customer research we have undertaken, the customer's stated preference is often that things should not generally fail and that when things do go wrong they should be fixed quickly. Building on that insight through more immersive 'revealed preference' research shows that customer's respond well provided there is a good response from the company, with good communication, extra support for vulnerable customers and a prompt return to normal service. Particularly where the event is perceived to be beyond the companies' control, for example a severe flood event, where multiple infrastructure providers are impacted. Customers can appreciate the difficult circumstances and are more tolerant of disruption.[7] [8]

Customer's tolerance of disruption can also be influenced by national messaging in the media and from other commentators, independent of their personal experience of the event.

It is challenging to have public debates about the differences between frequent, low consequence disruption and those large but rare events that have more significant impacts. Particularly in gaining meaningful cost and benefit information to enhance resilience to rare events. We would like to see better cross-sector sharing of evidence when the rare, high consequence events occur to facilitate wider learning. Customer research undertaken as part of our Manchester and Pennines Resilience project has shown that for customers, covering the cost of resolving low frequency/high impact events and not imposing a burden on future generations is of importance to them.

## Theme 3 - Resilience governance and decision making

**8. What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?**

The water sector is closely integrated with the environment in which it operates. Changes to policy in other sectors has significant consequences such as:

- Environmental legislation has driven much of the investment in the water sector since privatisation. This makes investment in other resilience priorities more challenging due to the impact on customer bills. If more was done to avoid pollutants entering the sewerage

[7] See Customer Research Summaries document submitted as part of our Business Plan in 2019: https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s1001_customer_research_summaries.pdf
In particular customer research into the impact of the Lancashire water quality incident on p91-95 and Tameside water quality incident – quantitative research on p96-97. More detailed customer research is available to the NIC on request.

[8] See also our Business Plan supplementary report "S4007 Franklaw Lessons Learned" https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s4007_franklaw_lessons_learned.pdf

system in the first place rather than relying on sewerage companies to remove them at the point of discharge, at high cost, then investment could be redirected to resilience.

- Reduction in local authority budgets has implications for other drainage infrastructure owners. Reduction in gully cleaning and maintenance of culverts leads to overspill into the public sewerage network, leading to additional flooding and a pressure for sewerage companies to invest to mitigate the deterioration.

- Policies around streetworks has significant implications for infrastructure operators with assets predominantly in the highway. Not all resilience activity can be planned well in advance and restrictions on access raise costs and performance risks.

- Loosening of building/planning regulations to promote house building embeds long term issues on water efficiency and provision of sustainable drainage. There is a need to look at the incentives for developers to proliferate a more sustainable approach as well as policy to enforce it. We offer some incentives to developers and customers but more government support would be welcome.

- Many regulations on farming and waste have implications for water sector resilience e.g. use of pesticides, microplastics, co-digestion with food waste, etc.

Devolution is helping with many of these issues as it promotes better local conversations at a more manageable scale for a regional infrastructure operator.

**9. How does the infrastructure system respond to uncertainty?**

Risk framework – Our corporate risk framework incorporates assessment of the potential range of outcomes across the portfolio of risks. Low likelihood and high consequence risks are reported specifically. New and emerging risks are also assessed on a regular basis.[9]

Financial viability – High quality viability statement provided out to 2025 providing robust assurance and confidence over our business plan. Strong liquidity and capital solvency position providing considerable liquidity headroom. Ability to absorb all 'severe but reasonable' company risk specific scenarios and the extreme common scenarios prescribed by Ofwat, whilst maintaining investment grade credit ratings. Extensive mitigations available in very extreme scenarios.[10]

Planning – Our asset planning factors in uncertainty in many areas, the most advanced of which is the provision of headroom within water resource planning detailed in our Water Resources Management Plan.[11]

**10. How have system wide resilience challenges been addressed effectively in the past?**

Our water supply security has been enhanced considerably over the last 25 years with the 1996/97 drought being the catalyst for change across the sector. Systems have evolved to better manage the

[9] See our Business Plan supplementary report "S4003 Corporate Risk Management Framework" https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s4003_corporate_risk_management_framework.pdf

[10] See our Business Plan supplementary report "S4006 Assessment of Financial Resilience" https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s4006_assesment_of_financial_resilience.pdf

[11] See our Water Resources Management Plan technical report on "Target Headroom" https://www.unitedutilities.com/globalassets/z_corporate-site/about-us-pdfs/wrmp-2019---2045/final-wrmp19-technical-report---target-headroom-2.pdf

risks including significant leakage reduction, water efficiency including customer metering, greater connectivity between supply zones, better monitoring and more sophisticated modelling. The Water Resources Management Plans have evolved over the years and are a powerful tool in delivering drought resilience.

However with water resources there are more options to enhance resilience. On sewerage, there are more constraints, for example interconnectivity is rarely an effective solution to flood risk. Drainage systems are more disaggregated in terms of ownership, more localised and providing additional capacity is comparatively costly. The Drainage and Wastewater Management Plans are a step in the right direction but it will not be as straightforward to address this system wide resilience challenge. There needs to be more focus on the future of drainage otherwise we'll keep building in problems for the future and increase the challenge of tackling the issues for future generations.

**Energy Networks Association written response**

**National Infrastructure Commission: Resilience Study Scoping Report Call for Evidence**

**Submitted 18 October 2019**

## Introduction

1. Energy Networks Association (ENA) represents the companies that operate and maintain the gas and electricity grid network in the UK and Ireland. Serving over 30 million customers, they are responsible for the transmission and distribution network of "wires and pipes" that keep our lights on, our homes warm and our businesses running. ENA is pleased to submit a written response on behalf of these companies and have focused our response in the areas where we have the greatest understanding and experience. For ease of understanding, our response is organised according to the key questions raised in the Call for Evidence.

2. Our energy network companies are recognised worldwide for their strong track record of safely, reliably and securely providing the UK with the gas and electricity it needs in three key areas:

   **Trusted performance** - The average gas customer will experience an unplanned interruption once every 140 years. For electricity customers, since 1990, there has been a 59% reduction in the number of customer interruptions, and an 84% reduction in length of customer interruptions**Error! Reference source not found.**. The average GB premises experiences a power cut once every two years and the average length is now only 35 minutes[1].

   **Reduced costs and increased investment** - Network costs are now 17% lower than they were at the time of privatisation[2] and are projected to remain flat, and in some areas fall, into the next decade. These costs are the same or cheaper than in other major economies. The UK's energy network companies have attracted some £100bn of investment since 1990[3]. They are forecasted to invest £45bn between 2013 and 2023.

   **Delivering innovation** - Network companies have spent a total of £99mn across 928 projects through the Network Innovation Allowance, and supported over 1,400 innovation projects since 2004. Independent research carried out by Pöyry has shown that innovation projects from the previous Low Carbon Networks Fund by local electricity Distribution Network Operators (DNOs) could deliver up to £1.7bn of benefits by 2031[4].

3. For our energy network companies, resilience means having the ability to deliver secure, reliable electricity and gas to the public at the lowest cost despite stresses or external threats. A sign of resilient networks is the robustness of physical infrastructure such as wires and pipelines and continuous energy supply to households and businesses even during extreme weather. For example, as temperatures plummeted during last year's 'Beast from the East' storm, gas network companies responded to the challenge. Despite national demand for gas during the storm increasing by an average of 55% (1220 GWh), the reliability of the gas networks remained at 99.9%.

4. Energy network companies rigorously assess and monitor potential risks to the gas and electricity networks, with mitigations in place to manage these risks. Each network company has

1 Ofgem annual report and accounts, 2018-2019
2 Ofgem blog: tougher price controls energy networks, March 2018
3 RIIO fast facts web, 2018
4 UK's electricity networks set out new opportunities for energy innovators to help deliver £1.7bn of benefits

comprehensive business continuity and emergency plans to ensure an effective response in a range of scenarios. Over the last decade, network companies have developed a greater awareness of issues which have the potential to physically impact network assets and prepared accordingly, for example developing more sophisticated flood protection programmes. More than ever, network companies collaborate to understand vulnerabilities and interdependencies, carry out research, plan for emergencies, and share best practice and lessons learned.

5. Ofgem's world-class RIIO regulatory framework has enabled energy network companies to invest in continually strengthening the resilience of the networks. Some £100 billion has been invested overall in the electricity and gas networks since 1990, at the same time reducing network costs to households by 17%. Within this, energy network companies have invested proactively in new technologies and approaches to improve the resilience of the networks particularly during events such as storms and floods.

**Ensuring resilience during current shocks or future changes**

6. As we take bold steps to transform our energy system and deliver net zero by 2050, it is vital that we maintain resilience. Growing amounts of intermittent renewable energies such as solar photovoltaic and wind power, and the connection of new technologies such as electric vehicles, present new challenges for planning and managing the networks. Further, the underlying physical nature of our energy network assets - which are interconnected nationally, regionally and locally - means that disruption in one geographic area may lead to impacts in other areas. Existing approaches and protocols which ensure resilience will need to evolve with the rapid changes in our energy system.

7. Energy network companies are actively developing new, smarter ways to manage the networks while keeping costs low for the public. As electricity network companies lay the foundation for a smart grid, new forms of flexibility are being used to match supply and demand at a local level. Gas networks provide vital storage and flexibility at times of peak demand and overall, demonstrated by the growing role of flexible gas generation plants in recent years. At peak times 61% of power and over 80% of heat and power is delivered by gas via the network. Given this, ENA believes a 'whole system approach' to policy, regulatory and market design is key. More than ever, it is necessary to maximise links and efficiencies between electricity, gas, heat, transport, waste, water and farming.

8. Our energy system will become increasingly digitalised over the next decade. Mapping the physical energy assets which are part of the UK's wider digital network will help with managing system-wide infrastructure vulnerabilities and ensuring resilience. Energy network assets - such as transformers, switchgear and cable and overhead line routes - are already mapped and monitored digitally by network companies to ensure operational parameters are met and issues such as system faults can be quickly identified and addressed. As our energy networks evolve, they will increasingly rely on digital operational telecommunications (OT). Enhanced OT will be required to facilitate and support the development of a smart grid. Improvements will be required in OT resilience and cyber security as energy network control and operation becomes more digitalised and many more devices and equipment are connected directly and indirectly to the network.

**Striking the right balance between costs, benefits and public expectations**

9. Costs, benefits and public expectations must be carefully balanced when setting levels of service to manage resilience. When adopting specific resilience measures, energy network companies carry

out a cost-benefit analysis, using customer numbers served by asset/s as a measure of societal benefit. Allowances to develop resilience projects are approved by Ofgem via the RIIO price control framework and reporting templates are regularly used to report outcomes. Further, investment in resilience measures is subject to regulatory agreement as it is reflected in the network-related portion of energy bills. Therefore, one of the key challenges is striking the right balance between additional direct costs to improve resilience and keeping costs low for bill-payers. Approaches to resilience also need to take account of commercial and technical feasibility.

10. ENA recommends caution in considering a common approach to set levels of service for resilience in different sectors. Such set levels may reduce an organisation's ability to deliver the required resilience measures, lead to unnecessarily high-cost solutions or result in assets being inadvertently under-protected. Instead, it may be more effective to apply resilience service levels in line with the importance of an asset to the operation of critical systems. For instance, for more critical assets, higher levels of service would be required. Prior to setting such service levels, there should be engagement with infrastructure operators to discuss and agree acceptable limits. Appropriate levels will ensure cost-efficient solutions and effective risk management for the benefit of everyone.

11. Even though widespread and long-term losses of energy are rare in the UK, in both gas and electricity, more can be done to ensure the public is prepared and knows how to respond to such events. While energy network companies are aware of interdependencies with other sectors, a more collaborative effort between energy, industry, telecommunications, transport and water can help to further strengthen the resilience of our system. ENA believes that resilience is reliant on each part of the system being individually resilient, which includes having well-developed contingency plans. All critical service providers, such as councils, hospitals and water companies, should have plans in place to determine how they will continue to operate during unplanned network outages.

**Current resilience governance and decision-making**

12. A range of industry guidelines, and government and industry engagement, determine the resilience services delivered by energy network companies under normal operating conditions and during emergencies. Energy network companies regularly work with the department for Business, Energy and Industrial Strategy (BEIS) on resilience and emergency planning. The NEWSAC process, a strategic agreement facilitating the mutual support of electricity Distribution Network Operators, is adopted during and immediately following severe events such as major storms. Strategic and emergency planning guidelines include ENA's *ETR138 Resilience to Flooding of Grid and Primary Substations* which provides guidance on the assessment and mitigation of flood risk and includes direction from the 2016 Government National Flood Risk Review.

13. Energy network companies are only able to respond to events which are known to have an adverse impact on the networks. Research is regularly undertaken to identify and establish different levels of risk and the cost of mitigating these risks balanced with taking action. For instance, there has been an electricity Distribution Network Operator flood protection programme in place since 2010 and key sites have been protected to 1:100 and 1:1000 pluvial and fluvial flood risk (dependant on customer numbers and cost benefit) and 1:200 tidal risk. All physical flood protection barriers have been designed to 2065 flood level based on UKCP09 data and include additional protection through a freeboard allowance. Flood protection measures will be updated to outputs from the UKCP18 data as understanding of the data increases and is incorporated into flood profile mapping.

14. Energy network companies have a strong track record of effectively managing resilience challenges. Resilience measures have been focused on energy network assets with the intention to protect supply so that other systems and sectors can continue to operate, to protect the asset/s or to minimise damage so that supply can be re-established as soon as possible after an event. Energy network companies also review lessons learned from national and international events impacting energy and other infrastructure, and are constantly gathering information that supports improvements in the prediction of events. An example is that many electricity network operators now operate a high-level metric between wind speed and the number of faults which feeds into their assessment of the number of faults teams required to react to a particular storm event.

15. Government resilience strategies and plans must be developed for the long-term, to give network companies the opportunity to build plans and deliver requirements in keeping with the regulatory framework. There must also be sufficient flexibility to deal with short-term risks arising from climate change or cyber security attacks. This ensures companies are empowered to act quickly and effectively, at the lowest cost to the public.

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www.nationalgrideso.com

18th October 2019

**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 us.

Yours sincerely

[via email]

Black Start & Business Continuity Manager

National Grid ESO
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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.

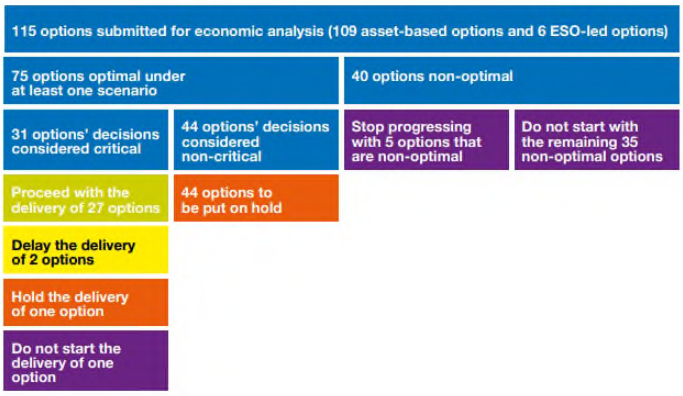
## Public acceptability of infrastructure services – balancing costs, benefits and public expectations

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:

Figure 5.1
How the options went through the process




**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
[9] https://www.nationalgrideso.com/innovation/projects/power-potential
[10] https://www.nationalgrideso.com/innovation/projects/enhanced-frequency-control-capability-efcc
[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

**National Infrastructure Commission - Resilience Study Scoping Report**
**Call for Evidence - EC-RRG members**
**(Closing date 20 October)**

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

1. What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?

*Much of the UK physical infrastructure was built or improved upon after the second world war in the 1950's and 1960's, whilst further updates or improvements continue to be made, the majority of this infrastructure (Pole, manholes, street cabinets, mobile masts, broadcast masts, underground and overhead cables) is sited or routed in alignment to this original post war design (alongside roads and over bridges some of which are now over 100 years old), these older structures were themselves often replacements of older roads and bridges, often they are not best suited or sited to minimise the modern stresses of severe weather, or changes that have occurred to the environment (that may be man-made such as traffic loads or natural hazards).*

*Vulnerabilities – The interdependency between utilities*

- *The Telecommunications Sector protects their core and hub infrastructure against the loss of power but are unable to do so for their end points such as mobile masts and street furniture (cabinets, masts & poles).*
- *Within the Power Sector, there is a requirement to have active monitoring (telemetry) for their power delivery infrastructure, the connectivity for this telemetry is delivered by the Telecommunications Sector.*
- *The Water Sector requires power for their pumping infrastructure and require telemetry provided by the Telecommunications Sector to assess flowrates, water levels, etc. within their network.*

*Vulnerabilities - Sub Sea Cables*

- *Prolonged connectivity problems between the UK and rest of the world (in the order of 4 weeks and above) would likely cause zone validation and expiry issues. This could come about as a result of the complete loss of all sub-sea cable connectivity into/out of the UK. Action would be taken to ensure connectivity via other means (manual updates to non-UK based nameservers, non-cable routes etc). Other than that, the highly resilient and distributed nature of the Internet infrastructure minimises the harmful effect of any vulnerabilities (e.g. power outages, connectivity disruption).*

    - Examples of systemic vulnerabilities that originate from the structure of the network at a system level, including the physical and virtual connectivity of assets (but not individual assets themselves) within and between sectors.

*Where new infrastructure sites have been selected in recent years in major cities, due to planning constraints, sites are often selected in areas they may be at a higher risk of flooding or other risks.,*

*Other infrastructure providers may also be faced with the same challenges, so there is the possibility of a number of critical services to a city being delivered from a restricted geographical area which potentially could be placed at a higher risk than the population that is being served from it.*

*The key threats to continuity of telecommunications services are:*
*Physical (e.g. extreme weather (including flooding, lightening, snow & ice, and wind & storms), fire, explosions, vandalism, sabotage).*
*Loss of key inputs (e.g. electricity, fuel, materials).*
*System/logical failures (e.g. single points of failure, back-up architecture).*
*Software failures (e.g. software error, network node cascade failures).*
*Electronic interference (e.g. radio, traffic overload, malware/cyber-attacks).*

*As the requirements for higher digital bandwidths and speeds are constantly increasing, to reduce latency and improve quality there is an increasing requirement for services to be delivered from the network edges (not core sites). Whilst delivery from sites on the edge of the network will reduce latency and improve the quality of service, there may be a risk that the points of delivery at the network edge may have a lower resilience than some of the network core sites (backup power or physical protection/defence for example).*

*In order to design a resilient and robust service, suppliers may contract some of the routing of their services via other providers networks (to improve geographic separation for example), these providers may in turn subcontract to other suppliers. Importantly, this interconnectedness requires a level of transparency (over routing and locations) to ensure those providers of networks and services are able to discharge their regulatory responsibilities effectively.*

*Local response organisations have responsibilities to ensure local critical services are maintained in an emergency in their own area, this may have the potential to result in in-appropriate prioritisation of resources in an emergency. (Assets that are located in their area, but are not providing critical service in their area (but providing local critical services in other areas) not prioritised for appropriate protection in the host area.) There may be a reluctance to share details of the assets concerned on security grounds.*

- What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?

*As the pace of change is constantly increasing and the dynamics of routing services can change minute by minute, there is little value in attempting to map services against the physical environment. Whilst physical assets could be mapped in this manner, the conclusions would likely only highlight concentrations of local (access) service delivery and not the more critical core functions which are important for wide scale service delivery.*

- *Understand the power autonomy of each sector's systems*
- *Understand the wider impact of the connected networks by understanding the telecommunications inter-connectivity across the sectors*
- *Understand the commonality of the inter connectivity by sector*

2. Aside from those included in the last National Infrastructure Assessment, 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?

*How are interdependencies tracked and monitored as "over the top" systems evolve, or new systems are developed that are dependent on National Infrastructure.*

- How have the current approaches to infrastructure resilience changed over time in order to become more effective?
- Examples of good practice approaches to resilience that demonstrate how an organisation, or sector has responded to significant changes including, but not limited to; technology, disruptive events and/or changing user demands.

*Whilst climate change and impacts from natural events has been a topic for some time there is a growing awareness of the increased frequency and scale of impacts arising as a consequence of these events. This, combined with society's increased dependence on modern technologies, has served to increase the focus on these services (both external to and internal within the supplier's own organisation). This combined with a very competitive market place has resulted in a keen desire to prevent failures and to learn from incidents when they do occur.*
*This learning and the need to improve services to maintain competitiveness, combined with newer technologies which may offer improved options to build in resilience at the design stage has resulted in more effective resilience, this continual and gradual trend is likely to continue in the future.*

- *More use of automated failover capability of telecoms systems*
- *The telecoms industry adopted a more resilient approach by introducing virtualisation and more active/active connectivity to reduce failover time*
- *NB: The ability, cost and practicality to deliver end-to-end resilience increases significantly at the telecom network end points*
- *We have and continue to increase the resilience of our infrastructure by setting up nodes and nameservers in multiple locations around the world*

**Public acceptability of infrastructure services**

3. How are costs, benefits and public expectations balanced when setting levels of service?

*The Telecommunications sector is largely supported by private industry, where costs and benefits are set on a commercial basis, nevertheless public expectations are paramount as the public are usually consumers of the communications services that are offered, additionally the sector regulators also take a close interest of public and governmental expectations and may regulate the sector accordingly.*

- *Examples of how each of these factors have been considered when setting a desired level of service, either as a requirement or a target.*
- In our experience, public expectation is for the Internet and services running on it to continually operate, DNS provision is expected to be constantly available and we work to that service availability for the UK Top Level Domain TLD.

- The Telecommunications Sector plans and maintains its network in accordance with customer demand and Ofcom obligations and regulations. Local factors such as planning, access to assets etc. remains a issues with negative responses from local communities to infrastructure

4. 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?

*We believe it would be preferable to set levels in accordance with the criticality of the service to the community or other sectors, in setting any approach due consideration should be placed on the environment which the sector operates in, including legislation and regulation.*

*The various regulatory bodies should work together to understand inter-dependencies to drive regulation changes that are cost effective, practical and sustainable to deliver complementary service levels.*

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

- Please provide evidence from direct public engagement which demonstrates public tolerance of disruption and the appetite for resilience investment in the sectors covered by the study (energy, water, digital and transport). This includes, but is not limited to, outputs from willingness to pay surveys, focus groups and deliberative public engagement.

*Where the public increasingly rely on telecommunications infrastructure in their daily home and work lives, the tolerance for infrastructure disruption has become significantly lower than in the past.*
*While in general society's appetite to make this infrastructure more resilient is clear there remains a disconnect between the uplift in expectation and the willingness to pay for the upgrade in service quality.*
*The public in general react negatively to infrastructure disruptions, and the Telecommunications Sector is now seen as a critical utility.*
*The public also should consider what plans they have in place mitigate the risk of disruption to telecommunications services.*

**Resilience governance and decision making**

6. What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?

*Many organisations in the communications sector are CCA (Civil Contingencies Act) category two responders and may also be members of the EC-RRG and as a result may support information flows and national level decisions where that is appropriate in an emergency.*

7. How does the infrastructure system respond to uncertainty?

- Examples of how uncertainty over a particular variable, such as the nature of an anticipated risk, has affected the level of resilience decision makers choose to build into a system.

*The infrastructure itself is often designed to work within pre-set parameters, these are often set in advance so generally infrastructure will respond according to the operating environment. Uncertainty may be caused by a lack of situational awareness in the following areas:*

- *Market place*
- *Financial environment*
- *Interworking or interdependencies with other infrastructure or projects*
- *Current operating environment*
- *Technology lifecycle (developing new protocols, testing of design outcomes etc.)*

*Where there is human involvement either in the planning, deployment or operating lifecycles of infrastructure then the following responses may occur as a result of uncertainty:*

- *Delays whilst situational awareness is achieved to improve decision making*
- *Inappropriate investments (financial or resource)*
- *Failure of infrastructure to operate within known designed parameters (as a result of uncertainty in the design stage)*

*The telecoms industry is complex and does not respond well to uncertainty with infrastructure change, which takes a long time to implement. Uncertainty delays the rollout of planned infrastructure change and impacts customers negatively.*

*Power autonomy time scale is not mandated across the telecoms industry - each operator follows its own policy.*

8. How have system wide resilience challenges been addressed effectively in the past?

- Examples of how different policies, incentives or decisions across a system have interacted effectively to address an identified cross sector vulnerability and improved the resilience of the system overall.

*By working closely with partners, government departments and related agencies with the sectors concerned being involved in industry led groups for example the EC-RRG for the communications sector in addition to other engagements.*

# Consultation Response: Systemic issues that make infrastructure vulnerable to current shocks and future changes

Chris Dent, Kate Simpson and Jim Smith[1][2]

We are pleased to respond to this consultation response, providing a range of general points in policy and analysis approaches, illustrated from our experience in electricity security of supply and the built environment.

For context, Dent has 13 years' experience in energy systems analysis research with particular emphasis on security of supply and wider issues in decision support for policy and for capital planning. Simpson has ten years' experience studying domestic retrofit and building level energy use, this has included retrofit processes plus modelling and measuring space heating energy and internal environment data. Smith has several decades of experience in relevant areas of system reliability assessment and decision support.

### 1. *What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?*

Systemic vulnerabilities originate from the structure of the network at a system level, specifically the physical and virtual connectivity of assets (but not individual assets themselves) within and between sectors.

There are a number of examples in electricity security of supply. Wide area disturbances in other systems have originated in issues around exchange of information or operational planning on the boundaries between system operator areas within the same interconnection, including NE USA (2003), Italy (2003) and the European interconnection (2006). The consequences of the 9 August 2019 blackout event were greatly magnified by interaction between the original electricity system fault and its effect on the rail network[3]. More generally, the GB electricity system relies increasingly for supply adequacy on gas fired power stations (and in the event of a national gas supply shortfall, domestic gas supply takes priority over electricity generation), and there are concerns over how cyber-security issues can have consequences for other infrastructure networks.

### 2. *What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?*

Variables with interdependencies, for example external and internal temperature, air quality, energy supply, water levels, flood risk, building and infrastructure physical and geometry data, population statistics, green space and biodiversity.

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[1] The authors are affiliated with the Alan Turing Institute (Dent and Smith are Turing Fellows, Simpson Visiting Researcher). In addition Dent is Chancellor's Fellow and Reader in Industrial Mathematics at the University of Edinburgh, and a Co-Director of the Centre for Energy Systems Integration; Smith is Professor of Statistics at Warwick University. They write in a personal capacity.

[2] The authors may be contacted at chris.dent@ed.ac.uk.

[3] See https://www.dur.ac.uk/dei/news/?itemno=39555 for more detailed discussion of this event, and @chrisdentmaths on Twitter for further commentary on National Grid's final report.

3. ***Aside from those included in the last National Infrastructure Assessment, 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?***

Issues include the need to retrofit existing building stock to meet the zero carbon targets set out in the Climate Change Act (2008). However, the majority of past research on retrofit has been limited to building energy performance modelling and performance assessment. The modelling and decision making tools could be extended to include consideration of flood risk, overheating risk, energy security and enabling autonomy in case of system failure.

More widely, when performing such assessments, there is a need to consider a full range of systemic changes to the background against which infrastructure is operated, including climate, social changes and changes in user demand, and development of technology.

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

In the energy sector, there has been much reliance on large scale computer models for analysing infrastructure resilience. It is doubtful whether bottom up system modelling is effective in all circumstances, variously due to the system under study being far more complex than any model could be, lack of direct data on rare classes of events, or uncertainty in future background meaning that detailed system modelling involves undue speculation over how the system develops in detail over time. Alternative approaches might be more effective, starting from mapping interactions between different infrastructure components at higher level. For example higher level models can admit a level of compartmentalisation which splits problems up into more manageable components, making resilience studies more feasible, especially when considering rare events and less well observed parts of the system.

5. ***How are costs, benefits and public expectations balanced when setting levels of service?***

Please see comments under 6 on common monetary quantification.

6. ***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?***

It is in principle attractive to use common principles across sectors. We note here a number of caveats on this which should be properly considered.

There are different engrained paradigms of expectations in different sectors. One example within the electricity sector is the different social and political reaction to customer disconnections arising from[4] (a) local network faults, (b) absolute capacity

[4] See https://www.dur.ac.uk/dei/resources/briefings/blackouts/ for more detailed discussion.

shortfalls at national level, and (c) consequences of sudden fault events on the national transmission/generation system. There are also differences in paradigms between sectors, for instance in electricity if all network components are available it is not acceptable to disconnect customers, and in data networks it is normal practice to manage congestion by slowing connections. This provides a key starting point for developing common principles in a practical context.

If common principles are to be developed, then this should be based on appropriate metrics. In particular, attempting a common monetary quantification of potential outcomes may or may not be natural. There are both general issues of different phenomena not being easily comparable; and also specific issues that considering uncertain quantities in expected value terms may remove information on variability of outcome which is highly relevant to the public or decision makers, in which case other visualisations or utility functions may be needed. In electricity security of supply this latter is an example of a 'modelling what one can model' issue, in which expected value indices have been used historically partly for computational convenience, rather than because they reflect the true interests of decision makers and society. This is especially the case when issues like public acceptability are significant and when the analysis is performed for or at least scrutinised by stakeholders who may not share the same priorities

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

In responding to this question, we consider a dwelling retrofit to be an infrastructure disruption, since it requires householders' to tolerate disruption within the home and street and potentially to decant during the work. In Simpson's PhD research[5], the process of retrofit was found to be highly disruptive due to householder changes in work hours, the creation of noise, dust, odour, unexpected activity and delays resulting from planning, sequencing and workmanship. The cost was an additional expense. While we must decarbonise the building stock and know it is technically possible to do so, we must minimise disruption and create incentives which overcome these challenges. Digital tools to enable better planning, sequencing and information could assist with the challenge.

Please see also comments under 6 on engrained paradigms.

***8. What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?***

No specific response to this question.

[5] Simpson, K. (2017) Energy efficiency refurbishment of UK owner-occupied homes: the householders' perspective. PhD thesis, Loughborough University

***9. How does the infrastructure system respond to uncertainty? Examples of how uncertainty over a particular variable, such as the nature of an anticipated risk, has affected the level of resilience decision makers choose to build into a system.***

In building retrofit, uncertainty exists in terms of potential carbon savings, potential for installed technologies to not work correctly or not work alongside other technologies, for example solar thermal panels and back-up gas or electric-fuelled water heaters, potential for insulation to cause damp issues. This type of consideration could be minimised with better sharing of information and data. As yet, flood risk and overheating of urban areas has not been fully considered alongside low carbon retrofit. Retrofit may offer opportunities to overcome these issues, while protecting the embodied carbon locked into existing building stocks.

Further work on systems modelling of interdependencies between city level services would be beneficial for enabling deeper understanding to inform decision-making.

***10. How have system wide resilience challenges been addressed effectively in the past?***

Smith, together with his colleague Simon French[6], carried out work after Chernobyl (the RODOS project) assessing policies to ameliorate risks of nuclear contamination considering among other factors human health issues (such as cancers and infertility risks); agricultural contamination and contamination of water supplies; what the general public would countenance happening; and of course cost.

By compartmentalising the processes involved it was possible to manage overall uncertainties and better understand the resilience of different policies, whilst the measures of such resilience to different stakeholders could be examined using a multicriteria decision making approach using attributes like those above. While this example is from crisis management not infrastructure resilience, it contains much relevant material on rare event risk assessment with limited direct data

[6] For more detail see French, S. & Smith, J.Q. (2016) "Decision Analytic Framework for a Decision Support System for Nuclear Emergency Management " in UK Success Stories in Industrial Mathematics, Eds Aston, P.J., Mullholland, A.J. & Taut, K.M.M. Springer, 163 -171. Available at https://link.springer.com/chapter/10.1007/978-3-319-25454-8_21.

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Inspiring the extraordinary

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19th October 2019

**Dear National Infrastructure Commission**

**Re: Resilience Study scoping report - Response**

I really enjoyed reading the Resilience Study scoping report. Infrastructure has traditionally been viewed as a discipline driven by engineering and physical sciences, encompassing the basic physical and organizational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of society that enable us to live our lives and take advantage of technological advances. However, the way in which humans choose to use and interact with physical infrastructure, especially the built environment, can determine the success or failure of developments and new technologies and also their resilience. I think the report provided an engaging and detailed account of the topic and its governance. My response is structured around themes of definitions, language, and understanding interrelationships between multiple hazards and risk chains.

**Defining resilience**

Resilience is a contested concept with a much broader range of definitions existing within the academic literature than presented in the scoping study (e.g. Manyena 2006; Bahadur *et al.* 2010; Cutter 2016). In academic research two major differentiations between definitions of resilience exist, those derived from engineering, and those from ecology (Hollin 1973; Walker and Cooper 2011). Engineering resilience is defined as "*the ability of a system to return to an equilibrium or steady-state after a disturbance*" (Davoudi 2012). Definitions of resilience grounded within engineering thinking are focused on 'bounce-back' (Davoudi *et al.* 2013) and levels of resilience are dictated by how much resistance a system puts up to a disturbance and how readily it rebounds to its pre-disturbed state. In contrast ecological resilience focuses on the magnitude of a disturbance that a system is capable of absorbing before it is altered into a new state by external forcing; a continuous process of persistence followed by adaption (Adger 2000; Folke 2006), often characterised through multi-scale adaptive cycles (Carpenter *et al.* 2001).

Although different, both definitions assume the presence of equilibria or a steady state within systems, whether this is a pre-existing situation to which a system can return (as in engineering resilience) or a new one to which a system can transition (as in ecological resilience) (Davoudi *et al.* 2013). These definitions are often combined in operational definitions of resilience and the nuanced meanings debated in academic research become eroded and conflated into straightforward, everyday uses. For example, research undertaken to support the implementation of the EU Floods Directive (Thieken *et al.* 2014) argues that resilience is a three part process: (i) resistance to a shock or disturbance; (ii) recovery from the disturbance, with the time taken to return to a pre-shock state an indicator of resilience; and (iii) adaptive capacity, or the ability of the system to learn from past shocks and adjust to new conditions. Of these three facets of resilience, (i) and (ii) can both be seen to be drawn from an engineering conceptualisation of resilience, with (iii) incorporating Hollins ideas of adaptation to a new state in response to a disturbance.

Of these stages of resilience, resistance and recovery are frequently the focus during responses to hazard events such as floods. For example, the UK Environment Agency (EA) 2018 information campaign regarding flood resilience carries

the strapline "*Prepare, Act, Survive*" (https://floodsdestroy.campaign.gov.uk/). This statement is a clear focus on the resistance of individuals and communities to flooding, and the survival of their pre-existing situation in the aftermath. A focus on emergency response is also reflected in the Cabinet Office definition of community resilience as "*communities and individuals harnessing local resources and expertise to help themselves in an emergency, in a way that complements the response of the emergency services*" (Cabinet Office 2011). Recent national policy has also reflected this response and recovery focus. The UK National Flood Resilience Review (Defra 2016a) focuses on the resistance of critical infrastructure to flooding, and how quickly services can be returned to normal following a flood event. The companion Property Flood Resilience Plan (Bonfield 2016) focuses on residential property and the installation of measures to "*help prevent flood water ingress into a building or aid rapid recovery*".

It has been argued that this focus on response and recovery is because UK resilience policy is grounded in command and control thinking, something which Manyena (2006) argues is common for disaster resilience programmes globally. The need for measurable metrics and the demonstration of effective management integrates easily with the response and recovery aspects of resilience, which are easily controlled and measured, for example how long it takes a flood-affected family to return to their homes. Emergency response also integrates well with the focus on individual self-reliance. Individuals and households can be encouraged or instructed to prepare, through information campaigns such as "Prepare, Act, Survive", and these efforts can be coordinated from the top-down to integrate with the actions of the emergency services (Cabinet Office 2011). In contrast, developing long-term adaptation based resilience requires a hands-off, locally-driven approach which cannot be easily measured, controlled, or directly affected by government expenditure (Edwards 2009).

However, the definitions and interpretations of resilience are full of assumptions that need to be carefully thought through in practice. For instance strap lines such as "Prepare, Act, Survive" don't take into account what happens beyond the aftermath of an event. 'Returning to normal' can also be problematic if your normal is not sustainable and limits wellbeing. It is also very difficult to evidence any of these terms.

**Resilience governance and decision making: the language of resilience**

The technical language of resilience across policy, practice and research is well developed. However, common words from policy and practice often have uncommon meanings for communities and individuals (e.g. Bracken and Oughton 2006). *Dialects*, *metaphor* and *articulation* are three overlapping aspects of language which have been identified to play an important role in developing understandings between different disciplines and sectors of practice. *Dialects* represent the difference between everyday use of a word and specialist, disciplinary use of a word (Bracken and Oughton 2006). Dialects are also produced by the same word having slightly different meanings within different disciplines/contexts (Bruce *et al.*2004), which may also be different from their everyday meaning. Words which are in everyday use tend to be those that cause the most difficulty. The conversation may be well developed before it becomes apparent that a particular word has a specific disciplinary interpretation as well as its everyday use. This situation can lead to frustration for those coming together from different perspectives. The second aspect of language is *metaphor*. The use of metaphors is common in everyday discourse and is embedded in our language; we rarely think about them or are aware that we use them. When working within disciplinary teams we tend to have common metaphors on which we draw to express and explain ideas. For good communication we need to be aware of the times at which we move into separated speech communities and when the form of metaphor being used may be misinterpreted (Bracken and Oughton 2006). The final aspect of language highlighted by Bracken and Oughton (2006) differs from the first two in that it is a process rather than a register of speech. *Articulation* involves deconstructing one's own disciplinary knowledge in conjunction with those of other disciplines in order to understand the building blocks and thereby reconstruct a common understanding. The idea of *articulation* is particularly stimulating and an accurate description of the very active discussions involved in framing and researching a problem or event. Slightly

different definitions of the same word can highlight alternative starting points in terms of thinking about a problem, related to disciplinary backgrounds or sector practices. Breaking these down and developing a shared, common understanding creates a more powerful platform from which to communicate.

The aspects of language outlined above are best illustrated around resilience in terms of the use of the word recovery, a key term and phase of working with communities post event to help them get 'back on their feet'. In technical, practitioner terms the recovery phase begins as soon as the first responders have come to the end of their phase of work dealing with an emergency or disaster. However, for victims and those affected by an emergency they are likely to be in a state if shock, feeling very vulnerable, stressed and often not coping. The term recovery has a very different meaning to these people who often feel they are struggling to cope. Being talked to about recovery can very easily undermine efforts to support victims and increase tensions during uncertain times of managing emergency events. Common understanding derived from shared languages thus pay a vital role in enhancing the relations of trust that are necessary for effective working across policy and practice and with communities to grow resilience.

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

Understanding the complex systems that inform understanding resilience of infrastructure is in its infancy. One key aspect of infrastructure resilience is managing the impact of natural hazards. Many regions are prone to events that include more than one natural hazard, with interrelationships between the hazards that impact the same location during the same time period (Gill and Malamud, 2014; Leonard et al., 2014). These have been termed multi-hazard events and are usually based on physical phenomena (e.g., thunderstorm, mid-latitude cyclone). For example in winter 2014, the UK experienced a succession of major storms that led to severe damage due to wind, flooding and avalanches in Scotland (Met Office, 2015). In a recent review 19 different modelling methods were identified to quantify natural hazard interrelationships which were clustered into three broad modelling approaches: stochastic, empirical, and mechanistic (Tilloy et al 2019). The purpose of this research was to aid cross-disciplinary approaches for better understanding potential risk related to multi-hazard events.

What is less well understood is how such multi-hazards interact with systemic risk to impact infrastructure. Systemic risk is most usually referred to as the risk of a breakdown of an entire system rather than simply the failure of individual parts. It has been most readily applied In a financial context to capture the risk of a cascading failure in the financial sector, caused by interlinkages within the financial system, resulting in a severe economic downturn. Yet systemic risk can be widened to include all social, cultural and economic characteristics of people impacted by emergencies. There has been little research to explore how mutli-hazards, systemic risk and vulnerabilities related to factors such as income, heath, and education come together to impact community resilience and how people might fair in light of an emergency. The complex interactions between hazard, risk and resilience can result in conflict after emergency events, readily inflamed by inequalities. There is therefore a need for the development of a tripartite methodology enabling the voices of communities, practitioners and researchers to be considered as a whole. Ethical approaches to supporting and working with communities are vital.

I hope these thoughts are useful in the collecting evidence to support the Resilience Study scoping report. If you require any further information please do not hesitate to contact me.

Yours sincerely

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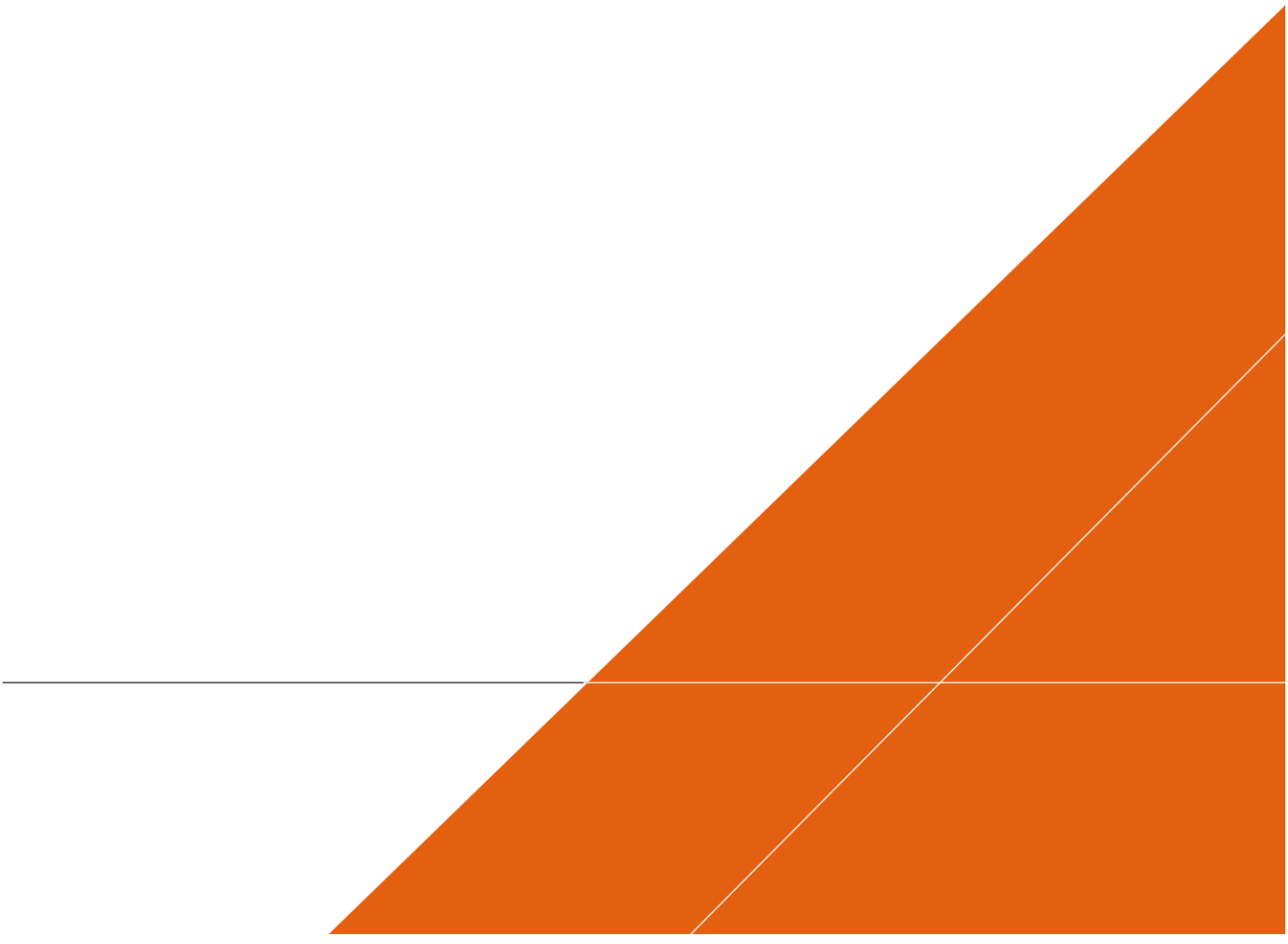
ARCADIS Design & Consultancy for natural and built assets

# RESILIENCE STUDY – SCOPING REPORT

## Response to the Call for Evidence

OCTOBER 2019



~~Resilience Study Scoping Report~~
~~Call for Evidence~~

## Introduction to our response to the call for evidence

At Arcadis, we believe in improving quality of life. This belief is synonymous with the work of the National infrastructure Commission. We are environmental professionals, management consultants and engineers who are focused on built and natural assets. Arcadis welcomes the opportunity to respond this call for evidence and in responding, we have focused on issues associated with physical assets rather than business systems or customer management solutions.

Through our work delivering significant resilience projects around the world, our goal is always to help our clients reduce the gap between resilience planning and resilience implementation. Increasingly however, we are recognising that there is an additional gap that needs to be closed – between the emergence of long-term risks to resilience associated with climate change and the willingness of consumers to pay for investment through charges or through taxation.

We trust that the issues raised in this response will support the work of the NIC. If we can be of further support, we will be delighted to provide further input into the study.

## Question 4

*How have the current approaches to infrastructure resilience changed over time in order to become more effective? − Examples of good practice approaches to resilience that demonstrate how an organisation, or sector has responded to significant changes including, but not limited to; technology, disruptive events and/or changing user demands.*

The main change that we perceive to be affecting the management of infrastructure resilience over time has been the drive to reduce unnecessary expenditure through the adoption of risk and condition-based methods of the assessment, comparison and planning of resilience-related investment.

This can also be seen through the adoption of a management approach based on the 4 Rs – resistance, reliability, redundancy and response and recovery – which in turn enables a shift away from a reliance solely on capital expenditure.

The ability of organisations to respond to this challenge has supported by technology enabling the capture and management of asset data and the running of multiple simulations of different investment scenarios.

Within Arcadis we have multiple examples from the UK and Europe of the application of system-wide, data-enabled, condition-based asset management solutions. These enable the infrastructure owner to focus their investment more effectively.

Severn Trent Water and Yorkshire Water for example have both adopted *predictive, enterprise-wide analytics* solutions for condition-based asset management provided by Arcadis subsidiary, SEAMS, that have supported regulatory outperformance. The latest iterations of these solutions feature direct integration with Enterprise Resource Planning (ERP) systems as well as dashboard interfaces aimed at equipping senior managers to use modelling tools directly.

We also recognise that regulators are making wider use of benchmarking and comparison across all aspects of utility performance. Not only can this approach be extended to the assessment of resilience, but this can also be used to communicate risks and actions to customers and stakeholders as well. In response to this trend, Arcadis has developed an operational resilience measurement methodology, which provides a bottom-up approach to resilience assessment, measuring multiple hazards and providing a more holistic assessment of resilience

The resilience methodology is built in three steps:

1. **Asset List** - schedule and understand the assets to be assessed
2. **Risk Assessment** - a data-driven risk assessment based on a common risk framework
3. **Resilience Score** - Resilience scores for customers and the utility that are used to target resilience improvement plans

Through the presentation of the results at the level of the Demand Monitoring Zone (DMZ), the data can be presented to provide insights to customers as well as system managers and regulators. Using the results, utility owners can test for potential solutions in different scenarios to determine the optimum combination for system-wide resilience.

Through the application of this methodology, we have helped our water industry clients to achieve the following successful outcomes:

- Northumbrian Water – secured £50 million for resilience improvements in AMP 7, impacting 2.7 million customers
- Southern Water – improved resilience planning across 600 sites, impacting over 2 million customers and identifying £16 million of savings
- United Utilities – following an incident which affected 700,000 people, transformed the organisation into a sector leader for risk and resilience. Our work has improved resilience planning and reduced the likelihood of such events recurring.

## Question 5.

*How are costs, benefits and public expectations balanced when setting levels of service? − Examples of how each of these factors have been considered when setting a desired level of service, either as a requirement or a target.*

One of the major challenges that infrastructure providers face in the UK is public expectation of the 'levels of service' for each infrastructure sector. These can vary between sectors, as such there is no clear definition of 'levels of service' nor is there a consistent threshold across sectors. There are also marginally different levels of service between service providers in a sector – e.g. differences in compensation events and compensation payments by water companies etc. Furthermore, expectations change over time, particularly with respect to customer experience, such as information provision during a service interruption.

Public expectations with respect to service continuity are generally very high. With the near universal adoption of technology, the expectations of public have changed. Not only is there an expectation of uninterrupted levels of service for digital solutions e.g. mobile phone coverage for emergency services, but also greater expectations for uninterrupted operation of other utilities.

In the UK, a highly regulated environment sets the levels of service for different service providers based on customer engagement, safety and legal aspects. As part of PR14, OfWat connected the levels of service with performance commitments based on which the water companies would either get a reward or a penalty. The evolution of this mechanism has continued with the introduction of the C-Mex customer service incentive in PR19 which focuses on the customer experience rather than service.

The regulator has addressed 'affordability' by asking water companies to propose value for money performance commitments with incentives to deliver on the commitments through 'outcome delivery incentives'. Although this approach has helped encourage companies to improve their services to customers, by stretching them to provide high level of service, it has focused mainly on 'business as usual' requirements including safety, environmental protection, reliability, customer service and social outcomes. This mechanism has only an indirect relationship with asset management investment and does not guarantee continued level of service during events/emergencies or investment in long-term resilience. To address this issue, Ofgem have introduced a monetised assessment of network asset risk health for gas and electricity distribution and transmission networks to provide further incentivise spending on network health.

With uncertainty around climate change, there is a need to invest and build resilience such that in an emergency disruption is minimised. In order to achieve this, water companies will need to make substantial CAPEX and OPEX investments upfront for events that have a low likelihood but high impact. We have found that the engagement of Consumer Challenge panels as part of the assessment of performance commitments and incentives has demonstrated a reduced willingness on the part of consumers to contribute to these significant investments in the future maintenance of service levels. This can be characterised as an unconscious application of a high discount rate on the future costs of network failure compared to current investment. This makes it more difficult to maintain investment to sustain current service levels into the

future. In our view, and as resilience risks increase, the regulatory system will need to adapt to provide further long-term, pointed incentives to utilities to drive their resilience investment.

Whilst stakeholder engagement does raise some challenges associated with the planning for long-term investment, there is no doubt of the benefits of engagement associated with the setting of present-day service levels. When the benefits of a project or investment are made clear, and details of various options provided, in many cases, affected members of public will show a keen interest. This direct engagement does help to manage public acceptance of a particular level of service. For example, a clearly articulated message around the reasons for increased water bills, may support public acceptance of a maximum service disruption standard. In the event of a service problem, this agreement will help manage to public perception of the service provision and the acceptability of the risk.

One area where we recognise that service levels are particularly difficult to set concerns 'system of systems' performance. This principle recognises that the performance of networks will be dependent on other infrastructure aspects including energy, telecommunications etc. Whilst it might not be possible to set a consistent Service Level Agreement across all providers, an 'adaptation pathways' approach can be utilised whereby investment planning is undertaken for a range of scenarios and options refined as more data becomes available.

One emerging trend with respect to infrastructure service levels concerns the emergence of premium services. Examples on the railway include the Heathrow Express and the HS1 Javelin Service. This raises the question as to whether infrastructure should be designed for 'everyone,' putting people with diverse backgrounds and perspectives at the heart of decision making. The level of service required and the public perception of the value of the service will vary between different groups of society in different parts of the country. Well paid commuters might prefer fast premium service whereas others might prefer a slower, lower cost service on a regular train without interruptions. Addressing the needs of a diverse range of people at the service planning phase and following the principles of 'inclusive design' can support better decision making in setting the 'level of service' that majority of UK residents want.

## Question 8.

*What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?*

The UK government's national level infrastructure policies, incentive structure and information flow are subject to continual change. One of the major reasons for this is the 5-year political cycle which inhibits the party in power to commit to sustained long-term investment, given that parties have their own political priorities. An example is funding for Transport for London which has been reduced both as a result of decisions by national government to reduce central funding, and by regional government through the promotion of a fare freeze at an election.

Funding periods also potentially have an impact on the ability of some organisations to manage their investment programmes. Whilst the regulated utilities, Network Rail and Highways England can deliver Totex programmes over a 5 to 8-year control period, other organisations, Transport for London for example, manage major maintenance programmes on the basis of annual funding allocations.

A further policy constraint is the hybrid organisation of UK infrastructure provision into privately and publicly owned and managed organisations, creating complex relationships at a regional level (water, gas and electricity) or at a system level (Network Rail and Train Operating Companies).

The information flow between government departments is poor. There is lack of coordinated working between departments, the culture of working in silos results in delays and duplication of efforts. There is no common data platform nor is data held in formats which can be used across departments or infrastructure organisations. For example; Local Authorities, Water Companies and the Environment Agency often use different sets and formats of LiDAR data for the same area, which makes coordinated working less efficient.

Concerns around the security issues associated with the sharing of data prevents organisations to share data openly. At times, data is not shared because the costs of sharing are perceived to be greater than the

expected benefits and concerns around lack of competitive advantage. We acknowledge the excellent work undertaken by the CPNI in developing best practice for the security management of digital asset information

Issues associated with effective data sharing affects the level of service under normal operating conditions and get exasperated during an emergency when there is an urgent need to have coordinated plans across organisations which depend on the availability of ready and reliable quality of data.

Analysis of existing studies suggests that, by tackling these barriers, increased data sharing in the future could lead to annual benefits from data in the order of £15bn across the UK's infrastructure sectors, compared to current levels of around £8bn (Deloitte analysis of Cebr (2016), 'The Value of Big Data and the Internet of Things to the UK Economy'; McKinsey Global Institute (2013), 'Open data: unlocking innovation and performance with liquid innovation'.

This issue illustrates how the Regulated Asset Base (RAB) model continues to influence spending decisions on networks. The operation of the RAB model has been subject to reform for some time, with regulators adopting a bias towards TOTEX in order to counter incentives to invest in the Asset Base. We agree with the NIC observation that data is infrastructure but observe that utilities have not been provided with appropriate incentives to invest and maintain a robust and complete infrastructure dataset. With the rapid development of thinking around Digital Twins promoted by the Digital Framework Task Group and Cambridge Centre for Digital Built Britain, we believe that the regulatory model will need to be adapted quickly to enable appropriate investment in digital assets. This change may be required during regulatory control periods to accelerate the adoption of Digital Twins.

One final issue which we believe that NIC should consider as part of this review is the role of Central Banks in determining the cost of finance and whether the adoption of dynamic price regulation might mitigate emerging problems that are associated with the unconventional monetary policy adopted since 2010. A case in point is the step change in Return on Capital being allowed by the regulator in forthcoming control periods, which is having a significant impact on both utilities' business plans and their investability. We do not consider that the potential impact of this issue on the ability of utilities to make long-term investments in the resilience of infrastructure has been properly considered as the regulators have sought to secure best value for customers.

## Question 9.

*How does the infrastructure system respond to uncertainty? − Examples of how uncertainty over a particular variable, such as the nature of an anticipated risk, has affected the level of resilience decision makers choose to build into a system.*

We live in a world where uncertainty is the new normal. If we build long lasting infrastructure to design codes only, we will continue to expect failures of critical systems and experience its negative impact on the quality of life. The uncertain and complex nature of climate change demands that we build and position infrastructure so that reliability hinges on it 'adapting' to this uncertainty.

Currently we respond to uncertainty by preparing 'risk management' plans. These often focus on the risk of an asset rather than the whole system and do not take into account the wider infrastructure system of systems. Since the infrastructure we have created is 'interconnected', failure of one part could potentially lead to cascading failure of the entire system. For example, a water main burst or surface water flooding can lead to power failure, associated communications (mobile) failure thus have a knock-on effect on the service a hospital provides.

Whilst we do not have backup capacity in place, users of infrastructure will continue to suffer the risk of service outages. Learning to utilise natural systems that complement 'grey' infrastructure (e.g. sustainable urban drainage (SuDS)) and changing the mindset from risk management to resilience building will help to mitigate these risks. Resilience building needs to include all three aspects, structural, social and natural. People need to be placed at the heart of resilience building. No amount of technologies, methods and processes will succeed fully until the time when communities are prepared for disruptions and are able to respond to them and bounce back by being agile and adaptable. Furthermore, we have the opportunity to

use digital disruption to our advantage as an enabler to build additional resiliency, for example, by using electric vehicles and battery storage as a back-up to conventional power systems.

Currently Infrastructure design often focuses on large, centralised systems intended to last for decades which can withstand environmental hazards to a preselected level of risk. The problem is that the level of risk is now uncertain and as such extreme event forecasts may be a little or a lot worse. The financial and operating models that go with the design of infrastructure systems are based on historic rather than forecast extreme events. In the UK and globally we are now experiencing the events are happening at a greater scale and greater frequency. With no absolute data on the intensity and frequency of extreme events that might occur over the next few decades, we can only 'adapt'.

Infrastructure providers have to accept that there will never be accurate data forecasts, we will need to make long term resiliency decisions based on a set of imperfect data. In time as more data becomes available, we can either refine or modify options. The changing profile of risk needs to be communicated more effectively to stakeholders in an easy to understand format.

One example of this is the Thames Estuary 2100 project which has applied the 'adaptation pathways' approach to manage tidal flood risk over the century. Whilst this is a flood case study, we reference it because it is an excellent example of long-term, scenario-based planning. Drawing up different scenarios and options for different sets of sea level rise (variable) has provided the flexibility to select options. This model has helped decision makers to plan scenarios without allocating and wasting unnecessary expenditure and by building the 'resiliency' in the system. It has helped avoid unnecessary commitment to flood defence infrastructure due to lower than predicted sea level rise or render the infrastructure redundant owing to a bigger surge event.

Uncertainty in climate change projections can have an impact on water resources planning over long term. Flexible strategies in which infrastructure is proactively designed to be changed in the future will have the potential to meet future water supply demands without expensive and unnecessary over-building.

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**Consumer Council for Water (CCWater) response to National Infrastructure Commission's Resilience Study scoping report and call for evidence: October 2019**

| **Systemic issues that make infrastructure vulnerable to current shocks and future changes** | |
|---|---|
| 1) What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?<br>– Examples of systemic vulnerabilities that originate from the structure of the network at a system level, including the physical and virtual connectivity of assets (but not individual assets themselves) within and between sectors. | **Combined answer to questions 1 – 4.**<br><br>Within the water industry over the last few years, we feel that there has been better dialogue and planning, and an improved focus on resilience. However, from a customer perspective, these positives are yet to deliver real improvements on the ground.<br><br>The water sector is vulnerable to extreme weather events as well as the cumulative effects of longer-term weather patterns. It is also required to protect the natural environment it depends on and ensure that it meets its obligations to consumers. Current approaches to infrastructure resilience in the water sector have developed in response to extreme weather events (floods and droughts) and relatively recent sector level analyses of future water service challenges (climate change and population growth) and needs (infrastructure development, demand management and environmental protection).<br><br>Since the result of the Review that Sir Michael Pitt conducted, into the flooding events of 2007, the water industry has been working to address systemic resilience issues in its sewerage network. As a result, the water industry has improved its understanding of which assets, both for clean water and on the sewerage system, are vulnerable to flooding. We have also seen steps taken to reduce the impact on consumers from the assets most at risk. However, we note that surface water flooding remains a key area of concern.<br>The 2018 freeze-thaw event exposed vulnerabilities in the water supply network and led to a systematic review |
| 2) What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities? | |
| 3) Aside from those included in the last National Infrastructure Assessment, 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? | |
| 4) How have the current approaches to infrastructure resilience changed over time in order to become more effective?<br>– Examples of good practice approaches to resilience that demonstrate how an organisation, | |

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| or sector has responded to significant changes including, but not limited to; technology, disruptive events and/or changing user demands. | of the sector's ability to cope with widespread, multi-sector (and infrastructure) failures. CCWater conducted research into how consumers perceived this event[1]. However, not all of the recommendations have been actioned and not all steps taken have been tested 'in anger'. We have concerns that vulnerable consumers are still potentially at risk during these types of events.<br><br>There appears to be a good dialogue between the water industry, regulators and Government, Defra. In addition, a mix of changes in Government policy, legislation and approach, and changes in approach and policy from the industry itself ensure that resilience has a much greater priority. However, this improved focus needs to translate into action on the ground if companies are to develop more resilient services.<br><br>The following are examples of how the water sector in general learns from past events and builds on these to tackle the future.<br><br>The Floods and Water Management Act of 2010 was legislation designed to tackle flood resilience, amongst other issues, while the industry led the more recent work of the 21st Century Drainage project (now finished), which considered how to improve the long-term resilience of the sewerage system.<br><br>In 2016, the 21st Century Drainage Programme published a document setting out the challenges in this area over the next 25-50 years and how they should be dealt with[2]. These recommendations led to the proposals in Defra's 2019 consultation on 'Improving our management of water in the environment'. This included proposals for statutory drainage and wastewater management plans.<br><br>On the water supply side, In response to the NIC's report, Government and the industry have begun to address the challenges identified and recommendations |

[1] CCWater (2018) 'Customers' experiences of water supply interruptions following the freeze-thaw events of March 2018'
[2] (2016) '21st Century Drainage Programme - the context'

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| | made by NIC to ensure that water resources are resilient now and in the future.<br><br>Defra is currently considering policy options on reducing personal water use and increasing the resilience of water supplies. A National Water Resources Planning Framework is due to be launched in January 2020. The water companies also recently published a Public Interest Commitment in which they agreed to halve leakage by 2050.<br><br>Alongside these policy changes, CCWater has conducted research into the most disruptive weather events, such as the freeze-thaw event as mentioned. This focused on customers' experience, including those customers who were especially vulnerable. The aim was to identify gaps in the water companies approaches. We also report each year on progress with resilience issues[3]. This evidence should lead to changes in the industry.<br><br>Water companies will have considered all recent policy developments when drafting their WRMPs and their business plans which set out their proposed expenditure for the next five years, from April 2020. These two regulatory processes have now been more closely aligned to ensure the business plan can reflect agreed water resources investment. Under the new National Framework, there are going to be regional water resources plans in addition to individual company plans and these should take into account the needs of other water dependant sectors. So this would appear to show that there has been a move towards a more holistic approach to long-term planning in the water sector but it is very early on in its development. |
| **Public acceptability of infrastructure services** | |
| 5) How are costs, benefits and public expectations balanced when setting levels of service?<br>– Examples of how each of these factors have been considered when | **Combined answer to questions 5 – 7.**<br>At present, for water supply planning purposes, the level of service that companies must seek to attain is resilience to a 1:200 drought event. This is set out in the Guidelines issued by Defra and the Regulators. However, |

[3] CCWater (2019) 'Water Water Everywhere? Delivering resilient water and wastewater services.'

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| setting a desired level of service, either as a requirement or a target. | this may change in light of the further work being undertaken as part of the National Framework. |
| 6) 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? | Water companies undertake customer research and public engagement on their draft WRMPs and business plans and this includes willingness to pay, acceptability and affordability.<br><br>Given the dependencies across sectors (particularly energy, water and IT), planning to a set of consistent standards of resilience would seem to have value. |
| 7) How does the public respond to infrastructure disruptions and what is its appetite for making different sectors more resilient?<br>– Please provide evidence from direct public engagement which demonstrates public tolerance of disruption and the appetite for resilience investment in the sectors covered by the study (energy, water, digital and transport). This includes, but is not limited to, outputs from willingness to pay surveys, focus groups and deliberative public engagement. | As mentioned in response to questions 1 – 4, we have conducted research into customer response to water infrastructure disruptions, during the 2007 flooding in Gloucestershire, after the flooding of the Mythe treatment works[4] [5] and Hull[6], as well as the freeze-thaw event.<br><br>In general, our research suggests that customers are more forgiving if they can see that an exceptional event has overwhelmed local infrastructure. However, a recurring criticism and concern is the lack of communication from water companies during critical events.<br><br>We have also looked at customer attitudes towards resilience more generally, and their awareness of the bigger picture around water resources, including its future availability.[7] This finds that once consumers are aware of the challenges and future risks they support action being taken to address them and expect those with responsibility for essential infrastructure services to be doing what is necessary to secure services now and in the future. |
| **Resilience governance and decision making** | |

[4] Accent for CCWater (2007) Domestic Customers' Views on the Loss of Water Supply and Compensation

[5] Accent for CCWater (2007) Response to Loss of Water Supply

[6] MRUK for CCWater (2009) Hull Flooding Research

[7] Community Research for CCWater (2017) Water Saving: helping customers to see the bigger picture

| | |
|---|---|
| 8) What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies? | **Combined answer to Questions 8 - 10**<br><br>We have largely covered the key issues in our response to questions 1 – 4.<br><br>The key processes for progressing resilience within the water sector are water companies' WRMPs, which set out their response to future demands, challenges and uncertainties over the long-term; drought plans dealing with short and more sustained drought events; and five yearly business plans/price reviews. The sewerage undertakers are also now required to produce long-term drainage and wastewater management plans, which will be taken into account in future, price reviews.<br><br>In response to past major events, the water industry has taken action to improve resilience; however, more needs to be done, as evidenced by some recent significant service failures.<br><br>The sector has had a decent understanding of the impacts of climate change for more than a decade but we feel that more needs to be done to prepare for, and adapt to, climate change.<br><br>We are encouraged that improved frameworks have been, and are being, developed to help the sector plan to increase resilience. However, we question whether companies and regulators are fully geared up to enable these plans to become action on the ground. We are concerned that progress could stall and consumers suffer as a result |
| 9) How does the infrastructure system respond to uncertainty? Examples of how uncertainty over a particular variable, such as the nature of an anticipated risk, has affected the level of resilience decision makers choose to build into a system. | |
| 10) How have system wide resilience challenges been addressed effectively in the past?<br>– Examples of how different policies, incentives or decisions across a system have interacted effectively to address an identified cross sector vulnerability and improved the resilience of the system overall. | |
| | |

Emailed to: resilience@nic.gov.uk

Resilience Study Scoping Report
National Infrastructure Commission
Finlaison House
15-17 Furnival Street
London
EC4A 1AB

20 October 2019

Dear Sir/Madam,

**National Infrastructure Commission: Resilience Study Scoping Report: Call for Evidence**

I write in response to the National Infrastructure Commission Resilience Study Scoping Report: Call for Evidence.

**Summary of our response:**

In our response we support the work that the National Infrastructure Commission is doing both on infrastructure resilience and also on Strategic investment and public confidence – looking at regulation. We put forward the case for building public resilience as an important part of the wider infrastructure resilience. We argue that by looking at the what members of the public face in terms of problems and the outcomes they obtain that we can help to improve public trust and confidence today in infrastructure. And that building trust and confidence now is essential if the public are going to trust and engage fully with the infrastructure changes of the future to achieve net zero by 2050.

We also put forward the idea that Strategic Redress is a key piece in the wider regulatory landscape and a way for regulators to widen the tools available to them to look at the whole customer view. We ask the National Infrastructure Commission to promote strategic redress to regulators in different sectors. This approach would align with the National Infrastructure Commission's view that the current court-based consumer enforcement regime is ineffective, arduous and time consuming and that regulators need a more enabling administrative compliance and enforcement model for consumer protection.

We will also highlight a framework that we have been working on to try and align what the public think are fair outcomes and what businesses think are fair outcomes – the intent, execution and outcomes framework. And finally, we will explain why consumer/public resilience should be broadened out to include parts of regulated markets that are not regulated and that the resilience of small and medium sized enterprises (SMEs) should be looked at.

**About Ombudsman Services:**

Ombudsman Services is a not-for-profit private limited company established in 2002 which runs a range of discrete national ombudsman schemes across different sectors including energy, communications and an appeals service in private parking. Each scheme is funded by the companies under our jurisdiction and our service is free to consumers.

In 2018 we received 174,855 initial contacts from complainants and resolved 68,063 complaints. In the energy sector we received 108,349 initial contacts and resolved 45,667 cases, and in the communications sector, we received 62,233 initial contacts and resolved 21,251 cases. We also operate a private parking appeals service – POPLA and for 2018 we received over 67,000 appeals.

We are:

- to our consumers, the people they can turn to for impartial advice and solution that's fair;
- to our partners, the people they look to for knowledgeable and insightful ways to help them reduce complaints by enabling them to make the changes they need to deliver better customer services;
- to our regulators, champions in protecting rights as well as partners in information sharing, we share our analysis so that regulators and business partners can make improvements; and
- to our people, here to enable them to deliver clarity to consumers and partners through meaningful work.

**General comments:**

We welcome the opportunity to provide comments to this resilience study call for evidence. We responded to the earlier Resilience Study consultation in April this year and the consultation around regulation in the energy, water and communications sector. We welcome the recently published Strategic Investment and Public Confidence report. As we highlighted in our earlier responses, Ombudsman Services operates in a range of sectors which provides us with a unique insight into some of the issues that might affect resilience across sectors. We also highlighted the need to look at consumer resilience in terms of building public trust and confidence in how infrastructure is built, managed, maintained, changes with new technologies, and the need to resolve things quickly and fairly for the public when infrastructure doesn't work for whatever reason.

<u>The current Resilience Study Scoping report and the Strategic Investment and Public Confidence Report:</u>

We think these two pieces of work are linked and we welcome both. We note and agree that:

- there is a strong focus on building public confidence in regulation, in:
    - making retail markets work for consumers;
    - ensuring regulation acts fairly for consumers; and
    - improving co-ordination between regulators.
- acknowledging that regulators need the right tools in order to act quickly to address consumer detriment, for example, recognising that the current court-based consumer enforcement regime is ineffective, arduous and time consuming and that Regulators need a more enabling administrative compliance and enforcement model for consumer protection; and
- there needs to be a focus by regulators of the distributional consequences for consumers and businesses of their proposals.

From our experience, combined with the work of the National Infrastructure Commission we think that it is key that infrastructure resilience is looked at in a macro way in terms of getting the infrastructure hardware to work, be updated and for investment to be provided. However, we also think it is important to look at consumer or public resilience in terms of building public trust and confidence in infrastructure – the micro level. To build the public trust and confidence we think you need to look at what is happening to members of the public/consumers currently. Why are they complaining when things go wrong, what are they complaining about, and what do they think should be done to reach a fair outcome. If the public think that, when they make a complaint about infrastructure because something has gone wrong, they are treated fairly and the outcome achieved is fair, then they are more likely to trust infrastructure and be more willing to change as infrastructure changes, for example, moving to electric vehicles or new ways of heating their homes and energy efficiency measures. This public trust and confidence in infrastructure is essential if future targets, such as, net zero by 2050 are to be achieved.

We also agree with the work of the National Infrastructure and reports from the National Audit Office and the Public Accounts Committee (highlighted below) which highlight that, with markets changing so quickly, regulators working in isolation will find it difficult to be agile and identify consumer detriment early. There is a role for a range of organisations to help regulators here. For example, to help share data and insights to identify consumer detriment early and act quickly. The wider regulatory landscape working in this way is much more informed and agile. An

example of where this does work well is in the energy sector via the Tripartite working where Ofgem, Citizens Advice (including the Extra Help Unit) and the Energy Ombudsman meet regularly to share data and insight on key issues affecting consumers in the energy market. We explain more about the Tripartite working in this response under the heading Resilience governance and decision making below.

From our perspective, as a provider of ombudsman schemes in a range of sectors, we think that we have a valuable part to play in the wider regulatory landscape working together. We can provide what we call Strategic Redress. Which means fulfilling the wider roles of an ombudsman scheme, which are:

- resolving individual consumer complaints;
- using the aggregated data from those complaints to deliver insights that can help us work with the companies that operate in the sectors that we cover, to improve their customer services and complaint handling; and
- utilising our data and insights to help improve policy development for consumers by working with regulators, consumer advocacy bodies, government departments, policy makers and other stakeholders. This helps to improve public trust and confidence in markets and across markets.

We think that more can be made of strategic redress in sectors and across sectors and this will, for example, help regulators broaden their toolkit options and provide a much more 'whole customer view'. We would welcome discussing this more with the National Infrastructure Commission, the United Kingdom Regulators Network, regulators and other stakeholders. In fact, we would like the National Infrastructure Commission to promote the use of Strategic Redress to regulators in different sectors as a valuable addition to help improve public trust and confidence in markets.

We now focus our comments around two of the three headings set out in this call for evidence – Public acceptability of infrastructure services and Resilience governance and decision making.

**Public acceptance of infrastructure services:**

There are examples of regulators such as Ofgem and Ofcom setting guaranteed standards and auto compensation schemes for what are basic levels of service for essential services. So, if there is an energy supply outage for a certain period, switching provider is not achieved in a certain time, or there are issues with broadband or landlines then the public are guaranteed financial redress. Whilst these provisions to protect the public are sector specific, each of the regulators will have sought evidence and insight as to what level of service is acceptable and what level of redress is appropriate when the level of service is not acceptable. They have done this by asking stakeholders in the sector for their views and looking at available data and insights.

We agree with the points made in the Study that there needs to be much more cross sector coherence in response to infrastructure resilience, especially when things go wrong. We also think that whist guaranteed standards and auto compensation are good things, that they only form the basic redress provision and very often only financial redress provision. We think that to build public trust in infrastructure resilience that there needs to be a much more holistic approach to protect the public from detriment caused by the failure in infrastructure. There may well be a range of factors, or one factor that complicates other factors, that affect the public, especially members of the public in vulnerable circumstances. Therefore, it is crucial that the public has access to independent consumer redress such as an ombudsman scheme.

We think that prevention is better than cure and that stakeholders from across different sectors should work together to look at infrastructure resilience in order to update and improve it. This should also include horizon scanning to spot major impacts before they happen and there should be enough scenario planning ahead of things going wrong. However, we also think that when things do go wrong with infrastructure that there needs to be a cross sector response, with clear roles and responsibilities outlined. And that this is followed by an open and transparent analysis of the infrastructure failure, what the impact on the public was, how effective the response was, and what are the lessons learnt.

<u>The importance of the public voice in infrastructure development leading to better outcomes for the public:</u>

We think it is important that the public voice feeds into infrastructure policy decision making and that the outcomes of policies are looked at in terms of how they affect the public, to ensure they are positive and fair for the public, especially members of the public in vulnerable circumstances.

As we highlighted in our response to the initial infrastructure resilience study, there have been a number of reports published looking at how regulators, for example, need to understand more fully the implications for the public of their policies. These include, the:

- National Audit Office report highlighted that while regulators have a good understanding of key consumer issues, there are common challenges across sectors and regulators can be more specific in defining and measuring consumer outcomes;
- the Public Accounts Committee (PAC) report called for regulators to demonstrate they are delivering positive outcomes for consumers. The PAC highlighted that consumers are facing the same challenges across sectors and has called for greater consistency between regulators to ensure better services and prevent consumers being exploited; and
- Competition and Markets Authority (CMA) put forward proposals to the Government on reform of the competition and consumer protection regulation of markets. The CMA concluded that more can be done to put consumers at the heart of markets and ensure that consumer protection takes priority to reduce consumer detriment.

Again, we think that Strategic Redress can be a useful tool is helping to meet some of the challenges outlined above, in terms of regulators being aware of the outcomes for consumers from their actions or policies, and also whether consumers think those outcomes are fair. Below is a framework that we have produced for trying to look at aligning what consumers think are fair outcomes with what companies, regulators or other stakeholders think are fair outcomes.

A framework to look at helping build public trust and confidence in a sector - Intent, Execution and Outcomes:

At Ombudsman Services we have looked at a model of improving public trust in sectors by trying to align outcomes that members of the public think are fair with what companies think are fair, when things go wrong. Looking at the data from complaints, we think there is a mismatch between what the public think are fair outcomes and what companies consider fair. We think there is merit in looking at the relationship between the intent of companies when it comes to customer service (especially when things go wrong), how that intent is executed in practice and what the outcomes are and whether they align to what the public thinks is fair.

The diagram at Figure 1 below helps to illustrate what we mean.

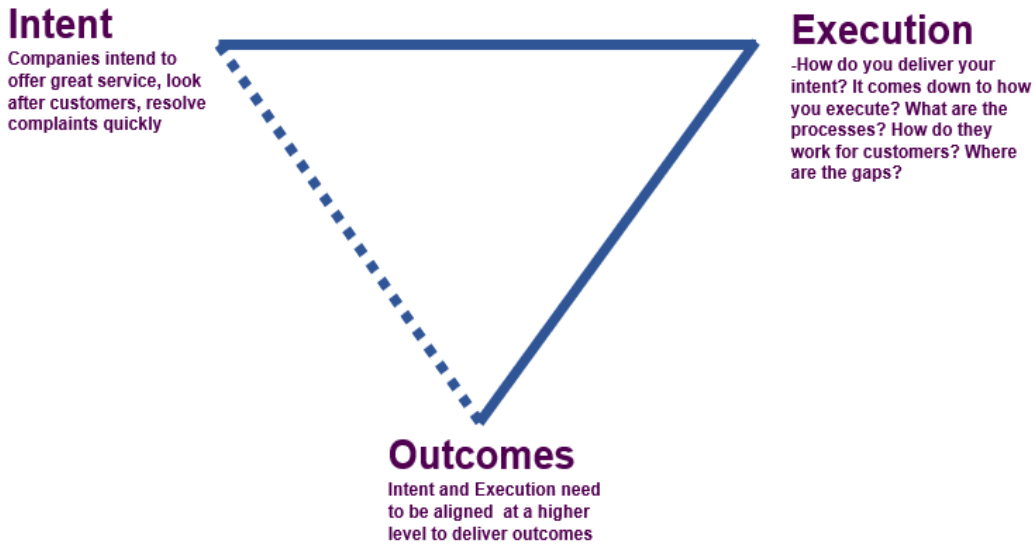


Fig 1.

Where the is a disconnect between the outcomes the public thinks are fair and what companies think are fair, we call this the execution gap. If the intent at a high level within a company is good but the outcomes are regarded as not being fair by the public then it must come down to the execution part.

Whilst we have based this framework on how individual companies in a sector operate and how by aligning outcomes with what the public see as fair, we think it can be used across sectors and from the perspective of companies, regulators and other stakeholders to build public trust across sectors when things go wrong, including when infrastructure fails. To put it simply, if the public and companies, regulators and other stakeholders think the outcomes are fair there is alignment and the public is more likely to trust sectors to correct things when they go wrong. Attached at Annex A is a report we have published on this framework looking at the energy sector in more detail.

Should a consistent approach be set with levels of service in different sectors?

We think that to build public trust and confidence in infrastructure, especially when things go wrong, there should be similar levels of service across sectors and a higher level of service where members of the public are in vulnerable circumstances. For the last five years we have commissioned independent research called Consumer Action Monitor that looks at how the public in the UK acts when they have a complaint, how they complain, why they don't complain, and what level of trust they have in business. The research cuts across many sectors and the report form this year can be found at https://www.ombudsman-services.org/about-us/annual-reports/consumer-action-monitor-report . We believe that there should be consistent standards to protect the public across different sectors.

Extending the scope of independent redress to help build wider public resilience:

To help build the importance of Strategic redress as a tool that the wider regulatory system can use to help build public trust, confidence and resilience in sectors and across sectors, we think it is important to update the coverage of strategic redress within sectors. For example, within the energy sector there are parts of the consumer market that are not covered by regulation in the same way as the gas and electricity supply consumer market, such as:

- heat networks and district heating – though we know the Department for Business, Energy and Industrial Strategy is looking at this area in terms of regulatory and investment frameworks;
- third party intermediaries, such as price comparison website and energy brokers;
- boiler installation and servicing;
- heat pumps;
- the supply and distribution of liquid petroleum gas and other fuels; and
- electric vehicles.

So for any members of the public that source their energy or are involved in some way in the above parts of the energy market, they do not have the same protections via regulation, consumer advocacy or strategic redress that members of the public do that source their energy through gas and electricity. This does not seem fair and even counterproductive given that some of the areas listed above will be vital to achieving net zero by 2050.

We also think that it is just as important to consider the resilience of SMEs when it comes to looking at infrastructure resilience. The data and insights we have, show that whilst SMEs do not have the same protections that the public have, they face similar issues in terms of complaints, information and negotiating asymmetries, and vulnerability. Attached at Annex B is a report we published looking at how to build trust amongst SMEs when engaging in markets and ensuring that they get a fair deal. We think there is read across in terms of helping to protect SMEs when infrastructure resilience goes wrong. The SME market is crucial to the UK economy and that is only likely to increase post Brexit. Yet many SMEs are vulnerable businesses for lots of similar reasons that the public may be vulnerable.

We think that by bring these unregulated parts of the energy sector into the regulated part that consumer trust and confidence will increase because there will be checks and balances in place to protect consumers – regulation, consumer advocacy and independent redress.

**Resilience governance and decision making:**

As we highlighted in our response to the initial resilience scoping study, we think that there are better ways that organisations can work together in a more proactive and preventative manner by joining up policy and strategy development, effective horizon scanning, and sharing of data and insights to make decision making and outcomes for the public more effective, fair, and joined up. We think that as well as including the organisations and groups that are

involved directly in infrastructure development and resilience, that it should also include other stakeholders with relevant data and insights as to what the public is thinking and how they are reacting when things go wrong with infrastructure. We highlight this in the case study below where we have been able to help when infrastructure resilience has been breached.

As you know, in the energy sector there is the Tripartite model. This involves Ofgem, Citizens Advice (including the Extra Help Unit) and the Energy Ombudsman meeting on a regular basis to share data and insights around what is happening in the energy sector in terms of domestic consumer and micro business consumer complaints. This includes looking at specific energy providers that are causing concern or consumer detriment, issues that are appearing, horizon scanning and most importantly what action is to be taken and by which organisation. There is also the potential for a similar model to this in the communications sector. With the work that the Department for Digital, Culture, Media & Sport is looking at in reforming consumer advocacy in telecoms. We have proposed that a version of the Tripartite model would work well in the communications sector in the future.

**Flooding in Lancaster, 2015:**

In the Study, you highlight the case study of flooding in Lancaster in 2015. Ombudsman Services was keen to help in this difficult situation. We discussed with the relevant network provider in that area how best to help and cope with complaints from members of the public who had lost supply of energy during the severe weather. Approximately 30,000 members of the public out of a potential 70,000 members of the public had claimed for loss of supply. The network provider had followed industry standards and as a result was initially of the view that it would explain to members of the public that no guaranteed standards payment would be made and that members of the public, if they disagreed with this, could bring their case to the Energy Ombudsman. We suggested that a better approach, and one that would provide a better journey for members of the public and try and help retain trust and confidence, was if Ombudsman Services helped the network provider resolve complaints from members of the public at the first tier (this is the point where a complaint by a member of the public is made to the network provider and before it is escalated to the Energy Ombudsman). This would shorten the process the member of the public had to go through to make a complaint and also reduce costs to the sector at a time when resources were needed elsewhere.

We worked with the network provider on our decision-making principles and put those onto our website. The network provider agreed to follow those decision-making principles when trying to resolve complaints at the first tier. So, members of the public, with a complaint, could see in an open and transparent way that the network provider was trying to resolve their complaint in line with the principles that we had published. Clearly, if a member of the public felt this was not the case, then they could escalate their complaint to the Energy Ombudsman. In addition to this, we also set out best practice and provided scenarios to help members of the public establish whether a guaranteed standards payment was due because of a loss of energy supply. We also worked with Ofgem on the approach that we and the network provider had put forward. We think this approach helped to inform members of the public about what they could expect and also make the complaint process a lot quicker, whilst reducing unnecessary costs to the sector, which ultimately are paid for by the public. This was done at speed at a very difficult and stressful time for around 70,000 members of the public.

Please do not hesitate to contact us if you would like further information regarding our response.

Yours sincerely,

Matthew Vickers
Chief Executive and Chief Ombudsman

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# National Infrastructure Commission: Resilience study scoping report

## Submission by Water Resources South East (WRSE)

Water Resources South East (WRSE) is an alliance of the six water companies operating in the south east of England. The water companies involved include Affinity Water, Portsmouth Water, South East Water, SES Water, Southern Water and Thames Water. Together they serve 19 million customers and provide 6 billion litres of water per day. It also involves a number of stakeholders including Defra, the Environment Agency and Ofwat. More information on WRSE can be found at www.wrse.org.uk

We welcome the opportunity to contribute to the NIC's ongoing work on resilience, not least as WRSE intends to develop a regional multi-sector, resilience plan ahead of the next round of Water Resource Management Plans (WRMP) in 2024. Our aim is to plan for a wider set of resilience risks beyond drought, that addresses the needs of other sectors that are dependent of water – through a systems-based approach.

This will include the development of a resilience framework that will be used to ensure that we identify and understand the impact of different events on both the public water supply and the supplies used by other major users. It will also assess how the interventions identified in the multi-sector regional resilience plan will build resilience for all water users.

Our role will be to build consensus between companies and sectors in developing the plan and facilitate its progress through the enhancement of regulatory, policy and planning processes. Our expectation is that it will include a combination of fixed infrastructure, soft infrastructure, demand management and leakage interventions. This is a major challenge, but we believe it will be the first truly regional multi-sector resilience plan in the UK and potentially internationally.

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

**1. What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?**

Vulnerability assessments of the UK infrastructure are likely to show that:

1. It is sensitive to climatic risks
2. It is at risk of key asset failures
3. There is limited supply chain capacity during an incident - particularly a large incident
4. There are Institutional issues where clashes between legislation lead to conflicting views and vulnerabilities.

There are a number of dependencies between water and the other sectors within the scope of the study. The water industry is dependent on power to keep its network and process plants running. When this fails there can be an impact on customers such as supply interruptions and flooding; and on the environment if it results in pollution.

The energy sector is highly dependent on water for the operation of traditional power stations. With increased focus on decarbonisation and the changing face of energy generation the sectors' water needs in the future may be very different. Both the amount of water required and when it is needed may change, which brings with both opportunities and challenges when it comes to how water is used and traded within catchments. This is something that should be addressed through a future resilience framework.

Likewise, the industry relies on the telecoms network to allow it to remotely monitor sites and be alerted promptly to issues should they occur. This will an area of increasing dependency as water networks are made "smarter" which is something many companies are looking to develop and invest in over the coming years to allow more targeted investment and pre-emptive action to address issues before they impact customers.

However, a key issue is that it is only the water industry which has a statutory duty to supply. All other institutions do not have this legislative requirement. Because of this, in certain circumstances the water sector's ability to meet its statutory duty is compromised because other sectors do not have the same legal duty to return services.

Some of these issues were explored in the WRSE drought sprint event. This highlighted a number of issues and potential solutions including setting up new temporary management arrangements to co-ordinate the operation of the water supply system in the WRSE region and the prioritisation of actions to maintain supplies. We would be happy to share the outputs of this work.

It is also important to recognise that water is provided through a natural system, which supports a range of different users who have their own systems which are not designed to meet the range of events a water company is expected to cater for. This means that during such events these industries are more likely to fail. This includes farmers, power companies, paper mills, mineral companies etc.

To date, there has been little collaboration between these users or an understanding of future needs. Developing a more holistic, systems-based approach to water management is essential both to ensure there is enough water available to meet the needs of and mitigate against the impact of drought on all water users. This is something being addressed through the National Framework and regional groups. WRSE intends to consider the future requirements and assess the resilience of other sectors through the resilience framework as we develop the regional resilience plan.

As we identify future water and wastewater infrastructure requirements it will be essential do this in a way that factors in uncertainty, particularly associated with climate change. The vast majority of water infrastructure has been designed under assumed stationary (a dynamical stable climate which varies within assumed boundaries against assumed probabilities). In addition, existing infrastructure has been designed through a largely functional risk management focussed approach, and therefore the existing system has limited inbuilt resilience.

The approach to the development of new infrastructure to build resilience is changing and there is a real opportunity through the work of the NIC to develop a structured approach to assess interdependencies between key infrastructure providers and the temporary structures that would be required.

**2. What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?**

There should be a provision on the digital infrastructure providers to ensure that there are backup systems of control. Key national infrastructure should be identified and protected with a higher level of digital security. In this respect the advice notes underpinning the SEMD should be reviewed through cross industry working groups to ensure all key infrastructure providers work with each other to ensure a secure combined digital approach.

**3. Aside from those included in the last National Infrastructure Assessment, 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?**

As outlined in our first answer a systematic approach to assessing the interdependencies between the physical systems, legislative frameworks and temporary management arrangements should be undertaken. These could be done through facilitated workshops to go through the actions for either known events or to explore system vulnerabilities. Both approaches could explore the physical systems and legislative interdependencies to address the scale of the challenges. The results of these workshops could lead to a series of updates to advice notes or policies which will improve the overall resilience of the UK infrastructure. This can then be taken forward by ensuring:

- There are clear requirements placed on all infrastructure providers;
- Funding follows agreed infrastructure plans;
- Legislative conflicts are resolved before events and those that cannot be resolved before an event a temporary working arrangement is put in place;
- Resilience across all infrastructure providers is based on a phased, adaptive approach which seeks to ensure the UK society and economy are not severely compromised;
- Accountability and join-up across regulation which works during extreme events or situations.

Addressing these points will be a start, but as the infrastructure providers work through scenarios or situations it is likely that other issues will be raised. Therefore, as we become more sophisticated and our level of understanding of resilience increases, the need for a central body that co-ordinates an ongoing multi-sector approach will becoming increasingly important,

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

Water companies are improving the overall resilience of their systems. This has included the separation of wastewater systems to prevent flooding; the development of stochastic sequences to plan for more severe droughts; the development of resilience methodologies to improve cyber security and by undertaking catchment schemes to improve the overall environmental resilience of a catchment. There are numerous examples of schemes which can be promoted for resilience purposes, however a standard for the industry has not been developed which would allow measurement through outcomes, design standards or both. Given the resilience duty, there may be benefit in standardising the approach in the future, whilst still allowing companies the flexibility to innovate.

Ofwat's requirement and guidance for resilience frameworks in PR19 was a good start and a critical first step on the sector's journey to greater resilience. The business plans submitted by water companies included resilience frameworks which were world class – however only a handful of companies scored highly in this area in Ofwat's Initial Assessment of Plans.

These frameworks are now starting to influence planning - particularly long-term strategic planning for Water Resources. The sector in now on track to enter the next phase on thought leadership and the next generation of strategic infrastructure could/should be planned and designed with greater resilience, consideration of multi sectors and the environment.

## Public acceptability of infrastructure services

**5. How are costs, benefits and public expectations balanced when setting levels of service?**

Water companies carry out extensive public engagement with customers to inform the development of business plans and WRMPs. A range of methods were used by companies including focus groups, panels, workshops, online surveys and advanced approaches to willingness to pay to understand customers' priorities and expectations.

Individual water companies will be in a position to provide further details of how they determined the appropriate balance of cost, benefit and public expectation when setting levels of service.

**6. 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?**

This is a policy decision, but it is fundamental when considering the resilience of the UK national infrastructure that it is clear what the policy is trying to achieve.

All industries will have specific resilience challenges, but there are few common challenges which span a number of industries. A policy approach which outlines what an industry should be resilient to will limit the ability to adapt to new challenges. An outcome-based assessment might be better, but this may lead to a very narrow, industry specific approach being adopted in which multi-sector plans will not be funded. Therefore, it might be better to adopt a hybrid approach in which expectations are set out for industry and regulators have to consider cross sectorial benefits when resilience projects are being assessed for funding.

Water companies are required to consult and reflect the views of their 'own' customers. If government /regulators want consistency, then they can direct but this could result in consumers losing some choice as policy will drive the service/price contract. That said, it may be possible for companies to propose a consistent level of service to customers, with departure by exception based on customer views. The NIC approach of including the social impact of a loss of service as well as the cost of trying to maintain a service using temporary arrangements is crucial to understanding what interventions should be put in place. Particularly if natural capital valuations can be included in such assessments.

What will be important if a more consistent approach is taken to setting service levels in different sectors, is understanding customers' expectations about service resilience in the round and allowing them to consider and express their priorities across all sectors. This will enable policy makers to better understand the public's resilience priorities, set appropriate standards and drive investment in the areas viewed as most critical.

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

In water, significant disruptions to service are uncommon yet when they do occur there is low tolerance from the public due to the essential nature of the service provided. Good communication

during and after the incident appears to be a consistently important factor in how the public responds and their perception of companies following the incident. Unsurprisingly factors such as the scale and duration of the incident tend to drive the public's reaction, this is further compounded by the wider impacts such as damage to the environment and disruption, media coverage and the political response.

Events such as the flooding of the Mythe water supply works show the impact such events can have on society. The scale of the event (the number of customers impacted) combined with the duration of the event led to civil disturbances.

Water companies and the Consumer Council for Water (CC Water) have carried out research with customers following events and incidents. For example CC Water conducted customer research following the Beast from the East in March 2018 https://www.ccwater.org.uk/wp-content/uploads/2018/06/Customers-experiences-of-the-freeze-thaw-events-of-March-2018.pdf

However, this focussed primarily on how the companies responded to the incident, rather than testing customers' views on resilience following the incident.

Individual water companies will be able to provide details of their own research in this area and customers' appetite for greater resilience.

## Resilience governance and decision making

**8. What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?**

There is no overall vision of what the UK government wants from its infrastructure providers regarding the continuity of services during extreme events or events that effect a number of sectors. Legislation setting out a duty to supply only exists for the water industry. The other industries work on a best endeavours basis. As it appears that society's level of tolerance of disruption to key services is now lower it may be appropriate to review and strengthen legislation associated with key sectors' duty to supply.

Typically, the UK has segregated the issue of resilience and service preservation into a set of sector specific standards, guidance or legislative requirements. These have served the individual industries fairly well in the past but multi-sector incidents have had to be managed through a gold command type incident response. At this level of co-ordination, a clear set of plans need to be formed quickly and implemented, which usually results in an expensive, inefficient solution being put in place that generate longer term issues which then need to be resolved. Therefore a multi-sector approach should be developed. The approach should be underpinned by:

1) Clear policies which deliver the objective(s) of government;
2) Identification of the government body who will decide on legislative or policy clashes during an event(s);
3) Identification of the primary and secondary sectors who have a duty to maintain and operate their systems and who will have to work together in order to provide multi-sector resilience;
4) Agreement on what interventions -including cross sector - that should be put in place before the events and which will be dealt with during the events, we see this as a schedule which could expand in the future;

5) Agreement on the priorities of service provisions during an incident of event, i.e. where will the limited supply chain capacity be directed;
6) Identification of temporary executive institutions to authorise interventions required to avoid or recover from resilience type events;
7) Co-ordination and agreement of the public messages during an event.

To tackle these points a clear map of the multi-sector interdependencies should be produced and then used to identify issues and solutions to the points raised above. This structured approach should be continually reviewed by one lead authority, to make sure the industry and regulators are providing a co-ordinated response.

**9. How does the infrastructure system respond to uncertainty?**

In answering this question, the infrastructure system is interpreted as both the service providers and the regulators.

Uncertainty is probably the single biggest challenge for utilities in terms of funding schemes to provide resilience. The limited headroom in all systems (infrastructure, environmental and societal) and our limited understanding of how quickly these can decay and break under different events leaves the UK in a vulnerable position.

The current planning and regulatory systems are typically evidence based, for example WRMPs have until recently been based entirely on historic drought events – not on potential future events. Making the case for funding for resilience to events that have not yet happed has been a challenge.

The more extreme the event we aim to plan for, the greater the level of uncertainty and the less likely they are to be funded through the current regulatory process.

Typically, resilience has been considered from a probability perspective - how likely an event is to happen – rather than the impact that an event will have. Given the resilience challenges we are now facing and the interdependencies between sectors, now might be the time to put more weight on the impact of an event rather than its likelihood. The development of more advanced resilience frameworks to identify and assess risks across sectors will support this approach.

**10. How have system wide resilience challenges been addressed effectively in the past?**

Whilst infrastructure planning has improved over the past decade there is still a lot of ambiguity around what should and should not be considered when planning for resilience and also how uncertainty is resolved and by when. If the UK is to become more resilient then some clear timescales need to be put around when this needs to be achieved by.

The industry has developed and will continue to develop a number of techniques that will cater for this such as: adaptive planning, stochastic weather generation, regional multi-sector planning, emergency contingency plans, drought plans, functional continuity plans, but these plans and planning techniques are sector-specific and therefore at the national level it is not clear how much they will increase the overall resilience of the country.

There are other techniques which can be used to provide cross sector assessments of resilience, but these should be tied into national planning assumptions to ensure that resilience isn't undermined by future requirements on the systems. The regional planning approaches being developed by the water sector starts to address these challenges by considering a multi-sector needs, understanding how the system reacts to different events and identifying where there is vulnerability in the system

which could impact on the provision of services. The regional plans will be published in January 2022 for consultation and we hope they will start to show a better integration of integrated system risks.

There is a clear need for a holistic view of the UK's infrastructure resilience to be taken and regularly reviewed so that all sectors can meet the Government and societies' expectations. Where there are shortfalls, integrated action plans can then be developed to address them which are prioritised appropriately. We urge the NIC to consider how best this could be achieved.

# National Grid Electricity Transmission Response to the National Infrastructure Commission: Resilience Study Scoping Report Call for Evidence

This response represents the views of National Grid Electricity Transmission (NGET), which owns and operates the high voltage electricity transmission system in England and Wales and plays a vital role in connecting businesses and homes to the energy they need.

The England & Wales Transmission network we manage is highly reliable under normal operating conditions and it is also resilient because we have plans to manage less frequent, but potentially higher impact events. NGET actively plans to prevent, withstand, mitigate, respond and adapt to the impact and/or duration of such events. Key threats that we have hardened our network against over our current regulatory period (RIIO-T1) are flooding, cyber-attack and physical threats.

National Grid Electricity Transmission believe that there is a growing interdependence between infrastructure sectors, with energy and communications playing central roles in the future operation of transport, networks and essential services. The pace of technology change and sectorial decarbonisation, amongst other developments in society and the energy landscape, are enhancing reliance on electricity for society and businesses. In addition, our stakeholder engagement indicates that society's tolerance to loss of electricity supply events may reduce as dependency on electricity in our daily lives increases. Resilience coordination across sectors is also becoming increasingly important in the face of growing cross-sector infrastructure and service interdependence.

When planning the resilience of Infrastructure in the future, whether it is across businesses, one sector or multiple sectors, proactive development of measures, metrics, and/or a collective framework for assessment and mitigation will be key step to future resilience assurance.

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

1. **What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?**

As detailed in the Energy Resilience Partnership Future Resilience of the UK Electricity System report1, there's a considerable and growing dependence of the UKs infrastructure upon electricity:

- *Clean water supply; electricity is required for the filtration, treatment, pumping and pressurisation process, for the water industry.*
- *Security and access systems; that provide access control across modern buildings and broader supervision of our cities and roads.*
- Communications Networks; there is a cyclical relationship between electricity and the communications and broadband networks, where the communications and broadband networks require an electricity supply to operate. However, many electricity network operations depend on communications and broadband networks for normal operation, highlighting the co-dependency of the networks. There are a diverse number of *communication networks, with special secure networks provided for control systems, providing some resilience through diversity.*

[1] Energy Resilience Partnership, Future Resilience of the UK Electricity System report, Available: http://erpuk.org/wp-content/uploads/2018/11/4285_resilience_report_final.pdf

- *Financial and payments systems rely on electricity and communications/broadband to function normally. As our use of cash and cheques declines, particularly as we move to smartphone payment systems, this dependency will only increase further. As an extreme example of where the future may take us, cryptocurrencies such as Bitcoin and Ethereum are entirely dependent on power and communications systems for their operation. The hardware failures at VISA, in June 2018, highlighted the impact of a relatively short duration event on our ability to complete financial transactions.*
- *Provision, and production processes, of other fuels such as natural gas and even petrol/diesel at the pump rely on electricity for their delivery to the consumer.*
- *Trade and Economy; many contributors towards the UK trade and economy, have an element of dependency on electricity Industry and manufacturing plants require electricity for machine operations. Retail and supermarkets depend on electricity for refrigerating produce, financial transactions, security, access, lighting and heating. Rail networks require electricity for signalling and points across the entire network, as well as powering a significant number of trains across the network.*

The electricity system is dependent upon digital infrastructure[1] including broadband communications networks for day-to-day operations, however there is diversity in the communications networks that support this activity. Many technologies deployed on the electricity system are dependent on broadband/digital networks, which are dependent upon the electricity system. Therefore, there is a cyclical dependency between electricity and communications with each dependant on the other, where the societal impact for loss of either network increases. Loss of the communications and broadband networks would make operating the electricity system more difficult day-to-day and even more so during response to an extreme event. Due to the continuing and growing interdependencies between the electricity system and the communications/broadband networks, the future resilience of both systems should be considered in conjunction with each other.

**2. What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?**

Digital networks are increasingly integrated into our lives. Whether it be with tablets and smartphones, or connected devices, our dependence is likely to increase further. As described in section 1, the impact of disruption to these digital networks has the potential to cause widespread disruption to other infrastructure.

Digital Infrastructure can be divided into four building blocks[2]:

1. *Hardware components such as sensors, cameras, and microphones to extract and collect the data by detecting movement, capturing images etc*
2. *Semiconductors to analyse and process the information*
3. *Telecom networks and information-exchange to connect one device to another, and further bind them to a cloud based network*
4. *Software applications and platforms to integrate data and create user interface, analytics, automation technology etc.*

Each of these building blocks have physical components that need to be mapped to understand the sectors contribution to systemic vulnerabilities. In addition to these building blocks, data storage is an important element in digital networks and their physical components in the form of servers and data centres should be mapped in this exercise.

All these physical components require electrical energy, either directly or indirectly. The failure to supply energy to any part of the chain, either directly or from energy storage, will cause the failure of the whole

[2] Digital Infrastructure: enabling the world of tomorrow, KPMG, 2014, available: https://assets.kpmg/content/dam/kpmg/pdf/2014/12/CII-CONNECT-2014-final.pdf

chain. The dependency of digital networks upon the electricity system is also described in the answer to question 1, should also be mapped to understand the systemic vulnerabilities.

3. **Aside from those included in the last National Infrastructure Assessment, 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 last NIC National Infrastructure Assessment, in 2018, considered changes to infrastructure associated with the following future drivers:

- Building a digital society - the rollout of full fibre connectivity and 5g,
- Low cost, low carbon – including de-carbonizing the energy sector
- Revolutionizing road transport – the rollout of electric vehicles and associated infrastructure
- Transport and housing for thriving city regions – whole city planning for future infrastructure
- Reducing the risks of drought and flooding – adapting to climate change

These categories cover broad changes to the UKs infrastructure in the future. Specific aspects in the categories that may not have been considered previously are:

- Green House Gas (GHG) free heat: this may be via electrification of heat, likely in combination with hydrogen or potentially 'clean/green' gas. These changes will bring about substantial changes to the physical architecture of supply and demand systems.
- The impact on the design of the electricity system and networks due to power demand associated with rollout of electric vehicles and the GHG free heat.
- The interdependency of all infrastructure, and consequential failure of any one element disrupting the other infrastructure systems is a topic of its own and often omitted from infrastructure assessments.

Additional areas that need to be considered are:

- Stress test the impact of significant changes to regulation and policy on infrastructure which may cause significant changes to how infrastructure is planned and operated.
- The reliability of backup power generation for hospitals & emergency services, communication and data centres or other future use cases associated with building a digital society.
- A requirement for legislation to consider impacts on interdependent infrastructure even when it is not the area being legislated for is critical. Example smart car charging, all third party failure mechanisms must be understood, for example operation of charger follow a loss of supply event.

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

Owners and operators of Critical National Infrastructure have had to adapt to over recent years due to more extreme weather, cyber security associated with digital threats and physical security associated with the threats posed by terrorism and other physical threats.

The threat of cyber-attack is now notably different compared with the start of the RIIO T1 period, as recognised by Government through increased investment and legislation in this area. We actively monitor cyber threats and use threat intelligence from specialist organisations to inform our cyber strategy and investment plans. By being agile and enhancing our capabilities, we will not only be able to respond to new threats quickly, we will be able to develop longer-term strategies on how to maintain a network resilient to cyber threat

Electricity network companies have spent £130 million on flood defence work from 2010-15, with a further £100 million due to be spent on flood defence by networks before 2021.[3] In the RIIO T1 period, National Grid focused on mitigating our greatest threat of extreme weather – flooding. We tailored our flood defence planning to take account of future requirements and site specific considerations.

Physical security has been upgraded at multiple National Grid sites under the Physical Security Upgrade Programme (PSUP). The PSUP is a Government mandated initiative to protect the UK's most essential infrastructure. The Centre for the Protection of National Infrastructure (CPNI) worked alongside the Department of Business, Energy and Industrial Strategy (BEIS) to combine their privileged access to information and threat intelligence to analyse and inform risk assessments.

However, there is still a need to address interdependency which is potentially the largest blind spot to our current resilience capability and has the potential to cause significant disruption.

## Public acceptability of infrastructure services

5. **How are costs, benefits and public expectations balanced when setting levels of service?**

Within the electricity sector, Transmission licensees are required to be economic and efficient when planning investments, provide system capacity that is adequate, reliable & operable and to facilitate Demand Security and Generation access. To this end, Transmission licensees – both onshore and offshore – are mandated by their licences to comply with the National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS), which sets out criteria and methodologies for planning and operating the GB Transmission System.

The NETS SQSS seeks to balance the cost of investment and maintaining the network against, the cost of operating the system and the impact of the level of network unavailability in order to minimise the total cost to electricity consumers. High impact low probability events and threats that present a resilience challenge are considered separately to the investments planned against these criteria.

Our specific resilience plans are consulted upon within our RIIO T1/2 stakeholder engagement forums that shape our final proposals to the regulator Ofgem. The stakeholders were drawn from, Academia, energy industry, large industries including car manufacturers, regulators and consumer groups. Several government agencies inform specific aspects of Infrastructure owner's resilience plans; they provide central government, regulators and operators with advice on Infrastructure risks and mitigation.

The regulator Ofgem scrutinises our proposed investment plans (including those that cover resilience plans) on behalf of the UK government and public. They have a responsibility to ensure that we are economic and efficient and that we have adequate funds to carry out the investment activity required to provide system capacity that is adequate, reliable & operable.

6. **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?**

A consistent approach would be helpful when setting levels of service within different sectors because it would make it easier to compare resilience plans across sectors; it would help share best practice between infrastructure providers; it would help to articulate the where cross-sector dependencies and it may allow resilience investments to be compared in multiple sectors.

As recommended in the Future Resilience of the UK Electricity System report by the Energy Resilience Partnership (ERP)[1], proactive development of measures, metrics, and/or a collective framework for

[3] DEFRA, 2018, available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727252/national-adaptation-programme-2018.pdf

assessment and mitigation, will be key step to future resilience assurance; whether it is across businesses, one sector or multiple sectors.

This should recognise the excellent work that infrastructure providers, networks and utilities deliver today in managing resilience, but should also plan for paradigm shifts across sectors in planning for a resilient future. This ambition can only be realised through new levels of cooperation between organisations and sectors that can impact, or be impacted by, future resilience measures - three coordinated tiers of activity are therefore proposed:

- Resilience principles, measures or metrics that can be applied across sectors interchangeably – being able to account for cross-sector dependencies and assure overall infrastructure resilience through application of high-level resilience principles consistently across sectors. These would need to be sufficiently high-level to apply to all concerned sectors, but with sufficient description such that they can be interpreted by discrete sectors. Flexibility would also be required to account for future resilience threats (unknown today) as they emerge. Collective agreement of a resilience definition, measures, metrics and/or principles would be needed across sectors and respective regulators.
- Sector-specific interpretation of resilience principles, measures or metrics to provide future resilience assessment and mitigation actions. Within the electricity sector, our ongoing resilience work and collective knowledge will aide this, and allow the sector to contribute to development of appropriate cross-sector measures and actions. Sector-specific measures would require recognition by the appropriate regulatory frameworks to support resilience action in the interest of bill payers.
- Individual businesses could interpret, utilising subject matter experts, the sector-specific measures and apply them to their business planning activities. These business plans would require recognition from the appropriate regulatory or market authorities.

Wide engagement of the public if conducted adequately may reveal desired levels of service for different infrastructure both now and in the future. For example, it is important to understand how the growing reliance on electricity in society and business impacts the tolerable period to lose power, following an exceptional event in the future. A consideration of the power needs and expectations of society and business should be feed into policies and the mitigation/response required in the future. The following actions have been proposed by the Energy Resilience Partnership[1] to help achieve this goal:

- *Appropriate representatives of the public, such as Local Authorities, Government and Citizen's Advice Bureau, should be engaged to accurately reflect on society's needs and expectations. These representatives could also provide insight on how society will use power in the future.*
- *Government policy should reflect business requirements and future aspirations for power use. Appropriate representatives of business, such as Confederation of British Industry (CBI) or Government departments, should be engaged to reflect business requirements and future aspirations.*
- *Evaluation of society and business expectations should include the value they place upon amenities, including energy, heat, transport, broadband/communication networks.*

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

We have conducted stakeholder engagement to ascertain views on the expectations of how resilient transmission system should be and the requirement for resilience in the future, given the expectation for increased resilience on the electricity system. We asked our stakeholders what the tolerance is to power disruptions today and in the future in five geographical locations, industrial, cities, towns, villages and rural. In general, our stakeholders indicated a lower tolerance in cities and towns for power outages currently. However, they indicated going forward the amount of time a power outage is tolerated, even following a major incident is expected to fall across all five geographies.

## Resilience governance and decision making

8. **What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?**

There are a variety of models for how infrastructure is owned, operated and delivered in the UK, including: public ownership, capital procurement, economically regulated private ownership, Public Private Partnership/Private Finance Initiative (PPP/PFI) and private ownership[4]. The pathway for how national level decisions impact the level of service delivered varies between these different ownership models.

Economically regulated private ownership is the model that exists within electricity and gas networks, water utilities and the rail network. The required service level is mandated by regulation, and regulatory bodies that are separate from the government oversee the performance of the infrastructure owners & operators. The responsibilities between Government and the regulator within economic regulation are distinct; on the basis that high-level decisions that involve political judgement are taken by Government and day-to-day regulatory decisions are undertaken by regulators[5].

In the electricity sector, transmission licensees such as National Grid Electricity Transmission, are required to be economic and efficient when planning investments, provide system capacity that is adequate, reliable & operable and to facilitate Demand Security and Generation access. To this end, Transmission licensees are mandated to comply with the National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS), which sets out criteria and methodologies for planning and operating the GB Transmission System.

Another factor that affects the level of service delivered by Electricity Transmission licensee is the management of network risk in accordance to the Network Output Measures (NOMs) methodology. NOMs seeks to maintain the network risk as associated with the probabilities of failure modes of assets that compose the network and not High Impact Low Probability (HILP) threats such as the risk exposure to flooding. The asset interventions required, to achieve the required risk score, in the form of monetised risk, are identified in the transmission licensee in their business plan prior to the regulatory period. Once in the regulatory period the licensee can be flexible in how it achieves the risk score.

The regulator Ofgem scrutinises our proposed investment plans (including those resilience) on behalf of the UK government and public. They have a responsibility to ensure that we are economic and efficient and that we have adequate funds to carry out the investment activity required to provide system capacity that is adequate, reliable & operable.

The requirements for most of resilience investments, to secure against emergency conditions are ultimately driven by Government. An integral part of the UK governments National Security Strategy is to secure the UK's most essential public and private sector services against wide-ranging threats and hazards. To this end the Lead Government Departments (LGDs) responsible for the UK's 13 critical infrastructure sectors to produce annual Sector Security and Resilience Plans (SSRPs), which cover all hazards and security threats relevant to each sector. The SSRPs are produced by officials in the LGDs, in consultation with infrastructure

[4] Investing in UK Infrastructure, HM Treasury, 2014: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/357135/infrastructure_pitchbook_28072014.pdf

[5] Principles of economic regulation, BIS, 2011: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/31623/11-795-principles-for-economic-regulation.pdf

owners and operators, regulators and government agencies, before being signed-off by ministers. The SSRPs describe6:

- LGDs' approaches to critical sector security and resilience;
- their assessments of significant risks to their sectors;
- their approach to security and resilience in the UK; and
- activities they plan to undertake to mitigate and respond to those risks.

Several government agencies inform specific aspects of Infrastructure owner's resilience plans, as they provide central government, regulators and operators with advice on Infrastructure risks and mitigation. For example, the Centre for the Protection of National Infrastructure (CPNI) provides protective security advice to businesses and organisations across the UK's National Infrastructure. They also provide integrated advice on physical and personnel security, aimed at minimising risk and reducing our vulnerability to terrorism, espionage, and other national security threats. The National Cyber Security Centre (NCSC) was established in 2016 as part of the Government Communications Headquarters (GCHQ) and brings together cyber expertise from a wide range of previously disparate cyber organisations. The Centre's main purpose is to reduce the cyber security risk to the UK, working with businesses and individuals to provide authoritative and coherent cyber security advice and cyber incident management, underpinned by world class research and innovation[6].

BEIS as the UK Competent Authority and Lead Government Department (LGD) for gas and electricity emergencies is responsible for the development, review, updating and testing of the arrangements contained in the National Emergency Plan (NEP) for Downstream Gas and Electricity supply emergencies.[7]

The Energy Emergencies Executive (E3) has been established with representation from BEIS, Ofgem and National Grid to consider the risks to the supply of gas and / or electricity to consumers, and identifying ways to manage these risks.

Detailed emergency planning activities are undertaken by the joint industry and government emergency planning body, the Energy Emergencies Executive Committee (E3C) and associated Task Groups, reporting to E3. This body, and its Task Groups, consists of experts drawn from the gas and electricity industries as well as government, agencies, regulators, Trade Associations and Industry Bodies.

**9. How does the infrastructure system respond to uncertainty?**

In risk analysis, risk is traditionally defined as a function of probability and impact. The probability is the likelihood of an event occurring and the impact is the consequence of the events.

Events that are considered in resilience planning are often classed as High Impact Low Probability (HILP) events. However, in many cases they may be more accurately described as high impact, uncertain probability as there is not enough statistical data to have an informed probability of their occurrence. Also, the probability of these events changes over time in unexpected ways, making HILP events and the threats that cause them hard to predict and build into risk models. For example, disruption caused by drones on may not have been considered very probable until the disturbance at Gatwick Airport caused by drone activity in December 2018.

However, the impact of disruptive events can be quantified more easily and efforts made to harden critical locations, against events with sufficiently severe impact. Prioritisation can be made on infrastructure that has cross sector impacts following disruptive events. An example where resilience hardening is focused at critical locations to protect against credible but uncertain threats would be physical security reinforcements.

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[6] Public Summary of Sector Security and Resilience Plans, Cabinet Office, 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/786206/20190215_PublicSummaryOfSectorSecurityAndResiliencePlans2018.pdf

[7] National Emergency Plan for Downstream Gas and Electricity, BEIS, 2016: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/577707/National_Emergency_Plan_for_Downstream_Gas_and_Electricity_2016.pdf

These physical measures have the potential to improve resilience against a variety of threats; this is another consideration when planning the level of resilience investment, versatility of a resilience solution strengthens its needs case.

The electricity sector has, and is anticipated to continue to experience significant change over the next 10 years. Decarbonised electricity from low carbon generation is anticipated to decarbonise other sectors (e.g. transport and heat) which means that dependence on electricity for broader societal use is likely to increase. From a resilience perspective, this increased dependence may mean that the impact on consumers, business and society of a given high impact, low probability event today could be higher in the future. As the interdependence between sectors like electricity and communications also continues to grow to meet the future needs and expectations of consumers and modern services, ascertaining collective resilience for essential services across all underpinning sectors will be important. We recognise the need to consider the impact of future energy sector and cross sector changes in our future resilience plans and measures.

We are continuing to engage stakeholders via established industry forums plus our own resilience stakeholder engagement and collaborative work with DNOs to make best use of existing industry work and direction in this area. We believe that development of new resilience measures and solutions will need to be developed between now and 2030 to ensure our networks remain resilient for the range of possible futures that we can expect. Both before and within the RIIO-T2 period, we will continue to develop our assessments of future network resilience requirements with industry and stakeholders to propose appropriate responses to recognised future industry challenges.

**10. How have system wide resilience challenges been addressed effectively in the past?**

Key examples of system wide resilience challenges that have been focused on in recent years are the risk associated with the threats of flooding, physical security and cyber security.

Co-ordinated response to the threat of flooding was stimulated after the floods of 2007, where thirteen people died and hundreds had to be rescued after parts of South and East Yorkshire and Gloucestershire flooded. Sir Michael Pitt was asked by the UK government to carry out a review of the country's flood defences. The Pitt Review: Lessons learned from the 2007 floods, focussed on; flood risk management, the resilience and vulnerability of critical infrastructure, the emergency response, emergency planning and the recovery phase. The Pitt review was the genesis of the UK governments Sector Security and Resilience Plans (SSRPs)6.

In the energy industry, specific steps were taken following the flooding in 2007 including steps to protect electricity substations from flooding; the Energy Minister requested a comprehensive assessment of the resilience to flooding of primary and higher voltage substations and the steps that may be taken to mitigate current and future risks. The Energy Networks Association (ENA) Substation Resilience to Flooding Task Group, reporting to the Energy Emergencies Executive Committee, (E3C) was asked to lead this work within agreed Terms of Reference. The ENA Task group worked with the Pitt review to have a coordinated approach.

The Task Group Report was delivered to E3C and The Energy Minister at the end of March 2008. The report was accepted and the recommendations adopted, including the development of Engineering Technical Report (ETR) 138 that was originally published in October 2009. ETR 138 provides guidance on how to improve the resilience of electricity substations to flooding to a state that is acceptable to customers, Ofgem and Government using a risk-based methodology and taking account of a cost/benefit assessment for each site[8].

Under the most recent version of ETR138, all NGET substations are considered critical. This view of criticality is based on operating voltage (anything above 132kV is considered as critical) and the potential for

[8] Engineering Technical Report 138 - Issue 3, Resilience to Flooding of Grid and Primary Substations, Energy Networks Association, 2018

a societal impact of 10,000 customers or more. This is in line with the 2016 National Flood Resilience Review (NFFR) target resilience levels for critical local infrastructure.

The principles within ETR 138 have been used by electricity transmission and distribution companies to develop their flood resilience plans and have carried out major flood resilience works to protect their substations. As of July 2018, Electricity network companies have spent £130 million on flood defence work from 2010-15, with a further £100 million due to be spent on flood defence by networks before 2021[9].

[9] The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting - Making the country resilient to a changing climate, DEFRA, 2018, Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727252/national-adaptation-programme-2018.pdf

**From:** _____
**Sent:** 21 October 2019 07:46
**To:** Resilience <Resilience@nic.gov.uk>
**Subject:** Call for Evidence - Resilience Report - Scoping report

**Response as requested**

1. When Data networks are connected together, particularly in IP routing, the physical transmission core is often unknown to the operator utilising the data network. This has resulted in planned work by the physical infrastructure provider causing disruption to data network operator. Neither parties understanding the impact. Unplanned events causing the breakdown of the physical infrastructure can cause congestion of loss of service. By design the data network operator will purchase a link between two points, not declaring the need for diverse routing or separate physical routing, furthermore the physical transmission supplier may sell the transmission link to many different data network operators. This risk and vulnerability should be managed and with accurate central database of physical routes and the type of data carried. The impact of the vulnerability being realised is increase where common utilised also share the same physical tunnels or ducts in the same location. Example tunnel fire central London in Holborn Loss of Mobile networks across several providers, loss of gas and electrical supply and restricted access to physical infrastructure due to the threat of further explosions.

2. All physical cabling, data network and physical infrastructure that is shared across ALL utility and data network companies. A common risk register which is managed by a Central Team, including loss of power supply, loss of water and sewerage processing and flood maps, up to date, and simple for them to be understood and accessible. This information would also assist Local Emergency Planners to better understand the risks to public safety if certain infrastructure should fail, eg Bridges collapsing and roadways flooding.

3. There is a need for a common policy about resilience of the UK infrastructure being delivered. This should as part of the operating licenses of the infrastructure owners and monitored, either by the regulator or a new audit organisation. Failure to provide resilience could incur a fine and potential loss of operating license.

4. The experience of the loss of infrastructure by the physical providers, the technical changes in design and capability, closer monitoring of performance and the pressure of customers, via social media, has increased the awareness of the system providers to ensure their systems are resilient and the service is available. Trends in Major failures of Network & physical infrastructure failures should be reviewed to see if the trend and impact is decreasing. There may be less failures but larger impacts to the systems.

5. System providers, in the communication industry, operate under a fairly tight profit margin. EBITDA and return on investment targets are used across the industry to ensure the system providers are financially sound which in turn drives the levels of service provided. Competition and customer choice and location will also factor into service levels. However this is area of weakness in the measurement of the service levels. No agreed level set but the regulator and the current level of measurement and targets set are too vague and of little use to the customers when making a choice of which system owner to choose. A majority of customers tend to focus on the deals on offer not the actual system availability.

6. Yes they should. How this is achieved will be a challenge and a central regulatory body may need to be introduced to set the standards.

7. In the communications, digital industry customers complain very quickly and in large numbers when the service or systems break of fail. The willingness of the customer to pay for extra resilience is not evident in the consumer world but corporate customers are open to such additional charges providing the service or system used is fully resilient.

8. I have no evidence that any policy or regulator really drive National Infrastructure resilience. Digital Service providers provide resilient systems and service because it is financial beneficial to have a stable service, less to fix or repair and less customer complaints to deal with. These activities are non –profit fuctions within a digital business and the sector is keen to kept these function cost down.

9. No evidence

10. The only driver has been from Network sharing agreements in the digital sector and through internal problem management. Audit and BSI standards throughout the digital industry have also increased awareness and the need for resilience in systems and the work force.

Hope the helps

Best regards as ever

_____

Anglian Water serves the largest, flattest and driest water company region in England and Wales with one of the fastest rates of new housing growth**.** We are the water and water recycling provider for over 6 million customers in the east of England, covering the area between the Humber and Thames estuaries and including around a fifth of the English coastline.

Our region is particularly vulnerable to the impacts of climate change, most notably from drought and flooding, and is critical to UK agriculture and the food supply (containing half of England's Grade One agricultural land). Our Business Plan proposes investment to support 200,000 new homes to be built in our region by 2025, and in addition to this, the prospect of a million or more homes by 2050 as the plans for the Oxford-Cambridge Arc come to fruition in one of the most water-stressed parts of our region. Our business and the area we serve face a plethora of resilience challenges over the coming years. Therefore, we welcome this call for evidence and hope this response is useful in informing your recommendations for national policy.

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

**1. What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?**

*– Examples of systemic vulnerabilities that originate from the structure of the network at a system level, including the physical and virtual connectivity of assets (but not individual assets themselves) within and between sectors.*

In terms of physical infrastructure, each infrastructure provider will understand their own network and the vulnerabilities within but these are not always overlaid in a way that highlights particular areas of weakness, and information regarding specific upstream infrastructure is not always readily available.

Anglian Water works in partnership with those responsible for other critical national infrastructure both during normal operating conditions and emergencies to ensure that essential services are prioritised and maintained.

Planning is supported by liaison with other infrastructure providers through Local Resilience Forums and other multi-agency groups but currently digital infrastructure is considered separately to traditional infrastructure providers within these groups. Anglian Water has been instrumental in setting up and contributing to a Multi-Agency Support Group with the aim of encouraging agencies across the region to plan jointly for hazards affecting the provision of essential services, and has co-ordinated exercises to test responses to a variety of hazards and threats including cyber attacks, large scale power failures and subsequent consequences including telecoms outages.

**2. What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?**

Where critical digital infrastructure is identified, in the same way that physical network infrastructure can be overlaid to understand systemic vulnerabilities the same process could be carried out for digital networks.

Digital services are increasingly complex systems often connected both physically and virtually via infrastructure maintained and supported by a variety of third parties. As IT services become more specialised and sophisticated, these capabilities are more often contracted in by organisations. This can present a challenge where these suppliers then hold contracts on behalf of the client as the chain of communication becomes elongated, making quick responses problematic.

In addition, critical infrastructure may have services hosted by the same provider without being aware of this fact, so that in an outage affecting the service provider, several critical infrastructure providers could be affected by the same problem. This information is often considered sensitive for commercial and security reasons.

This is mitigated by disaster recovery and business continuity arrangements in place with both the contractor and the critical infrastructure provider. Anglian Water is externally certificated to ISO22301, the international standard for business continuity, and as part of its supply chain processes assesses contracts tendered in terms of resilience and cyber security.

**3. Aside from those included in the last National Infrastructure Assessment, 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?**

A key vulnerability is the increasingly extreme weather linked to climate change. The country has experienced weather patterns recently that will become the norm; notable examples include the 2012 drought and floods, 2013 winter flooding and tidal surge, and the 2003 and 2018 summer heatwaves. The Beast from the East in February 2018 was also symptomatic of climate change, with a severe cold snap followed by a rapid thaw causing problems across the country for below-ground infrastructure. As these events become the norm hitherto unknown extremes in weather will arise.

That is why it is critical to deliver long term resilience in line with the available evidence and research, such as Water UK's Water Resources Planning Framework 2015-2065 and the NIC's Drier Futures report. Current policy trajectory is welcome, such as Defra's Strategic Policy Statement to Ofwat in 2017. However, its objectives will not be delivered in the next five year period because of Ofwat's focus on reducing bills in the short term at the expense of the long-term investment needed to deliver resilience and underpin sustainable housing growth.

The regulator is disallowing £6billion of resilience investment across the whole of England, with more than £1billion of this directly impacting the resilience of water services and the natural environment in the east of England. We support the recommendations of the NIC's Strategic Investment and Public Confidence report, specifically the need for government to set a longer-term strategic vision for each of the regulated sectors to support lasting plans and stable funding, and regulator consultation with metro mayors about regional needs. However, we would welcome greater consideration as to how regulators are held to account for the delivery of such strategic policy statements.

The projected switch off of the Public Switched Telephone Network (PSTN) in 2025 will create opportunities and risks in moving to exclusive use of Voice Over IP (VOIP) technology.

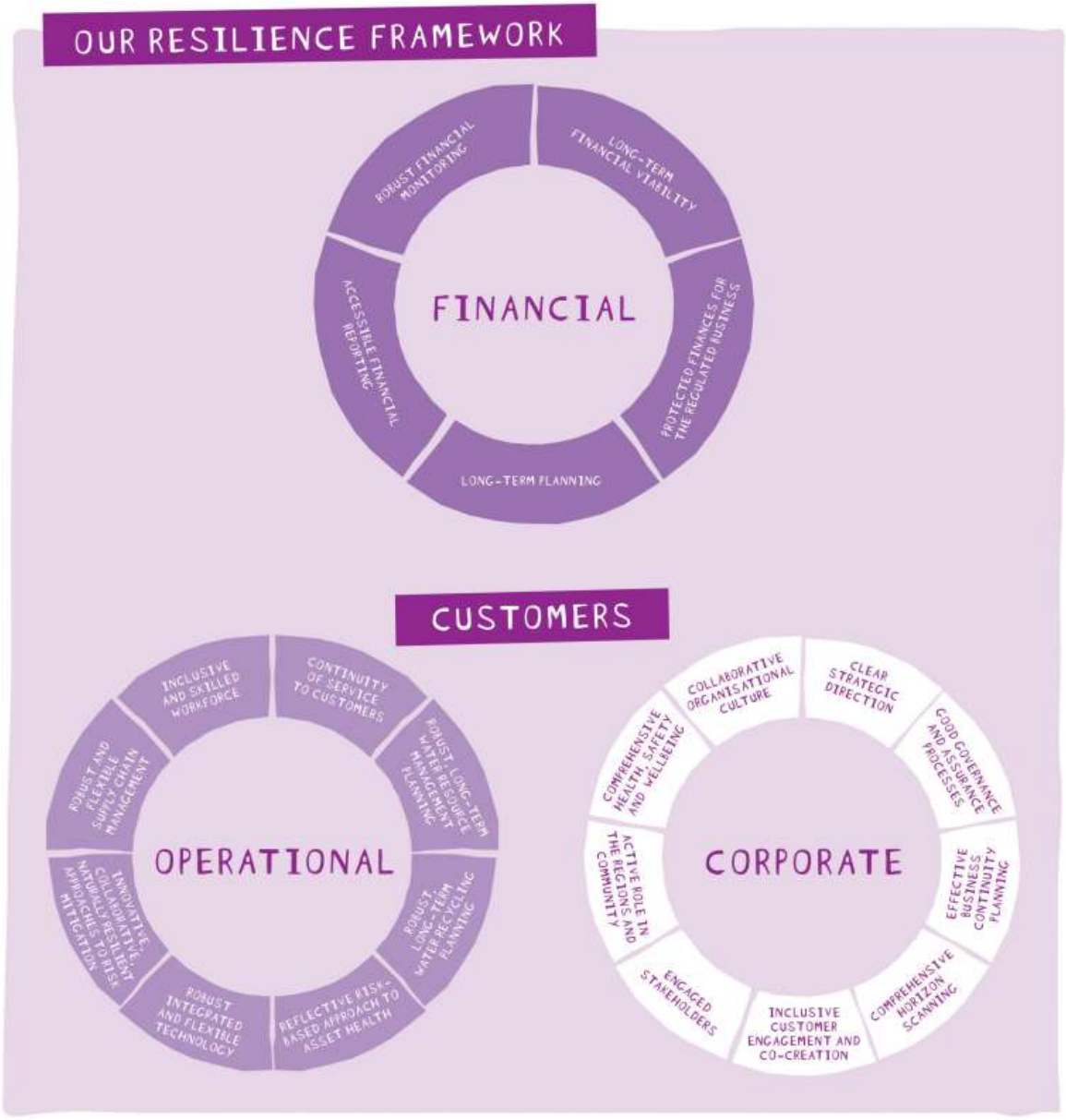
PSTN functionality has often been used as a layer of resilience to back up newer VOIP networks and is being reviewed at this time to ensure sufficient contingencies are in place for any critical services currently supported by this technology. Anglian Water regularly reviews its use of digital services taking into account both current and future needs and develops roadmaps for technologies, ensuring this is linked to resilience requirements for essential services.

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

*– Examples of good practice approaches to resilience that demonstrate how an organisation, or sector has responded to significant changes including, but not limited to; technology, disruptive events and/or changing user demands.*

In terms of resilience to climate change, infrastructure organisations are not limiting themselves to just consider physical risks, such as drought and flooding. They are also extending their focus into transition (and liability) risks. Water companies are taking action to reduce their exposure to the risks and costs associated with the decarbonisation of energy in the UK. This includes investing in energy efficiency programmes, switching to renewables, and becoming more flexible in the production and use of energy. Water companies in England have recently made a sector-wide commitment to become net zero carbon by 2030. Additionally, in 2017, Anglian Water became the first European utility company to issue a sterling Green Bond. This move opened up a new source of low-cost finance, and has proven very successful.

Ahead of PR19, and in line with our refreshed Strategic Direction Statement, Anglian Water developed a resilience framework with Arup, which is designed to be all encompassing. It considers three key resilience themes – financial, operational and corporate – which allow our business to deal with short term stresses, alongside the longer terms stresses such as climate change. We believe this serves as a model for others to follow:



The study in full can be viewed here.

Additionally, in recent years Anglian Water has worked closely with infrastructure providers to develop a more in depth understanding of dependencies. This takes place through traditional resilience relationships but also through its commercial and contractual arrangements.

**Public acceptability of infrastructure services**

**5. How are costs, benefits and public expectations balanced when setting levels of service?**

*– Examples of how each of these factors have been considered when setting a desired level of service, either as a requirement or a target.*

Our PR19 and WRMP consultation processes with customers explicitly looked at the balance between costs, benefits and public expectations in line with our Strategic Direction Statement. This is guided by four overarching aims which are central to business planning and operations:

- Making the East of England resilient to the impacts of drought and flooding.
- Enable sustainable housing and economic growth in the UK's fastest growing region.
- Becoming a carbon neutral business by 2030.
- Deliver a significant improvement in the ecological quality in our catchments.

Our PR19 business plan (from p135) describes the customer engagement process in more detail. Ofwat awarded our plan their only 'A' rating for customer engagement. See more on this under Q7.

This complements Water UK's Public Interest Commitment and our developing social contract. Additionally, Anglian Water has made legally binding changes to its Articles of Association – the company's constitution – to place a duty on our directors to ensure that social and environmental value are considered, equally alongside financial interests, in all business decisions.

**6. 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?**

In terms of resilience to climate change, we support the recommendations of the Taskforce on Climate Change-related Financial Disclosures (TCFD). Specifically, we support their call for all organisations to carry out a Scenario Analysis, and we would welcome a more consistent approach to this. The technical document can be viewed here.

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

*– Please provide evidence from direct public engagement which demonstrates public tolerance of disruption and the appetite for resilience investment in the sectors covered by the study (energy, water, digital and transport). This includes, but is not limited to, outputs from willingness to pay surveys, focus groups and deliberative public engagement.*

PR19 customer engagement

During the process of developing our PR19 business plan, we took part in an extensive consultation, co-creation and engagement exercise with over 500,000 interactions with customers to discuss their priorities and preferences for our 2020-2025 business plan. Time and again, our customers were presented with options showing the trade offs, costs and benefits of long term resilience, and we gained a detailed understanding of public expectations. Our customers overwhelmingly supported an increase in investment to improve the resilience of services even if it meant a slight increase in bills between now and 2025. When offered the choice between Ofwat's plan, promising a £50

reduction in annual bills, and our plan promising a 30% increase in investment, two thirds of our customers supported our plan[1].

On the whole, our research shows that there is a lack of awareness surrounding the security of long term water resources. However, resilience is consistently ranked among the most pressing issues by our customers. For an in depth analysis of resilience among our customers, please see here (p.145).

On supply interruptions, our research showed that it is a key concern for customers, but customers are mostly satisfied with the current reliability of supplies. In a corresponding willingness to pay survey, around two thirds of customers opted to maintain the current levels of service (p.151).

We have also developed a Societal Valuation Programme that seek to measure customer preferences through estimating the economic value that customers give to aspects of water and wastewater services. These customer valuations can then inform the benefits of investments that improve or maintain service levels, feeding into cost-benefit analysis and helping to prioritise investments across the range of services provided as part of PR19 investment planning and the WRMP. In addition, evidence on customer valuations informs - alongside other evidence and key considerations - the performance ranges for ODIs (Outcome Delivery Incentives).

Our Outcome Delivery Incentives within our PR19 business plan were developed based on this research, taking into account customer views.

For the detailed outputs of our engagement on willingness to pay, attitudes towards levels of service and supply interruptions, please see the annexes to our PR19 business plan here**.**

Water Resource Management Plan 2019
In the development of our draft Water Resource Management Plan 2019, we also carried out a stakeholder consultation exercise. A summary of the questions and engagement mechanisms can be found here (p.20-24). The detailed findings of the consultation exercise can be found here. When offered the explicit choice between investing now in response to climate change or waiting until future AMP periods, our customers told us to invest now.

**Resilience governance and decision making**

**8. What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?**

Outcome Delivery Incentive measures set for the water industry include metrics for interruptions to supply, unplanned outages and customer satisfaction. These all have resilience implications both in normal operating conditions and emergencies, and are key drivers in terms of investment and performance management.

The Security and Emergency Measures Direction (1998) requires water companies to be able to provide its customers with 10 litres of water per person per day where water supplies have been interrupted, rising to 20 litres of water per person per day after 5 days. Anglian Water works to this statutory requirement when investing in emergency response procedures and capabilities to ensure that public health and welfare is protected. Anglian Water is audited against this legislative requirement each year. The Civil Contingencies Act (2004) also identifies requirements for Category 1 and 2 Responder organisations to prepare, respond and recover from incidents and emergencies which includes critical infrastructure providers.

[1] PR19 Draft Determination Representation. Anglian Water – 2019. P.12.

In the past year, the Cabinet Office has produced Resilience Standards aimed at creating a national view of resilience capabilities across Local Resilience Forums. These set out both good and leading practice and provide a baseline for organisations to assess themselves against to understand both good and leading practice in a variety of areas, including cyber resilience.

**9. How does the infrastructure system respond to uncertainty?**
*– Examples of how uncertainty over a particular variable, such as the nature of an anticipated risk, has affected the level of resilience decision makers choose to build into a system.*

As mentioned, in our proposed PR19 business plan, we included over £500 million of investment to connect 200,000 new homes to our water and sewage networks by 2025. However, there is inherent uncertainty within growth figures, which has a consequence for the level of funding Ofwat provides for growth and a knock-on impact for water sector business planning.

Housing is clearly a priority for the government. Current targets are accounted for within Local Plans, developed by planning authorities. However, we also know that the government intends to build an extra 1 million homes within the Ox-Cam Arc region, which will be largely in addition to those expected in Local Plans. In our PR19 plan, we have laid the foundations to cater for the extra 1 million homes – a significant undertaking that requires action sooner rather than later. However, we are facing a challenge from Ofwat who have dismissed housing growth projections within Local Plans. Instead, Ofwat has created its own forecast based on ONS projections despite government planning guidance saying ONS data is not a reliable source for projecting new housing. The resultant forecast does not track the recent trend in new connections. As a consequence housing growth in our region will be underfunded by £350 million over AMP7.

In this case, we chose to plan for the larger number of homes owing to the pressures on water resources in the Ox-Cam Arc area and the strength of the government commitment to the policy initiative. We believe this to be the right approach because water resource management is a long term exercise that can slow down housing delivery if not undertaken in an appropriate and timely manner. Our response and approach to this is governed in line with our resilience framework, and highlighted in Q4.

**10. How have system wide resilience challenges been addressed effectively in the past?**
*– Examples of how different policies, incentives or decisions across a system have interacted effectively to address an identified cross sector vulnerability and improved the resilience of the system overall.*

Cyber attacks are a key risk identified in the Cabinet Office National Security Risk Assessment which are becoming more frequent and sophisticated.

In response to this risk, recent investment by government aimed at improving cyber resilience capabilities across all sectors including the provision of regional Cyber Resilience advisors within MHCLG and training and exercising support through Local Resilience Forums. This system-wide approach is in its early days but is showing a positive impact in bringing cyber response and traditional resilience capabilities together in the multi-agency planning context.

Anglian Water has also significantly invested in its cyber security capabilities including an award-winning awareness campaign aimed at improving employee cyber security and minimising the risk of a variety of cyber threats including phishing attacks.

Please see our Systems Approach to Resilience document to see how Anglian Water has managed resilience challenges in the past. Within this are a number of case studies and examples of how stress and shocks are mitigated.

# NIC Resilience Study scoping report call for evidence

## Response from the British Hydro Association Tidal Range Alliance

### Introduction

Events in summer 2019, including electricity supply interruptions, prompted the National Infrastructure Commission (NIC) to issue a call for evidence about how best to provide resilient infrastructure.

This response from the Tidal Range Alliance (with thanks to Prof Chris Binnie MA, DIC, HonDEng, FREng, FICE, FCIWEM) focuses on how tidal range electricity generation can add to the resilience of the UK's electricity supply system, identifies an analysis gap of the critical impact of intermittent renewable energy sources on the country's balance of service and requests that the resilience benefits of tidal range, including its contribution to addressing the challenges of Climate Change be included in the NIC's Resilience Study.

### Resilience

*"energy security seems to be of high public concern"*[1]

Government policy for some years has been to focus on driving down the cost of electricity to the consumer. The events of the summer 2019 and the concerns raised during the 'Beast from the East' earlier in the year have raised public concern over security of supply.

Increasing reliance on intermittent sources of renewable energy at a time when Government is encouraging significant uptake of electric vehicles will place even more stress on the system.

We would suggest that further research is carried out into both the technical challenges of balancing supply and demand in the future in parallel with consumer research into the acceptability of potentially higher prices for electricity should that help guarantee security of supply.

### Need for diversity

"*The National Infrastructure Assessment published in July 2018 ... recommended ... increasing deployment of renewable ...*"[2]

Following the power interruption at 5PM on 9th August 2019, which impacted hundreds of thousands of people, Andrea Leadsom, the Secretary of State said "*Friday's incident does however demonstrate the need to have a diverse energy mix.*"[3] Having a diverse renewable energy mix would boost resilience of the electrical supply system because of less reliance on uncontrolled intermittent solar and wind sources.

[1] NIC Resilience study September 2019 page 23
[2] NIC Resilience study September 2019 page 7
[3] Infrastructure Intelligence 15/8/2019

In May 2011 CCC stated about renewable energy "*The optimal policy is to pursue a portfolio approach, with each of the different technologies playing a role. In the case of renewable technologies such as offshore wind and marine, this will require the resolution of current uncertainties and the achievement of cost reductions."*[4] "*Analysis for this review by Poyry shows that deploying a diverse mix of renewable, including significant levels of tidal range...reduces the need for peaking plant, energy shedding and also facilitates a lower-carbon mix of thermal plant."*[5]

Below we consider briefly our understanding of each of the appropriate renewable sources.

**Nuclear**

About nuclear *"Once the power station is operational, it has very low marginal costs and is inflexible, expensive to turn off and on. It is therefore the most baseload power stations on electricity systems."*[6]

Thus it is inflexible, expensive, capital cost tend to rise and projects delivered late, requires very long term expensive waste storage, and relies on imported uranium fuel.

"*The Sizewell project could even be competitive with the cost of offshore wind according to the firm*" EDF Energy "*once the cost of backing up the wind farms when the wind doesn't blow is taken into account."*[7] We have been unable to trace this assessment but a similar assessment could be done for tidal range where the short nil output could be covered by existing pumped storage or battery technology.

**Gas**

Gas generation with Carbon capture, usage, and storage is a flexible method of coping with intermittency. There is a risk to some of the electricity sources from geo-political events. The UK is no longer self-sufficient in gas supplies, and in future much of Europe's is likely to come from Russia.

"*Indigenous generation has security of supply advantages over those which depend on imported fuel supplies. Where we rely on either imported power or imported fuel stocks, there is inevitably a greater risk of interruption than for domestic alternatives. Tidal power uses UK sources of generation."*[8]

**Interconnectors**

"*Net imports through the interconnectors contributed 5.8% of electricity supply in 2015. 7.7GW of additional capacity has been granted regulatory approval*. Construction has already begun on the two links ... to Belgium and Norway."[9]

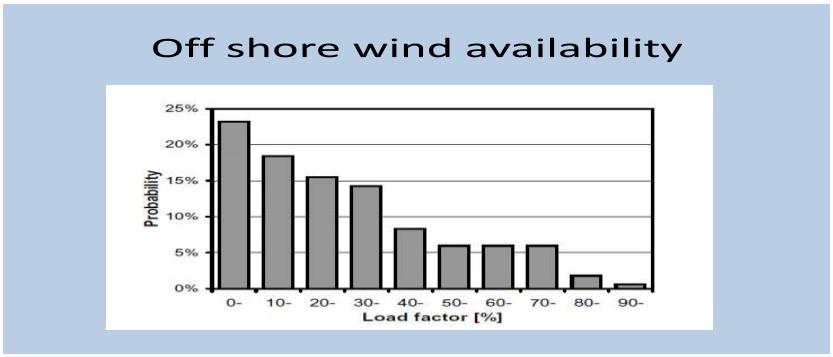
However, when we wish to draw from the European interconnectors they may also be at peak demand and may not have spare electricity, or may not want to supply, or may have excessive commercial terms (Brexit).

**Solar**

Solar does vary from day to day depending on the weather conditions and from season to season. Further, the most critical time for any electricity system is early on a dark winters evening when solar can contribute almost nothing.

**Wind**

[4] Committee on Climate Change. The Renewable Energy Review, May 2011 Executive Summary page 10.
[5] Committee on Climate Change The Renewable Energy review May 2011 page 78
[6] Dieter Helm The Nuclear RAB Model. June 2018. page 2
[7] The Guardian New UK nuclear funding model 14th July 2019.
[8] Northern Tidal Power Gateway. Strategic Outline Business Case September 2019. page 58
[9] House of Commons BEIS Committee. The energy revolution...2016-17 HC945 Jan 2017.paras 76 & 75.




The wind frequency histogram above[10] shows that for about 23% of the time the load factor is less than 10% of the rated output. It is also known that wind turbines may have to be shut down for several hours during a gale and during a winter Scandanavian high over the North Sea when minimal wind conditions can last there for several days.

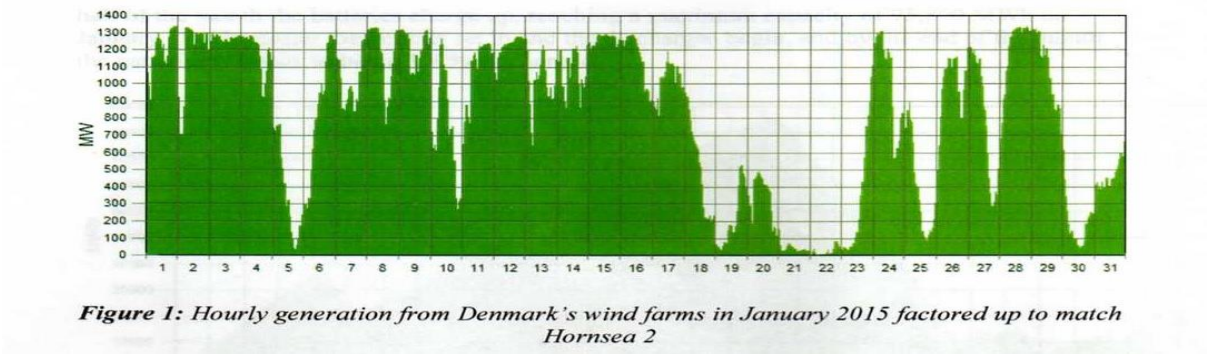



***Figure 1:*** *Hourly generation from Denmark's wind farms in January 2015 factored up to match Hornsea 2*

The image above[11] shows North Sea wind farm outputs for a random winter month when wind energy outputs should be high. Even so, about the 21st to 23rd there is a gap of about 2 ½ days when wind output was negligible.

**Ways of meeting intermittency**

Nuclear is baseload power so it will not be available to meet intermittency of renewable sources. Batteries have relatively short storage capacity, a few hours, and there is likely to be a substantial shortage of the minerals required for batteries, cobalt and lithium, by 2028.[12] Pumped storage is limited by the number of economic sites. Gas and then CCUS is expensive, especially when run as an intermittent source. Thus, having a reliable predictable source, tidal range, would be a great advantage.

**Cost of meeting intermittency**

"*The analysis supporting the CCC's net zero report suggests that the integration costs of wind and solar technologies may rise from £10/MWh at 50% renewable penetration to £25/MWh at 65%...at 75% penetration these costs would approach £40/MWh."* [13]

*"A flexible system with 70-80% renewable production by 2050 delivers lowest total system cost..."*[14]

**Regulated Asset Base funding**

For energy sources that have a very high capital cost and long construction period *"The cost of capital is so dominant that it can explain as much as almost half the costs of a project."*[15]

This is illustrated by the Thames Tideway tunnel scheme. The cost per householder when the project was to be financed in the private sector was some £70-£80/householder/year. Utilising Regulated Asset Base (RAB) funding this was reduced to £25/householder/year. Large tidal range schemes and nuclear power schemes are similar high capital

[10] I have had this image for about a year and am now seeking its source.
[11] Roger Andrews The real strike price of offshore wind September 2017 Figure 1.
[12] D.Tel Car Giants face £100bn hole to power the race to electric September 2019.
[13] Northern Tidal Power Gateway. Strategic Outline Business Case. September 2019. page 57.
[14] Aurora. Power sector modelling: System cost impact of renewable report for NIC, May 2018 page 9, and similar page38
[15] Dieter Helm The Nuclear RAB model. June 2018 page 3

cost long construction period schemes. There seems no reason why RAB should not also be applied to both such schemes with comparable benefits.

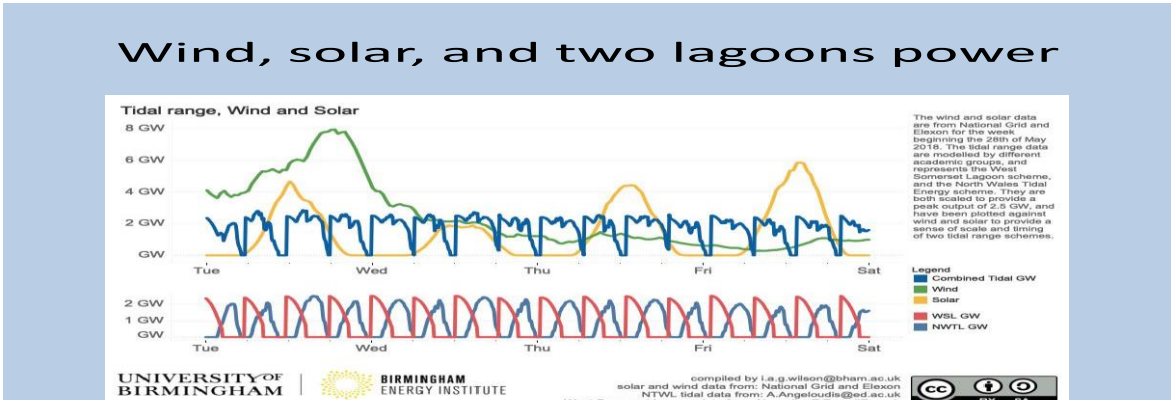
**Tidal range**

Tidal range lagoons can produce appreciable energy, the 7 lagoons in the Hendry Report producing some 30TWh/year.[16] The more extensive itp supporting report[17] lists 58 TWh/y. In addition, there is the traditional Severn barrage, the Morecambe Bay barrage, and the Wyre barrage adding about a net 20TWh/y. Thus, tidal range has a potential 80TWh/y. Some of these may turn out to be insufficiently economic. However, it does demonstrate that tidal range is an appreciable potential energy source.

One advantage of tidal range is that it is an indigenous, and predictable energy source. The intermittent "no generation" gap of a single scheme at spring tides is about 2 predicted hours. At neap tide, assuming no pumping, it can reach 3 to 4 hours depending on the scheme.

**Combination of two tidal range schemes.**
The time of high tide varies around the coast. This provides the ability for two or more schemes in different parts of the coast, to generate at different times, thus reducing the overall no output period.

The image below shows this effect for one scheme in the Bristol Channel, West Somerset lagoon (WSL), and a second off the North Wales coast (North Wales Tidal Lagoon) for a particular period, chosen at random. The image below also illustrates the natural variability and energy gaps of solar (yellow line) and wind power (green line) during that period.




This image above does not adequately reflect the situation at neap tides.

Cardiff University are studying the energy outputs of WSL in the Severn and North Wales Tidal Energy. There is effectively 1 hour 20 minutes difference in tidal conditions. Results show[18] that by starting generation in north Wales an hour earlier than optimum there would be no gap in combined output at spring tide. At neap tide, with such an operational system, the no power gap would be reduced to about 2 hours.

There would be some loss of energy for the North Wales scheme when it would be operating away from its optimum generation curve. If this is assumed to be only when the grid needs extra energy to meet peak demand in late afternoon, then the loss of income would be would probably be only a few %. Thus two, or more, selected tidal range schemes could provide nearly continuous power, currently assessed as for about 92% of the time. Studies are continuing to refine and confirm this work and seek to reduce the no generation period further.

The storage in a pumped storage scheme, for instance Dinorwig which has a capacity of about 1,728 MW for 5 hours, could cover the short neap tide, 1 to 2 hours, tidal no generation gap of these two schemes. Alternatively, this short period could be covered by battery storage or other short-term measure such as compressed air storage.

Thus, a short term, 1 to 2 hour, predictable intermittency happening several times a month, is much easier to cope with than a difficult to predict interruption of several days.

**Cost of tidal range**

[16] Hendry The role of tidal lagoons December 2016 Table 7 page 67.
[17] Itp Technical advisor support to the independent review of tidal lagoons November 2016 table 5.3 page 71
[18] Ahmadian/Binnie email 6th October 2019.

NIC stated, when considering the Hendry Review and the proposals by Tidal Lagoon Power[19] *"Unlike other low carbon technologies, the potential benefits of tidal lagoons are not being recognised through access to competitive contracts for difference."*

The CCC Renewable Energy Review 2011 states that tidal range "*Should be triggered as an option if relative costs improve..."*[20] CCC, BEIS, and NIC have all assessed tidal range but all of them have used historic and out-of-date data. The report "Updated consideration of tidal range power and its unit energy costs" assesses the change tidal range technology,

- 2-D analysis, optimisation of individual power phases using artificial intelligence to maximise energy output 7%, pumping to maximise power outputs, 8%, triple regulated turbines to improve turbine efficiency 15%, total increased energy 30%.
- Environmental impacts thus using ebb and flood generation with pumping to minimise loss of inter-tidal habitat (birds etc), reducing the number of turbine blades and using non-synchronous generation to minimise fish impact,
- Use of precast caisson construction, minimising wall height to reduce construction cost, reduced cost of compensation habitat, and post pathfinder economies of scale, an estimated total cost reduction of about 23%
- Use of Regulated Asset Base funding

That report demonstrates that unit energy costs have changed sufficiently and that tidal range schemes should now be considered for the energy mix.

**SUMMARY**

"*The key outputs from the main phase of the study are expected to be ... strategic recommendations about the research, tools and data that will be needed to improve resilience in the medium to long term.*"[21]

The Tidal Range Alliance suggests that the analysis above indicates that a re-assessment of tidal range is needed.

This will ensure that recent, credible, cost and engineering data and hydro/financial modelling is used in an updated feasibility study of tidal range projects – both as stand-alone schemes and in combination. Such a study would include:

1. Improving the energy output of tidal range schemes by further optimising the efficiency of the turbines under pumping and generation and optimising the starting and operational head,
2. Taking into account non-energy benefits such as contribution to CO2 reduction and mitigation of Climate Change impacts such as coastal flooding.
3. Valuing the predictability of tidal range supply to the National Grid and its importance to system resilience as demand grows (driven by EVs) and reliance on intermittent renewable energy supplies (wind and solar) increases.
4. Lowering the cost of construction
5. Improving the system of combining several schemes to minimise no generation gaps.
6. Gaining recognition for the financial and system benefits offered by tidal range schemes' very long operational lives.
7. Agreement on how Regulated Asset Base funding could operate for tidal range schemes.

As part of the UK's energy mix, tidal range has the potential to make a significant contribution to resilience by enhancing security and reliability of supply and, as such, can help the NIC address systemic issues that could potentially make the UK's infrastructure vulnerable to future changes and shocks.

20/10/2019

www.british-hydro.org

[19] National Infrastructure Commission Technical Annex Tidal power July 2018 page 5

[20] Committee on Climate Change. The Renewable Energy Review, May 2011 Table 1 page 23

[21] NIC Resilience call for evidence section 4 page 25

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Resilience Study Consultation
National Infrastructure Commission
Finlaison House
15-17 Furnival Street
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EC4A 1AB

20th October 2019

By email to: resilience@nic.gsi.gov.uk

Dear Sir / Madam

Thank you for the opportunity to respond to the National Infrastructure Commission's call for evidence supporting their resilience work.

As the monopoly water and waste water company for the Yorkshire region we are committed to delivering outcomes that meet the needs of our current and future customers and protect the environment. We're committed to playing our part in responding to the challenges of climate change and population growth through adaptation and mitigation, which will contribute to the commission's objectives.

Our response addresses questions 1, 4, 5, 6, 7, 8, 9 and 10. We would also refer you to our previous submissions to the Call for Evidence for the National Infrastructure Assessment in 2017 and our response to the Interim National Infrastructure Assessment Report in 2018.

We would welcome an opportunity in the future to discuss in more detail any aspects of our submissions. Should you have any queries regarding any elements of our response, please contact me at email address: amanda.crossfield@yorkshirewater.co.uk

Yours faithfully,

_____

Asset Strategy Manager,
Climate Adaptation

**Yorkshire Water Response to the National Infrastructure Commission's Call for Evidence for its Resilience Study Scoping Report**

Yorkshire Water has provided the following feedback with regards to the call for evidence published by the National Infrastructure Commission in October 2019.

**System issues that make infrastructure vulnerable to current shocks and future changes**

**Q1. What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture? Please provide examples of systemic vulnerabilities that originate from the structure of the network at a system level.**

**A1a. The interaction of our network with other drainage and flood risk management infrastructure**

As a water and sewerage company, our infrastructure interacts with drainage and flood risk management infrastructure owned and operated by other agencies. We have stated many times that the regulatory regime regarding sustainable drainage still requires further development and clarification. We note that the automatic right to connect to our network and the slow uptake of SuDS present challenges to the current and future resilience of the drainage network – both ours and that of other bodies such as local authorities and the Environment Agency.

In our previous NIC response we said
*"There are however a number of policy and institutional barriers to implementing SuDS more widely. A recent survey on SuDS by the Chartered Institution of Water and Environmental Management (CIWEM) 7 found that 70% of respondents think current planning policy does not sufficiently encourage SuDS and only 8% think the current standards are driving high quality SuDS. The report also highlights that there is no requirement for local authorities to report on SuDS uptake.*

*The government is undertaking a review of the automatic right of connection for surface water to sewers as part of its review of the Housing and Planning Bill. Although history may suggest the position will not greatly improve, progress has been made in devolved administrations.*

*In response to the European Water Framework Directive, Scotland introduced the Water Environment and Water Services (Scotland) Act 2003 for which it is a legal requirement for all developments of two or more properties to have SuDS.*

*Northern Ireland extended the powers of NI Water to adopt sustainable drainage systems and to require construction of SuDS through the Water and Sewerage Services Act (2016). The Act supports this by introducing restrictions on the right to connect new surface water sewers to the public network.*

*For England we need to remove the automatic right to connect for surface water to the sewer system, and consistently implement Schedule 3 (sustainable drainage) of the FWMA."*

The solution to the systemic vulnerability of our network interacting with others is greater partnership working and perhaps a more centralised body that manages flood risk. We have said in our previous response to the NIC that:

*"Integrated water management (IWM) is central to effective management of water, waste water and flood risks. IWM does require engaged and active partnerships working together and there may be value in having a single body or organisation managing from the centre. Improving the management of storm water will be an increasing imperative in the face of climate change and development. Legislation should be strengthened to encourage the provision of SuDS and water companies have a part to play in this alongside local authorities and developers."*

**A1b. The persistent underfunding of the sector presents systemic vulnerabilities**

We said in our previous response to an NIC consultation:

*"In regard to existing network infrastructure, UKWIR undertook a common research study to assemble evidence to determine whether an increase in rates of renewal and/or rehabilitation of water and waste water network infrastructure might be needed to ensure long term stability.*

*Their analysis indicated that under most scenarios considered, rates on expenditure on renewal and rehabilitation of water mains and sewer networks will need to increase if long term deterioration in levels of service is to be avoided. The range of increased activity and expenditure will be dependent on a company's relative network assets age and type."*

Having now received our draft determination from our regulator, Ofwat, we are surprised and disappointed to see that there remains a significant downward pressure on costs, beyond that which is sustainable, and which seriously risks the ongoing resilience of the water sector as a whole and the increased rate of expenditure the UKWIR study calls for. We (and others) have submitted independent economic evidence which challenges Ofwat's' assertion that stretching performance can be achieved without incurring additional costs, and that the economic modelling used by Ofwat shows that their notionally efficient company is unfinanceable using standard industry credit rating metrics. *"The excessive focus on lowering bills and costs in the current period jeopardises the company's ability to invest in the long-term health of the asset base."*

The water industry has made significant steps forward in identifying and delivering partnership schemes to manage the systemic risk of flooding however these schemes often fall outside of our regulatory regime and in times of drastically reduced funding it is these types of projects which are likely to fall by the wayside. Although challenging financial times can drive innovation, the percentage of water company funding that is available for discretionary schemes such as this is tiny compared to the statutory programme of work which must be delivered to regulatory timescales.

**Q4. How have the current approaches to infrastructure resilience changed over time in order to become more effective?**

We observe that a significant event followed by legislation is generally the driver for improvements in resilience. This is best illustrated by the 2007 floods, the Pitt Review and subsequent implementation of the Flood and Water Management Act, 2010 which has driven enhanced resilience and improved collaboration across risk management authorities. The continued refusal to implement Schedule 3 (the automatic right to connect and the requirement to install SuDS in new developments) is hindering further improvements in storm water management and future flood risk mitigation.

The introduction of regional water resources planning is a welcome step forward and should help drive resilience improvements particularly in the south of the country where there are many small water-only companies which have not historically collaborated to optimise water resources across their catchments.

The introduction of a new resilience duty for Ofwat in 2017 has driven a great deal of activity in the water sector although there are concerns regarding the level of funding allocated for the next business plan period. We also welcome the increased focus on partnerships and collaboration as a way of mitigating shared infrastructure risks however we note that partnerships can take more time, are riskier and require dedicated (and additional) resources to be successful.

We have welcomed the introduction of Resilience Direct and the renewed focus on mutual aid and shared training exercises with other Cat 1&2 responders. We recently supported the Whalley Dam breach with a team of reservoir engineers and have also benefitted from mutual aid help from our neighbouring water companies during events such as the 2015 floods. These arrangements work well although they are unlikely to cope well in national scale emergencies or in back to back events.

**Public acceptability of infrastructure services**
**Q5. How are costs, benefits and public expectations balanced when setting levels of service?**

Our business planning process follows a methodology set by our regulators and seeks to achieve a balance of costs and benefits, ensuring we meet our statutory compliance requirements, maintain our extensive asset base and meet public and stakeholder expectations. Our Levels of Service are agreed with our customers during our five-yearly business planning cycle and our most recent plan had the largest engagement plan to date. We engaged with over 30,000 Yorkshire Water customers for PR19, resulting in a plan that 86% of surveyed customers supported.

Along with most other water companies, we optimise our business plan using custom-built optimisation engines. These engines are populated with the statutory requirements we must meet, data from our asset deterioration models which predict how many assets we will need to repair or replace, as well as the needs and expectations of our customers in terms of service. The engine then choses the optimal mixture of solutions to achieve the best value programme for customers and the environment. As a heavily regulated sector, there are legal and financial criteria around the types of investment we can make which are not always fully appreciated by stakeholders.

We said in our previous response to an NIC consultation:

*"Ofwat has a responsibility to protect the interests of consumers of water and wastewater services. This includes promoting competition, encouraging fair prices and preventing unfair practices, setting maximum prices where*

*competition is insufficient, and ensuring good quality services are delivered. Within its framework of duties, the regulator also has to address intergenerational fairness. Assessing and justifying intergenerational fairness needs further consideration."*

Further to the requirement for Ofwat to consider intergenerational fairness for customers in England and Wales, this important dimension is considered at a European level. In its briefing note of September 2016, "Making the Right to Water and Sanitation a Reality Europe - The role of affordability mechanisms", EurEau[1], representing the European water sector, notes the legal content of the UN human right to water and sanitation[2] encompasses the following dimensions: availability, accessibility, acceptability, affordability and quality. And EurEau then states that *"'Availability' of water and sanitation means that water and sanitation facilities meet people's needs now and in the future. Therefore, current generations bear an inter-generational responsibility towards future generations: the latter should be able to enjoy affordable water and sanitation with the same (or higher) degree of safety and quality enjoyed by the current generation."*

**Q6. 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?**

We are cautious about any approach which seeks to set national sector wide levels of service as this risks exposing the company to unfunded obligations which are outside those we have already agreed with our customers and regulators. Different areas in the country face different risks and have different starting points and it is therefore highly unlikely to be able to set a one-size-fits all standard of service.

In terms of underlying principles, we would encourage consideration of the following aspects:

- Social justice – ensuring all customers have a minimum level of service, and providing for vulnerable customers, noting that vulnerability can be dynamic, transient and subjective.
- Affordability – it is important to note the above risk regarding unfunded obligations, and to acknowledge the role of the regulators in setting prices, as well as the ability of customers to pay for resilience improvements.
- Intergenerational fairness – we are concerned that the current way the water sector is funded and regulated is pushing resilience concerns out into the future and therefore the burden will fall disproportionately on future generations (e.g. investment in sewer replacement). Any approaches need to consider the needs of future generations of citizens, and the needs of the environment.
- Technical and social feasibility
- Planning assumptions – what is the baseline we are working from, what future scenario are we planning for?
- Transparency – how have different trade-offs been made and why between cost/deliverability/customer expectations.

**Q7. How does the public respond to infrastructure disruptions and what is its appetite for making different sectors more resilient?**

[1] http://www.eureau.org/resources/position-papers/99-making-the-right-to-water-and-sanitation-reality-europe-september2016/file

[2] In 2010, the United Nations General Assembly (UNGA) officially acknowledged the human right to water and sanitation in resolution 64/292. The UNGA calls upon states and international organisations "to provide financial resources, capacity-building and technology transfer … in order to scale up efforts to provide safe, clean, accessible and affordable drinking water and sanitation for all".

Customer interruptions to supply in the water sector are extremely rare compared to other sectors and our research shows that, in Yorkshire at least, customers are generally happy with their current levels of service and are not willing to pay for additional resilience. That said, our research also shows that recent experiences disproportionally affect customers' expectations so people who have recently experienced a supply interruption will display a higher willingness to pay than those who have not.

Across the Willingness to Pay study, there was a high tendency to stay with the status quo amongst customers. This trend was more marked than in our previous planning period (PR14) with approximately a third of customers sticking with the status quo throughout the PR19 survey; perhaps indicating either a fear of change in uncertain economic times or a satisfaction with the existing levels of service (this was also observed in the outputs from the cost adjustment claims research). Levels of WTP were lower than PR14; with 42% of household customers falling into the financially vulnerable category and high preferences for the status quo, perhaps reflecting the economic climate at the time the survey was undertaken. There is a definite tension between customer affordability and increased investment in securing future service.

The engagement we did with future customers (i.e. current teenagers) for our current business plan period (PR19) is not robust enough to respond to the specific question raised around WTP for resilience. However, the conversations we had with future customers may provide some useful insights. These conversations focused more on general awareness of water and the services we provide. What was clear from our discussions was that their priorities are centred around 'what is best for me', for example, becoming home owners, career development and other responsibilities. There is a low-level knowledge of issues and challenges for the energy sector, but for most it is not even on their radar. Future consumers prioritise first and foremost safety, affordability and elements of service that have a direct impact upon them. Whilst these hygiene factors are key, there was a feeling innovation underpins these factors, and therefore should not be overlooked. They also agreed that utility providers should be focussing on environmental issues in the longer term but did not have any substantial reason or understanding of how this would be achieved.

**Resilience governance and decision making**

**Q8. What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions as well as during emergencies?**

The water sector is heavily regulated and there are a raft of national level policies and decisions that affect us. These include the Water Act, the Flood and Water Management Act, and the Civil Contingencies Act as well as national, regional and local planning policy. Water Resource Management Plan guidelines and other methodologies set by our regulators determine a good proportion of the levels of service we provide.

Intense political pressure to keep bills flat despite the challenges of a changing climate, population growth and the largest statutory environment programme ever, means that there is a genuine risk of eroding resilience in the water sector due to insufficient funding. This assertion is widespread across the water sector and is supported by independent economic evidence. This risks de-incentivising resilience, stifling innovation and reducing the current levels of service agreed with our customers.

**Q9. How does the infrastructure system respond to uncertainty? Examples of how uncertainty over a particular variable such as the nature of an anticipated risk has affected the level of resilience decision makes chose to build into their system?**

Our decision making is not done in isolation, the choices we make about what, where and when to invest are either mandated by our regulators (such as investment in water quality schemes prescribed by the Drinking Water Quality Inspectorate) or arrived at through discussion and agreement with our regulators, customers and other stakeholders (such as agreeing targets for sewer flooding). These decisions all carry some degree of uncertainty whether it is over predicted population growth, the location and size of housing developments, or how customers will behave.

Our sector is generally perceived as risk averse and we tend to be conservative in our assumptions and planning as we provide such a vital public health service. For example, the Environment Agency methodology we use for our Water Resource Management Plans requires different approaches based on an initial assessment of risk for water supply zones. Zones that are high risk follow a more complex method with a greater level and detail of modelling than low risk zones. This ensures that high risk water supply zones use the best available evidence and incorporate a generous amount of headroom (i.e. contingency).

We believe that there are areas where our sector's ability to respond to risk uncertainty could be strengthened. For example, Yorkshire Water is not currently able to mandate the metering of household customers. This is because Yorkshire is not considered to be an area of water stress. However, climate change may mean that Yorkshire could become water stressed into the future, and we should be planning now for that eventuality – although the degree of future impact is still uncertain. This could mean that all water companies are allowed to install more household metering in anticipation of potential future water stress, rather than prevented from doing so based on their current position.

**Q10. How have system wide resilience challenges been address effectively in the past? Examples of how different policies, incentives or decision across a system have interacted effectively to address a cross sector vulnerability.**

The Flood and Water Management Act has improved flood risk management across the various agencies involved by encouraging sharing of data, development of joint schemes and a better, more joined up approach to incident management and post event recovery and reviews. We think there is more that can be done in this area (see previous comments regarding Integrated Water Management).

Delivery of the Calderdale Flood Action Plan via the Calderdale Flood Partnership Board is a great example of how multiple organisations can come together to deliver a range of projects and schemes that collectively help to enhance the resilience of a community, including cross sector vulnerabilities. Organisations working in partnership in Calderdale include Calderdale Metropolitan Borough Council, the Environment Agency, Yorkshire Water, Canal and Rivers Trust, Network Rail and many smaller organisations based in the community. Together this partnership has made great progress towards delivering against multiple themes that are included in the Flood Action Plan – infrastructure resilience, community resilience, natural flood management and traditional investment in flood defences.

TRIAD avoidance may also be another example of how the resilience of the system (in this case the electricity supply system) can be enhanced by devising pricing structures which incentivise heavy users to reduce their power use when demand is high. This helps ensure the stability of the National Grid.

ENDS

# National Infrastructure Commission Resilience Study: Call for Evidence

# Introduction

Network Rail would like to thank the National Infrastructure Commission for the opportunity to input into the Call for Evidence for their Infrastructure Resilience Study. Network Rail welcomes further engagement to discuss, expand, or provide further clarity on any of the points that have been highlighted in the body of the response below or in the supplementary materials which form part of this response.

Noting that different sectors and different parts of each sector are likely to have different requirements, Network Rail looks forward to outputs which provide recommendations specific enough for it to action and enable change in the transport sector and foster cross-sectoral collaboration.

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

## 1. What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?

The rail network in the UK is still largely a legacy infrastructure system based on one first constructed by the Victorians. Many of its assets were developed at a time when the cost of labour was low, leading to an approach which used labour intensive technologies and to infrastructure built in many cases to satisfy immediate needs.[1] It also means that the infrastructure Network Rail has inherited is not always suited to the needs of passengers in the 21st Century.

Some specific systemic vulnerabilities include:

- Track needs to be laid along low gradients which require greater earthworks;
- Greater earthworks, in turn, can have higher levels of risk associated with them (for example, cuttings are at a greater risk of collapse);
- Gauging and axle loading is not uniform across the network, and;
- Aged Infrastructure which can result in:
  - i. Lower reliability and resilience;
  - ii. Greater maintenance costs;
  - iii. Lower capacity, and;
  - iv. A lack of detailed information about the asset itself when compared to newer infrastructure.

The way in which the system architecture is used has also meant that the resilience of the rail network has decreased over time. Three of the largest contributing factors are:

1. The drive to utilise 'spare' capacity on the network currently available which has led to a lack of flexibility/resilience during disruption;
2. The adaptation of specific parts of the network to different traction types. This has allowed Network Rail to make the most use of its available capacity.[2] However, the lack of a uniform power supply on the railway means that not every train can run on every part of the network.
3. The franchising system (and geographic disaggregation of train services into discrete areas or routes) has resulted in less driver knowledge of alternative routes that could be taken during disruption.

The high utilisation of spare capacity noted in the above point has been exacerbated by the ongoing trend of opening 'through-city' services on the network. This opens previously isolated parts

[1] There was often also a drive to build as cheaply as possible. See, for example, the insufficient lining of the tunnels on the Hastings line when it was originally built. This led to a requirement for narrow trains which, in turn, meant that when the line was eventually electrified in the 1980s, the standard-sized electric multiple unit stock was too big for two sets of tracks through the tunnels and only one could be used. This places a constraint on the timetable.

[2] Electrified parts of the network tend to be more reliable than diesel but require the infrastructure in order to operate.

of the network up to each other and whilst this results in greater connectivity, it also means that delay can spread more easily to differing parts of the network. [3]

### 2. What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?

No Response

### 3. Aside from those included in the last National Infrastructure Assessment, 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 overall rail system has interdependencies with multiple other infrastructure providers and operational systems all of which may affect the vulnerability of the future system. Some of these include:

Changes to supply and demand of:

- Electricity providers;
- Fuel providers;
- Water providers, and;
- Other suppliers (e.g. British Steel) where their loss could significantly impact the rail industry.

Physical Architecture

- Other transport systems, or;
- Communications providers;

Infrastructure Policy

- Other Transport Systems;
- Environmental policy targets, and;
- Land management agencies.

Any of the above could significantly impact the operation of the rail network. In the case of land management, an example of this can be found in some areas where the rail network operates along the coast. Flood defence authorities in England and Wales have made the decision to stop maintaining multiple coastal defences which currently protect the railway. Network Rail's assets are not designed to be flood defences[4] yet they may, over time, become so as a result of these decisions and this will lead to some difficult strategic/political questions which should start being explored now.

[3] For example, such as those introduced by the Thameslink programme which linked Brighton to Bedford and to Peterborough which opened up the south of London to the north of London.
A similar impact may be felt when CrossRail opens. The impact of delay on the Western or Anglia routes of Network Rail will be able to spread to parts of the network that are currently isolated from these geographic areas.

[4] With the exception of some outliers such as the seawall at Dawlish which is a by-product of attempts to safeguard the railway.

In order to assess what level of resilience and adaption to climate change is required of the railway, it is important for Network Rail to know the level of service expected so that investment plans can be developed accordingly. Network Rail needs to work with Government in deciding the outcome which has the greatest possible benefit and needs Government to support the decision when made public, regardless of its popularity.

There are also two sets of more general uncertainties regarding the physical infrastructure of the rail network brought about by climate change:

1. The rate of change in extreme weather is not yet fully understood and this could have a significant impact on:
   i. The level of resilience required from railway assets, and;
   ii. The rate at which Network Rail needs to replace infrastructure. Feasibly, Network Rail may need to carry out some renewals at an accelerated pace.
2. Like-for-like replacement costs are significantly higher when building infrastructure to accommodate potential climate futures and Network Rail is not currently funded to make the network resilient on a whole-system scale.

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

Network Rail has developed multiple approaches over time in order to become effective. It has:

- Sought to better demonstrate the value of resilience to passengers for rail industry funders;[5]
- Developed plans to increase the level of capacity provided by the tracks (and therefore resilience through a corresponding reduction in reactionary delays);
- Developed plans to improve resilience through the reduction of primary delays through works such as the Weather Resilience and Climate Change Adaptation strategy (WRCCA)[6] or through longer term asset intervention strategies which focus on those interventions which have the greatest benefit to the network;
- Continually developed the professionalisation and training of roles relating to resilience[7]
- Increased the use of data analysis from multiple sources such as remote asset monitoring, information from local teams, and data from trains, to predict and prevent issues before they arise;[8]
- Designed redundancy into its assets and systems to minimise disruption, particularly in areas which could act as a vector for the spread of disruption, and;

[5] The value of resilience to rail passengers is part of the development of service enhancements. Conversely, poor performance erodes the business cases for enhancements to other aspects of the passenger experience.
[6] https://safety.networkrail.co.uk/home-2/environment-and-sustainable-development/wrcca/wrcca-strategy-2/
[7] This includes the professionalisation and training of control and command staff over the last couple of years with the addition of the Rail Incident Commander Course whose accreditation is embedded within the HR process for Regional, Route and National strategic controller roles. It also includes the hiring of specific resilience managers.
[8] The use of train borne detection on track assets for example, allows earlier identification of track defects through pattern recognition which can then be repaired before they become disruptive.

- Developed technologies which enable Network Rail to identify both pre-emptive repairs needed to the rail infrastructure and to find causes of major disruption post event.[9]

Network Rail also has multiple examples of utilising technology, for example the use of drones to monitor the track, to minimise disruption and improve resilience. For most asset types the causes of failure[10] are well known, and Network Rail puts controls in place to:

1. Reduce the likelihood of occurrence;
2. Detect the failure where possible;
3. Minimise the consequence, and;
4. Recover from the effects.

Network Rail applies system engineering and integration principles to ensure sub-systems across the rail network work together cohesively. However, this can present a challenge across infrastructure providers or where sub-systems are owned and operated by other organisations. The effects of disruption across these boundaries are not always fully known or appreciated. Network Rail also uses tools such as Failure Mode Effects & Criticality Analysis (FMECA) to understand this in more detail alongside technical specifications detailing requirements to ensure compatibility of asset systems.

## II. Public acceptability of infrastructure services

### 5. How are costs, benefits and public expectations balanced when setting levels of service?

There are several mechanisms through which costs, benefits, and public expectations are balanced when setting levels of service.

The Passenger Demand Forecasting Handbook (PDFH)[11] contains quantified estimates of the impact different service attributes on overall passenger welfare. Public expectations vary according to geography, particularly in relation to tolerance of crowding. This is captured in the PDFH.

Network Rail follows the Government appraisal and evaluation guidance contained in 'The Green Book'[12] for its projects and programmes, in addition to working through an investment decision framework which allows for a project to be cancelled should the costs of the benefits delivered become too high.

Over the last three control periods Network Rail's funding envelope has been set by Department for Transport (DfT) and the Office of Rail and Road (ORR) to only include renewals on a

[9] For example, the use of pantograph cameras on Overhead Line Equipment has enabled Network Rail to identify both to pre-emptively identify track defectives and helped to significantly reduce disruption in Euston in early August when a signal failure caused significant disruption.

[10] Examples include failure to due life expiry, their design, manufacturing/installation defects, insufficient maintenance, operating outside technical limits, and incorrect operation. Other potential causes include extreme weather, deliberate acts of harm, or technical incompatibility.
The national risk register also details wider potential considerations. Further information can be found in supporting document 5.

[11] https://www.raildeliverygroup.com/pdfc/about-the-pdfh.html

[12] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

'like for like' basis with no specific requirement to significantly improve performance. Department for Transport and Transport Scotland may need to consider what factors they would like to include in Network Rail's asset policies and strategies. Wholesale renewals could deliver the desired outcome, but it seems unlikely that the cost of such a plan would be feasible or acceptable to the public.

### 6. 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?

It is difficult for Network Rail to say that a universally applied approach should be used as:

1. The expected level of service may need to vary across sectors as well within different parts of the transport sector.
2. The role that railway performs for funders will vary by market, particularly as its funding becomes increasingly devolved.

The railway, for example, will always face performance impacts in adverse and extreme weather as resilience measures include actions that reduce performance to maintain safety standards (for example, temporary speed restrictions or reductions in the number of services). The scale of the network also precludes the prevention of all impacts. Rail's function as a part of a larger journey for passengers also means that there may be risks to passengers before or after they access the railway.

Therefore, Network Rail would suggest acknowledging the relative necessity of the infrastructure type to the functioning of society. The public would not expect the railway to maintain a full service in extreme weather and it is not necessary to the functioning of society in the same way as the energy and digital infrastructures which are much more critical.

Weather already has a significant impact on railway performance and safety and climate change will affect our ability to deliver an effective and safe service for our customers in the future. Fixing the issues climate change causes can be extremely expensive and difficult.[13] However, some alternative solutions could be to:

- Increase the resilience of associated infrastructure such as raising signalling equipment, so the most vulnerable assets are protected and recovery time is reduced when incidents do occur;
- To work with neighbouring stakeholders like farmers, Highways England and the Environment Agency to look for more holistic and cost-efficient solutions, or;
- To investigate other options when the risk of hazards such as flooding in the longer term becomes unacceptably high due to climate change. These could include:
    i. Raising the track;
    ii. Improving drainage;
    iii. Reinforcing defences, or;
    iv. Relocating the railway.[14]

[13] For example, track flooding along coastlines and rivers.
[14] Subject to funding

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

The key feedback the rail industry receives from periods of disruption is that passengers want:

- Reliable services;
- Enough room to have a seat;
- The provision of accurate and timely information regarding the service levels as far in advance as possible (for example, several months in advance for large enhancement projects), and that;
- that passengers are informed of the underlying reasons for disruption (whether weather-induced or maintenance related)

Passengers appreciate that disruption does occur as a result of extreme weather.[15] The public expects resilience, but some of the interventions required to deliver a resilient network (for instance, installing slab track in tunnels or electrification) inherently require up-front disruption to improve longer term resilience. The rail industry can quantify this in economic terms, but there are also often political consequences which cannot be quantified in the same way.

Activities such as 'Meet the Manager' sessions and working groups involving Train Operators, Network Rail, and local stakeholder groups can become successful and positive partnerships with our customers. These allow the rail industry to receive feedback directly from our customers, inform passengers of the short and long-term benefits of any work being carried out, and to explore options to minimise the impacts of disruption caused, for example, by station enhancements on our passengers.

## III. Resilience governance and decision making

### 8. What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?

The main policies that affect Network Rail as an owner/operator of UK Critical National Infrastructure from a resilience standpoint are:

- The Civil Contingencies Act 2004 and the duties of Network Rail as a category 2 Responder, for example, information sharing with, and participation in, Local Resilience Fora (LRFs)
- The 'Railways and Other Guided Transport Systems (ROGS) safety regulation which state that Network Rail will lead for the rail industry in planning for, and leading the response to, a major rail incident. This sets out minimum requirements for planning and liaison across the industry.
- The National Rail Security Programme (NRSP) which sets out the regulatory framework for security at rail critical national infrastructure sites.

[15] See *Transport Focus*, 'Reacting to extreme weather on the railways', found in supporting document 4

## 9. How does the infrastructure system respond to uncertainty?

The anticipated level of demand is subject to considerable uncertainty and this affects the level of resilience our funders require of specific parts of the rail network. Network Rail responds to this by developing a comprehensive set of scenarios which help the industry understand demand and cost uncertainties better.

The rail system has yet to fully respond to the need to enhance resilience to the projected impact of climate change. The English, Scottish and Welsh National Adaptation Plans include adaptation actions for the transport sector, but implementation of these actions is not monitored or mandated and they are not currently sufficient to adequately adapt the railway to the risk. There is also a lack of understanding of interdependencies across the infrastructure sector and how climate change might exacerbate any risks within the system.

Extreme weather is increasingly considered in the management of railway assets and the rail industry needs to move from a 'reactive' to a 'predictive' mindset when adding resilience to its infrastructure.[16]

## 10. How have system wide resilience challenges been addressed effectively in the past?

Network Rail has developed a tool which assess the vulnerability of asset types to future resilience challenges which are based on weather and climate impacts. This has helped to model risk and prioritise the required interventions.

Roughly 70% of delay minutes are a result of reactionary delay. In Control Period 4 the industry focus was on addressing primary delays, but as demand has grown and traffic has increased the focus has been on increasing capacity (and therefore reducing reactionary delay).[17]

Industry incentives are one focus of the Williams Review, an independent, industry wide review of Britain's railway commissioned by the Government aimed at providing recommendations for reform which will prioritise both the passengers' and the taxpayers' interests.[18] For instance, the incentive properties of the planned and unplanned disruption compensation mechanisms are designed to be neutral. However, the evidence supporting this assertion is weak, and the evidence that compensation regimes are important elements of operator's business models has increased as demand growth has slowed down. The alliancing model which the industry introduced in Control

The drive toward unified control teams and better possession planning in control period 4 was a success. During the major blockades associated with the London Bridge Station redevelopment, for example, the Thameslink Programme worked effectively with other travel organisations such as Transport for London, London Underground Limited, and other Train Operators. It did this by funding the modelling of specific timetables which identified the train

[16] As part of this, the North West and Central Region for example, is developing the 'Weather Proof Railway Plan' which aims to gather all the strategies, approaches, ideas and projects into one defined project in order to better respond to the risk uncertainty the weather may create. This project will also aim to improve resilience within designs of our infrastructure to ensure our design standards meet the current Government-led studies into extreme weather for the next 40 years.

[17] NB: The business case for CP5 electrification was partially driven by this.

[18] https://www.gov.uk/government/collections/the-williams-rail-review

service provision and travel patterns of passengers, leading to informed decisions when trying to manage the travel demand during the disruption caused by the blockades.

# Concluding Remarks

Thank you for providing Network Rail with the opportunity to input into the NIC Resilience Study. As stated in the introduction, Network Rail would welcome further engagement from the NIC if they have any further questions regarding any of the comments contained within this response. Contact details for this purpose are enclosed within the covering letter.

Network Rail looks forward to continued engagement with the NIC in order to better understand how cross-sectoral resilience can be fostered.

# NIC resilience study: scoping report – call for evidence

## Southern Water's response

October 2019


from Southern Water

# Executive Summary

We welcome the opportunity to respond to this call for evidence. As a provider of critical infrastructure in a region challenged by climate change and population growth we're pleased to see an increased focus on resilience. We fully support the NIC's work to examine the interconnections and interdependencies between different sectors.

Key points from our response include:

- Interconnections with communication and power infrastructure networks are critical
- There are a number of areas where policy intervention could help deliver more integrated, multi-sector approaches
- We've submitted a 3 year resilience action plan as part of our draft determination response This can be found on our website: https://www.southernwater.co.uk/media/2746/resilience-action-plan-final-publication.pdf
- The water sector is heavily regulated and levels of service (over and above statutory duties) are determined by Ofwat's price review process which sets levels of investment, performance commitments, rewards and penalties
- Measures of service and levels of service have been determined by individual water companies as part of the price review process
- We generally find customers prioritise service levels over bill reductions, provided protections are in place for those customers who struggle to their bills. However, this customer preference is not always reflected in price control settlements
- The price review process needs to ensure customers' and stakeholders' wider expectations, and long-term resilience challenges can be met
- Common standards for research methods, evaluation frameworks and valuation of externalities across sectors could contribute to greater consistency of approach across sectors
- Water Resource Management Plans and Drainage and Wastewater Management Plans will play a critical role in ensuring the water and wastewater infrastructure can respond to future uncertainty.

We would be happy to provide more information about any of the points raised.

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

1. **What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?**

Interconnection with communication and power infrastructure network is critical for Southern Water. Drops in voltage or power outages can impact multiple utilities. Our services are also critical for energy generation, food production, housing development and numerous other vital industries and services. In many cases these are also connected with each other creating regional 'system of systems'.

We commissioned an independent report – Water Futures in the South East – which informed our understanding of global challenges and regional resilience. This identified 6 critical drivers for a resilient water future, those most relevant for this call for evidence include:

- Changing climate: to meet this we must view regional infrastructure as systems of systems
- Ecosystem thinking: there is a need for a more holistic approach to understanding the environment and how ecosystems are interconnected
- Collaboration redefined: applying ecosystem thinking at regional, city and local levels will become the new normal to deliver resilience and accelerate innovation
- Digital transformational change: conventional approaches can no longer guarantee resilience, adopting new technology such as AI will increase resilience

The full report can be found on our website – https://www.southernwater.co.uk/media/1844/water-futures-in-the-south-east.pdf

We agree it is critical to examine the interconnectedness and interdependencies between different sectors. A key concept within our systems of systems approach is the evaluation of infrastructure from a systems perspective by applying network and nodal consequence analysis at an asset, site, catchment, zonal and inter-zonal perspective. We would be happy to discuss this in more detail if this is helpful.

2. **What are the physical components of the digital network that should be mapped in order to assess the sector's contribution to systemic vulnerabilities?**

No comments

3. **Aside from those included in the last National Infrastructure Assessment, 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?**

- Better alignment of planning and regulatory cycles between different sectors
- Funding mechanisms which facilitate co-funded activities
- Longer term planning, e.g. moving to 10 year rolling investment plans, plus regulatory methodologies which fully recognise the value of resilience as well as affordability issues Nationally-led customer research should define the key areas for common targets, accompanied by long term aspirations and 10-year rolling targets in these areas
- Linking water industry aspirations and targets to national policy and legislative drivers on climate change and the environment (e.g. 25 Year Environment Plan)
- Reviewing tensions between the WRMP process, new regional water resources planning process and Ofwat's periodic review of price limits
- Improved join-up between interlinked policy areas, e.g. water, energy, agriculture
- Improved mapping of power failure/'brown out' risks and more detailed analysis of the potential cascade effect of loss of services on other services
- Testing emergency plans using multi-sector approach
    - inform where resistance resilience needs to be improved either by new infrastructure or via behaviour changes (e.g. water efficiency labelling/building standards).

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

Southern Water faces a broad range of risks to resilience including population growth, groundwater infiltration of networks, climate change, shocks to energy and food production cycles, compliance failures, and increased cyber-attacks.

As part of our PR19 draft determination submission we submitted a resilience action plan which contains a number of key deliverables for the next three years including:

- Delivering transformational programmes that address lessons learnt from past failures
- Deploying our systems of systems approach across all resilience areas to deal with interconnectivity and cascading impacts, improving overall resilience
    - To enhance our systems based approach, we've explored learnings from other sectors – particularly banking
- Fostering a culture though our leadership, training and communications that understands resilience and looks to anticipate, plan and prepare for resilience shocks and stresses
- Active management, monitoring and reporting of resilience across finance, corporate and operations
- Strengthening the governance and assurance of resilience controls to ensure they are deployed as intended

The action plan, which includes a short executive summary can be found on our website: https://www.southernwater.co.uk/media/2746/resilience-action-plan-final-publication.pdf

In addition to traditional 'resistance' resilience which is built, there have been improvements in understanding response resilience, for example:

- lessons learnt from the freeze thaw experiences by the water sector
    - https://www.water.org.uk/publication/learning-from-the-impacts-of-the-2018-freeze-thaw/
- collaborative Brexit no deal planning

There will be further lessons to learn from the review of the Whalley Dam breach and emergency response.

# Public acceptability of infrastructure services

5. **How are costs, benefits and public expectations balanced when setting levels of service?**

In the water sector (over and above statutorily guaranteed standards), both the measures and levels of service have been determined by individual companies as part of the price review process.

Typically companies conduct qualitative research, as well as drawing on operational data, to determine the key service areas for improvement. Stated preference surveys have then been used to determine customers' willingness to pay for improvements. Service levels are set at the point at which the costs of further improvements exceed customers' valuation of them. Public expectations

are assumed to be captured within the identification of the service improvement areas and willingness to pay for these improvements. In some cases, for example in determining leakage targets, externalities such as environmental costs and benefits are also incorporated in to the cost benefit analysis.

To some degree Ofwat has revised this approach for the latest price review (PR19) by determining a core set of 15 service measures for which all companies should set targets. By requiring companies to consider setting targets at the projected upper quartile level for the sector, Ofwat introduced a requirement for companies to consider comparative performance, as well as customer willingness to pay, in setting targets. It is not clear on what basis the common measures were identified by Ofwat, but it is reasonable to assume that public expectations were a key consideration.

We support the introduction of these core service measures. Historically, there has been much focus on the need to reflect regional differences in service expectations, by companies taking the lead in engaging with their customers to determine local standards. However, specific local issues aside, it is not clear that there should be significant variation in public expectations across the country.

It is important however, that these common measures of service, and the target service levels, are grounded in robust evidence of public expectations. We welcome Ofwat's recent proposal to conduct more sector-wide research of its own to identify public expectations of service.

It is also important that the costs of this levelling-up process are recognised in the price setting process. We generally find that customers prioritise service levels over bill reductions, provided the services remain affordable for most and protections are in place for those customers who struggle to afford to pay for essential services. This customer preference is not always reflected in price control settlements.

It's critical to give proper consideration to customer and stakeholder views – reducing customer bills is rightly part of the regulatory assessment. However, the process also needs to ensure customers' and stakeholders' wider expectations, and long-term resilience challenges can be met.

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

In principle, it makes sense to take a consistent approach across sectors in setting service levels. In practice, it is not clear that there are a set of measures which could be applied across sectors in a simple way. More realistically common standards for research methods, evaluation frameworks and valuation of externalities across sectors would contribute to greater consistency of approach. This could be achieved through a 'Green Book' type approach, with all regulators setting clear expectations around its use.

The approach to determining levels of service that we describe in question 5 above, relies on company-specific research into customer valuations. While this research captures trade-offs between service attributes within sector, there are two very clear shortcomings.

First, the level of variation of customer valuation for the same service attributes between companies is implausibly large, and would appear to reflect differences in research methods as much as customer valuations. In this respect, the use of common research frameworks should

begin to address this. In addition, Ofwat-commissioned research should ensure a common valuation approach.

Second, it fails to take account of potential trade-offs between sectors, as opposed to between service attributes within sectors. Therefore there is no understanding of whether customers would prefer to invest a pound in improving rail services as opposed to energy networks or environmental standards. This could be addressed through collaboration between regulators. As we note above, Ofwat has committed to carrying out more of its own research in future and this could provide a vehicle for beginning to explore these cross-sectoral trade-offs in conjunction with other regulators. Alternatively, there may be a role for regional planning groups of the type that are beginning to emerge to co-ordinate water resource planning.

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

We undertook significant customer research and stakeholder engagement as part of the development of our 2020-25 business plan. Resilience related issues were a recurring theme, with customers and stakeholders wanting Southern Water to invest now to ensure the same level of service for future generations. Key highlights from a specific piece of resilience research are below and we have sent the full report for information. We would be more than happy to talk through the findings from this and our wider customer research and stakeholder engagement programme.

**Key customer insights:**

- **Environmental and climate change concern**: Customers shared strong levels of environmental concerns and the desire for individuals to 'do their bit' to reduce environmental impact and slow down climate change. An awareness that climate change cannot be slowed in the short term, there was a desire to adapt to slow it down or meet its future challenges in the long term (e.g. providing water butts to help manage extreme precipitation and store water for non-essential use)

- **Address increasing population growth**: Against a backdrop of dramatically increasing population in the South East, customers expressed a desire for Southern Water and the Government to influence water usage through initiatives such as:
    - Compulsory water efficiency measures in home (such as rainwater re-use), products or systems in new build properties
    - More water efficient domestic appliances
    - Water product labelling

- **Technology:** Customers have faith emerging technology will be able to solve most problems

- **Educating about water use**: 'Water literacy and education' was a recurrent theme through most areas, with customers believing awareness and proactive education across society (particularly among younger generations) was essential

- **Water availability**: There was greater anxiety over the lack of water availability (e.g. drought or increasing population demands), as opposed to having too much water (e.g. extreme deluge). Customers believed that adapting to too much water is do-able, compared to not having enough

**Domestic customers expect Southern Water to…**

- **Be protective of the environment** (including the impact of an increasing population and climate change): Customers are aware of the risks to the environment and water availability due to climate change and demands from an increasing population. They expect Southern Water to enhance the environment and optimise recycling wastewater
- **Take proactive measures for future scenarios:** Southern Water should be proactive to reduce the risk of events (within its control) going wrong in the future, rather than being reactive to them.
- **Educate them in more engaging and frequent ways:** Customers compare water to electricity and remarked on how it does not appear to enjoy the same high profile and acceptance that resources need to be preserved and nurtured through careful use. They also do not know how to address problems or know what action to take to 'do their bit' to be more efficient
- **Be financially sensitive and considerate towards bill impacts:** Strong reactions to price increases when planning for the future, for reasons that differ in different regions: some opposed to price increases in principle as Southern Water is a private company, and others opposed due to low income and difficulty in paying water bills that are already perceived as being higher than other utilities.
- **Communicate more frequently and meaningfully with customers:** Customers want meaningful communications on topics that impact them or are of interest to them, as opposed to not wanting to hear from Southern Water at all. Also to raise brand awareness as a number of customers still thought of Southern Water as 'The Water Board'
- **Tailor their approach by region:** Customers across different regions might come to the same conclusions, however their rationale is often different

# Resilience governance and decision making

**8. What are the main policies, incentives, information flows and other national level decisions that affect the level of services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?**

The water sector is heavily regulated and levels of service (over and above statutory duties) are determined by Ofwat's price review process which sets levels of investment, performance commitments, rewards and penalties.

Alongside robust analysis of future challenges, in-depth customer research plays a crucial role in company decisions on level of ambition and how performance should be rewarded. It is critical to give proper consideration to customer and stakeholder views – driving down customer bills is rightly part of the regulatory assessment, but Ofwat should also ensure customers' and stakeholders' wider expectations are met.

The balance of rewards and penalties can influence company behaviour and has the potential for sub-optimal outcomes in some circumstances, e.g. very large penalties and small rewards could focus attention towards penalty avoidance and away from wider customer priorities.

## 9. How does the infrastructure system respond to uncertainty?

Our WRMP process models thousands of potential futures, uses 'real options' assessments and incorporates customers' and other stakeholders' views to develop resilient, flexible solutions which meet our regions priorities. This resulted in a triple-track approach (demand, supply, catchment solutions) to ensure our services are resilient to a one in 500-year drought – beyond the statutory minimum of a one in 200-year event and aligned with the strategic direction adopted by the NIC.

The new DWMPs provide the basis for collaborative and integrated long term wastewater planning by companies and other organisations with responsibilities relating to drainage, flooding and environmental protection. Aligning these with the price review process will help provide a clear framework for all parties to work within, and should help provide more certainty for investment. It would also be beneficial to have a common data source for all stakeholders to ensure consistency and common approaches.

## 10. How have system wide resilience challenges been addressed effectively in the past?

- The National Water Framework is a good example of long-term planning by regulators, water companies and regional water resource planning groups – this improved collective decision making and recommended adoption of a national drought resilience standard
- Regional water resources groups such as Water Resources South East are developing regional water resource plans which incorporate the needs of agriculture and other sectors
- We're working with Fawley Waterside and Ebbsfleet Garden city on multi-sector approaches to deliver resilient and sustainable new towns
- Ofwat's gated process for strategic water resources schemes has incentivised collaboration across water company boundaries
- The Greater Brighton Infrastructure Panel was established in 2018 to oversee the delivery of the Greater Brighton Energy Plan and Water Plan and ensure that commonality and overlaps are exploited to maximise benefits and minimise duplication of effort. The Panel has increasingly focused on the concept of delivering 'resilience in the round'.

# ICE response to the National Infrastructure Commission Resilience Study scoping report

## Executive summary

This response focuses on the three main questions outlined in the scoping report. It is informed by ICE's institutional knowledge, our engagement with the public through polling and the expertise of ICE members and Fellows.

A core issue with resilience is a lack of a systems thinking approach within the built environment sector which can, and must, be addressed.

If the National Infrastructure Commission is to provide recommendations and frameworks to the Government which will successfully improve resilience in the UK's infrastructure networks, key to this will be encouraging infrastructure owners to work collaboratively. They must give due regard to each other's assets and how these operate within a wider system. Crucially, more emphasis must be placed on the fact that services rely on each other to operate and can be affected in a multitude of ways if one link in the chain fails.

This response supplements and should be read in conjunction with our evidence provided to the Commission in April alongside the Royal Academy of Engineering.[1]

## Recommendations

1. The infrastructure sector must place an emphasis on systems thinking, whilst adopting common approaches and frameworks that better share lessons learnt.
2. Working with polling organisations and other experts, the Commission should explore what levels of public knowledge exist around long-term resilience and what information would be necessary to garner public support for investment to meet long-term need.
3. Regional infrastructure strategies should be developed across England that consider resilience as a fundamental part of infrastructure planning and delivery.

## What are the systemic issues that make infrastructure vulnerable to current shocks and future changes and how could they be addressed?

The root concern when it comes to addressing current and emergent systemic vulnerabilities in infrastructure is a lack of systems thinking within the built environment sector itself.

Individual infrastructure assets do not exist in isolation and, to a higher or lesser degree, should be considered interdependent. Interdependencies occur for two main reasons. First, because one infrastructure asset or network will place demands on another, and second, because increasing demand, due to demographic shiftsand economic growth, or changes in technology, will increase one assets dependence on another[2] or create new demands which need to be met.

The electrification of heat and transport could result in demand on electricity consumption almost doubling by 2050.[3] A shift to renewable power, without adequate investment in battery and other forms of storage, is inherently less reliable than the energy mix in the UK today. Intermittent generation will require enhanced support for energy storage and other emerging technologies. This will ensure resilience for renewable energy generation, whilst providing alternatives to back up power generation.[4]

[1] National Infrastructure Commission (2019) Resilience Study Consultation responses - Royal Academy of Engineering and Institution of Civil Engineers Response to the Resilience Study Scoping Consultation
[2] ICE (2016) National Needs Assessment
[3] Ibid
[4] ICE (2018) State of the Nation 2018: Infrastructure Investment

A siloed approach does, however, permeate the sector. This means that individual asset vulnerabilities and risk management approaches are well understood, but systems resilience, and how infrastructure assets interact, is not. There is a lack of emphasis placed in the infrastructure space on communication and collaboration between infrastructure sectors, little retention of knowledge and barriers which undermine the ability to share best practice or institutional insight. This limits the ability to identify and exploit synergies and restricts the effectiveness of infrastructure as a system, or indeed, adds costs to the creation, operation and decommissioning of infrastructure assets.

## Cascade failure

A cascade failure is the knock-on effect of the failure of one or more assets on others connected to it. A breach in a flood defence wall during a storm may lead to the flooding of energy assets located in a flood plain, something which will likely become more prevalent as floods and winds become more severe and frequent, due to climate change.[5] That failure of the energy grid will then impact other assets. Rail lines might lose power, stranding trains, pumping stations might fail, exacerbating the flooding situation and electronic communications might be knocked out, complicating any recovery efforts.

The summer 2007 floods caused in excess of £3.2bn of economic damage and there was a "threat of power blackouts at the regional scale." Of the £3.2bn total costs, power and water utilities accounted for around £330m and communications and roads accounted for between £230m and £330m.[6] More recent flooding events have also had economic impact, with those in 2013 to 2014 costing some £1.3bn[7] and latterly those in the winter of 2015 to 2016 £1.6bn.[8]

A lack of a systems thinking increases both the likelihood and severity of any cascading failures which might occur as a result of an incident. This is because little planning may have gone into contingency, methods of avoidance, or rapid recovery.

A recent real-life example is the incident of the 9th August 2019, when a combination of a lightning strike and two power losses from generating facilities led to widescale disconnections from the national grid. Whilst most connections were restored relatively quickly there was an acute effect on rail services, which were disrupted for around 24 hours as up to 30 trains could only be restarted on site by an engineer.[9] Rail infrastructure which is more adaptive or had plans in place for wholesale power loss might have onboard battery back-up for either restarting engines or traveling short distances without direct grid power, as in the example of the Bombardier Talent 3 Locomotive.[10]

## Potential methods to address systemic issues

A lack of coherent systems thinking is a core concern to be overcome but steps can be taken in the short-term to address immediate issues.

### Identifying and utilising multiple lines of defence

Finding a method of responding to and learning from catastrophic failure was a core concept of ICE's 2018 report *In plain sight: assuring the whole-life safety of infrastructure.* This report recommends an approach to addressing failure which adopts multiple lines of defence. This "Swiss Cheese Model" mitigates against risks which could permeate inherent weaknesses in any system. It relies on analysis of the causes of failure, identifying how to reduce that risk and illustrates how apparently unrelated and often small errors in different parts of a complex system can combine to create catastrophic failure.[11]

ICE recommends an approach which breaks down lines of defence to knowing, applying and ensuring. This framework includes 13 individual lines of defence, including an understanding of asset condition, a framework for incident reporting, the installation of suitably qualified and experienced persons, independent scrutiny and assurance.[12] This principle could be applied on a system wide basis as much as to an individual incident or asset.

[5] Climate Adapt (2019) Flood defence framework for National Grid substations in United Kingdom (2019)
[6] Environment Agency (2010) The costs of the Summer 2007 floods in England
[7] Environment Agency (2016) The costs and impacts of the winter 2013 to 2014 floods
[8] Environment Agency (2018) Estimating the economic costs of the 2015 to 2016 winter floods
[9] Ofgem (2019) Technical Report on the events of 9 August 2019
[10] Bombardier (2019) Realise your vision with Bombardier TALENT 3 BEMU
[11] ICE (2018) In plain sight: assuring the whole-life safety of infrastructure
[12] Ibid

## The role of technology and common approaches to defining resilience

The growing importance of digital technology to the design, operation and maintenance of assets will provide data and automation for better decision-making and more efficient management. Digitally enabled infrastructure will also produce more opportunities for easier communication between infrastructure owners and classes in real time, supporting service delivery at peak times or at moments of disruption during incidents.[13]

Ensuring that there are common approaches to the recording, management and language around resilience will become increasingly important and will simplify cross-sector understanding and co-operation.

## The need for an integrated approach

Building contingency and resilience between infrastructure assets and sectors must be a key focus going forward. This can be achieved by fostering co-operation, collaboration and opportunities to better understand interdependencies. As with any process of transformation in culture, there will need to be focal points and actors willing to lead or be tasked with ensuring integration.

One way of achieving this is through the development of regional infrastructure strategies across England that consider resilience as a key driver of infrastructure provision and delivery. This is discussed in more detail on page four of this response.

# What does the public expect of infrastructure services and how should their views be considered in decisions about resilience?

ICE welcomes the Commission's contracting of a social research project to better understand the publics expectations of infrastructure resilience as set out in the consultation document.[14] There is a lack of research in this area and ICE hopes this will inform the debate around user expectations of levels of service and infrastructure resilience.

Whilst ICE has not conducted public polling or engagement work specifically on resilience, ICE has conducted polling on public attitudes to infrastructure performance, willingness to pay, and the public's desire to be informed.

The public have an appetite to learn more: over 60% of the public think there is not enough information about infrastructure and that more information about the benefits of specific projects would make them more interested in infrastructure.[15] In a separate poll, 61% of adults stated they would like more information about how public money is spent on UK infrastructure projects.[16]

The public are generally favourable about the impact infrastructure has and would like to see more invested. More than three quarters, 79%, of the public support the notion that infrastructure helps the national economy[17] and 75% of adults believe that more money should be spent on improving the UK's core infrastructure networks.[18]

There is, however, a disconnect between the cost of investment and the benefit derived which results in the public being unwilling to pay more. Some 59% of GB Adults would not be happy to spend more money on household bills even if it meant better utility services.

Sustained investment will be needed over the coming decades to ensure that infrastructure provision and levels of service do not fall. This will inevitably come from the public, either in the form of higher taxation or bills for the use of infrastructure networks.

In order to make the case for more investment there will need to be additional engagement with the public. They are willing to learn more and are responsive to arguments which link investment to benefit. ICE set out in a paper earlier this year that ministers should talk more about the benefits of major infrastructure projects, rather than the costs, a statement which 74% of the public agree with.[19]

[13] ICE (2019) What should be in the National Infrastructure Strategy
[14] National Infrastructure Commission (2019) Resilience Study scoping report
[15] ICE/Copper Consulting (2017) Independent survey of attitudes to infrastructure in the United Kingdom
[16] ICE (2018) State of the Nation 2018: Infrastructure Investment
[17] ICE/Copper Consulting (2017) Independent survey of attitudes to infrastructure in the United Kingdom
[18] ICE (2018) State of the Nation 2018: Infrastructure Investment
[19] ICE (2019) Reducing the gap between cost estimates and outturns for major infrastructure projects and programmes

ICE believes the disconnect might be down to the time lag between payment and delivery of infrastructure. Infrastructure can take decades to plan and deliver to meet resilience needs which may only become apparent in decades; a relatively intangible timescale. Working with polling organisations and other experts, the ICE recommends that the Commission explore what levels of public knowledge exists around long-term resilience and what information would be necessary to garner public support for investment to meet long-term need.

Whilst communicating this is a task for the infrastructure sector and its advocates as a whole, ICE believes the Commission is uniquely positioned to make this case to Government. It is critical that investments are linked to benefits and that there is a joined-up plan for infrastructure provision which draws the public in.

## Individual and community resilience

There is an interplay between user expectations of service and what is delivered in actuality. Levels of resilience can also be increased by the public themselves provided they have proper information. Those at greater risk of flooding can be enabled to provide their own contingencies with advice, for instance, by moving electrical sockets higher up the wall, installing stainless steel kitchens or using waterproof plaster, which increases resilience and reduces time for a home to recover.[20] Well communicated action plans in the event of disruption to service can also ensure customer expectations are managed and lessen the severity of these incidents or the need for emergency response.

Decentralisation of provision can also boost resilience and reduce the severity of network issues. Household generation and storage of power on a large scale would reduce dependence on the mains grid, whilst localised urban drainage and greywater recycling schemes could reduce the impacts of flooding events and the need for additional water supply.

The location of infrastructure should also inform resilience. Rural infrastructure has less in the way of redundancy if an asset fails than urban infrastructure. Any framework the Commission develops should be responsive to local needs and consider what can be done to enhance resilience in rural settings, including considering decentralised alternatives to national or regional networks.

# What changes to governance and decision-making could improve current levels of resilience and ensure future challenges are addressed?

Changes to governance and decision-making structures are needed which will support and entrench systems thinking in the planning, delivery, operation and recovery of infrastructure assets and systems. Governance of recovery responses and cross-sector collaboration is often fragmented.

First, there must be a consistent commitment by planning, advisory and decision-making bodies in considering resilience as a fundamental part of their process. There has been a lack of consistency in the past, with the ICE recommending to the Infrastructure Commission for Scotland, (ICS) that they include, in their key strategic drivers, the need to consider resilience as "a primary driver… understood within a systems context."[21] The OECD believes that, in the specific example of resilience to climate change, there are a number of barriers which can prevent climate-resilience planning, including long time horizons, uncertainty about the future, a lack of information and capacity, policy misalignments and externalities. If decisions do not benefit the economic case, are beyond the time horizons of decision makers, or incentives are distorted, resilience can be overlooked.[22]

Second, planning should be conducted at multiple geographic scales, including, crucially, at a regional level. Regional infrastructure strategies should be developed across England to ensure effective integration of networks.[23] More localised plans offer the potential to identify synergies and overlapping resilience dependencies in regional economies. Greater alignment of budgets, funding streams and programmes at the regional level for economic and social infrastructure would also contribute to greater productivity and more efficient use of resources, tying together planning and delivery.[24]

[20] ABI (2017) A guide to resistant and resilient repair after a flood
[21] ICE (2019) ICE submission – Infrastructure Commission for Scotland's Call for Evidence
[22] OECD (2018) Climate-resilient Infrastructure
[23] ICE (2019) What should be in the national infrastructure strategy?
[24] ICE (2019) State of the Nation 2019: Connecting Infrastructure with Housing

## About ICE

Established in 1818 and with over 93,000 members worldwide, the Institution of Civil Engineers exists to deliver insights on infrastructure for societal benefit, using the professional engineering knowledge of our global membership.

# Resilience Shift response to the National Infrastructure Commission Resilience Study Scoping report

The following response has been prepared based on the work undertaken by the Resilience Shift since 2017 which comprises research, development of tools and approaches, case studies, best practice reviews and convening events around the world to engage and inspire a community of practice.

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

***1. What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture?***

There are considerable differences in the types of governance across infrastructure sectors, that can affect the systemic vulnerabilities of physical infrastructure. For example, the Resilience Shift (RS) Ports and Logistics round-table discussion[1] highlighted fragmentation in governance/decision-making across individual ports and between other ports and, rail and road infrastructure.

In terms of global good practice, the RS round-table in Christchurch, New Zealand, highlighted that the electricity company in the city had gained trust and confidence from others through its swift response in being able to restore service following major earthquake events[2]. This had been the result of prior investment and planning.

***2. What are the physical components of the digital network that should be mapped to assess this sector's contribution to systemic vulnerabilities?***

Based on our current work, we are not placed to provide comment on this.

***3. Aside from those included in the last National Infrastructure Assessment, 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?***

RS work on the role of public policy[3] for critical infrastructure resilience highlighted several key challenges for infrastructure policy that include:

- Cross sectoral policy integration.
- Coordination across levels of government.

[1] https://www.resilienceshift.org/publication/resilience-shift-round-table-ports-and-logistics/
[2] https://www.resilienceshift.org/publication/round-table-christchurch/
[3] https://www.resilienceshift.org/wp-content/uploads/2019/04/ResilienceShift-Role-of-Public-Policy-FINAL-1.pdf

- Political and economic case for long-term investments – particularly valuing the contribution of one infrastructure system to another.
- Optimal balance of public and private involvement.
- Integrating with existing infrastructure.

Infrastructure policy needs a high degree of coordination and integration across sectors and jurisdictions. It needs to be flexible and dynamic, to be able to deal with considerable future uncertainty and be able to respond to changing circumstances, for example, demographic change, climate change or technological change. The increasing body of evidence of the effects of changing climate highlight the threat of future shocks on infrastructure systems, which are already subject to stresses on many fronts.

A policy learning approach is critical for '*wicked problems*'[4]. This would include fostering the capacities of policy actors to innovate and experiment with new mixes of policy instruments, monitor and learn through policy implementation, circulate and share those experiences, and consult locally on how different policy lessons might or might not apply.

Recommendations from RS work include the following potential adaptive policy mechanisms[5]:

- Trigger points into regulatory frameworks
- Staging implementation of economic instruments
- Creating policy sand boxes to allow for regulatory innovation.

In sectors where regulation is lightest such as Ports, the wider strategic role for society is less well integrated into their operation than where regulation is tighter, such as water. However, regulation by sector only leads to a lack of appreciation of the interdependencies between sectors. We believe this was evidenced in the RS Ports and Logistics round-table discussion[6] and RS work in the water sector[7].

The City Water Resilience Approach[8] (CWRA), co-developed by RS with the Rockefeller Foundation, SIWI and Arup adopts a holistic thinking approach. This recognises the importance of governance, and how this can impact the resilience of infrastructure systems. The development of the OurWater[9] tool, as part of the CWRA has enabled a developed understanding of the governance of critical infrastructure for the city of Cape Town.

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[4] Defined as those that are complex, unpredictable, open ended, or intractable. Source: https://www.researchgate.net/publication/275573005_Wicked_Problems_Implications_for_Public_Policy_and_Management
[5] https://www.resilienceshift.org/publication/role-of-public-policy/
[6] https://www.resilienceshift.org/publication/resilience-shift-round-table-ports-and-logistics/
[7] https://www.resilienceshift.org/activities/water-influence/
[8] https://www.resilienceshift.org/campaign/city-water-resilience-approach/
[9] https://app.ourwater.city/

The RS Technical Advisory Group[10] prepared a round-table summary insights paper, that is currently under review with the *Institution of Civil Engineer's Engineering Sustainability* journal. This paper draws a conclusion that methods for coordinating across sectors should be more widely adopted beyond existing emergency management measures. RS work on the role of legislation provides an example of this in Australia, related to the Emergency Management Amendment (Critical Infrastructure Resilience) Act 2014, in Victoria[11].

Short-term thinking can be a blocker to a lack of investment in infrastructure resilience, evidenced in the RS primer on Potable Water Resilience[12]. Other issues identified from the Potable Water Primer include:

- Resilience dividends are typically achieved over the long-term, while costs that are required to implement resilience tend to be in the short-term.
- Resilience can be eroded by efficiency and economy drivers, that again results from a short-term thinking approach.
- Single driver upgrades can be a challenge to holistic thinking. For example, there is a lot of current focus on climate change risks however, there should also be an awareness of other risks that may affect the infrastructure systems e.g. demographic change.

More could be done to incentivise infrastructure operators and owners to improve the management of interdependencies within and between sectors. This will ultimately support improved levels of service within and between sectors. Potential mechanisms for this could include knowledge sharing, building cross-sector understanding and increasing interaction between stakeholders.

A challenge for critical infrastructure is breaking down silos within and between infrastructure sectors. The infrastructure lifecycle value chain[13] is useful for connecting the concepts of resilience and value across the different parts.

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

Infrastructure sectors are evolving in various ways in terms of their approach to resilience. RS resilience primers[14] covering the *potable water, electric utilities, road and rail, and ports* in different geographies point towards a current significant focus on climate-related risks across infrastructure sectors. As mentioned in the response to question 3, this could lead to reduced action for other hazards and risks.

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[10] https://www.resilienceshift.org/approach/partners/

[11] http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/f932b66241ecf1b7ca256e92000e23be/857F6CE338E5719ECA2582F0000DFBC9/$FILE/18-036aa%20authorised.pdf

[12] https://www.resilienceshift.org/publication/resilience-shift-primer-potable-water/

[13] https://www.resilienceshift.org/approach/value-chain/

[14] https://www.resilienceshift.org/publication-category/resilience-primers/

The language used across infrastructure sectors can sometimes get in the way of clear communication and determination of what is effective. For example, '*risk*' and '*resilience*' are sometimes used interchangeably. The case study outlined in the RS role of legislation report[15] provides evidence of a move from a risk mindset to a resilience mindset in practice, through a change in thinking from security to recovery from all hazards, and from a move towards exploring scenarios with unidentified causes through simulation exercises.

The case study of DC Water's assessment of the resilience of its water system in the District of Columbia, USA is an example of an effective approach. Their analysis of resilience went beyond purely the physical infrastructure assets, which is often the focus of most assessments, to considering the effect of this infrastructure on the local communities and people. Working with the city of Washington, DC they considered the impact of the water infrastructure on city assets, including both physical (e.g. hospitals) and conceptual (e.g. tourism) assets. These city assets were considered critical for people's lives and needs to be protected.

**Public acceptability of infrastructure services**

***5. How are costs, benefits and public expectations balanced when setting levels of service?***

An observation made from the Christchurch[16] and the City-scale modelling[17] round-tables is that there is currently not enough communication with communities about agreeing what is an acceptable expectation for the resilience of infrastructure systems.

***6. 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?***

Based on our current work, we are not placed to provide comment on this.

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

Resilience takes several forms and can be expressed in different ways. Typically, it is characterised by robustness, adaptability, redundancy (duplication), and rapidity. A New Zealand telecoms company has changed its policy from acceptable level of reliability from 99%+ to 'always on' which has resulted in a change to its strategies for service provision. This does not necessarily have to apply to other sectors, such as roads. This is evidenced in recovery scenarios where some services are fully or at least partially restored more quickly than others.

The concept of asset criticality is a relevant consideration. The nature of the community affected is also relevant. This is discussed in the RS Christchurch round-table report[18] around the lessons for

[15] https://www.resilienceshift.org/publication/role-of-legislation/
[16] https://www.resilienceshift.org/publication/round-table-christchurch/
[17] https://www.resilienceshift.org/publication/round-table-city-scale-modelling-report/
[18] https://www.resilienceshift.org/publication/round-table-christchurch/

infrastructure resilience learnt from the reconstruction of Christchurch following the 2011 earthquake.

There is a lot to be learned from cities or regions that have experienced crisis, and what the public response was. Community resilience is not separate to infrastructure resilience, and often communities can pull together to lessen the impact of a disruptive event. In defining what the public think is tolerable, context is an important factor, and tolerance is unlikely to be hazard agnostic.

Lesson's from Cape Town's Day Zero crisis show that trust in the government is essential, and clear communication. It would be interesting to explore the link between public tolerance of disruption and information provided in advance.

**Resilience governance and decision making**

***8. What are the main policies, incentives, information flows and other national level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?***

Based on our current work, we are not placed to provide comment on this.

***9. How does the infrastructure system respond to uncertainty?***

Our infrastructure policy work has identified that there is a current need to develop adaptive policy to cope with uncertainty (see response to question 2 above). The RS Potable Water primer[19] has identified the following approaches:

- *Dynamic Adaptive Policy Pathways Approach*[20], developed by Deltares in the Netherlands. This approach allows the user to develop an adaptive plan that is able to deal with deep uncertainty.

There would be value in exploring further the application of adaptive pathways to other sectors, noting that this is most relevant to climate change. We are also aware of the American Society of Civil Engineer's Manual of Practice guidance on '*Climate-Resilient Infrastructure: Adaptive Design and Risk Management'*[21].

In the RS work on global food supply chains[22], a common theme that emerged was that of poor planning, including the inadequacy of national planning frameworks and their ability to offer operators flexibility in responding to market and demand changes quickly. Fragmented governance was also identified as a barrier to resilience, through non-transparent decision making and ineffective leadership.

[19] https://www.resilienceshift.org/publication/resilience-shift-primer-potable-water/
[20] https://www.deltares.nl/en/adaptive-pathways/
[21] https://ascelibrary.org/doi/book/10.1061/9780784415191
[22] https://www.resilienceshift.org/wp-content/uploads/2019/06/Supply-Chain_main-report_V2-1.pdf

Part of the issue for understanding uncertainty in infrastructure systems, as evidenced by RS work on resilience tools and approaches, is that potential users (e.g. infrastructure operators and owners, and government) find it difficult to find appropriate tools to help them measure resilience. Moreover, the co-benefits of resilience are often too broadly defined and difficult to measure. The Electric Utilities primer[23] identified that resilience should be part of procurement (from funding through to the execution of work). However, this also revealed that energy utilities have a lack of near term funding for resilience activities, and limited guidance on and availability of consistent hazard scenarios (including climate change).

***10. How have system wide resilience challenges been addressed effectively in the past?***

Ensuring that infrastructure systems are delivered and maintained in ordinary as well as extraordinary circumstances is what we define as *resilience value*[24]. One of the biggest challenges for critical infrastructure is breaking down the silos within and between infrastructure providers and customers along the supply chain so that everyone is focused on delivering resilience value where they can.

We have found that an infrastructure value chain is extremely useful for connecting the concepts of resilience and value in the context of the infrastructure lifecycle that will be familiar to everyone working on the design, delivery, operation of infrastructure systems. RS work has identified the challenges that users face in implementing tools and approaches to help them to understand resilience value and systemic risks[25]. Tool developers and users are often disconnected and building a community of practice is required. Moreover, this identified that there is currently difficulty in articulating the challenge that tool users are trying to answer.

RS work on the role of public policy[26] has drawn out a number of case studies that highlight potential mechanisms to increase the resilience of infrastructure systems. These include:

- **Public-Private Partnerships** that highlights how changes in PPP structures and processes are grappling with the policy challenge of how to best allocate risk to enable resilience.
- **Transferable Development Rights** that highlights how changes in land use planning frameworks are trying to resolve market failures arising as properties become more hazardous under climate change.
- **Rating Tools and Technical Standards** that highlights how above-compliance holistic sustainability rating schemes are evolving to incorporate resilience into infrastructure projects.

[23] https://www.resilienceshift.org/wp-content/uploads/2019/07/RP_Electric-Utilities_Final.pdf
[24] https://www.resilienceshift.org/approach/value-chain/
[25] https://www.resilienceshift.org/publication/resilience-tools/
[26] https://www.resilienceshift.org/publication/role-of-public-policy/

- **Complex Systems Modelling** that highlights how investments in collaborative research networks and complex systems modelling is generating new knowledge about infrastructure interdependencies.

The case study of DC Water (see question 4 response) represents an approach that has considered resilience beyond purely the impacts to the physical asset and has included the wider social impact and setting of infrastructure systems in terms of the service that they deliver.

The RS report on the role of legislation in critical infrastructure resilience[27] has focused on the Emergency Management Amendment (Critical infrastructure resilience) Act 2014 implemented in Victoria, Australia. Some key aspects of the Act itself include:

- Participation in a **resilience improvement cycle**.
- Annual submission of a **Statement of Assurance** that identifies emergency risks and specifies risk mitigation actions.
- A requirement to develop, conduct and evaluate annual **simulated emergency exercises**.
- Establishment of **Sector Resilience Networks** to promote collaboration and knowledge sharing between the Victorian Government and infrastructure owner/operators.

[27] https://www.resilienceshift.org/publication/role-of-legislation/

## About the Resilience Shift

The Resilience Shift exists to inspire and empower a global community to make the world safer through resilient infrastructure. More people than ever depend on critical infrastructure systems. Our aim is to ensure infrastructure systems are able to withstand, adapt to, and recover quickly from anticipated or unexpected shocks and stresses - now and in the future.

Supported by Lloyd's Register Foundation and Arup, the Resilience Shift provides knowledge and tools for those responsible for planning, financing, designing, delivering, operating and maintaining critical infrastructure systems.

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# IET response to the National Infrastructure Commission Resilience Study Scoping Report – further call for evidence

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

1. **What systemic vulnerabilities in the UK physical infrastructure network arise from its network architecture? Examples of systemic vulnerabilities that originate from the structure of the network at a system level, including the physical and virtual connectivity of assets (but not individual assets themselves) within and between sectors.**

Most of the UK's physical infrastructure was engineered many decades ago and in ways that recognised only the interdependencies that were relevant at that time. The systemic challenges are where significant changes in demands and use have occurred.

Examples are:

1) New vulnerabilities such as changing weather patterns from climate change and increased risk of cyber-attacks and increased disruption of systems interruptions.

2) New use cases such as the electricity system moving from a centralised to a distributed architecture without changing its underlying systems engineering and systems architecture.

3) Digitisation, which creates interdependencies that are invisible to traditional planning and operating tools, as well as increasingly becoming a large emitter of CO2 (e.g. data centre proliferation), and an increased dependence on different raw materials (e.g. lithium and cobalt) which can go unnoticed.

4) Societal changes, including reliance on internet service, including the internet as a platform for physical systems such as point of sale systems in shops, or cash machines, often without an understanding of potential cascade effects or in-built resilient functionality.

5) Other vulnerabilities as society has changed to embrace digital and the internet, for example people no longer carrying significant amounts of cash, or storing food at home, and the consequences of decades of reliable infrastructure service meaning that many people either do not have alternatives or the skills to develop alternatives to infrastructure service (e.g. open fires).

6) Fragmentation of infrastructure value chains, leading to accountability issues and also an inability to take a systems perspective. This also creates challenges for market coordination with the risk that markets might send conflicting signals or fail to exploit whole-system synergies.

The clearest account of the impacts of the various interdependencies is in the *Living without Electricity*, report an account of the flooding of Lancaster in 2014 which caused a significant power outage.[1]

[1] https://www.raeng.org.uk/publications/reports/living-without-electricity

**2. What are the physical components of the digital network that should be mapped in order to assess this sector's contribution to systemic vulnerabilities?**

The physical components of the digital network which are based in UK – the mobile phone masts etc. obviously need to be mapped but so too should those elements which are not within the state. The network of undersea data cables, particularly the trans-atlantic ones are a point of vulnerability. Fibre optic cables need to be mapped and protected both at their landing sites within the UK as well as along the cable length.

The prevalence of sat-nav systems underlined the importance of satellite communication. Space has already been identified as a battle-ground of the future. Satellites are susceptible to both malign interference and natural occurrences such as solar storms.

Data centres are another key element in the digital network which need to be identified and protected. As high consumers of electricity (with their demand only increasing) these are very vulnerable in the rare event of an electricity failure. However not all are necessarily within the land borders of the UK. For instance, the Republic of Ireland is an important centre for these installations.

The digital network always relies on the energy systems which feed them so that as the electricity system becomes more reliant on renewable resources the reliability of inter-connectors to neighbouring countries is also a factor to be considered.

**3. Aside from those included in the last National Infrastructure Assessment, 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?**

As electricity networks go through unprecedented changes with the integration of renewables and potential upcoming electrification of transportation and possibly heating, the levels of complexity and uncertainty that the system needs to deal with increase drastically. This raises two key issues:

- Linked to complexity: We need to ensure the current models (with assumptions mainly stemming from traditional operation of power systems with conventional synchronous generators) are able to represent the system behaviour accurately enough for very fast dynamic phenomena that occur in millisecond or even faster timescales.
- Linked to both uncertainty and complexity: With the increasing number of possible operating conditions due to intermittent behaviour of renewables as well as the possible increase in the frequency of extreme weather events, it becomes increasingly difficult to identify "worst case scenarios".

In general we need to ensure mechanisms are in place to predict and ideally prevent or mitigate the impact of blackouts, working across different sectors. This can be achieved by improving the mapping of the expected effect of loss of electrical supply as a function of time, not only on the electrical network itself but on other infrastructure also (e.g. transportation, communications, etc.) This can also help quantify the criticality of restoration processes that need to be in place to ensure the system is resilient.

The big missing piece is effective systems and system of systems engineering. We need to understand how our infrastructure systems are changing and reflect this into the design of all infrastructure investments. This needs to reflect complete individual infrastructures (ignoring

regulatory or ownership boundaries), and system of systems interaction between infrastructures. The systems need to include physical, virtual, commercial, regulatory and financial aspects so the consequences of decisions can be understood and extend to the point of end use within consumers' premises.[2]

It is essential that increased digitalisation is considered, and the points made in point 3 of question 1 are taken into consideration.

4. **How have the current approaches to infrastructure resilience changed over time in order to become more effective? Examples of good practice approaches to resilience that demonstrate how an organisation or sector has responded to significant changes including, but not limited to; technology, disruptive events and/or changing user demands**

National Grid ESO has recently finalised a consultation and produced an updated system defence plan.[3] In addition, they have recently run a request for information, called the stability pathfinder,[4] and have also identified system stability as the number one priority in the recently published innovation strategy.[5] Finally, National Grid ESO is going through changes in the procurement process of black start services (related to restoration and consequently resilience) in order to include new technologies.[6]

Further examples would be how network operators have re-evaluated and responded to flood risk through modelling, increased protection / mitigation and response (as appropriate) in line with climate change indicators – this links back to the Lancaster example from 2014.

Network operators have also invested in increased infrastructure storm resilience (overhead lines) again linked to climatic changes.

Another example is also the ongoing accelerated industry loss of mains (LOM) protection modification project which is gradually responding to the risk of distributed generation tripping during frequency events

As and when it is delivered, an effective smart energy management (or metering) system will also provide greater clarity on energy usage trends enabling better targeted pre-emptive investment in infrastructure.

A large amount of work is underway to test options for addressing future EV charging demand to enable inherent flexibility to be better exploited and make greater use of renewable energy supply and limit network constraint impact

**Public acceptability of infrastructure services**

[2] https://www.theiet.org/impact-society/sectors/energy/future-power-systems-architecture/
[3] https://www.nationalgrideso.com/document/147666/download).[3]
[4] https://www.nationalgrideso.com/publications/network-options-assessment-noa/network-development-roadmap
[5] https://www.nationalgrideso.com/innovation/strategy
[6] https://www.nationalgrideso.com/balancing-services/system-security-services/black-start

5. **How are costs, benefits and public expectations balanced when setting levels of service? Examples of how each of these factors have been considered when setting a desired level of service, either as a requirement or a target?**

No specific comment

6. **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?**

We would argue that a consistent approach to delivering value should be applied to all energy sectors to ensure optimum whole energy system investment

At a national level, underlying all issues relating to resilience, are the cascade effects (some of which may be unforeseen) which are a feature of our digitally connected infrastructure. Progress is being made in developing target driven standards within the power sector but there needs to be an on-going framework established to identify and investigate cross-sectoral interdependencies so that they can be evaluated.

This dialogue needs to take place at many levels, both within Government and between sectors. In any disaster situation, the first response is always local. Scotland provides some interesting examples of how resilience is being planned at a local level. For instance, in Orkney there are several initiatives which illustrate how the energy systems of the future might look. The ReFLEX (Responsive Flexibility) Orkney project[7] is a Virtual Energy System (VES) interlinking local electricity, transport and heat networks into one controllable overarching system. Employing widespread use of battery systems – domestic, business scale and vehicle to grid, this experimental system operates within a local energy microcosm in which 10% of homes have micro-generation and electric vehicles are nearly 4 times the national average and there is an over-supply of renewable energy from the wind and tides. Hydrogen is also being produced via electrolysis using spare capacity from renewables.

Some suggestions for consistency of approach may be considered in relation to;

1. *Involve the public.* Just as in the cybersecurity sphere, there needs to be sustained public education campaign to highlight the importance of resilience. Within an energy context, the involvement of Community Energy bodies and the encouragement of micro-generation might also be considered.
2. *Set targets.* Standards with targets are being developed in relation to electric power generation. Cross sectoral standards with similar targets need to be produced.
3. *Build resilience at a local level.* The devolved Governments and regional administrations within England (e.g. at mayoral level) have to be included. Resilience needs to be considered at levels below national. At all costs the "house of cards" effect needs to be avoided and the national picture ought to be a group of semi-autonomous resilience areas.
4. *Diversity needs to be embraced*. The current Scotland Energy Strategy sets out hydrogen as an indicative scenario for the future. As we increasingly become more dependent on electricity the benefits of other means of power generation ought to be considered in the context of the built-in resilience within the system.

7. **How does the public respond to infrastructure disruptions and what is its appetite for making different sectors more resilient? Please provide evidence from direct public engagement which**

[7] https://www.siiscotland.com/orkneys-responsive-flexibility-project-reflex-orkney/

**demonstrates public tolerance of disruption and the appetite for resilience investment in the sectors covered by the study (energy, water, digital and transport). This includes, but is not limited to, outputs from willingness to pay surveys, focus groups and deliberative public engagement.**

No specific comment

**Resilience governance and decision making**

8. **What are the main policies, incentives, information flows and other national-level decisions that affect the level of the services delivered by UK infrastructure under normal operating conditions, as well as during emergencies?**

Each of the major UK infrastructures has a different ownership and regulatory model, which makes generalisation difficult. Having different regulators and separate departments have created a vast array of, often, contradictory requirements across the different sectors and segments of the economy. For example, the relationship between control of strategy for resilience of many of our utilities is across multiple regulators; Environment Agency, Ofgem, Ofwat, Ofcom, etc. The industry that serves these sectors then interpret the different regulatory edicts to their own advantage – not to the advantage of the infrastructure system as a whole. Resilience is a consequence of all of these different complex interactions and is not therefore planned but evolved by learning where the gaps are by failures in the system as they occur. The closed loop then reinforces the fragmented outcome by a regulator acting to plug the problem without understanding the root cause of the problem in the first place.

In the electricity sector performance under normal operating conditions is governed by a diversity of performance standards set by the regulator, codes administered on behalf of the regulator, and standards administered primarily by the network industry. Many of these are old and identify prescriptive ways to do things based on the systems and solutions of the past, ignoring better solutions now available. An independent review of engineering standards in electricity has been commissioned by BEIS and Ofgem and is currently under way.

During emergencies there is a long history of the electricity industry working together to restore supplies to affected consumers. However, there are very limited standards for resilience (such as time to restore supplies to different classes of load following a major interruption).[8] A consequence of this is that estimates of time to reconnect all consumers following the extremely rare event of a national blackout now exceed seven days, sufficient potentially to result in substantive social disorder.

9. **How does the infrastructure system respond to uncertainty? Examples of how uncertainty over a particular variable, such as the nature of an anticipated risk, has affected the level of resilience decision-makers choose to build into a system**.

The 9th of August blackout has shown that despite measures taken, the level of understanding of the potential outcome of a disturbance in the network can still potentially be limited under certain circumstances. Similar to the so called “never events” in medical treatment, entirely preventing blackouts might be extremely difficult, if possible, at all. However, the level of impact to the society

[8] SQSS and EREC P2/7 do stipulate minimum planning standards for supply restoration following an outage according to class (i.e. group demand) of supply (SQSS also has operational standards)

and how quickly the system recovers can be managed by closer communication between different participants of the same industry (power industry) as well as across different industries (rail).

There is also a concern that uncertainty, or rather a function of systematic risk assessment can compromise resilience at many levels. At each stage of the investment, planning, operational, maintenance and de-commissioning phases, a lowest cost mentality can mean resilience suffers as it is always more expensive to do an analysis of the whole system impact of decision making. There is a danger, if best overall value life-cycles are not used, that it a degree of uncertainty is manufactured rather being truly uncertain.

10. **How have system-wide resilience challenges been addressed effectively in the past? Examples of how different policies, incentives or decisions across a system have interacted effectively to address an identified cross-sector vulnerability and improved the resilience of the system overall.**

A flaw in the current approach is that there has been a lack of appetite for investment ahead of proven need – for example. resilience investment tends to be approved post-event, sometimes overly so as a knee-jerk reaction or way to appease stakeholders rather than based on risk assessment. Mitigating a 1-in-100-year event tends to be given low priority until it happens. However, changes (see response to Q1 above) are now meaning that 1-in-100 year events forming the basis of many standards and designs are occurring much more frequently.

If you wish to get in touch about anything in the consultation or discuss anything further, please get in touch with IET Energy Lead.

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