RESILIENCE STUDY

Consultation responses

NATIONAL
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COMMISSION

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Resilience Study Consultation
National Infrastructure Commission
Finlaison House
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Dear Sirs,

Labour Market Resilience Inclusion within the Resilience Study Scoping Consultation

Thank you for the invitation to contribute to your study on the resilience of the UK's economic infrastructure, as commissioned by the Chancellor on 29 October 2018. This letter is to inform the scoping stage, and is in addition to the meeting of Sir John Armitt and the 28 utility Chief Executives and Managing Directors comprising the *Energy & Utilities Skills Partnership* in 2018, and my follow up meeting with Katie Black, Director of Policy, and subsequent labour market resilience rationale submission on 1 October 2018.

All of these engagements urge the National Infrastructure Commission (NIC) to include labour market and workforce resilience within the infrastructure resilience scoping and main phase.

Simply put, without the quantity and quality of workforce available to deliver and maintain UK infrastructure at an affordable cost, resilience of the infrastructure itself is an arbitrary point. This is particularly true for the critical energy & utility sector, who are the largest single contributor to the National Infrastructure Plan (NIP) and who also underpin almost every other UK business sector with their supply of environmental infrastructure and essential services.

Myself and sector colleagues would be pleased to meet to discuss any areas or give more detail as required. I look forward to hearing from you.

Yours sincerely

Nick Ellins
Chief Executive

Comment on Terms of Reference

We cannot see how the NIC can coherently evaluate or judge the actions needed to improve the resilience of the UK's national infrastructure with the existing terms of reference explicitly excluding the security of the supply chain and the UK's withdrawal from the European Union. Both areas are critical to current infrastructure resilience.

Supply chain

These mission-critical businesses are an embedded part of the infrastructure delivery model that builds and operates many of the UK's most vital assets, and their resources and expertise bring great innovation and cost saving.

They operate across multiple markets and multiple countries, and are not obliged to stay in the UK infrastructure market. They are at liberty to leave, or adjust their risk premia, should other business sectors or countries prove to offer lower risk or better returns or be more viable in the long-term. It is essential that the NIC does take into account the confidence and security of the supply chain when judging infrastructure resilience. These stakeholders are as crucial in judging infrastructure resilience, as in maintaining the confidence of financial investors.

The supply chain has no choice other than to work in the most sustainable and stable commercial environments. It is vital for UK customers' bills and service levels that these supply chain businesses see UK infrastructure as one.

UK Withdrawal from the European Union

This is crucial when considering every major aspect of infrastructure resilience including central and devolved government policy intent; market stability; policy affordability; regulatory approaches and financing decisions; City investment confidence; labour market resilience and the very operating model sustainability of the direct and indirect companies who deliver infrastructure for the UK economy. They are all impacted by the impending decisions over the withdrawal, including the ultimate affordability and needs of the UK's consumers and customers. To dismiss such a pivotal issue will leave the resulting study incomplete.

Consultation Questions

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

A1: We recommend that the NIC review the work of the water regulator Ofwat, where the subject has been studied in depth. This will also help to define '*resilience in the round'*, so that each element can be isolated and the optimal questions positioned.
https://www.ofwat.gov.uk/publication/resilience-in-the-round/

Ofwat advises that *"resilience in the round is about considering all aspects of resilience, including operational, corporate and financial resilience. Resilience is not just about outcomes and expenditure. It means making sure the right people, leadership, infrastructure, systems and processes, are all in place and working effectively".* **A key question for the NIC is whether UK infrastructure is resilient to the effects of UK labour market risks and workforce sustainability.**

The final methodology for the PR19 water price review (2020 to 2025) **enshrined workforce resilience** as a major component of its approach to 'resilience in the round'. The Ofgem RIIO-2 price setting process has just included **workforce resilience as an explicit requirement of overall resilience for energy**, in its Sector Specific Methodology consultations for the first time.
https://www.ofgem.gov.uk/publications-and-updates/riio-2-framework-consultation

Ofgem advises "*Resilience is not just about network assets: it is also about the people and processes put in place to build, operate, repair and maintain those assets, particularly when networks are under stress. Human resources with the right skills are essential to the safe and reliable operation of a network, without which the ability to deliver the services expected by customers would rapidly deteriorate."*

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study

A2: This response calls for the NIC to prioritise **labour market resilience** in the study.

Simply put, without the quantity and quality of workforce available to deliver the UK infrastructure creation and ongoing operation at an affordable cost, resilience of the infrastructure itself is an arbitrary point.

This is particularly true for the critical energy & utility sector, who represent the largest single contributor to the National Infrastructure Plan (NIP), and underpin almost every other UK business sector with their supply of essential services. We see no current evidence that the NIC can rely on the existing government labour market and devolved skills policy frameworks to protect infrastructure efficiency, productivity, workforce resilience and sustainability.

The UK labour market is at its most constrained since records began in 1975. HM Treasury describe the UK as "*at full employment*", with the Office of National Statistics reporting record high employment; record low unemployment; EU nationals working in the UK down; EU nationals emigrating up and the general costs of employment rising. We have been keeping the NIC briefed on these UK trends through the dashboard *'tracking the labour market towards BREXIT'*.

This ever tightening labour market position is all in addition to the well-known and recorded workforce challenges and skills gaps that already exist in the utility infrastructure environment.

With this tightening general labour market has come greatly increased UK-wide competition for the available talent. Currently, every major business sector in the UK is publicly reporting difficulty in accessing the skilled workers they need at a price they can afford. This is inevitably driving up employment costs, forcing efficient and competitive businesses to aggressively protect their human capital.

The environmental infrastructure sector – gas, power, water, sewerage and waste management/recycling - must therefore be able to compete effectively against other UK and European sectors, and needs to win the battle for talent, if it is to deliver its government and regulatory strategies, achieve the desired productivity, affordability and secure the levels of innovation and customer service needed.

We are calling on the NIC to conclude that the environmental infrastructure businesses do not have the policy and regulatory protection they need to access and retain a sustainable labour market. As the largest contributor to the £0.6 trillion National Infrastructure Plan, it seems logical that the NIC should wish to see environmental infrastructure utilities have optimum access to the labour markets and productivity.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies

A3: In considering labour market resilience barriers, there is currently no central guiding mind in the UK government for the labour needs of the sectors that are of critical strategic value to the UK. No coordinated workforce renewal and skills strategy exists for England, GB or the UK. Skills policy has been increasingly devolved to nations, local institutions and cities with no coordination between the elements, and what exists is primarily education based.

Utility employers' experience of the devolved system has shown that the four nations' policy makers are currently working in independent and often opposing directions, with no shared focus or any joint ambitions to ensure the infrastructure sector is protected. Whilst the new Industrial Strategy initially offered thinking in the round and stated clearly the priorities of sustainable 'infrastructure' and 'people', the sector's experience is that none of the proposed activity is targeted to enable, consider or deliver infrastructure or regulated utility outputs, and the solutions proposed are primarily focused in England alone. The clear labour market challenges the UK faces do not halt at the English borders, and 'thinking in the round' is now essential.

The environmental infrastructure utilities are also currently at a distinct disadvantage from those UK sectors that are currently receiving extensive financial and policy assistance on workforce resilience from central Government. Sectors such as rail, nuclear, construction (housebuilding), life sciences, nursing, automotive and others are all deemed to be sectors of strategic value, and have received extensive support from their sponsoring departments and central government.

Whilst not one of those sectors, or society itself, could function each day without the products of the regulated utility sector e.g. fresh water, sanitation, heat, light, power and waste management, it is not yet defined as a priority sector by UK government.

As the largest single contributor to the NIP, there is enough risk and potential market failure evident, for the NIC to embed labour market resilience in its study.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome

A4: Yes.

All of the basic policy and regulatory mechanisms to create and deliver a sustainable labour market strategy for the whole UK already exist in isolation. What is missing is coordination. The vast majority of the necessary stakeholders are also in place, but with no central coordination to guide their efforts towards one goal.

The general need for a resilient, skilled and sustainable workforce has increasingly been recognised by central and devolved governments, as a key challenge for all the main UK business sectors in a post-European business environment.

The UK Government Industrial Strategy does provide a working example of how sectoral interdependencies and barriers are intended to be overcome by unified action, across all agencies, stakeholders and business communities.

The Industrial Strategy already explicitly recognises ‘people’ as one of its five key pillars for action, and the vital nature of ‘infrastructure’ as another pillar. The two are deemed key to the future of the UK economy.

Whilst the Industrial Strategy has not delivered central and devolved government coordination or UK labour market resilience so far, the basic philosophy remains a mechanism that could address and overcome the sustainability challenge. HM Treasury has a major responsibility here, and needs to step up as a champion for coordinating infrastructure resilience.

Former Commercial Secretary to the Treasury, Lord O’Neill, previously advised: “It is crucial we have the right people with the right skills in place to build and maintain our first-class infrastructure, essential to rebalancing our economy.”

Vodaphone

Priorities for the next NIA/Resilience study

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

- What does the current resilience landscape look like across all sectors
- What should the future landscape look like.
- What are the sector differences

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

1. Power resilience requirements by sector
2. Telecoms future strategies and reliance on power

Resilience issues emerging from sectoral interdependencies

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

- There should be closer coordination between regulators so that regulations are fit for purpose in view of cross sector interdependencies. This should bring balance is the overall resilience maturity of all stakeholders.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

- Within the telecoms industry a Blackstart impact assessment was done.

Many Thanks,

[name redacted]
Business Resilience Manager

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Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

It is difficult to have a conversation on resilience that is uninformed by an appetite for risk. Building resilience into infrastructure has potentially huge cost implications. For example, a nuclear power plant is an expensive capital expenditure even in the most accommodating of circumstances. A nuclear power plant that is expected to withstand the impact of a commercial airliner can be exponentially more expensive.

Resilience is not an open ended concept. It needs to be bounded by an appetite for taking risk to ensure finite national resources can be used most efficiently to protect as much of the national infrastructure portfolio as possible. The government, therefore, needs to prioritize its critical infrastructure and offer a clear event threshold for which it expects critical infrastructure to continue to function. This means establishing national guidelines that build upon established civil engineering codes of practice to ensure that the government's appetite for taking risk informs spending priorities.

[name redacted]

Director, Infrastructure Risk Management

[contact details redacted]

ETI Response to NIC Consultation on Resilience

Introduction

1. The Energy Technologies Institute (ETI) is a public private partnership between energy and engineering companies and the UK Government which is able to draw on the business and engineering expertise of key global players engaged in the UK energy sector (ETI private sector members: BP, Caterpillar, EDF, Rolls-Royce and Shell)[1].

2. Over the past ten years the ETI has developed strong credentials in national energy system analysis, informed by the latest industrial and engineering expertise. This enables us to explore the lowest-cost decarbonisation pathways, under a range of assumptions, constraints and uncertainties. Our analysis has been widely cited by academics, government and by the Committee on Climate Change in its advice to government.

The ETI's Natural Hazards Project

3. In the absence of documented and easily accessible methods for characterisation of the full range of hazards relevant to the UK, the ETI commissioned a three-phase project delivered over 5 years by a consortium led by EDF and including Mott MacDonald and the Met Office. The project outputs included a series of documents describing good practice methods of natural hazard characterisation with demonstration through accompanying case studies. These documents and the associated review processes were rigorous; the outputs are hosted on the websites of the I Chem E and I Mech E[2] and are freely available to organisations, individuals and industry. This consultation response concentrates on the learning from this project.

Consultation Responses

4. Question 2; what issues should be prioritised? The vulnerability of infrastructure to natural hazards should be one of the priorities. The need for the ETI project was based on the lack of accessible good practice including the characterisation of the various causes of flooding. This suggests that there are likely to be unknown latent vulnerabilities in the UK's existing infrastructure. In particular, the impact from space weather and hazard combinations are likely to be least well understood. In addition, vulnerability is expected to change with the impact of global warming and associated climate change.

5. Question 3; are there barriers to addressing resilience? The lack of available and user accessible documentation was recognised as a barrier by the ETI in 2013. The ETI sought to make progress against this barrier. Operators of assets and systems together with owners, insurers and regulators might have the opportunity to use consistent language and methodologies based on recognised and peer reviewed good practice. Intellectual property transfers are planned to enable these documents to be updated in the future based on further research and methodology demonstration.

Response prepared by Mike Middleton, Strategy Manager for Nuclear at the ETI. 14th March 2019.

Questions in response to this submission should be addressed to Mike.Middleton@es.catapult.org.uk

[1] https://www.eti.co.uk/about
[2] http://www.imeche.org/policy-and-press/energy-theme/enabling-resilient-uk-energy-infrastructure

Submission to National Infrastructure Commission's

Resilience Study Scoping Consultation

– A Response from Resilience First

Introduction

In response to the NIC's Resilience Study Scoping Consultation, Resilience First offers the follow submission for consideration.

Question 1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

- *The true meaning of resilience in the national debate*. There is a primary need to state and explain what resilience means in the context of the study. There is a plethora of existing definitions of resilience: this presents a constant problem of understanding and interpretation. Resilience is commonly viewed as a return to the status quo ante, and frequently misses the point of the inherent need to adapt or evolve over the long term in the light of the new circumstances. In any debate on national resilience, adaptation is key as many of the systemic challenges or disruptions cannot be avoided but need to be managed and mitigated. The study should put a clear stake in the ground on a full and clear interpretation of resilience if it is to present a meaningful response.

- *The importance of long-term sustainability and competitive advantage over short-term profitability*. With five-year political horizons but multi-decade infrastructural demands then a key issue is how to square this particular circle. Gaining consensus that survives the electoral process and international issues requires broad, cross-party consensus on national goals. The conundrum also applies to business where bottom-line margins are often more operational than strategic. The issue of how we become more strategic in our planning is a crucial question if we are to remain competitive as a nation and make business as a whole more sustainable – to survive and thrive.

- *Operationalising resilience*. Resilience can only work if the strategies and policies at the top end can be interpreted at the lower end. All the modern infrastructure in the world will not automatically make a nation resilient. (See also comments below on people and communities.) The plans and policies need to be translated into language that can be commonly understood and processes than can be universally applied. However, both need to be adjusted for small, medium and large organisations – where needs are very different – but can be placed on a common platform. This key question is therefore how to gain acceptance of, and traction with, resilience for a multitude of different 'users'.

- *Comparison with (and lessons from) other countries*. We tend to think we are the best but there are many ways of tackling a problem and other countries have stolen a

march, often because they face larger and more frequent national challenges or disruptions than the UK and/or they can make better use of resources in national programmes. We should learn the good practices and be willing to adapt our methods in that light. The question is what is best in class.

Question 2: **On the basis of your response to Question 1, what issues should be prioritised in the resilience study?**

- *Measuring resilience and priorities*. In order to manage, one needs to measure: this is true also of priorities. Resilience is not an easy capability to assess but there are tools that facilitate it on a qualitative rather than quantitative basis: there is no absolute level of resilience. Some degree of measurement could allow various responses to be assessed and compared in the face of challenges such as climate change, pollution, flooding and drought (reverse sides of the same coin). Such measures would then be able to contribute to discussions on, say, the value of a building a strategic water pipeline or the benefits of siting multi-modal transport hubs. It could also be used to improve the recovery from national or area blackouts based on the location of key assets rather than technical switching protocols.

- *Generic frameworks v risk matrices and registers*. Because of the wide and growing range of challenges, as well as their intensity and frequency, it is becoming more difficult to adopt a resilient stance to separate risks. There are also the unknowns. There is therefore a need to shift to a more general or threat-neutral position, one that covers all stops across a broad horizon scan. Generic frameworks, with common and holistic responses, could be easier to understand and apply. Hence, a useful priority for the study could be an examination of what constitutes such frameworks.

- *The importance of people and communities*. It is said that London is not a resilient city because of its infrastructure – it is resilient because of its people. Populations and their culture and collective experiences contribute to national resilience in a significant way: people in Dhaka are more resilient to flooding than those in London, for instance. Therefore, it would be worth exploring in the study the role of people and communities in both absorbing the challenges and adapting to change when looking at infrastructural needs. Resilience should adopt a whole-population approach. Business communities, and factors that binds them, are the bedrock of national resilience and should be the foundation of any wide-area, long-term planning.

- *The role of regulation and legislation*. While government is reluctant to regulate and legislate, there is a clear requirement when it comes to protecting the national infrastructure i.e. ensuring our national security. On the one hand, there appears a reluctance of politicians to claim authority for the state to introduce tougher protective measures by law or regulation in ensuring national security. (CPNI is only remitted to address physical threats from terrorism.) On the other, there appears a reluctance of the private sector to accept responsibility and liability for national security. This is in spite of around 80% of the critical national infrastructure being in private hands. Consequently, it leaves the partnership without clear lines of responsibility or

accountability. This needs to be addressed if we are to avoid confusion in planning and protecting our long-term, infrastructural needs.

- *Mapping interdependencies*. The ever-increasing complexity of inter-relationships and inter-dependencies in national, regional and local functions makes it very difficult to follow any silo-based recovery processes. The mapping of these cross-sectoral relationships has begun but it is at a rudimentary stage and much more needs to be achieved. This could and should be a key priority of the study.

Question 3: **Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?**

- *Failing to adopt the Fusion Doctrine*. In the Foreword to the 2018 National Security Capability Review, the Prime Minister talked of a new Fusion Doctrine 'to improve our collective approach to national security, building on the creation of the NSC [National Security Council] eight years ago so that we use our security, economic and influence capabilities to maximum effect to protect, promote and project our national security, economic and influence goals.' Both the public and private sectors are listed in that doctrine. This laudable aim is regrettably not yet matched by actions to achieve its goals. The issue of national resilience should be part of the doctrine as it affects national security. In fact, national resilience provides deterrence against external threats i.e. the more prepared we are, the more we can proactively resist malign threats or trends.

- *Lack of co-ordination by government departments*. When it comes to dealing with major incidents or disruptions which threaten our wellbeing and infrastructure then there is a need for greater co-ordination between organisations and capabilities as, together, the public and private sectors would be much stronger i.e. a force multiplier. There is a need for greater central co-ordination e.g. a minister and ministry for civil defence/protection that could muster the resources of various departments in time of national need or planning ahead. The remit of the CPNI could also be expanded to include a wider interpretation of resilience and the ways of protecting the critical national infrastructure from a range of challenges.

- *Limitations of Civil Contingencies Act 2004*. The CCA, now 15 years old, is designed to bring together parties concerning with civil emergencies. The Category 1 and 2 responders in the Act could well be expanded to include a third category that involves more businesses connected with the sustainability of the national infrastructure. Business will play a large part in any national civil contingency.

Question 4: **Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?**

- The 'Anytown' project organised by the London Resilience Partnership has usefully tried to map out the interconnections of services and utilities in London.

- The Energy Research Partnership has produced a good report on the future resilience of the UK electrical system.

National Infrastructure Commission | Resilience study scoping consultation

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

There are two key questions that BT would like the National Infrastructure Assessment to answer about resilience

- Could a clear concise guidance statement be provided for the Communications Sector (Fixed and Mobile providers) about expectations around providing adequate levels of resilience

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

BT would like the three risks listed below prioritised in the resilience study, these risks currently have the potential to cause major impacts to the Communications Sector (Fixed and Mobile providers) and the UK's Critical National Infrastructure

- Loss of mains power on a National or Regional scale (Blackstart type scenario) including resilience/protection to prevent loss, notification of blackstart events, priority restoration as well as back-up generator fuel supply and security of assets
- Security Attacks (Cyber or Physical) to the Critical National Infrastructure of the UK
- Surface Water Flood Risk to Critical Infrastructure Assets (Power & Communications) including alerting and notification of risk/threats.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

- BT has experienced difficulties when engaging with other Sectors (Power Gas & Water) at a National UK level to address and resolve BAU issues, resilience issues and cross-sectoral interdependencies (examples below)
- Restoration of power to damaged street cabinets
- Preserving the supply of water for BT cooling infrastructure (i.e. adding to tier 2 utility/cat 2 responder categorisation) such as for data centres, fixed, access and mobile networks that underpin CNI and potential impacts to society
- Raising the priority of repair to events such as burst water mains flowing into BT infrastructure such as for data centres, fixed, access and mobile networks that underpin CNI and potential impacts to society

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

- BT has engaged with individual power and water companies to resolve BAU issues, resilience issues and cross-sectoral interdependencies
- BT are unaware of a National UK Forum were BAU issues, resilience issues and cross-sectoral interdependencies can be highlighted and addressed
- BT would suggest that the UK would benefit from a National Strategic Group where Utilities/Category 2 Responders engage to discuss issues and interdependencies that have the potential to impact the multiple sectors or the UK's CNI.
- Regular cross sector discussion and representation from the groups listed below would be beneficial to overcome BAU issues, resilience issues and cross-sectoral interdependencies and barriers to resilience issues.
    - Water UK
    - Electronic Communications Resilience Group (EC-RRG)
    - Energy Networks Association (ENA)
    - Emergency Executive Committee (E3C)

KCOM

KCOM response to the National Infrastructure Commission resilience study consultation

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

As technological developments progress at pace, the supply chains and the general population of end users are becoming increasing dependent on this technology, much of which is underpinned by our national infrastructure, the supply chain of this technology is becoming increasingly complex and deep.

Increasing the resilience of infrastructure does increase the costs to end users either through the cost of the service or through general taxation, whilst failure of infrastructure does incur costs to society in general which can be difficult to fully evaluate.

Is the balance of cost and risk to society appropriate for our future national infrastructure?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

It is becoming increasing difficult to map out the dependencies and as this acceleration of technological development continues any mapping work rapidly becomes outdated.

We believe therefore that at least four elements need to be considered in more detail

1) A continuous and detailed study of all infrastructure failures or near misses with potential cascade impacts so that lessons may be identified and factored into future deployments.
2) More education to end users, so that they are more aware of their dependencies and may better prepare for any catastrophic or cascading failures.
3) A debate or discussion as to how systemic tests could be conducted, testing of individual elements is often conducted but the full impacts of a complete system breakdown may never be realised without a periodic real test, however even a test could have severe impacts and may not be palatable, therefore an agreed methodology may be needed, or different testing scenarios with a view to gaining a more comprehensive picture of interdependencies and vulnerability.
4) The appetite for end users to be able to fund any improved future national infrastructure resilience or accept the risk for the period of the infrastructure lifecycle.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

As mentioned above the main barrier is knowledge, with increasing depth of the supply chain and related interdependencies, knowledge of the resilience of the whole supply chain is limited and once gained is quickly outdated as technological developments continue at pace.

Whilst resilience may be designed in systems and services, the increasing complexity of the technology means that it is increasing challenging to test the designed resilience systemically (which should include the human/techonology interface), without causing real impacts to society.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The Communications industry has had continuous and regular engagements both with its supply chain and end users, this has been facilitated by industry organisations individually and also as part of collective engagements, which are often supported and promoted by lead government departments, such as the Electronic Communications – Resilience and Response Group (EC-RRG), which is supported and promoted by the Department for Digital, Communications, Media and Sport (DCMS), with the support of DCMS, engagements with other government bodies has been also established . Other engagements have been via Local Resilience Fora, conferences such as the Electric Infrastructure Security Council, promoted by Lord Toby Harris and the engagement with the National Grid and their investment plans (RIIO2 et cetera).

The Communication industry via the EC-RRG continues to seek to foster closer working relationships with other National Infrastructure organisations.

NATIONAL INFRASTRUCTURE COMMISSION

RESILIENCE STUDY SCOPING CONSULTATION

INFRASTRUCTION ASSESSMENT INTITIATIVE

[name redacted]

COMIT PROJECTS

Q1. *What are the key questions that the next National Infrastructure Assessment should answer about resilience?*

As we look into the future of the UK, it is generally agreed that we must better understand and have a more positive effect on the society in which we live. As we look at Maslows hierarchy of needs, the provision of infrastructure to supply water, food and homeostasis are essential for society to exist and thrive. The resilience of this infrastructure and our ability to understand how that will impact on society I would feel is critical towards our national survival and growth.

The monetary value of an asset and its impact on the regional, national and global economies can be relatively easy to measure, but this economic value may not have any bearing on its value to society.

In my opinion and many others, I interact with, the current NISMOD methodology is complex, difficult to access and requires significant data to carry out. This prevents/ reduces its use by local authorities and infrastructure owners who are reluctant to spend time and money on training staff, conducting the data collection and analysis and effectively managing the outcome.

Therefore, my answer to question one is a set of questions aimed at teasing out this type of value:

1. What is our current ability to recover from National Infrastructure difficulties quickly?
2. What can be done to improve our ability to recover even faster?
3. What should be the consistent simple methodology for mapping each infrastructure sector and at what level should we assess each sector down to (to deliver maximum value)?
4. What should be the consistent simple methodology for mapping across sectors, whether they are parent/ child or interdependent relationships?
5. What should be the consistent simple methodology for defining National Infrastructure criticality, vulnerability, recoverability and societal impact.
6. How can we simply and consistently quantify, measure, monitor any impact on society?
7. How do we create a simplified, standardised, consistent, cross sector network model that will not only show impacts and relationships but analyse each for their resilience?
8. Who will own and maintain, secure and access such a network model once its complete?

The answer to the above questions will allow the UK to prioritise and fund the protection and recoverability strategy for our critical national infrastructure.

Q2. *On the basis of your response to question 1, what issues should be prioritised in the resilience study.*

A significant portion of the work in how to map infrastructure and define its criticality, vulnerability, recoverability and societal impact has already been done through engagement between CPNI, Government Departments and Industry. The UK armed forces are also using rapid assessment and analysis tools to assist in resilience assessment and disaster recovery in many locations around the world. As you would expect these methods are simple yet powerful in carrying out these tasks. There are multiple examples of this that have already been done.

In my opinion one of the most significant tasks for UK resilience would be to quantify, measure and create the ability to monitor the impact of each asset (and to define what level of granularity) in the cross-sector network on local, regional and national society.

This can have many factors which create a complex set of information variables; for example, a relatively low value water pumping station may provide clean water to a big proportion of a city or the exact same asset in a different location may provide it to a few thousand homes. Those in the city have no way of gathering fresh water from natural resources, but may be able to purchase bottled water, which can be transported in along another piece of infrastructure. So, the financial value might be the same, but the social value may be vastly different based on many different factors.

Secondly and one might argue more importantly is that the expertise to conduct cross-sector analysis from a resilience perspective (other than NISMOD) is missing. The utility of a simplified method as used by the military would allow wide-scale disaggregation of the analysis, allowing more cross sector collaboration to occur.

Q3. *Are there specific barriers to addressing resilience emerging from cross sectorial interdependencies?*

Having been exposed to most of the major infrastructure owners around the world and specifically their asset information management during both CAPEX and OPEX phases of the lifecycle I can see the barriers to addressing these falling as follows:

1. Mandating any National Infrastructure Recoverability Attributes will take political, managerial and monetary resources.
2. Each individual organisation records different information about their assets with different methods of measurement and definition. This is an interoperability nightmare when we need to combine information from across sectors in times of national disaster.
3. Most Infrastructure is privately owned and therefore specifically directs their functional/ performance monitoring information towards economic targets. These targets are restricted to what benefits them or their shareholders.
4. Commercially they only know that their electricity is supplied by X or that the communications is supported by Y. They don't necessarily (need or want to) understand which substation, power line or transformer delivers it or what those suppliers rely on to uphold their delivery.
5. They have little or no concept of how their infrastructure impacts society on a local, regional or national level.
6. Once a database of the "hubs and connectors" across all sectors has been established this will cause its own two issues:
    a. Keeping this up to date and ensuring information is kept accurate and unpolluted. (as soon as information is deemed untrustworthy stakeholders are less likely to want to rely on it.
    b. Some of the data model will contain highly sensitive information that in the right hands can be used to make significant decisions around UK infrastructure, but in the wrong hands could be used to destroy the very thing we wish to protect. Data security and controls will therefore be key strategically.
7. Culture and history: Each organisation will have their own way of doing things and will declare that they've been doing it the longest and their way is best. They will then argue that everyone else must do it the way they do it. Before getting them to change or do additional work a significant barrier must be overcome in dealing with the culture and attitudes of the

organisations. Removing these barriers by delivering an “outsider” solution that is already proven, is simple and will cost them nothing to educate their staff will be essential.

I feel that having a Nationally Recognised simplified approach will help to resolve all of the issues listed above.

Q4. *Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?*

The CARVER analysis methodology has been used since ww2 to help analyse the importance of assets in conjunction with military targeting. The method was reversed and updated by the Royal Engineers to form the basis of their “Infrastructure Assessment” methodology designed to assist in the relief efforts of countries after natural disasters. Helping to map out the cross-sector infrastructure and identify the priorities of efforts aimed at stabilising society and helping them to recover. Most recently this was conducted in Nepal after the earthquake and the British Virgin Islands after hurricane Irma hit. The methodology is documented into a standard operating procedure and taught in a 2 to 5 day course by 170 (Infrastructure Support) Engineer Group.

This proven methodology starts with identifying key assets, creating a link matrix for each sector down to the agreed level, creating a network diagram before carrying out a Criticality, Accessibility, Recoverability, Vulnerability, Effect and Recognisability study and analysis.

This single sector assessment is then brought together with other sectors and a interdependent cross-sector analysis is conducted.

The final report identifies areas of concern that are critical to national infrastructure, where vulnerabilities lay and what planning needs to be put in place to increase resilience.

A demonstration project was recently conducted using a waste water treatment plant as a microcosm of national infrastructure, as it contained interdependent “hubs and connectors” from Transport, Water, Communications, Power, Sanitation, Fuels and Chemicals. This study was conducted in using permissive and non-permissive data gathering techniques, to demonstrate what could be achieved in a disaster zone that was too hazardous for humans to be present.

The non-permissive team used autonomous technologies, open source data and their cross-sector infrastructure knowledge to deliver a full analysis of the site within 48 hours. This analysis closely matched the permissive team apart from a few minor differences. This pilot case study can be viewed on the COMIT website, who provided many of the technology partners for the assessment.

This proven approach could be easily scaled up to deal with UK infrastructure, taught to each of the sectors to ensure consistency and then brought together in a nationwide resilience database.

Case studies, briefings and details can be provided on request.

Contact details:

Author: [name redacted]– Digital Infrastructure Advisor (COMIT lead)

Methodology lead: [name and contact details redacted] - Officer Commanding, 527 Specialist Team RE

National Infrastructure Commission – Resilience study scoping consultation 2019
Response to consultation from Suffolk Public Sector Leaders

Email responses to: resilience@nic.gov.uk by 1st April 2019

Suffolk Public Sector Leaders (SPSL) was formed in 2009 to consider issues of strategic importance to Suffolk and is supported by the Suffolk Chief Officers Leadership Team (SCOLT). SPSL welcome the opportunity to comment on the NIC consultation for a study to examine the resilience of the UK's economic infrastructure and agree that the NIC could add the most value by focusing on cross-sectoral, systemic and long term issues. We also welcome the approach to consider the full range of economic infrastructure including: transport, energy, water and waste water, flood resilience, digital connectivity and solid waste.

Recognising the format of the consultation and the page limit to responses the key points we would like to make are given below. We would welcome the opportunity to discuss this consultation in more detail with the NIC and contribute to the work as it develops.

Q.1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

(i) What is the **capacity for modal shift**, e.g. from road to rail or rail to road; in times of infrastructure collapse? Should this be considered alongside a **national strategy for the distribution of freight**? With the Port of Felixstowe receiving over 40% of the UK's containerised imports and handling nearly one-third of containerised exports we need a **transport network,** not just a road network, that is resilient.

(ii) The NIC should review how resilience on transport networks can be improved through the **re-instatement of redundant infrastructure**. For example, what is the benefit of improving rail routes that were previously double tracked but currently operate as single lines?

(iii) What is the relationship between energy generation / distribution, the increasing shift to electric passenger / small goods vehicles and the provision of improved road networks? And related to this question what **impact does geography have in terms of resilience, thinking specifically of an urban / rural split**? The 2018 assessment recommends Government support for a network of a single rapid charger in areas of 20,000+ population – this minimum level captures only **seven** centres of population in Suffolk, roughly half the total population. **Reliance on private transport in rural areas** is, however, of increased importance relative to urban areas as there is significantly less public transport available and our services (education, training, employment, health, social) tend to be concentrated in our main towns. From a resilience point of view the NIC should address the extent to which individual points are uniformly accessible to all drivers.

(iv) The all energy coast, located along East Suffolk and into Norfolk, generates and distributes a significant proportion of all the UK's energy, and with the move towards more electricity needed for transport and home heating it is even more critical that our facilities are both invested in and the coast is protected. This energy generation is against a backdrop of having 12% of households in Suffolk living in fuel poverty. How can we ensure we have **a resilient energy generation network AND can make access to energy more affordable / efficient for all**?

(v) In considering improvements to and expansion of all economic infrastructure the next NIC assessment should also consider the **ability of the UK labour market to respond to this need** and ensure we have the right training provision / skill sets across the country. What can be done to ensure NSIPs can be delivered against the national Government timelines without displacing labour from regional / local residential and industrial development?

(vi) While recognising the difficulties of agreeing a single definition of resilience, we believe the NIC should work to **refine the definitions** currently used across the range of national / supra regional infrastructure providers and operators to ensure there is a high degree of consistency and scale in what is considered by each.

Q.2 On the basis of your response to question 1, what issues should be prioritised in the resilience study?

SPSL believe all the questions we have put forward should be considered, but if resources are constrained we would like to see the priority given to considering the resilience of the **transport network** (road and rail) and the modal shift that could be accommodated should any one part of the network (passenger, freight or aggregates) fail.

In Suffolk we are working to develop integrated transport solutions across modes and routes. We need to see a greater balance of investment in our strategic and major roads alongside increased investment to maintain and expand our local road network while also improving passenger and freight rail services. Investment in the A14 and upgrading the Suffolk stretch of the route to Expressway status alongside improvements in the rail network are critical if we are to remain resilient at the local / regional level.

Q.3 Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

The provision, operation and maintenance of the UK's economic infrastructure are not straightforward and hence there are a number of barriers to addressing resilience.

There has been improvement in aligning investment plans, e.g. RIS 2 from 2020-2025, CP6 from 2019-2024, Anglian Water Assessment Management / Drought plans 2020-2025 and we welcome this; but more can and should be done to work across organisational boundaries, their geographies and across providers.

At a local government level we need to see greater coordination between Government departments, e.g. DfT, BEIS, Defra; in their decision making and funding of infrastructure at a regional level. We need to see greater co-ordination at national level that is reflective of the NSIPs being put forward and their resulting needs and impacts. For example greater consideration should be given to the impacts of NSIPs on the transport network during the construction phase with planning starting sooner and funding packages for local areas agreed.

Electric vehicle use in place of petrol and diesel equivalents is set to experience strong growth over the next 20 years and the UK government continues to encourage this trend through actions in support of '*The Road to Zero – next steps towards cleaner road transport and delivering our Industrial Strategy'.* A shift towards decentralised, low-carbon electricity production is accompanying this but the extent to which these trends are coordinated, particularly with respect to electricity grid resilience, is less obvious. Our region is highly network-constrained and the trend to

electrification in transport and other sectors (such as home heating) will place greater emphasis on the resilience of this network, particularly in rural areas.

In terms of knowledge there needs to be significantly more work done on digital connectivity; the threats we face (individuals, organisations, businesses) from cyber attack; and the awareness of how / when to upgrade or maintain services. Other types of infrastructure delivery is matched by wide-ranging public awareness and education campaigns – e.g. a license to drive and rules on how to use the roads; but at a national level we have largely left digital communications up to the individual to work through and ensure their own safety.

The NIC assessment should lead on ensuring all data can be shared between these regional groupings without additional cost being borne by the Local Authorities and minimising the need for duplication of effort in maintaining an up to date evidence base to use for prioritisation and investment decision making.

Q.4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

There is a wealth of academic, national and international research on infrastructure resilience of which the NIC will be aware and likely consider in this study. We would expect the NIC to begin by looking at all UK Government work on resilience for example, Highways England's resilience mapping of the SRN through route strategies.

As Local Government Leaders we will stress that greater consideration must be given to the relationship between national investment in infrastructure – a central government decision; and regional / local growth needs – managed at the regional / local level.

In the widest sense of an infrastructure system we will not be able to demonstrate resilience if long term national investment is not more evenly distributed across all regions, both rural and urban; and more fully integrated with local investment planning and decisions.

Matthew Hicks
Leader Suffolk County Council

Response to National Infrastructure Commission's Resilience Study Scoping Consultation by Filip Babovic, PhD.

In response to questions 1 and 2:

Generally speaking, there is a consensus with regards to the sort of threats economic infrastructure systems may be exposed to in the short-to-medium term future. These threats encapsulate rising sea levels, technological change, and more extreme heat waves. However, there is disagreement surrounding the rate at which these trends will arrive and their magnitudes. This disagreement is largely due to the uncertainties surrounding how these trends will develop over time, and how other factors will co-evolve in response to these changes.

The future conditions to which the UK's infrastructure systems could be exposed to contain a variety of uncertainties, these uncertainties stem from both epistemic and stochastic sources.

To address this, the planning and design of new infrastructure must ensure a degree of future proofing, allowing infrastructure to easily and rapidly adaptation to changing conditions. By future proofing newly built or existing infrastructure, the UK's infrastructure can deliver maximal value for money and support economic growth despite the uncertain future that is being faced. This future proofing is especially needed in the realm of telecommunications and "smart infrastructure" where cycles of technology development are particularly quick.

This future-proofing can be promoted with the adoption of more robust design criteria or by building more flexible infrastructure. Developing more robust implies that elements of infrastructure are oversized so that they can operate effectively under a wide range of conditions. Alternatively, flexibility allows for infrastructure to adapt to changing conditions over time by taking advantage of options designed into the infrastructure system.

Both methods of future proofing require higher levels of investment into infrastructure components that may never be used. For example, flood defence levees may be built higher and wider in order to make them more robust; however this increased maximum height may never be fully utilised. Alternatively, highways may be built with the ability to quickly add or remove a lane which is also an option may never be used.

In order to meet its goals the NIC must promote future proofing. To support this, the NIC needs to push for evaluations of return on investment (ROI) to reflect the uncertainty surrounding the future, as single, deterministic, projections are not appropriate foe the world we face. The NIC will also need to make recommendations about what RIO metrics reflect this uncertainty so that designers can act accordingly, for example, the value at risk. By having to ensure that infrastructure performs across a range of futures infrastructure designers will modify their designs using whatever future-proofing method is most appropriate.

NIC resilience scoping study consultation

Q1. What are the key questions that the next National Infrastructure Assessment should answer about resilience?

a) What is resilience? It can be defined in a very narrow way, that is the resistance of infrastructure to stress, so that action to improve resilience is also narrowly focussed. This, however, may miss the wider elements of resilience, including avoidance and recovery. Avoidance can be important, for example, where a particular infrastructure element is dependent on other infrastructure, a common instance being the dependence of a pumping station on grid electricity. Avoiding this dependency by, say, installing a local generator, improves resilience. Equally it may be more cost effective to accept occasional infrastructure failure but have a really good system in place to recover. It would be useful to learn how different infrastructure providers are approaching resilience. There is a danger that by taking a too narrow view the most cost-effective approaches to improving resilience may be missed.
b) How is resilience measured? What metrics do different infrastructure providers use to measure resilience? Is resilience monitoring used as a means of driving improvement?
c) How well is the relationship between resilience and efficiency understood? To what extent has resilience been compromised (for example by the removal of redundancy) in a drive for infrastructure "efficiency"?
d) How well do we understand extreme events that might affect infrastructure? For example, the 2016 National Flood Resilience Review demonstrated that possible maximum rainfall events may have been underestimated by between 20% and 30% across the UK.
e) How well do we understand infrastructure interdependencies? For example, historic flooding events have demonstrated the cascading effects of progressive infrastructure failure. Infrastructure interdependency was highlighted as the most challenging aspect of infrastructure vulnerability by the 2010 Engineering, Infrastructure & Climate Change Adaptation Strategy Group.
f) To what extent do infrastructure operators engage with customers (end users) to manage resilience? What other stakeholders influence infrastructure resilience such as spatial planners and urban designers? To what extent are they engaged in building resilience?

Q2. On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Items a, d, e and c from the above list in that order of priority.

Q3. Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Resilience to flooding can be approached from many different angles and is governed by a wide range or responsible bodies and other stakeholders. Despite efforts by Defra and the Environment Agency (and its counterpart in other member states of the UK), there is a lack of a national framework for flood risk management with a common agreement on standards. This means that not all the measures to improve the resilience of communities are being exploited. In particular, the failure to implement "Designing for Exceedance" means that opportunities to improve the resilience of communities to surface water flooding in urban areas is being missed. This is due to the lack of a joined-up approach between water companies, local lead flood authorities and local authority drainage departments. Current plans to implement Drainage and Waste Water Management Plans provide an opportunity to address this however.

Q4. Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The Defra Round Table on Flood Resilience has brought together professional bodies, the insurance sector, contractors, consultants, and representatives of flood risk management authorities. This is a good example of cross sector working and has enabled good progress to be made on improving the resilience of the existing building stock to flooding. Demonstration projects have been successfully completed and new industry guidance is due for publication later this year. It is anticipated that this will play an important part in enabling affordable market led flood insurance to be delivered for property after the end of Flood Re.

[name redacted]
March 2019

Reference
NIC–0319

Date
28 March 2019

Cadent Gas Limited
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Coventry CV7 8PE
cadentgas.com

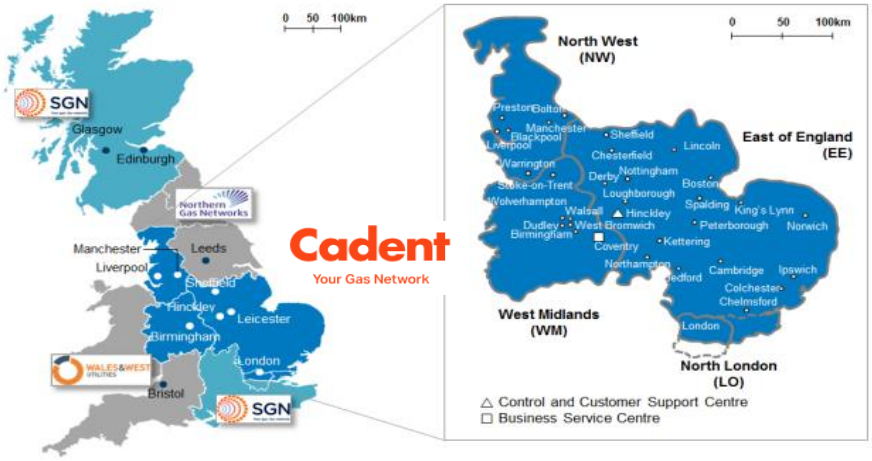
NIC Resilience Scoping Consultation- March 2019

Via email to resilience@nic.gov.uk
https://www.nic.org.uk/publications/resilience-study-scoping-consultation/
Deadline 1st April 2019

Cadent Response to NIC Resilience Scoping Consultation – March 2019

Cadent owns and operates four gas distribution networks in the UK, providing a safe, reliable and efficient network that transports gas to homes, schools, businesses from the Lake District to North London and from the Welsh Borders to the East of England. We serve 11m customers across this footprint and are the largest gas distribution company in the country.

Our size and scale ensures that we are a unique position to work collaboratively with the Government to shape policy which will reflect the critical importance of gas and the gas networks as the most cost-effective and efficient pathway for the country's transition to a low-carbon energy system.



Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Cadent has a Resilience and Security team sitting within its Corporate Security function which continuously monitors, reacts to and plans for a range threat vectors which could impact our immediate operational ability and our capacity to evolve as a fit for purpose business equipped to meet future energy demand. Below we have listed in order of importance (thus answering q.2) .

Network Resilience;

- Ensuring the operation integrity of our network for BAU and our ability to react outages, supply interruptions, surges in demand and 3rd party damage to our network.
- We have an ongoing relationship with the BEIS Energy Development and Resilience team which consists of information sharing and learning to ensure best practice response to incidents.

Security – threat vectors including;

- Terrorism
- Cyber threats
- Hostile state actors

We are actively engaged with both CPNI (Centre for the Protection of National Infrastructure) and the NCSC (National Cyber Security Centre)

ISS Project - We are currently part way through a project to hard our critical sites across our network footprint.

National security Project – this project is focused on the upgrading the infrastructure at the 2nd tier of importance across our network.

The future of gas;

- Supply; north sea, fracking, import
- The genetic make-up of gas and ensuring that our network is suited to transport this. Biomethane, SNG, hydrogen (both blending and in pure form)

Future Challenges;

- aging work force, skills gap, automation in the future

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

As detailed above.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Resilience Direct – this is a fantastic tool which has the potential to bring together best practice across industry sectors, but has considerable shortfalls. For example, at present the system is able to upload 10 megabites of typical schematics. This is limiting our capacity to engage more with the tool. We would welcome Government facilitating the upgrading of this tool so that is can be used more.

For more details please contact:
Emily Wilson-Gavin, External Affairs Manager
Emily.Wilson-Gavin@cadentgas.com

Department for Transport

Question 1 – What are the key questions that the next National Infrastructure Assessment should answer about resilience?

- How do we define resilience?
    - Do we mean the ability to bounce back quickly, provide redundant systems to reduce impact while an event is occurring or both?
    - Do we mean the resilience of overall systems in terms of keeping the country running or do we mean the ability to deliver services in a resilient manner to end users?
    - Are you interested in the resilience of infrastructure, services or both?

- What place does ministerial / departmental reputational risk play here?
    - If we are trying to be purist, then we shouldn't allow for reputational risk, and we would concentrate just on the systems.

- Which bits of resilience should HMG be involved with, and which do we leave to service providers?

- How well do we understand our current level of risk with regards to resilience issues?
    - What methods are available to measure existing risk?
    - How do we pull together our understanding from individual sectors to understand interdependencies?

- What level of resilience do we want to achieve and when do we want to achieve it by?
    - What level of resilience do different stakeholders want us to achieve (citizens, sectoral policy experts, security services, Cabinet Office etc.)
    - How do we set goals? Do we need to ensure resilience is improved by a specific time to link with external changes (climate change, 5G, political change etc.)
    - Who should pay, and how much?

- What are the boundaries between resilience and response planning; what are the boundaries between resilience and strategy? Can we export risks from the resilience space to strategic thinking?

- How could we identify future risks to resilience, score their likelihood/impact and where should we draw the line in terms of knowing how far to mitigate them?
    - How do we treat high-impact low-likelihood issues?
    - How do we treat low-impact high likelihood events taking into account that concurrently or frequently over a longer timescale they can have a high impact?
    - Do we understand how events in individual sectors can cause events in others? For example, are we aware of low impact events in one sector can raise the likelihood of high impact events in others?

- Would we like to be talking to the public about the high impact low likelihood events?
    - Do we know how? What about using unconventional means such as drama?

- What thinking has been done elsewhere that we can learn from (academia, foreign nations, private sector etc.)
    - How do we assess how valid work or thinking done elsewhere is correct or if it applies to the UK? For example, work done by another entity may apply to different political, climate or geographical realities.
    - How can we adapt work done elsewhere to suit our needs?

- How do we ensure that colleagues working on resilience issues are conscious of and acting appropriately to mitigate the risk of adversaries using the information collected and stored on UK resilience?

Question 2 – On the basis of your response to question 1, what issues should be prioritised in the resilience study?

- Developing a central understanding of what we mean by resilience.
- How we develop a consistent approach across sectors for identifying, protecting and improving resilience while respecting the bespoke nature of individual sectors and sub-sectors?
- How do we further develop our understanding of the interdependencies and supply chains between different sectors?
- Ensuring that there are processes in place to protect important data on UK resilience.
- Achieve a clear high-level understanding of the key resilience issues currently faced by the UK as well as what issues are on the horizon.
- Understanding the key external factors that affect UK resilience and are likely to affect it in the future.
-

Question 3 – Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

- Data security can make it difficult to share sensitive data between Government Departments.
- Different Departmental priorities and organisational structures can make it difficult to link up. This is sometimes made worse by organisational restructures and staff turnover.
- Within Departments, colleagues are often not aware of each other's work streams meaning that sometimes people are left out leading to a loss of important perspectives.
- Science and technology research on resilience matters is a particular area or capability that needs to be further developed and exploited within Departments, given that it is critical to identifying effective options to improve the resilience of systems.
- Different sectors have their own interpretations of resilience which can make it difficult to meaningfully connect on a common set of principles.
- From a security perspective, some colleagues do not have high enough security clearance to take part in discussions or view documents.
- In terms of staff workload and prioritisation, colleagues may need to focus their limited time on other issues judged to be more urgent.

Question 4 – Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

National Infrastructure Commission

Resilience Study Scoping Consultation

Background to CIWEM

CIWEM is the leading independent Chartered professional body for water and environmental professionals, promoting excellence within the sector. The Institution provides independent commentary on a wide range of issues related to water and environmental management, environmental resilience and sustainable development.

CIWEM welcomes the opportunity to respond to the National Infrastructure Commission on its consultation resilience priorities for the next National Infrastructure Assessment. This response has been compiled with the assistance of members from our Climate Change Network.

Response to consultation questions

1. **What are they key questions that the next National Infrastructure Assessment should answer about resilience?**

   As well as addressing issues in terms of resilience with insufficient, aging and outdated infrastructure or the lack of progress in new infrastructure projects, the next National Infrastructure Assessment should answer questions about the long-term climate resilience of current and future planned infrastructure projects.

   The latest projections from the Met Office under the UK Climate Projections project show that all areas of the UK are projected to experience warming and that there is a "greater chance of warmer, wetter winters and hotter, drier summers"[1]. Their highest emissions scenario signifies that the UK will likely require significant further adaptation. The UK needs an infrastructure system which is resilient to these changes in climate.

   The next NIA should answer questions about what work is required in order for UK infrastructure to be resilient to the latest forecast changes to our climate, the timetable required to implement any necessary changes, and which bodies should facilitate this work.

[1] Met Office. 2018. UK Climate Projections.

2. **On the basis of your response to question 1, what issues should be prioritised in the resilience study?**

   In addition to transport, energy, water and wastewater, and digital communications infrastructure, we would advocate resilience of urban development and coastal infrastructure should be a priority area for the next NIA. Urban development is particularly sensitive to increases in heat which are already being experienced and projected to become more frequent as the climate changes.

   The Committee on Climate Change (CCC) have recently published several reports assessing progress on adaptation and climate resilience in UK infrastructure, and are due to publish a review of the government's latest National Adaptation Programme this summer. Their report on Managing the Coast in a Changing Climate concludes that in the future some coastal infrastructure is likely to be unviable in its current form, and that this is not being addressed with the required urgency[2]. Their UK housing report also concluded that "efforts to adapt the UK's housing stock to the impacts of the changing climate: for higher average temperatures, flooding and water scarcity, are lagging far behind what is needed to keep us safe and comfortable, even as these climate change risks grow"[3].

   The NIA should pick up on the priorities identified by the CCC in their adaptation work, particularly coastal infrastructure, housing, water efficiency, flood resilience and heat resilience.

3. **Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?**

   Data availability, access to it, its format and usability varies greatly across different sectors, which is a barrier to addressing resilience. Additionally, we believe that design standards, for example, whether they include climate change forecasts, also varies across sectors, as does institutional capacity to plan for future climate changes. The institutional and legal framework for addressing climate change adaptation in projects is also a barrier. All of these must be addressed in order to facilitate resilience issues emerging from cross-sectoral interdependencies.

4. **Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?**

   The proposals to place water resources planning onto more of a regional footing is a good example of where the benefits of working across boundaries are being addressed in a water context. Whilst the obvious focus of this will be water companies, regional planning groups will also include consideration of the needs of a range of other sectors, such as agriculture, energy and navigation. This should aid the identification of priorities and opportunities for collaborative solutions at a higher

[2] Committee on Climate Change. October 2018. Managing the coast in a changing climate.

[3] Committee on Climate Change. February 2019. UK housing: Fit for the future?

spatial scale than was possible under the company-level water resources management planning process. The Commission should consider whether there would be benefit in planning other aspects of infrastructure on more of a regional basis.

Resilience Study Scoping Consultations – NIC

Q4. Are there are examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The Data & Analytics Facility for National Infrastructure (DAFNI) has been developed to provide a common platform for Government, Industry and Academia to explore the application of models and data in addressing challenges including those arising from extreme events. DAFNI provides a significant opportunity to commence addressing the technological, cultural and knowledge constraints that have limited the ability for cross-sectoral analysis of resilience to be achieved in a comprehensive manner.

DAFNI consists of five key components:

1. National Infrastructure Database (NID) – Provides a central datastore with a common interface through which to access and publish the myriad of datasets required to analyse infrastructure resilience. This includes access to resources including Ordnance Survey, Office for National Statistics and Open Street Map.
2. National Infrastructure Modelling Service (NIMS) – This is the critical part of the service that will allow the NIC to address the complexity of exploring the resilience domain. This provides access to a number of cutting edge models developed across academic institutions and provides unique mechanisms through which to couple multiple models to explore resilience across a systems-of-systems approach.
3. National Infrastructure Cloud Environment (NICE) – The underpinning service that provides access to the vast computational resource necessitated in order to run this analysis at a granular and national scale.
4. National Infrastructure Visualisation Suite (NIVS) – Provides an intuitive and simplistic manner through which to visualise and perform visual analysis of data help within in the NID or rendered as a result of modelling work within the NIMS.
5. DAFNI Security Service (DSS) – Provides the compartmentalisation necessary to allow industry, academia and government to work together without violating data protection, personal sensitivity or commercially sensitive policies.

These services have already been leveraged in the delivery of a number of pilot projects that have both furthered the research and improved their availability for use within wider studies. A core example of this is some recent collaborative work that has been undertaken into providing access to a Digital Communications model for the assessment of infrastructure strategies. Developed by Dr Edward Oughton at the University of Oxford the visualisations developed collaboratively and accessible through DAFNI provide a means through which to assess the cabling topography and enable analysis of potential resiliency challenges or opportunities.

Resilience Scoping Study – WSP Response

TO	National infrastructure Commission	**FROM**	[name redacted] – Head of Public Affairs, WSP
DATE	**01 April 2019**	**CONFIDENTIALITY**	**Public**
SUBJECT	**National Infrastructure Commission Resilience Scoping Study – WSP Response**		

Introduction

WSP is delighted to submit its response to this consultation paper, and contribute to informing the Commission's important study on the resilience of the UK's national infrastructure. We stand ready to support the NIC as it develops a framework to consider resilience across economic infrastructure, for application during the next National Infrastructure Assessment. In this short response we give WSP's views on resilience priorities and on issues emerging from sectoral interdependencies, and hope to be involved in any subsequent initiatives that the NIC undertakes on this important topic.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

WSP views resilience as a critical objective of the National Infrastructure Assessment and welcomed the announcement that the NIC would be undertaking further study on this topic. As an engineering and planning consultancy operating on all aspects of the built environment, we have devised our Future Ready approach, which aims to increase systems wide resilience of the UK's infrastructure and built environment as a whole.

This study is timely, as while there has recently been a great deal of talk about the need for resilience, and a number of initiatives have emerged such as London First's Resilience First programme, there has been too little discussion of what this really means, especially in terms of how one can rationally measure resilience and how different levels of resilience might be paid for and by whom. **In essence, the key questions that ought to be appraised in the study are: resilience OF what, TO what events and FOR what purpose?**

There are technical aspects to this and more political ones. Technical aspects include the **scoping of the events to which infrastructure and the built environment as a whole could or should be resilient**. Such events might be weather/climate change related (eg sea-level rise and/or flooding), cyber security related (malicious hacking for DDoS or remote control), terrorism related (disruption to tube stations or significant infrastructure links), third party damage or simply capacity related. Many infrastructure systems are designed and operated to meet various standards of reliability and capacity in the face of such challenges; resilience of systems is related, at the first order, to the level of reliability and redundancy provided in and between systems. Regulation of privatised utilities has tended to drive out redundancy on the basis of cost efficiency.

Inter-related or cascade events within sector, where for example rail service on a line is interrupted due to flooding or landslide causing delays and over-capacity on other lines, are also assessed by service providers. To some extent, service providers also assess the risks of cascade events occurring outside of their sector which have an impact on their service; for example, power supplies to rail and water companies are well understood to be critical to service provision and thus, in water and rail services for example, contingency

plans for power supply in the event of a mains failure are generally well developed. **It would be useful to collate and assess the scope and congruence of such planning, to understand where gaps exist and what has led to decisions to accept such gaps.**

However, it remains the case that the inter-dependencies of these systems, and how the resilience of one affects the other merits more study, which is why this study is welcome.

From a political perspective **there are questions around what assets are to have improved or specified levels of resilience, how that resilience is to be provided** – e.g. through increased redundancy, better contingency planning etc – and how will any cost increase be justified and allocated to customers and tax payers.

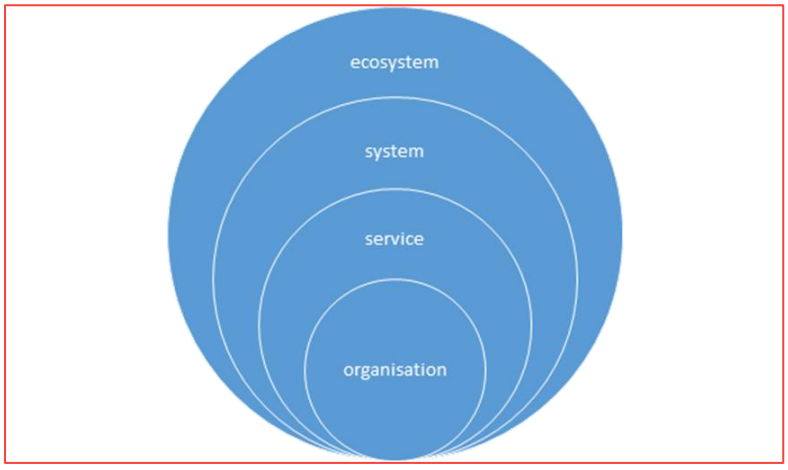
The determination of what resilience should look like will also have implications in terms of expectations, of what is a desirable outcome. This in turns plays into the political discussion about resilience.

Operating across sectors, WSP takes a multi-sector perspective, recognising that systems have multiple points of vulnerability, and that as digitisation advances the risk of propagation between systems can paradoxically increase. We are increasingly looking at the role of natural solutions to increase resilience, for example using biodiversity and green spaces in cities, and ensuring that we promote environmental net gain in the projects on which we work**. We hope that the NIC will give particular attention to the role of natural solutions in driving resilience**.

A key starting point seems to be the **need to devise a prism through which to present the levels at which resilience needs to be developed**. At WSP we consider resilience at different levels.

Resilience relies on mutual reliability, in much the same way as a healthy ecosystem. Disruption can take place at different levels, and interdependency can be documented to understand the impact. **Assessment might take the form suggested below.**

Organisation – is the organisational entity staffed and able to function? Plant and other systems are being maintained and kept safe, even if the services cannot be provided. If this is in place the infrastructure can deliver a service.



Service – is the organisation able to provide a set of core services to the catchment area (e.g. power without billing)? If this is in place the infrastructure can deliver a system.

System – a complete of services, provided within catchment. If this is in place the infrastructure can form part of an ecosystem.

Ecosystem – a set of services that forms part of a fully integrated critical national infrastructure supply ecosystem.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

There are measures of redundancy which are relatively easy to establish but as yet there are few if any generally accepted measures of resilience; either within sector or, where sector fragilities can interact, cross-sectorally. **Work should be done on establishing how to measure this**. In economic terms, the level of resilience which should be provided will always be a balance between the cost of providing redundancy and/or recovery resources and the costs to society, environment and the economy of being subject to the service failure.

The cost benefit assessment process is normally used for looking at such options; eg the Flood and Coastal Erosion Risk Management process assesses the damage which could be caused by a range of flood events over threshold, weighted by the probability of the event, compared against the costs of various options to mitigate the damage. In the private sector, companies will look to balance the broad set of costs of failure against redundancy, recovery plans and insurance coverage.

There are more deterministic approaches used in some sectors. For example, in the electricity networks area the original approach was to ensure specified levels of system redundancy against events in accordance with relevant legislation, codes and standards (such as Engineering Recommendation P2/6). In the most recent price regulation regime (RIIO-ED1) Ofgem have allowed the DNOs additional funding for improving network resilience using a CBA approach. CBA may not always be appropriate so it is possible that cost-effectiveness assessments may be more appropriate.

Some comparison of the current approaches at a sector level around levels of service and the events against which such levels of service are planned to be maintained would be helpful. Once a common understanding is reached of the approaches and the outcomes that result, it will be easier to discuss how cross sectoral issues can be assessed and an assessment of how to respond, either through capital investment or effective contingency planning. **How risks which require contingency plans are structured and tested would also be useful to throw light on good practice and sectoral differences**.

Given that any change in current approaches to provision of redundancy and recovery may invoke new costs, it will be important to understand **how the regulated industries at least would account for this and how costs to consumers would be split** appropriately.

Where there is a need to arrange a rational split of costs between different sectors or companies **there may need to be a body responsible for approving that investment**.

We note that the Network and Information Security Directive is to be implemented and, given the increasing reliance of systems on this underpinning infrastructure, it might be a good time to review how the competent authorities are exercising or planning to exercise their roles, and/or what findings have been made.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Yes, there are several; as noted above, unless and until there is common understanding of how the various service providers assess system redundancy and resilience, it will be difficult to properly examine cross sector cascade cases, and determine rational approaches effectively.

There is currently an understandable reluctance for companies to release what is potentially commercially sensitive and confidential information about their vulnerability to any event. Resolving this might be achieved through commonality of event type/return period, analytical process and costs; or by **having an over-arching body which could collate the information** and put it on a common footing and make decisions about gaps and vulnerabilities; or by getting a common regulatory/contractual/legal approach to meet the need. Whatever option is selected would need to have sufficient flexibility in it to meet changing pressures and needs; there is no doubt that in the future sensitivities of systems will alter and the sensitivities of the general public – expectation, social and economic pressures etc – will alter the weight to be ascribed to system resilience..

In addition, whilst there are for example sector level co-operation agreements in place, it is not clear that there is consolidation and cross-fertilisation of contingency planning cross-sectorally. There are Local Resilience Fora, and more central Government agencies and control systems but there seem to be no common standards and approaches for communications and control of inter-utility management. This is an area the NIC could make a call for a powerful body to help integrate and drive this UK-wide.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

There have been examples such as the investment in flood protection for utility assets thus protecting services from specified levels of service failure of flooding. There are other examples, but it is probably true to say that such situations have mostly arisen as a result of a cascade type of failure having happened thus revealing a previously unmanaged vulnerability. In such cases, the response of the involved parties has been to become more engaged and to share more information about the exposed risks and impacts so they can be resolved, jointly or otherwise.

The Alan Turing Institute Programme on Data Centric Engineering's Response to the National Infrastructure Commission's consultation Examining the future of infrastructure resilience

Background

The Alan Turing Institute is the national institute for data science, with a mission to make great leaps in data science research to change the world for the better. The programme on data-centric engineering (DCE) will develop critical data analytic capabilities to address the challenges in improving the performance and resilience in engineering systems and national interdependent infrastructure nexus. The evidence presented in this document will be based on three of the Turing DCE Programme's grand challenge areas:

1. **Resilience:** Resilient and Robust Infrastructures

2. **Monitoring:** Monitoring Safety of Complex Engineering Systems

3. **Design:** Data Driven Engineering Design under Uncertainty

The expertise of Professor John Moriarty (Queen Mary University of London) and Professor Julie McCann (Imperial) has been instrumental in this submission.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

The main questions identified by Turing researchers are two-fold. One concerns the risk of cross-sectoral contagion, which occurs when a vulnerable entity in one sector plays a sufficiently central role in one or more sectors. In this way, networks of vulnerability can exist between entities in different sectors. Disruption to one entity can then create 'channels of contagion' to other entities, even in different sectors.

The other concerns the ability of systems and their underpinning infrastructures to withstand, adapt and recover from stressors, and how to quantify this resilience through the use of 'digital twins'. Designing for resilience is an important part of this. In many cases, infrastructures that support transport, energy, water and waste water, flood and solid waste are over 100 years old, designed for serving citizens, rather than for stresses that have emerged in the intervening years. These include increased scale of the population in cities, expense of maintenance, and climate change pressures. An important consideration is how to move away from retrofitting these infrastructures in order to maintain them, to ensuring that these fixes also make the systems more agile and dynamic, and therefore more resilient to future shocks.

Modern materials and computing technologies are beginning to demonstrate a way for these dynamics to be automatically controlled. This is giving rise to more creative design strategies, such as adaptive architectures, dynamic reconfiguring of water networks, and local diverse energy production.[1]

It is increasingly recognised that virtual models of physical assets, or 'digital twins', can provide useful insight and the ability to analyse asset-behaviour from data collection. Sensor-based systems can feed these models to enable future planning and 'what if' experimentation to observe the reactions to shocks. Live data from these sensors can feed online digital twins to observe current behaviours, and increasingly this can include automatic control and decision support. However, new analytics,

[1] See references [4], [5] and [6] below

statistics and machine learning methods are needed to enable near-real time online updates and understanding of these increasingly complex systems; many current approaches rely on extensive training offline.

Further, single asset models will not capture the integration and interactions of many different systems. There are multiple modelling techniques aiming to understand the flow of knowledge, artefacts and resources between systems, and many of these approaches are being used to better understand shocks. However, some of these, such as Life-Cycle Analysis (LCA) are populated manually with data from questionnaires and document analysis, and much of the data to fully understand resilience is closed and unavailable to those carrying out LCA.

More needs to be done to understand that ICT-based infrastructure is not separate to the infrastructure which it is monitoring – indeed it is part of it. This means that ways need to be found to understand the resilience of both the ICT infrastructure and the critical infrastructure in question, and their combined resilience. We need to know what the 'co-design' mechanisms are, how this will affect current understanding of control and stability under disturbance, and its quantifiable and guaranteed return to stability. Disturbances from the physical world, such as impact of moisture on the movement of soil, temperature effects on railway lines etc., are reasonably well understood and modelled. However, the same is not clear for ICT based systems – indeed sensors de-calibrate when batteries run low, and temperature affects wireless communications. Known as cyber-physical interactions, they have the potential to seriously affect the resilience of our infrastructures, and they are not well understood.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

The issues to be prioritised should be:

- Characterising the interdependencies that exist between entities, including those in different sectors.
- Seeking ways to combine sensing instrumentation, actuation and a spectrum of data analytics to enable joined up thinking about how assets interact and impact on each other across ecosystems (for example in cities or across countries).

For the former, characterising these interdependencies will enable models such as multi-layer networks (see for example [1]) to be constructed representing these interdependencies, which may then be analysed mathematically to establish potential channels of contagion. In particular the 'centrality' of each entity may be calculated and, thus, the degree of disruption across different sectors which could result from its potential failure. The result is more complete risk assessment for potential hazards. Further, such analysis may suggest ways to help mitigate channels of contagion.

For the latter, the increasing dependence on digital technologies requires understanding the impact of cyber-physical interactions, including how the physical system and its environs impact the behaviours of the digital system and vice versa, and how this should be considered over time as both infrastructures age. As new joint co-designs of infrastructure are required, so too are joint maintenance programmes, techniques, approaches and tools. Digital Twinning should view the ICT infrastructure and the physical system as one.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

In order to analyse cross-sectoral interdependencies as a multi-layer network so that we can understand contagion, it is necessary to describe them in a common way across different entities and sectors (see, for example, [1]). Thus a common modelling approach should be determined, so that mathematical analysis can be applied.

Furthermore, being able to chart and fully understand interdependencies is key to addressing cross-sectorial resilience. One way to do this is to use advanced combined online Internet of Things (IoT) and LCA to facilitate pilot analysis of infrastructure systems, which can then be fed into a more integrated 'digital twin' to enable stress tests of many sectors and their interaction. This allows us to identify actions to improve the resilience of national infrastructure systems and inform investment decisions.

For successful integration of a LCA, access to open data and proprietary data, without compromising privacy or competitive advantage of data holders, is key. Government has a role to play to lead on building the incentives to encourage data sharing and regulating access to data. Indeed, it is not only data that must be shared to enable identification of interdependencies in resilience across sectors; models must also be shared, to ensure that representations used across sectors are compatible and can be combined.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The risk of contagion across sectors has an example in banking. Networks of contractual relationships are created when financial institutions trade in products such as over-the-counter derivatives. However, the variety of different products makes the interdependencies between institutions challenging to interpret at a total level. In [2] Bianconi and coauthors carried out a multilayer network analysis for the Bank of England of the vulnerabilities caused by these interdependencies between financial institutions. The method applied was Functional Multiplex PageRank which is, in turn, based on the centrality principle of Google's PageRank algorithm[2]. This work resulted in improved tools for monitoring and mitigating channels of financial contagion.

Another example of cross-sector resilience is demonstrated by a project on use of smart technology in the wine industry in England and Wales. This involved understanding the interdependencies that arise with water and energy challenges. LCA[3] and workshops identified key challenges such as:

- Growing a species which is marginal for the UK climate;
- Developing technical capacity to manage vineyards and wine production;
- Gaining recognition and market share in the face of established overseas competition;
- Developing and maintaining appropriate standards of quality and in developing quality control mechanisms that are effective and affordable for vineyard and winery operators.

Intra-industry collaboration plays a part in sharing knowledge around improving yields, developing and deploying smart technologies and improving the industry's identity as an environmentally benign, high quality local product. The industry is working toward knowledge sharing platforms with other similar industries to explore, among other things, streamlining production-distribution, the benefits

[2] This principle looks at which web pages are most important or influential given the links from other websites.
[3] Life Cycle Analysis is a technique to assess environmental impacts associated with all the stages of a product's life, from raw material extraction through to materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. Life Cycle Analysis can help avoid a narrow outlook on environmental and resilience concerns through compiling an inventory of relevant energy and material inputs and environmental releases.

from technology development including sensors for farm-environment impact, monitoring, connectivity and data sharing on the field with initial field deployments, and sharing best practice to mitigate risks in seasonal production.

References:

[1] Ginestra Bianconi. Multilayer Networks: Structure and Function. Oxford University Press, 2018.

[2] Bardoscia, Marco, Ginestra Bianconi, and Gerardo Ferrara. "Multiplex network analysis of the UK OTC derivatives market." Bank of England Working Paper number 726 (2018).

[3] The Role of Smart Technology in the Future of English and Welsh Wine Production against Water and Energy Challenges (EPSRC WefWebs 2017).

[4] Fox, Michael, ed. Interactive architecture: adaptive world. Chronicle Books, 2016.

[5] Wright, Robert, et al. "Adaptive water distribution networks with dynamically reconfigurable topology." Journal of Hydroinformatics 16.6 (2014): 1280-1301.

[6] Hashmi, M. H. S. M. K., S. Hänninen, and K. Mäki. "Survey of smart grid concepts, architectures, and technological demonstrations worldwide." 2011 IEEE PES conference on innovative smart grid technologies latin america (ISGT LA). IEEE, 2011.

The potentially broad nature of resilience means that it will be essential for the Commission to prioritise the questions that this framework will seek to answer. Prioritisation should consider current and future resilience issues, for the UK economic infrastructure within the scope of this study. The study is expected to focus on transport, energy, water and wastewater, and digital communications infrastructure.

Given its strategic role, the Commission also believes it is likely to add the most value by focusing on cross-sectoral, systemic and long-term issues.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Given that resilience, both in terms of the associated challenges and the actions needed, is a socio-technical and political issue, it will be key that the questions should take this much broader perspective (i.e. go beyond the technical questions and answers).

Questions would need to recognise the difference between resilience of infrastructure and resilience of the services that infrastructure provides.

This includes as suggested in the brief to consider the cross-sectoral and systemic challenges and opportunities associated with dependent and interdependent infrastructure. To what degree is resilience threatened and enhanced by the current and evolving interdependencies (including physical (e.g., co-location), technical, economic and political interdependencies)? How to define the system of interest when considering dependencies and interdependencies such that implications for resilience is more comprehensively considered.

There is a need for questions related to foresight to understand the potential nature of the infrastructure needed in the medium to longer terms. For example, the changing nature and scope of services (transportation, energy, water and telecommunications) and how these will influence the resilience of infrastructure, including as a result of interdependencies.

Expectations related to resilience – political, social, economic (investments), operators and owners (and their shareholders), threats to and opportunities to enhance resilience as a result of change (social/demographic, technical, environmental, climate, economic (investments), policy (national and international)). I would be useful to be able to chart these expectations over time and seek to explore the changes that have occurred and drivers thereof (often related to choices made).

Questions related to valuing resilience and how can we better value resilience as part of enhancing resilience, including in the broader sense (economic, social, environmental and political value)?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

There is a need to understand and explore pathways and frontiers to resilience, including in the context of how these can and will affect how and what services are delivered.

Implications and roles of big data and related technologies from the perspective of understanding and exploring the potential of big data and these technologies in contributing to strengthening infrastructure resilience, but also as a basis for understanding the state and directions of infrastructure resilience.

The adequacy of the regulatory environment in the UK to address resilience, including from a systemic basis (including dependencies and interdependencies). This also includes considering the adequacy in the context of changes that are occurring and are projected to occur in the services and delivery technologies, and changes in the environment and society in and to which those services and technologies will be expected to operate and deliver.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Two areas of concern related to being critical barriers to resilience are valuing resilience and the planning system. These barriers and resolving them will require working with partners in policy, practice and academic communities.

On valuing resilience:

- The need to have an effective and accepted means of valuing resilience has a number of dimensions and is particularly challenging. It is suggested that the accepted economic model is lacking and needs to be challenged (not an easy task considering the entrenched nature of the economic community)
- Valuing resilience and investments in enhancing resilience will be critical to moving beyond simple responsive actions. The community (economics and resilience) will need to be engaged in accepting the need to challenge current thinking and in defining an appropriate way forward.

On the planning system:

- There is a need to understand the extent to which the current planning system and rules are acting as a barrier and enabler to resilience. To what extent is the planning system able to effectively consider resilience and the need to enhance resilience in a timely manner, including dealing with potential conflicts and trade-offs in both space and time. The ability to move away from being responsive (post-disaster) to also considering building better and building back better.

Concern that engineering solutions developed to help make UK infrastructure more resilient will not be adopted unless these are accompanied by changes in behaviour of those having to act.

Capabilities and abilities associated with big data and associated technologies. Particularly important in the context of dependent and interdependent networks is the sharing of this data. There are at least two barriers – the means of appropriately handling such data, including extracting value in terms of understanding resilience; and the means and willingness for appropriately sharing this data and information, particularly to understand dependencies and

interdependencies in the terms of the associated challenges and solutions associated with strengthening resilience.

Sector-based policy and regulation, but also sector-based management of infrastructure. Limited opportunities, but also incentives for resilience-focused dialogue and jointly exploring resilience. This includes opportunities in fora that are non-confrontational or not hampered/restricted by regulatory/legislative wrangling.

Knowledge and the availability of evidence on the existing and evolving nature of resilience, including that capable of assessing potential options for enhancing resilience. This also includes that required to support the assessment of infrastructure developments and plans in the context of implications for resilience from a systemic perspective.

It is clear that although understanding resilience (what constitutes resilience and the lack thereof, and what constitutes enhancing resilience) is important, it is not necessary to dwell on definition development. There is a need to take advantage and embrace the broad definitions / perspectives of resilience when taking action to strengthen resilience.

There is a need to better promote and demonstrate the role of resilience in terms of its contributions to prosperity and wellbeing. Resilience efforts, except immediately following a significant event, are often perceived as being of lower priority relative to other prosperity and wellbeing objectives.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Fora promoting enhanced dialogues around addressing interdependencies within the Infrastructure Operators Adaptation Forum dialogues related to exploring interdependencies as part of the Adaptation Reporting Powers process. Additionally, there is the dialogues within the Yorkshire operators' adaptation forum.

Investments by the research councils (e.g., EPSRC and UKRI) that are working with the infrastructure operators, the broader research community and policy makers to explore resilience and means of enhancing resilience. These include:

- Research fellowships such as those under engineering for sustainability and resilience;
- Research projects: Those recently awarded under the UK Climate Resilience programme; Stepping Up – focusing on big data collection and modelling of the scaling up of water, energy, food nexus innovations and networks; and UKCRIC – a portfolio of research and innovation facilities and programmes with a mission to underpin the renewal, sustainment and improvement of infrastructure and cities in the UK and elsewhere (https://www.ukcric.com))
- Networks such as ENCORE – establishing a network in engineering complexity resilience; research network plus initiatives;

Investments within the European Commission through its H2020 project related to understanding resilience of critical infrastructure. Example RESIN – Climate resilient cities and infrastructures (http://www.resin-cities.eu/home/) and EU-CIRCLE – A pan-European framework for strengthening critical infrastructure resilience to climate change http://www.eu-circle.eu).

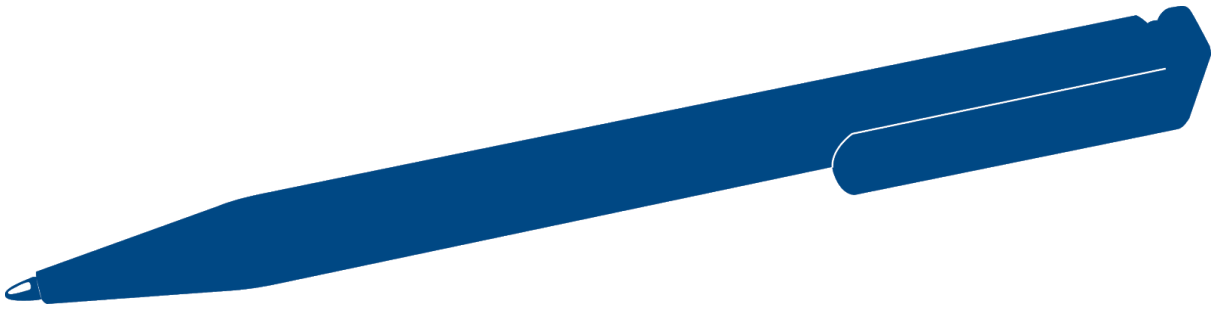
Response to National Infrastructure Commission consultation

1. Question 1:
    a. Decide on a definition of Resilience. From Emergency Management lexicon (and being a practitioner I'd recommend this: "Ability of the community, services, area or infrastructure to detect, prevent, and, if necessary to withstand, handle and recover from disruptive challenges".
    b. Engage with Local Resilience Fora / Forums. They deal with this / plan for such failures on day to day basis and are the responders.
    c. Utilise the National Risk Register and central government's National Risk Assessment and the Planning Assumptions.
2. Question 2:
    a. Consider the primary risks identified in the National Risk Register – once assessed by your personnel.
    b. Critical risk is loss of electricity and the national power outage / 'Black Start Recovery.
    c. Ref your next section –sure, avoid duplication, but understand the parameters in which we operate so you can also avoid gaps. Also,
    d. Note that the main response is organisational resilience which relies on BCM – this is an internal issue to each and every organisation, though some may be posed by Regulators etc. Delivery of BCM and the development of organisational resilience is a company business.
3. Question 3:
    a. Terminology – try to use one definition of Resilience
    b. Developing resilience culture within organisations / sectors / government
    c. Lack of engagement with LRFs
    d. There is no UK Agency for delivering Resilience centrally – e.g. NEMA. Current system provides lack of cohesive, directed emergency management / resilience preparedness relying on the excellent joint working between Category 1 responders, and engagement with category 2 responders and also with businesses / other bodies. The Civil Contingencies Act provides the framework but not enough. And within regulated organisations, those delivering resilience activities are under-funded and under-resourced for this job. Money is redirected to other issues e.g. social care and education - unsurprisingly. The only way to guarantee the resources required, as well as directed, centrally managed, cohesive emergency management, with cohesive processes, systems, training, resources, technology to create a resilient public sector with links to the private sector is a centralised agency dedicated to emergency management and the development of BCM for category 1 responders. .
4. Question 4:
    a. Some LRFs have combined to delivery responder activities as a single organisation (e.g. Staffordshire, Kent) but too few and still not having central government buy-in / taking of responsibility to deliver this massively important activity from a centralised basis.

[name redacted]
Head of Resilience, Buckinghamshire County Council
(answering in an unofficial capacity)

National Infrastructure Commission - Resilience Study Scoping Consultation

Citizens Advice submission
April 2019



citizens advice

Contents

Introduction

The resilience of the infrastructure of the country, in terms of utility supplies such as water and energy, is vital for consumers to be able to conduct their daily lives effectively and efficiently. Any loss of an essential service can have negative financial and social impacts for an individual or business which differs dependent upon circumstances. Consumers with vulnerabilities, such as ill-health or being in fuel poverty, have much higher negative consequences from outages as they are much less able to independently respond to a crisis. It is therefore crucial that infrastructure companies that are tasked with maintaining our essential services not only ensure security of supply but also have measures in place so that the higher impact of loss of supply on those with vulnerabilities is adequately addressed. Contingency and emergency response plans to manage outages need to be robust, well-thought through, and involve relevant multiple agencies to ensure coverage. Provision within these plans has to prioritise those least able to help themselves.

In the increasingly interdependent world of smart technologies, where one utility service may need to work in combination with another, there will be an increasing risk to resilience of the system. Adequate planning by infrastructure companies will need to account for these increased risks in areas such as cyber security, technical data failings, and also consider any knock-on effects where one essential service fails and impacts others (for example, broadband failures impacting electricity flexibility and Demand Side Response mechanisms).

The infrastructure companies, regulators and policy makers must learn the lessons from major recent incidents, such as the Beast from the East cold-weather event in 2018 and the Lancaster floods in 2015, to formulate robust and socially inclusive contingency plans. Regulators will need to ensure that those emergency plans are fully implemented and prove effective, when the need arises.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Are infrastructure companies focussing appropriately on security of supply?

Building resilient infrastructure and ensuring security of supply is of tremendous importance, however, such improvements come at a cost to the consumer. As such, consumers should be consulted upon the price that they would be willing to pay to ensure a higher degree of security. We are aware that consumers can value security of supply differently dependent upon their circumstances and the consequent financial and social impacts an outage can have. For instance, the Electricity North West research report[1] on the 'Value of Lost Load' (a measure designed to capture the average value a consumer would pay to avoid an electricity outage) showed how various demographic and environmental factors affected valuations. The report showed how the standard VoLL measure had under-represented certain groups, particularly those with vulnerabilities or who were fuel poor.

Research in the water industry has shown similar differences in willingness to pay for security of supply with those with vulnerabilities more likely to place a higher value on security[2].

Examples of different viewpoints were highlighted from consumers:

- Who have never experienced outages versus consumers that have experienced frequent or long outages.
- From urban versus rural locations.
- Who were fuel poor versus those who were not.
- Who had disabilities versus those who did not.
- Of different genders and age profiles.

We understand that many network companies have recognised the importance of capturing the views of its varying consumer demographic groups but we

[1] Electricity North West, September 2018, 'The Value of Lost Load'.
[2] Impact Utilities Report, February 2018, commissioned for South Staffordshire Water for the 2019 Price Control, 'Willingness-to-pay research to support PR19'.

would reiterate the importance of capturing all relevant views of consumers, particularly from those with vulnerabilities, or on low income. There should also be a clear methodology for reconciling the trade-offs of differing consumer views that will need to be made to reach decisions on planning and paying for security of supply.

Are infrastructure companies adequately prepared for larger scale incidents?

In general, utility companies respond well to service outages. But the 2018 'Beast from the East' cold-weather snap followed by a rapid thaw revealed that numbers of water companies were ill-prepared for the event. Ofwat's report[3] on the water companies' actions noted several specific failings. We think that it is, therefore, vital that all infrastructure companies have:

- Robust and effective plans for handling eventualities affecting supply.
- Up-to-date data collection on:
    - Where incidents have occurred and the timeline for resolution of issues.
    - Consumers with vulnerabilities, including the type of support that may be needed, and how to achieve that support.
    - Stakeholders that can support consumers, for instance, local councils, charities, and other agencies with pre-planned mechanisms for action.
- Excellent communication systems to ensure that all consumers and stakeholders have clear and accurate information on problems, emergency resources, and timings.
- Adequate communications access so that all consumers can reach the infrastructure company to report problems and seek help.
- Pre-planned coordination responses with other agencies and infrastructure companies to share resources, where applicable.

How is resilience in electricity supply likely to be affected by increased Demand Side Response, and what are the timelines for these changes?

Resilience to supply in electricity may be positively affected by increased Demand Side Response by consumers. Our own research[4], however, points to the likelihood of relatively modest uptake of such schemes in the near term by domestic consumers. There will be a need for policy makers to enable higher

[3] Ofwat, 19 June 2018: 'Out in the cold: Water companies' response to the 'Beast from the East'
[4] Citizens Advice, July 2017, 'The Value of Time of Use Tariffs in Great Britain'.

uptake through encouragement of simple time of use tariffs, smart technologies, coupled with adequate consumer protections to provide confidence in the system.

Are agencies beyond infrastructure companies adequately resourced to be able to assist with supply events? Are these stakeholders and groups fully included in planning?

In an outage event, local support agencies can play a vital role in giving practical help and advice to people experiencing supply problems. These agencies can include councils, third sector organisations, and local community and religious groups. Recent central and local government cutbacks have impacted these agencies in terms of resourcing and it may be suitable to look to how centralised contingency planning budgets could help to support these groups. In addition, infrastructure companies should be including these stakeholder agencies within their own emergency response planning to widen coverage and target those most in need during an outage scenario.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

We have addressed these issues within Q1.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Increasing risks in data resilience and control through cross-sectoral interdependencies

There is likely to be increased bundling of utility products and services for consumers provided through one company. In addition, consumers will be reliant upon multiple types of service to run their homes and businesses, such as using broadband or other communications to run electrical and smart devices. Infrastructure planning will need to consider the knock-on effects of the failing of one service and how it can impact other utility supplies.

Localised flexibility and Demand Side Response in the electricity market should assist with localised resilience for supply. However, there may be increased risks in terms of consumer data security, especially with the interoperable nature of the technologies. Cyber security breaches or technical failure may negatively impact resilience to the system. There will need to be strong policy and planning, and effective implementation of plans to protect consumers' data from these risks and the consequent effects upon resilience of utility supply.

Data sharing for the Priority Services Register (PSR)

Citizens Advice has undertaken research[5] into energy companies' practices when identifying and recording information on people with vulnerabilities for energy company PSRs. At present, each infrastructure company maintains its own PSR for those needing extra support and has a separate registration system. It would be more effective if infrastructure companies could share data on those requiring extra support and agree a common framework for identifying and recording that data. We are aware that there is an effort by water and energy companies[6] to proceed in this direction for shared data but that there is more work which needs to be done.

Planning for cross-sectoral interdependencies

The Lancaster floods caused major infrastructure failings in supply of electricity and broadband, mobile coverage, and the ability to receive communications, including radio[7]. It will be important to address the impact of multiple infrastructure outages and how infrastructure companies and wider agencies respond to protect consumers, particularly those with vulnerabilities, from such wide-scale failings.

[5] Citizens Advice, January 2018, '9 million people are missing out on support with their energy supply'.
[6] Ofgem, Ofwat and UKRN, November 2018, 'Making better use of data to identify consumers in vulnerable situations: A follow-up report'.
[7] Lancaster University, 'Living without electricity: One city's experience coping with loss of power'.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

No response provided.

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Published April 2019

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Landscape Institute
Inspiring great places

NIC Resilience Scoping Study Consultation

Response from the Landscape Institute

Summary

The Landscape Institute (LI) aims to lead and inspire the landscape profession to ensure it is equipped to deliver its purpose under our Royal Charter for the benefit of people, place and nature, for today and for future generations. We represent over 5,000 landscape architects, planners, designers, managers and scientists.

The National Infrastructure Assessment 2018 states that "Infrastructure delivery depends on the availability of the right skills, the approach to construction and project management, the depth of the supply base, and the capability of government and other infrastructure owners and operators to act as an intelligent client". Landscape professionals can support effective and timely delivery through landscape-led approaches to infrastructure planning, and can identify and enable key opportunities to implement green infrastructure and other measures during development, in order to achieve multiple benefits for society and the economy.

Landscapes and how they are designed, managed and used by the public have a major impact on national infrastructure, including road, rail, energy, power and communications networks, water and waste management, and city growth, and vice versa. The key resilience proposals from the NIA 2018 related to landscapes included ensuring resilience to extreme drought through additional supply and demand reduction a national standard of flood resilience for all communities by 2050 and measures to make cities healthier, more liveable and better designed for living. The Landscape Institute is currently seeking case studies that illustrate where landscape professionals have made a positive impact in the delivery of infrastructure projects in the UK and abroad. This will be developed into new guidance to assist members with the planning and delivery of infrastructure projects[1].

The following consultation response outlines the many ways that landscape professionals can contribute to the delivery of sustainable and resilient national infrastructure networks.

For more information, please contact our Head of Policy and Influencing, Aaron Burton at aaron.burton@landscapeinstitute.org.

[1] https://www.landscapeinstitute.org/news/infrastructure-guidance-case-studies/

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Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

a) Review UK and international knowledge and approaches relating to resilience of current and future economic infrastructure systems, including how this can be understood, definitions, ways of assessing resilience, treatment of interdependencies and the management of the risk from different threats and hazards.

- Can the Ofwat definition of resilience, "resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future" be applied more broadly?
- How can the definition of resilience produced by the Ofwat task force and the resilience duty placed on Ofwat be applied to wider infrastructure concerns and regulators/ departments/ planning bodies?
- How can the resilience approach being taken at the city scale (e.g. 100 resilient cities) be better applied to the National Infrastructure Assessment?

b) Develop an understanding of public expectations and response to the potential loss of infrastructure services and review alternative options and contingency planning, for example, in the light of technological advances such as cyber threats, and behavioural changes.

- What is the public perception of, and response to, potential loss of infrastructure during resilience events?
- How can behaviour change be better utilised to support infrastructure resilience (e.g. public involvement in maintenance of public green infrastructure networks, potential forprovision and maintenance ofprivate green infrastructure such as SuDS systems within residential and business properties that can help overall wastewater and drainage management)?
- How can we support communities seeking to take a more active role in landscape management (e.g. for resilience of green infrastructure linked to flood resilience), protection and design by promoting co-production and knowledge exchange?

c) Develop an analytical approach that can be used to better understand the resilience of economic infrastructure systems, and the costs and benefits of measures to improve this.

- How can we better identify the multiple benefits from resilience actions and utilise these in discussions around both capital and maintenance funding for more resilient landscapes?

d) Undertake pilot analysis of infrastructure systems (for example through 'stress tests' of sectors, geographical areas or companies) to identify actions to improve the resilience of national infrastructure systems and inform investment decisions.

- How can stress testing the resilience of infrastructure at a landscape-scale identify actions to improve resilience?

e) Make recommendations to government on the resilience of economic infrastructure, how best to assess resilience, sharing of good practice, actions needed and data collection or analysis to inform the next National Infrastructure Assessment.

- How can an improved planning process ensure joined-up working between different infrastructure needs, for example integrating green infrastructure for flood risk and wider climate resilience when making changes to communications, energy and water and wastewater infrastructure?
- How can taking a more integrated approach to planning for national infrastructure, addressing issues of regulatory silos, help improve resilience?
- What are the skills and types of professional expertise that will enable resilience in national infrastructure?

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Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

We have identified several issues in relation to national infrastructure that could be addressed by this resilience study.

Sustainable Drainage

Sustainable drainage systems (SuDS) are a key element of green infrastructure that have multiple benefits. However, these are being delivered less well in England than in Wales or Scotland. A recent report by the LI and the Construction Industry Council[2] highlights the huge step change still needed in this area. The report found that 96% of local authorities report that the quality of planning submissions for SuDS are either 'inadequate' or 'mixed'. And as of 2017, 25% of local authorities had no formal SuDS policies in place, nor any immediate plans to implement any. This is putting communities under threat of surface water flooding as climate change continues to put pressure on our landscapes.

Answers to some of the questions proposed above could help address some of the issues being faced around delivery, adoptions and maintenance of SuDS to enable drought and flood resilience of national infrastructure networks.

Integrated Water Management

There are many different names and definitions for integrated water management. In our response we are referring to a holistic water cycle approach to managing water resources, water quality, and flood risk management. New Drainage and Wastewater Management Plans are in development by water companies[3], however there is a risk that they will not account for the potential benefits of water reuse that may help fund the creation and management of green infrastructure such as SuDS whilst delivering more resilient, semi-autonomous systems, moving away from centralised water and wastewater supply services.

With pressures from drought also increasing, particularly in the East and South-East of England, water reuse via SuDS can provide an alternative and more resilient decentralised water supply option. An example exists in the North West Cambrige water reuse scheme that combines SuDS and water reuse[4]. Anglian Water, for example, are promoting water neutrality and are looking at incentives for integrated water management through SuDS and water reuse. However, there remain barriers to developers implementing these approaches.

Environmental Net Gain for new infrastructure planning

The Government has recently consulted on proposals for Environmental Net Gain. They have announced that they plan to move forward with statutory requirements for biodiversity net gain. However there is a risk to large scale infrastructure proposals if wider environmental and social benefits around flooding, drought and biodiversity are not considered as these benefits may not be realised.

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2 https://landscapewpstorage01.blob.core.windows.net/www-landscapeinstitute-org/2019/01/11689_LI_SuDS-Report_v4a-Web.pdf

3 https://www.water.org.uk/policy-topics/managing-sewage-and-drainage/drainage-and-wastewater-management-plans/

4 http://www.nwcambridge.co.uk/vision/sustainability/water-recycling

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Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Respondents to the LI and CIC survey suggested the following policy changes are required to address delivery fo SuDS in England:

- Making SuDS requirements statutory and covering minor schemes
- Implementation of Schedule 3 of the Flood and Water Management Act 2010 (FWMA) – thereby establishing SuDS Approving Bodies (SABs) within LPAs, which must approve all new drainage schemes, requiring that they meet national standards
- More emphasis on 'true/green' SuDS and those that deliver multiple benefits, i.e. water quality, amenity, biodiversity
- Removal of the right to connect to public sewers
- More power to create regional policies and standards

A major issue within government, regulators and water companies is working in silos. This separation of biodiversity, water quality, water resources, flood risk, urban planning and design, among others, often means that the multiple-benefits from more integrated approaches aren't achieved. This should be addressed through the lens of resilience in the next National Infrastructure Assessment.

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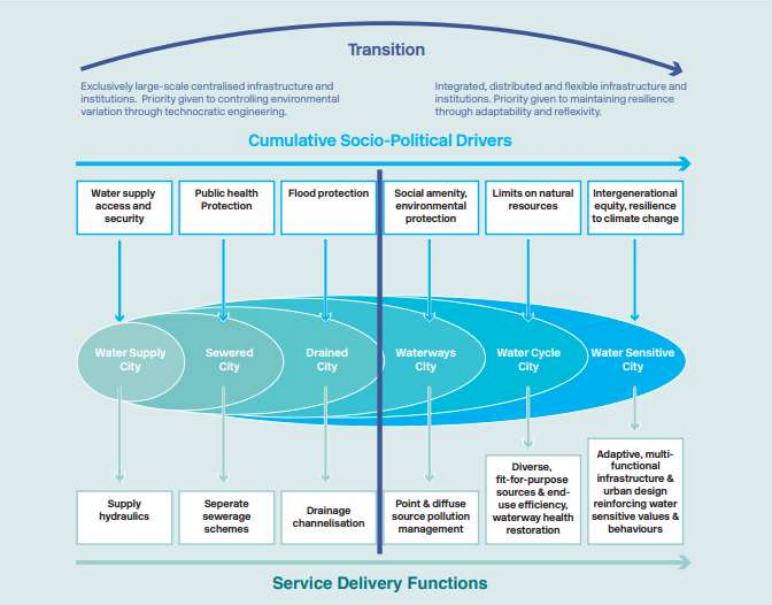
Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

There are international examples where barriers to resilience around sectoral interdepencies have been overcome. We present two case studies below:

Transitioning to Water Sensitive Urban Design in Australia

In response to the Millennium Drought followed by major floods in Eastern Australia, the concept of Water Sensitive Urban Design was developed. By taking an integrated approach to urban water management, cities such as Melbourne had to overcome many sectoral interdependency issues and problems linked to organisations operating within silos. The key transition factors for Melbourne are outlined in a report on their transition and are included in the Figure below[5]. These factors have been considered for the UK in a scoping study, however many of the proposed actions from this haven't been taken forward because of the structure and the industry and approaches to regulation of the water sector in the UK[6].



Managing the Urban Heat Island in Singapore

Another example of a coordinated approach is in management of urban heat islands in Singapore. In 2017 Cooling Singapore was set up with the aim: to remove heat from the urban system, and thereby improve outdoor thermal comfort. This initiative will require a cross-institutional effort and a 'whole of government' approach due to many areas including energy policy, transport, building standards, planning and public health. This approach is in the planning stages but builds on previous successful initiatives such as the Active, Beautiful, Clean Water Programme, which has delivered improved flood management through blue-green infrastructure led and designed by landscape professionals[7].

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5 https://watersensitivecities.org.au/wp-content/uploads/2016/05/TMR_A4-1_MovingTowardWSC.pdf

6 https://www.waterwise.org.uk/wp-content/uploads/2018/02/CIRIA-2013_Creating-Water-Sensitive-Place.compressed.pdf

7 https://www.landscapeinstitute.org/journal/winter-2019/ (pp. 37-18)

SP ENERGY NETWORKS

Network Planning & Regulation

By email: resilience@nic.gov.uk

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

Date
1 April 2019

Contact / Extension
Lynne Bryceland
0141 614 3124

Dear colleague

SPEN Response to National Infrastructure Commission Resilience Study Scoping Consultation

This response is from SP Energy Networks. SP Energy Networks (SPEN) holds three electricity network licences. We own and operate the electricity distribution networks in the Central Belt and South of Scotland (SP Distribution) which serves 2 million customers, and Merseyside and North Wales (SP Manweb) which serves 1.5 million customers. We also own and maintain the electricity transmission network in the Central Belt and South of Scotland (SP Transmission). Our business and our staff live and work in the communities we serve and recognise the energy we deliver is a critical to life and the economy. Maintaining security of supply, as well as good quality of service, is essential to all of our customers. SPEN is part of the Iberdrola group, which is one of the largest utilities in the world.

SP Energy Networks welcomes the opportunity to respond to the National Infrastructure Commission's Infrastructure Resilience Study Scoping Consultation, especially as the scope of this study will partly focus on the energy sector. Our response to the consultation questions can be found in Appendix 1.

Please don't hesitate to get in touch with me, should you have any questions in relation to this response.

Yours sincerely

Lynne Bryceland

Lynne Bryceland
Transmission Policy and Licence Manager

SP House, 320 St Vincent Street, Glasgow. G2 5AD

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Appendix 1
SP Energy Networks Response to National Infrastructure Resilience Study Questions

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

The key questions that SPEN proposes the next National Infrastructure Assessment should answer on resilience are:

(i) How is the end-to-end assessment going to be completed for resilience? Current efforts are focused on a sector by sector basis. These need to further reflect and enhance the way that critical infrastructure operates. This should also include the impact and role that government organisations may place in the response to key issues that arise.

(ii) How transparent is the guidance around resilience delivered to each sector and how is this information fed down to the individual organisations within each sector? Furthermore, how does this lead to a clear (or unclear) inter-sector awareness of the key resilience issues?

(iii) Further details should be provided on the development of scenarios which represent the range of resilience issues that may be tested.

(iv) Evaluating the role in which stakeholders can suggest ways in which greater sectoral co-operation and guidance on resilience scenarios can be tested.

Q2: On the basis of your response to Question 1, what issues should be prioritised in the resilience study?

SPEN considers that the resilience study must prioritise (i) inter-sector awareness and the assessment of key resilience issues; and (ii) greater transparency on the specific resilience issues that are being considered.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

We agree with the Commission that the current issues arising from cross-sectoral interdependencies are not fully understood or acted upon. We also agree that one of the key barriers to addressing resilience emerging from cross-sectoral interdependencies is data sharing across sectors. This includes who is sharing data and how it is being shared. Furthermore, we find that there should be clear priority given to data-sharing across sectors, something which is not already in place.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

SPEN are aware of examples where the telecoms and energy sectors work closely together, allowing some barriers to resilience issues to be addressed. However, we believe that further collaborative working is required in order that to gain full benefit.

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1st April 2019

Email to: NIC – resilience@nic.gov.uk
From: British Ceramic Confederation

BCC RESPONSE TO NATIONAL INFRASTRUCTURE COMMISSION RESILIENCE STUDY SCOPING CONSULTATION

The British Ceramic Confederation (BCC) is the trade association for the UK ceramic manufacturing industry, representing the collective interests of all ceramic sectors. Our 90-plus member companies cover the full spectrum of ceramic products and comprise over 90% of the UK industry's manufacturing capacity. Membership of BCC is diverse, including manufacturers of:

- Bricks
- Clay Roof Tiles
- Clay Pipes
- Gift and Tableware
- Floor and Wall Tiles
- Sanitaryware
- Refractories
- Industrial Ceramics
- Material Suppliers

In the UK our sector (including suppliers to the industry) employs over 20,000 direct full-time employees, generates £2bn in annual sales and is an active exporter, with over £0.5bn in export sales. Our membership comprises a range of mostly SMEs operating single manufacturing sites (~75%), through to larger UK-based and multi-national organisations operating multiple manufacturing sites.

The industry is energy-intensive (but not energy-inefficient) with energy costs making up to 30-35% of total production costs[1]. By virtue of the significance of energy to their overall costs, our members (and energy-intensive industries - EIIs - in general) have already been driven to invest in, and maximise the efficiency of, their operations over several decades. The sector is capital-intensive with long investment cycles (a ceramic kiln typically has a lifetime of over 40 years). Many of our members operate continuous production processes which are designed to run for many months / years without stopping.

The primary energy use in ceramic manufacturing is for kiln firing and drying. The industry as a whole is gas-intensive, with the energy mix being around 85% gas (4.5 TWh) and 15% electricity (0.65 TWh). Gas is effective for high-temperature direct firing from around 1,000 to 1,750 °C; although some companies use electric arc / induction firing to achieve the higher firing temperatures required; which can be up to 2,750 °C. Around 45% of energy expenditure is on electricity.

Consultation response

As illustrated in the introduction the ceramics industry relies on secure and affordable energy supplies, and many other aspects of the UK economy and infrastructure. We therefore think it is important for the Commission to consider the following in their resilience study.

The resilience of the supply and generation of energy whether through oil products, gas, electricity or other types of energy is vital. As an example, an interruption to the UK's gas supplies could take many months to recover from with each connection requiring a visit to re-commence supplies.

It is clear there will be changing demands for oil products (diesel / petrol), natural gas, electricity and potentially hydrogen from both a long-term perspective (over several decades) to the very short-term (minutes and days). The impact of government policy and market changes are vital to understanding the UK's resilience.

[1] Composition and drivers of energy prices and costs: case studies in selected energy-intensive industries https://ec.europa.eu/growth/content/composition-and-drivers-energy-prices-and-costs-case-studies-selected-energy-intensive-0_en

In addition, the study should include the interactions between energy supplies with transport and heat, given the likely changes in these sectors such as increasing numbers of gas-powered lorries, increasing numbers of electric or part-electric vehicles, potential changes to the sources of heat and increasing renewable electricity generation (particularly on the volatility of gas demand from power stations). There are both opportunities and challenges due to these likely changes.

The UK is, and will be increasingly dependent, on digital technologies to operate and control a variety of infrastructure and associated systems. Thus, their reliability and resilience are an issue the Commission should be considering. This is especially important given the failure of a digital system typically results in the system coming to a complete standstill rather than just reduced capability or operations.

We would welcome an understanding of the Commission's position on resilience, for example, the situations and scenarios the Commission is trying to ensure the UK is resilient to, while acknowledging the very extreme events which cannot be accounted for. We also think the resilience of businesses and economies to price volatility is important, typically with energy for example, prior to any disruption (or threat of) prices rise and this has an impact on international competitiveness and for attracting investment to the UK.

Although the Commission is focused on long-term investments and changes it is likely to be short-term events which test the UK's resilience. We would also like to understand the Commission's position on how and where the responsibility for ensuring resilience lies between the government and markets.

Please feel free to contact us if you require any more information.

Yours faithfully

Dr Andrew McDermott
Technical Director

Jon Flitney
Technical Policy Officer

NIC infrastructure resilience study

The Environment Agency welcome the opportunity to respond to the National Infrastructure Commission (NIC) scoping paper, assisting with shaping of the new infrastructure resilience study.

The Environment Agency has a key role in delivering and enabling infrastructure which helps to protect people and the environment. We are a delivery body, advisor and regulator on a range of environmental, flood risk and energy infrastructure, competent body for the Water Framework Directive and an advisor on climate change resilience and spatial planning.

We welcome the continued engagement with the NIC on infrastructure resilience in relation to our work on flood and coastal erosion resilience, water supply, sewerage, waste and regulated industry. Please find our response to the March 2019 scoping paper below.

For further information, please contact:

Andy Howe, Senior Advisor - Sustainable Places
andy.howe@environment-agency.gov.uk

1 April 2019

Q1: What are the key questions that the next National Infrastructure Assessment (NIA) should answer about resilience?

The next NIA should inform our understanding of how resilient infrastructure is to flooding, coastal change and other environmental hazards as identified in the National Risk Register of Civil Emergencies. Ideally this should include infrastructure sites, networks and the interdependencies between networks. This will help others plan and invest to minimise the disruptions when infrastructure is impacted – for example by flooding, heat waves or drought. This would support emergency planning, incident management, and identifying joint investment opportunities. The description of resilience needs to respect security and commercial sensitivities around infrastructure data.

We encourage the next NIA to:

- Assess whether and how infrastructure providers and spatial planners are formally adopting scenario planning to 2100.
- Consider whether and how infrastructure providers are preparing for a 2 degree rise in temperature, but planning for a 4 degree rise based on the UKCP18 predictions.
- Consider what resilience of infrastructure could look like for places – taking a place based approach within a national framework.
- Consider how infrastructure networks can achieve equality in resilience for people and places, and the extent to which local and strategic growth plans can help achieve this.
- Explore the pros and cons of creating a common understanding/language about resilience standards between infrastructure providers, spatial planners and the Environment Agency, and how this is conveyed to the public.
- Review the 'cascade effect' of infrastructure failures caused by flooding and the extent to which infrastructure providers look in insolation at their risk, for example a broadband hub which is located outside of the flood plain, but has a single point of failure over a bridge.
- Consider the role of natural capital in providing resilient services to society and the economy, and the role that green infrastructure can play in increasing the resilience of more traditional 'hard' infrastructure to hazards. Protecting and enhancing natural capital (delivering a net environmental gain) can reduce the need for infrastructure investment and running costs, if it is designed in from the outset.
- Highlight that resilience is not just about the large, short term impacts but also 'slow burn' issues, driven by incremental pressures or deteriorating assets, for example sewer networks typically have asset replacement cycles up to many hundreds of years, an inter-generational asset life.
- Consider the role of innovation and how expectations may change around infrastructure performance and resilience. For example what society accepted for the environment 30 years ago, might not be acceptable now. The next NIA could explore how infrastructure sectors factor in changing objectives/societal shifts over the long-term.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

The resilience study should:

Establish a safe and secure forum where national infrastructure datasets can be brought together from different infrastructure providers and analysed. Our recent infrastructure impacts analysis within our long-term investment scenarios (LTIS 2019) for flood and coastal risk erosion, while ground-breaking, was limited due to problems gathering data about infrastructure site resilience, redundancy within networks, disruption duration and access to telecommunications data. It will be difficult to improve our understanding of infrastructure resilience, or for the public to understand resilience for a place unless the data and information is made available. Key LTIS findings are outlined in our response to Q4.

Encourage infrastructure providers to assess and make public the current resilience of their infrastructure. This will ensure that people and risk management authorities understand their current level of resilience (for the place they live) and are able to make more informed decisions about the actions they need to take.

Encourage infrastructure providers to future proof their investments to remain resilient under predicted climate change scenarios, and identify opportunities for innovation around developments in the flood plain. We will be working in conjunction with local partners in the OxCam Arc to test this approach.

Advocate, the role of green and blue infrastructure in improving infrastructure resilience and how greening grey infrastructure can improve the resilience of existing infrastructure. For example, considering how highway resilience is improved through Highways England's Road Investment Strategy investing to manage surface water more effectively. And the importance of green and blue infrastructure in helping society be more resilient to climate change impacts, such as overheating, and reducing the concentration of pollutants.

Consider the impacts of more frequent extreme weather events on infrastructure from flooding, drought and higher temperatures, which will impact on performance and maintenance. For example, low river flows can affect power generation capacity, biodegradable wastes may need to be collected more frequently as a result of higher average temperatures and extremes of temperatures lead to increased risk of pipe fracturing, increasing risks of leakage and pollution.

Consider if there is a case for decentralisation and more distributed networks to increase resilience.

Consider the resilience of non-mains water supply outside of the water industry. For example, what level of resilience is in place and needed in future in for agriculture, electricity generation and industry, and the resilience of private water supplies. We also encourage looking more broadly at the resilience of supply systems, not only to drought, but to better understanding their vulnerability to peak demand, and whether water companies are consistent in this area.

Consider the degradation of existing infrastructure assets and the impact on long term performance. For example, the extent that water resources and wastewater assets operate as they are designed to.

Explore the role of innovation and changing societal objectives, for example the public acceptability of combined sewer overflows is likely to decrease in future, putting additional pressure on water company assets, making them less resilient to meeting environmental and society's needs.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Specific barriers to addressing resilience include: lack of knowledge sharing between infrastructure providers on resilience standards; commercial sensitivities; up-front costs around meeting common resilience standards; smaller 3rd party owners of infrastructure that cannot afford resilience; lack of knowledge around ownership of 'orphan' infrastructure assets; investor confidence and uncertainties about future risk.

Barriers to addressing resilience also include differences in planning approaches across sectors. For example, farmers don't have the same resources, investment timescales and planning horizons that water companies have, tending to plan on much shorter timescales. The energy sector is different again, and in our experience has particular commercial sensitivities regarding data sharing.

There is a lack of clarity on third party ownership of infrastructure assets. Building and maintaining infrastructure to keep pace with climate change will remain critical to the future resilience of people, property and other infrastructure. The responsibility and management of infrastructure is fragmented. For example, there continues to be challenges with the consistency and quality of our coastal infrastructure, and our confidence in the level of protection it provides to coastal places.

There is a need for better integration around key dependencies and safety critical elements across infrastructure sectors. For example, electricity sub stations serving a particular size population are resilient to particular standard, but water company (and other sector) assets with higher designed resilience may rely on power from these substations. In any given place, all infrastructure operators need to work together. Failure of one piece of flooding and coastal change infrastructure compromises them all, and, ultimately, the safety of people living and working behind them.

Some key infrastructure is privately owned, with limited legal responsibilities on owners to maintain it in a proper state. As local people and partners develop the combination of tools they require to deliver standards, for example around flood and coastal resilience, it may be necessary to review the responsibilities of infrastructure owners, and to encourage greater collaboration between infrastructure owners to make better use of public funding and resources.

Drainage and wastewater management plans (DWMPs) are providing a new basis for more collaborative long term planning by water and wastewater companies, working with other organisations that have responsibilities relating to drainage, flooding and protection of the environment. Defra have recently consulted on making DWMPs statutory, which would enable companies to target their investment more effectively, and help improve integrated planning and resilience across the sector.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

We worked with the University of Oxford to develop the long-term investment scenarios (LTIS 2019) which explore the impacts of flooding from rivers and the sea on transport and utilities infrastructure. This is ground-breaking work using a unique set of national infrastructure modelling tools to analyse sites, networks and the interdependencies between networks.

While the analysis did not have access to data about the resilience of individual sites, it was able to identify that over 60% of properties in England are served by infrastructure sites and networks located in (or dependent on others in) areas at risk of flooding. The results highlight the importance of infrastructure resilience. 41% of transport and utilities infrastructure assets are in areas at risk of flooding, of which 36% is at direct risk of flooding and 5% is at risk due to dependencies on electricity. As a result of this study we understand the impacts of flooding on infrastructure better, and it strengthens the case for investment in Flood and Coastal Erosion Risk Management (FCERM).

We are preparing a new FCERM Strategy for publication as a consultation in May 2019 and as a final Strategy in early 2020. This strategy focuses on three themes; Climate Resilient Places, Todays Growth and Infrastructure Resilient in Tomorrows Climate and a Nation of Climate Champions. It proposes introducing flood and coastal resilience standards. Flood and coastal resilience standards could be achieved through a range of different tools including constructing flood and sea defences, asset management, catchment solutions such as natural flood management as well as community and business resilience. It recognises that every place is different and so the exact combination of tools selected will need to be tailored to a particular place and reflect the local aspirations and opportunities, economic and environmental needs of that place and people.

We co-ordinate the Infrastructure Operators Adaptation Forum (IOAF), a collaborative, knowledge sharing forum of infrastructure operators, government-funded bodies and academics. Members developed several case studies showing how better collaboration between organisations can help prevent failure cascading through interdependent infrastructure systems. We contributed to the Energy Research Partnerships 2018 'Resilience in the Energy System' report. This explored future resilience of the system, including infrastructure, and sought to define resilience.

Water Resources East is a good example of how to consider water resource resilience issues across sectoral boundaries. Their programme brings together partners from a wide range of industries including water, energy, retail, the environment, land management and agriculture, to work in collaboration. The goal is to develop a long-term, multi-sector water resource strategy for the East of England - an integrated strategy, with trade-offs between sectors that balance the needs of all partners.

Water and sewerage companies have legal responsibilities for ensuring effective drainage and sewerage, however they are not required to put in place long-term plans for managing wastewater. Through the collaborative work of the 21st Century Drainage Programme, the water industry has begun to produce DWMPs on a voluntary basis, facilitating a more joined-up approach with other risk management authorities, improving climate change resilience and helping water and sewerage companies manage their assets over the long term.

Water and sewerage companies have also directly invested to increase natural resilience as part of catchment programmes for many years, although these have often focused on land they own themselves, or specific risks to sources of raw water. For example, Yorkshire Water has recently pledged to plant one million trees across its land over the next ten years in a bid to reduce flood risk, offset carbon emissions and support the creation of a Northern Forest.

Local Resilience Forums are likely to provide valuable local case studies of cross sectorial dependencies, and practical solutions.

Response to National Infrastructure Commission "Resilience study scoping consultation"

Prepared by J Dora, owner of John Dora Consulting Limited and Chair of the Infrastructure Operators' Adaptation Forum, and N Pyatt, Director of TRIOSS.

1st April 2019

Note: The views expressed are those of J Dora and N Pyatt

Introduction

JDCL[1] and TRIOSS[2] welcome the opportunity to respond to the National Infrastructure Commission's consultation, and to help inform the Commission's development of a framework for considering national infrastructure resilience.

We would welcome further engagement and discussion on the issues identified in our response.

Response to questions

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

- Is the scope and coherence of current initiatives sufficient?
    - There is a lot of focus on cities but they are dependent on a wider system of infrastructure;
    - Some infrastructure resilience planning prioritises on an over narrow perspective of the impact of failure. In particular, the railway industry considers impact on train paths and timetables rather than that to the ultimate aim of the rail system – to move passengers and freight;
    - Assessment[3] of the wider economic and social benefits is not routinely considered but when tested shows many times the level of benefit than current criteria (eg DfT's 'WebTAG) detect. We feel this leads to insufficient resilience planning;
    - Interdependencies between infrastructure operations and other dependent services are under addressed.
- Are the institutions in place to develop the scope and coherence of infrastructure resilience required?
- Is the "capacity to make resilient decisions" of key decision makers affecting infrastructure resilience sufficient to meet the challenge, particularly in a climate changing world where infrastructure decisions "lock-in" vulnerabilities for decades; with retrofitted adaptation often costly, difficult and disruptive?
- Are we using the best available tools and processes to understand and address the issues?

[1] www.jdcl.eu
[2] www.trioss.global
[3] Cowley Bridge Junction example see link (free registration required)

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

- The scope and coherence of infrastructure disruption impact assessment;
    - Is it reflecting the full impact?
    - What are the implications for resilience planning when greater scope and coherence in impact assessment is made?
- Is a city-centric perspective of vulnerability sufficient for the country's infrastructure resilience e.g. the SW England peninsula has an economy greater than Birmingham yet is vulnerable to disruption at some key infrastructure bottlenecks with high disruption risk e.g. the main rail line to the region crossing the Somerset Levels?
- Understanding:
    - Systemic impacts that cross system boundaries because of the interdependent nature on infrastructure (examples: energy impacts affecting transport; ICT impacts affecting water);
    - How to quantify and prioritise across infrastructure sectors;
    - The system of decision makers that affect infrastructure resilience and related interdependencies;
    - The capacity to make resilient decisions of key decision makers;
    - Which are the low adaptive capacity decision makers that are holding back the ability of the rest of the system to become more resilient;
    - Measures that will raise the quality of their decision making and so strengthen the wider system;
    - How to benchmark what good decision-making capacity looks like and develop decision-makers to that level e.g. through emerging ISO standards like ISO 14090 on resilience and capacity to make resilient decisions.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

- There is a lot of focus on resilient cities. Much less on inter-city system resilience, or the resilience of none-city economic regions e.g. the South West England peninsula has an economy greater than Birmingham and is vulnerable to disruption at key bottlenecks e.g. single rail lines and few trunk road connections. Work being done in Somerset shows that these are extremely vulnerable within the range of climate change projected in the UKCP18 climate projections. But these projections and their impacts have not yet been considered by the relevant bodies; and where this is happening at local level, it is not replicated nation wide, nor is it always supported at national level, so limiting options for local action;
- Interdependencies between utilities and services are under explored. Frameworks for addressing them are insufficient. When they are explored a common set of findings are:
    - Resilience planning is being done in silos using different processes, projections and scenarios;
    - Assumptions are made about the actions of other organisations which turn out to be untrue and require revised resilience planning;
    - The quality of planning varies widely;
    - There are vulnerabilities that no organisation has direct responsibility for;
    - The capacity to implement a resilience strategy, especially related to extreme events, are dependent on how widely the event impacts. With climate change these events are going to be increasingly extensive and dilute the resources available to

implement individual plans e.g. the 2013/14 floods were a combination of many individual storm events, each manageable in isolation, but together massively over stretched available resources;

- The wide variability of decision-making capability and capacity for infrastructure resilience, along with the systemic nature of infrastructure resilience (infrastructure operators are rarely completely in control of the options they have for resilience) means that the value of good practice can be held back. These relationships and levels of capacity, when understood, can help to unlock systemic restraints to resilience.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

- Somerset County Council is convening an integrated climate resilience initiative, incorporating The County and District Authorities, major infrastructure operators and representatives of other parts of society that are affected by extreme events but are not decision makers in resilience processes e.g. Federation of Small Businesses.

Resilience Study Consultation – Southern Water's Response

We welcome the opportunity to contribute to the resilience study at an early. As a provider of critical infrastructure in a region challenged by climate change and population growth we welcome the increased focussed on resilience.

The National Infrastructure Assessment was an important contribution to a crucial conversation and we look forward to continuing to support this vital work.

Much of our response reflects points we have made in previous consultation responses, either to the Commission or other government bodies. We have provided more detail of many of the examples referenced previously, but would happily do so again.

We recommended reading Water Futures in the South East, a thought-leadership piece we commissioned from international experts, for an overview of the megatrends which will impact the resilience of our sector in the future.

What are the key questions that the next National Infrastructure Assessment should answer about resilience?

The key questions we would like to see the next National Infrastructure Assessment answer are:

- How can resilience be defined and consistently measured across different infrastructure and sectors?
    - Are there new / additional metrics which could measure the financial benefits of investing in resilience?
    - How can infrastructure planning move from least-cost to best-value approaches?
- What quick-win, no-regrets policy levers should be used without delay to improve resilience?
- Should there be a minimum standard of resilience to droughts across and what should this be?
    - Should the minimum standard be set based on the level of resilience required in water stressed regions, or should those regions have higher standards?
- How effective are Drainage and Wastewater Management Plans at increasing resilience? How could they be improved or aligned with other plans?
- How can planning cycles and funding mechanisms be better aligned across sectors to facilitate greater collaboration and innovative solutions (such as catchment management)?
    - This will be particularly relevant for Drainage and Wastewater Management Plans as they are particularly impacted by local authority planning for housing and flood-risk management as well as national flood-risk planning

The next NIA should also review the actions taken by government and infrastructure providers as a result of the previous assessment. If suggested actions have not been taken, the NIA should explore why and, if appropriate, recommended alternatives.

On the basis of your response to question 1, what issues should be prioritised in the resilience study?

The issues we would like to see prioritised are:

- Standardised definitions and measures of resilience across and within different sectors
    - Including new metrics focussing on best-value rather than least cost planning

- What the minimum standard of drought resilience should be and should it be based on the most water stressed region?
    - Are there other minimum standards of resilience which should be considered and implemented?
- How planning cycles and funding mechanisms could be better aligned across sectors to facilitate greater collaboration and innovative solutions (such as catchment management).

Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Barriers to addressing cross-sectoral independencies include:

- Planning and regulatory cycles not always aligned in terms of timing and planning horizon
- Commercial sensitivities around data sharing – particularly between infrastructure providers and large-scale users such as industry and agriculture
- Inconsistent data around housing and population projections – with different data being used in different plans at different times
- Infrastructure data not standardised across sectors and no centralised repository means accessing data can be challenging
- Inability to demonstrate the value of resilience to either justify investment decisions or develop cases for joint-funding
- Lack of join-up between interlinked policy areas such as water, energy and agriculture
    - The Future Homes Standard was announced in the spring statement and the official announcement said homes would be "future-proofed with low carbon heating and world-leading levels of energy efficiency" without mentioning water efficiency. This despite the Committee on Climate Change's recent report on the future of housing specifically referencing water efficiency as a necessity.

Lack of alignment between planning cycles, as well as different predictions on housing and population growth can make wastewater investment planning challenging. We may invest in increased network capacity that is then no longer needed or uncertainty around housing growth may mean infrastructure is not funded ahead of need.

We believe there are a range of resilience benefits which can be achieved through better understanding of the water, energy and agriculture nexus. Crucial to addressing this is water needs being given the same consideration as energy during policy making.

Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Examples of where this has been, and is being addressed, are

- Regional water resources groups, such as Water Resources South East, developing a region-wide resilience strategy incorporating the needs of industry and agriculture. Regional groups are also forming a network to work across company and regional boundaries
- We are working closely with Fawley Waterside and Ebbsfleet Garden City on early, multi-sector approaches to deliver new towns and build sustainability and resilience in from the beginning
- We are also working with Eastleigh Borough Council in Hampshire to support, encourage and, where appropriate, incentivise water efficient behaviour in the borough – in both existing homes and new developments

- The Brighton ChaMP project is a collaborative endeavour between the South Downs National Park Authority, the Environment Agency, Southern Water, the University of Brighton and Brighton & Hove City Council, working together with Natural England and the Brighton and Lewes Downs UNESCO Biosphere (the Living Coast) to protect the environment and a crucial source of water
    - Examples of activities include:
        - Supporting farmers and land managers to adopt catchment sensitive farming methods and alternative land use practices
        - Working in urban areas to introduce sustainable drainage systems to reduce contamination of groundwater

National Infrastructure Commission

Resilience study scoping consultation

Response from Ordnance Survey

Response from Ordnance Survey

Ordnance Survey (OS) welcomes this consultation and its premise that economic infrastructure is an increasingly interdependent system.

Our position is informed by our:

- Production and supply of data to the UK Infrastructure Transitions Research Consortium (ITRC) and steering board membership of DAFNI, on which the NIA is based;
- provision of mapping and geographical data to Government and the public sector (covering over 5,000 bodies across England, Wales and Scotland) free at the point of use through a collective agreements, including support during emergencies;
- membership of the Natural Hazards Partnership which contributed to the Sendai Framework and peer review of the Hyogo Framework;
- involvement in work supporting the London Olympics in 2012 (see Annexe 1) and ongoing support for local resilience fora
- commercial relationships with energy and water utility companies and infrastructure owners such ports, airports and Network Rail, both directly and through commercial partners;
- involvement with the Energy Data Taskforce, Digital Framework Task Group and Digital Transformation Task Group aiming to secure data resources to support the interdependent and dynamic system of infrastructure with a suitable data infrastructure.

Based on this foundation and perspective, our answers are focused primarily on the impact and opportunity of sharing data and curating information to take a cross-sector view of historic, real time and simulated future operations.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

We note three types of risks which arise from an increasingly interdependent infrastructure system which the NIC may seek to assess and address through the next NIA:

1. Physical Interdependence
2. System interdependence
3. Societal dependence

These interdependencies are considered in turn below.

Physical interdependence

It is often the case that infrastructure assets (such as pipes and cables) occupy the same physical space in constrained environments, as illustrated in Figure 1 below. As a result, damage to one asset can result in multiple system failures. A notable example was road damage in the Lake District in 2015 when damage to the A591 south of Keswick also affected the electricity supply. The DEFRA Flood Resilience Review of 2016 sought to review and address these issues.

Figure 1 Colocation of Multiple Infrastructure Assets

System interdependence

In addition to the physical proximity of individual assets, entire local or regional infrastructure systems can be interdependent and vulnerable to cascading effects. A well-documented case study is the Lancaster floods following Storm Desmond in 2015, where electricity failure led to the jamming of the emergency services phone lines and cessation of railway services, which might otherwise have provided a safe means of exit from the town.

The challenge of cascading effects is illustrated in the example below, showing part of Carlisle during the flood event of 2005. The flooding of roads has left several buildings, shown in purple in the lower central part of the image, isolated from other services. In the same way, the flooding of the sewage works and power station in the top left of the image will have left their own constituencies without key services. These interdependencies could all be modelled as part of the flood protection prioritisation process. This is illustrated in the example below, Figure 2, showing part of Carlisle during the flood event of 2005. The flooding of roads has left several buildings, shown in purple in the lower central part of the image, isolated from other services. In the same way, the flooding of the sewage works and power station in the top left of

the image will have left their own constituencies without key services. These interdependencies could all be modelled as part of the flood protection prioritisation process.

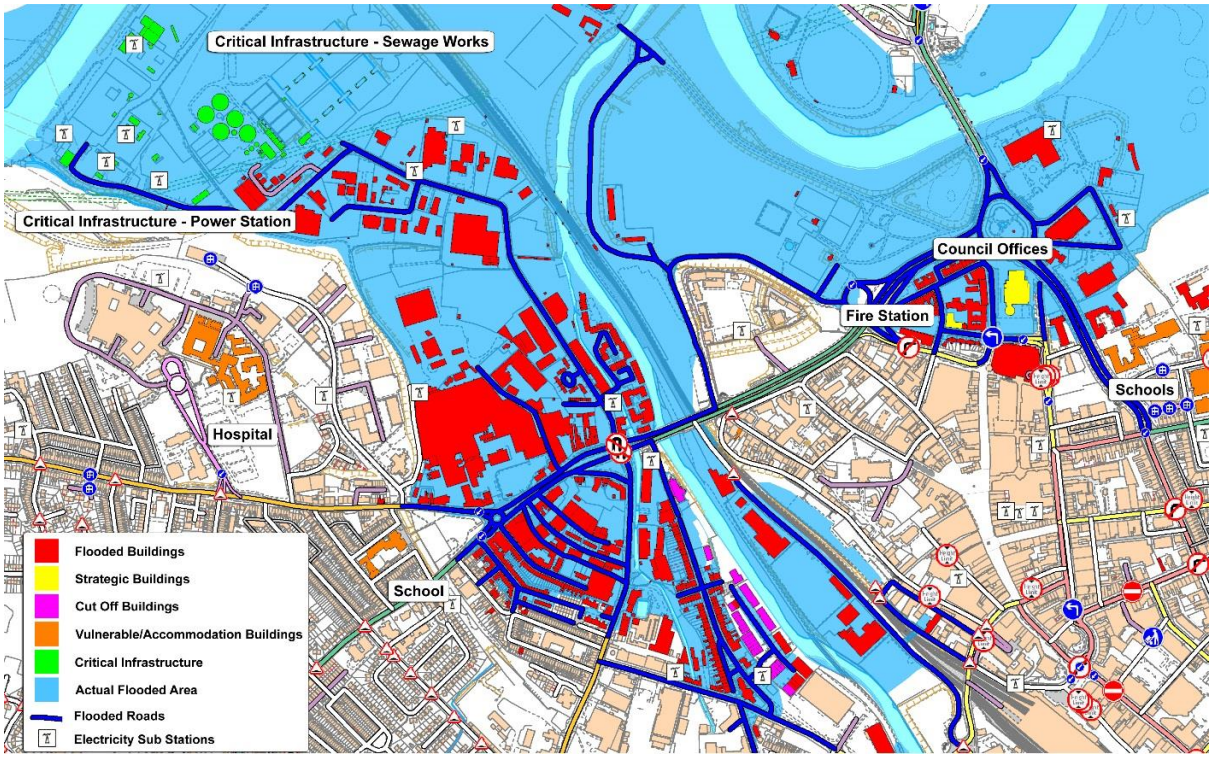

Figure 2 System interdependence, illustrated by the Carlisle Floods

This is the principle that underpinned ResilienceDirect[1], a data visualisation tool for the resilience community developed by OS on behalf of the Cabinet Office. Built with open source components to exploit the value of a geospatial approach to data, it provided a common operating picture.

In addition, increasing access to real-time information gives affected people the means to respond to asset, service or system failures, resulting in increased knock-on demand for neighbouring or related systems. For example, the Battersea Park trackside fire near Waterloo in July 2016 resulted in overcrowding of Victoria and Clapham Junction stations rather than just on the lines affected by the fire.

Societal interdependence

The impact of a single critical asset failure can have far-reaching impacts beyond the system or network of which it is part. For example, the Cockermouth bridge collapse in 2015 impacted the population severely when travellers were forced to take long diversions to cross the valley.

[1] https://www.ordnancesurvey.co.uk/business-and-government/case-studies/resilience-direct.html

Figure 3 Impact of the Closure of the Memorial Garden Bridge in Cockermouth 2009

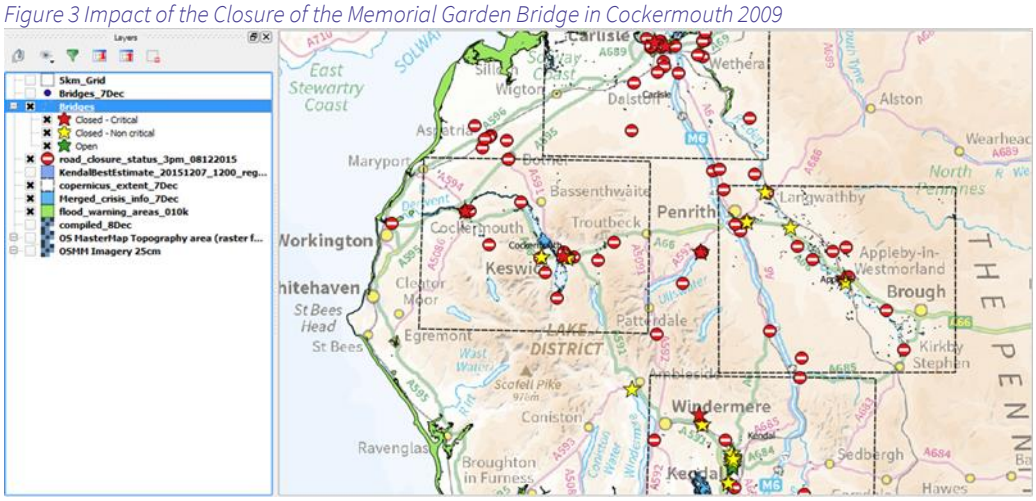

Figure 4 Diversion Following Cockermouth Bridge Collapse

During the same flood event the Tadcaster bridge over the River Wharfe (Figure 5) was damaged, impacting transport, utilities, communications and power services. Retrospective academic research suggests that the bridge failure might have been predicted by increased satellite monitoring.

Figure 5 Ordnance Survey Data Showing Tadcaster and the bridge over the River Wharfe

Analysis of the road (or other) network can reveal which assets or crossings will have the greatest impact on population movements, freight volume or business activity. With such information, an increased monitoring regime and appropriate contingency measures can be put in place to prevent or minimise harmful disruption.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

We note the significant work which has taken place in this area, most notably the UNISDR Hyogo Framework for Action: "While the UK deserves much praise for these [resilience] achievements, a few areas still leave scope for improvement. For example, a new momentum should enlarge the focus of the UK resilience approach from emergency preparedness and response towards more prevention and vulnerability reduction. In particular, an effective risk management process, with potentially large impacts and high likelihoods, especially when these are growing, could be better achieved through vulnerability reduction than through preparing and responding to the event. Floods and droughts are examples of the types of risks that may require more long-term, whole-of-society approaches to their reduction, as climate change may have an impact on those in the future."

In particular, we recommend analysis to identify and address:

- Points and locations where critical infrastructure assets are co-located and vulnerable to disruption;

- Cost benefit analysis for the monitoring of single points of weakness and their impact in the event of failure for infrastructure networks; and
- Where best to embed systems-level thinking on resilience to ensure the right balance between monitoring shared stresses on the system and making operational decisions to mitigate those.

We note the NIC's Data for the Public Good report, and its recommendation that the opportunity for collaboration through technology and data will have a significant economic impact in the UK and advocate research in to the benefits of a capability for multiple infrastructures and stakeholders to securely exchange and model data across conventional systems.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

In our experience, more high-quality information supports resilience across sectors, but the specific barriers include:

- Poor quality information relating to underground assets
- Information in siloed or legacy systems which cannot be shared between departments or organisations. Specific constraints include the cost of making the data available, potential liabilities due to incorrect information and concerns for security and data privacy.
- Incompatible business and regulation models (including safety cases) which fail to incentivise a cross-sector approach.
- Specific industry and short-term approaches in both the private and public sector leading to point solutions rather than sustained and systemic intervention to allow oversight.

We see a recurring need for better information, better ways of securely sharing that information and business and regulation models to support it.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Our answer to Q4 below notes the various and ongoing efforts to tackle this multi-stakeholder issue. We welcome the current activity overseen by the Centre for Digital Built Britain and Energy Systems Catapult, bringing together views from across the spectrum to define the Gemini Principles on which multi-agency data collaboration should be based.

We have listed specific examples below.

Project Iceberg: This collaboration between OS, the Future Cities Catapult and the British Geological Survey identifies numerous examples where data exchange between utility sectors has resulted in better outcomes that fundamentally increase the resilience of the systems they cover.

National Underground Assets Group (NUAG): Established in 2005, NUAG was designed to address issues of transport network interference from maintenance of buried infrastructure (energy, water, waste). Additional benefits were identified around event/incident management, system-of-system impacts, and safety of life. Recommendations were carried forward in a new BIS PAS (256). However, the project was prematurely closed through a lack of clarity of objectives compared to the resourcing available.

Assessing Subsurface Knowledge (ASK): Established in 2012, this initiative coordinates data between 20 diverse partner organisations in Scotland, and now Wales, focusing on subsurface data to effectively de-risk development opportunities through multiagency exchange of data. Resilience of future services is addressed through realistic modelling of demand as well as the practical implementation of resilience functions such as Sustainable Urban Draining Systems.

Digital Built Britain (DBB): This is a BEIS-led initiative to enable better planning, delivery and management of infrastructure through advanced data management and analytics, adopting a system-of-systems philosophy. DBB is now being delivered via the Centre for Digital Built Britain (CDBB).

Road Administration Information System (ROADIS): This was established in 1986 in Japan, following a major incident. It enables a central oversight of the locations of above- and below-ground infrastructure. This has resulted in improved inter-agency cooperation for infrastructure planning and incidence response.

Staffordshire Heineken Project: An Innovate UK-funded project to streamline roadworks by combining the highway maintenance schedule with planning information from utility providers and telecommunications companies.

NEUI Hub: Project NEUI Hub aims to establish a sharing platform enabling stakeholders to view a comprehensive map of underground apparatus for the purposes of utility strike avoidance, more efficient planning, reduced occupation of the highway, and identification of currently unknown risks in our buried infrastructure.

Three local authorities and principal utilities operating in the North East region took part in the Northumbrian Water Innovation Festival and shared detailed network information with Local authorities who also shared street lighting, SSSIs and previous industrial works. The project is part of the DFTG Digital twin pilot programmes.

Project Hades with the GLA in London (https://maps.london.gov.uk/ima/) are seeking to collate information about underground assets with the stated outcomes including more efficient asset maintenance, support for future planning Safety of Life, Strike Avoidance and Traffic Disruption.

Geospatial Commission Unlocks: The government's Geospatial Commission, announced in 2017, was established to improve the quality of key, publicly-held data and make it easier to access and use. By doing so, it is estimated the commission will unlock up to £11 billion of extra value for the UK economy each year. This has led to four projects to break down barriers and unlock value. Collectively known as the 'Geo6', is a

collaboration between OS, British Geological Survey (BGS), Coal Authority (CA), HM Land Registry (LR), UK Hydrographic Office (UKHO) and the Valuation Office Agency (VoA).

- Data Discoverability - The problem we are addressing is there is an incomplete picture of the Geo6 geospatial data held by each organisation. Our aim is to make location data easy to find and access by recording and publishing data in ways to help users find the data they need. We have published consistent data catalogues of all the geospatial data we hold.
- Linked Identifiers (Unlocks 1,10) – documenting the challenges associated to linking geospatial datasets and recommending an approach to make it easier.
- Licencing (Unlock 4) – creating harmonised data sharing licences that are common across the Geo6.
- Third-party usage (Unlock 16) – documenting and harmonising the use of third-party data across the Geo6 organisations.

Annexe 1: The Olympic Mapping Portal

The Olympic Mapping Portal was developed by the London Metropolitan Police for the London 2012 Olympic and Paralympic Games to ensure the safety and security of citizens during the event. The portal provided an efficient and secure way to view and share mapping and associated intelligence throughout the Games.

Prior to London 2012, the Metropolitan Police used different geographic information systems (GIS) to supply mapping and associated data to its stakeholders. Information was maintained in separate databases and the different systems did not link together. To enable a common operational picture for both the police and external users, a system providing a single, definitive source of all Olympic data was needed. The Olympic Mapping Portal was subsequently created using a wide range of Ordnance Survey's mapping data to provide a location and place dimension to the information held. New datasets, such as the Olympic torch route, were also created by Ordnance Survey for use within the portal. The portal ultimately contained a large data catalogue of more than 300 layers of information enabling users to upload and download data in common GIS formats.

The portal was accessed by over 2,000 users and 46 government agencies during the Games and continues to be used. Authorised users across the country are able to view the same map and the same information in 'real time' and this information can be used to deploy police resources effectively, particularly when supporting national events. Additionally, by creating a catalogue of map symbols, users have access to a common set of icons and pictures for geographic features enabling effective data sharing.

The portal led to the adoption and implementation of geospatial data standards, a common set of map symbols and a metadata standard that ensures all new data loaded into the portal is compliant with INSPIRE (Infrastructure for Spatial Information in Europe). Moreover, the centralised view provided by the portal has negated the need for users to distribute copies of data across teams or to hold local copies of data which is now processed and distributed centrally.

Further information: https://www.ordnancesurvey.co.uk/business-and-government/case-studies/metropolitan-police-ensure-safety-london-2012.html.

About Ordnance Survey

Ordnance Survey (OS) is a government-owned limited company, the entire issued share capital of which is held by the Secretary of State for BEIS, who is represented on the OS Board by UKGI.

Ordnance Survey captures over 500 million features that collectively represent the British landscape, describing in detail entities from solar farms to signposts in its Master Map of Great Britain as part of its National Mapping Agency role. This geographic dataset maps every part of our ever-changing landscape from the Atlantic coast of the Outer Hebrides to street-level changes in the centre of the City of London.

We provide national and international services to governments and commercial organisations based on our knowledge, skills and understanding of location data and geography. OS is engaging in a variety of collaborations to help identify and define the emerging requirements of new systems, processes and business models to support our evolving Public Task.2 These collaborations span the following topics:

- National strategies for digital infrastructure and asset management
- Infrastructure planning for 5G communications
- Smart city standards and business models
- Linking Internet of Things data feeds to a consistent mapping framework
- Internet of Things city-scale demonstrator (spanning mobility, health, environment and culture use cases)
- Data exchange for connected and autonomous vehicles
- Location privacy for connected and autonomous vehicles
- Data standards and frameworks for sub-surface assets
- Infrastructure interdependencies and resilience scenario modelling

The perspective and authority that we bring to these projects is derived from our operation at scale (that is, our continuous maintenance of the geospatial database for the whole of Britain, which includes making 20,000 database updates each day), and from our Public Task in supporting and underpinning all aspects of the UK's public sector.

For further information, please contact:
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Email: miranda.sharp@os.uk
Tel: 023 8005 5558

[2] https://www.ordnancesurvey.co.uk/about/governance/public-task.html

NIC Resilience Scoping Consultation
SSEN response

Deadline: 1 April 2019

About us

Scottish and Southern Electricity Networks (SSEN), operating under licences held by Scottish Hydro Electric Power Distribution plc, and Southern Electric Power Distribution plc, owns and operates the electricity distribution networks in the north of Scotland and central southern England, supplying over 3.8 million homes and businesses. SSEN, under license held by Scottish Hydro Electric Transmission plc, also owns, operates and develops the high voltage electricity transmission system in the north of Scotland and remote islands.

SSEN employs around 4,000 people in the UK and has invested over £3bn in critical national electricity infrastructure over the last three years. SSEN also has a strong record of helping to facilitate low carbon technology, with our transmission network in the north of Scotland now supporting over 6GW of clean, renewable electricity.

Our first priority is to provide a safe, efficient and reliable supply of electricity to the communities we serve. We manage, maintain and operate roughly 130,000km of overhead lines and underground cables across GB, in addition to over 100 subsea distribution and transmission cables which power our remote island communities and provide strategically important electricity links in rural Scotland (such as Kintyre-Hunterston and Caithness-Moray).

As part of the SSE plc group, SSEN is a Fair Tax and Living Wage Employer, making a £8.5bn contribution to UK GDP in 2017/18.

Executive Summary

- As a provider of critical national infrastructure, **SSEN would like to highlight the importance of electricity networks to the resilience of the UK's economy**; especially as policy and decision makers focus on greater decarbonisation in the fields of heat and transport.

- **In our response we have highlighted the key areas of resilience that SSEN is actively working on as part of our future business planning and the day-to-day operation of our network**, collaborating with a wide range of stakeholders and working groups to ensure that barriers and threats can be identified and addressed where possible.

- Key areas of focus for SSEN include **Black Start, our next transmission price control RIIO-T2, ensuring continued communications support on our network as we move to a more digitally focused society and addressing wider regulatory issues.** Further detail on each can be found in our response below.

- **We welcome the opportunity to input into the NIC's resilience scoping consultation at this early stage in the process** and hope that the points outlined in this response are taken into consideration as the NIC progress this work stream and make key recommendations on UK resilience to decision makers.

SSEN's detailed submission to the consultation can be found below:

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

As a provider of critical national infrastructure, SSEN would like to highlight the importance of electricity networks to the resilience of the UK's economy; we deliver an essential public service that provides critical support to the UK's infrastructure. The importance of delivering a resilient electricity network extends not only to the reliable supply of electricity for our customers and businesses, but also

supporting wider interconnectivity in key resilience sectors which rely on electricity supply such as transport and telecommunications. As we continue to decarbonise our economy, with a particular focus on heat and transport, the critical importance of electricity networks will only increase.

In our response we have highlighted the key areas of resilience that SSEN is actively working on as part of our future business planning and the day-to-day operation of our network, collaborating with a wide range of stakeholders and working groups to ensure that barriers and threats can be identified and addressed where possible.

We welcome the opportunity to input into the NIC's resilience scoping consultation at this early stage in the process and hope that the points outlined in this response are taken into consideration as the NIC progress this work stream and make key recommendations on UK resilience to decision makers.

Q2 and Q3: On the basis of your response to question 1, what issues should be prioritised in the resilience study? Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

From an electricity networks perspective, SSEN would like to highlight the following resilience priorities for consideration as part of the scoping consultation:

i) RIIO-T2

In preparation for the next regulatory price control period, covering 2021 – 2026, SSEN's transmission business has been engaging with customers and key stakeholders to understand what requirements and expectations will be needed from our future network over the next decade. This feedback is being used to directly shape and influence the drafting of a business plan for this period, with a first draft expected to be published later in 2019.

As we explore the key areas of focus for our business plan, resilience remains a key priority as we set objectives and ambitions for the future of our network. Stakeholders have told us that network reliability is essential and that there is a high economic and social cost for households and businesses if their supply of electricity is interrupted.

Based on this feedback, in our RIIO-T2 ***Emerging Thinking*** document, we set out our initial thoughts on our business plan's focus areas, identifying the following key aims for the continued resilience of our network:

- **Make cost effective interventions** of around £720 million to achieve the goal of no interruptions for electricity customers due to transmission system faults.
- **Adopting data and risk driven approaches** to the operation and maintenance of the network, with expenditure to enable asset data gathering, analytical tools and new ways of working.
- **Investment in systems** to combat physical and cyber threats to network security.

Investment over the past decade means that the reliability of the GB transmission system is now greater than 99.99%. However, energy sector changes - such as decarbonisation and decentralisation - along with emerging global risks - including climate change, cyber security and physical security - mean that the prevailing security of supply cannot be taken for granted.

While these major threats are not new, the nature of the threat regularly changes and, hence, so must our readiness. Our planning for the RIIO-T2 period encompasses a review of our strategic asset spares and emergency response procedures, as well as the roll-out of investments to upgrade system restoration

capabilities during a 'Black Start' scenario. Further information on the work we have been undertaking on Black Start can be found below.

ii) Black Start

Black Start is the procedure to recover from a total or partial shutdown of the GB Transmission System. This entails isolated power stations being started individually and gradually being reconnected to each other to form an interconnected system again.

The failure of the transmission system is one of the highest rated risks in the UK Government's National Risk Register, and is considered to be a high impact, low probability event. Although a total shutdown of the transmission network, has never happened, the consequences would be significant, resulting in huge social and economic impact.

There are numerous Black Start work streams ongoing at UK level, highlighting the societal impacts, communications issues and reviewing black start standards. Since 2016, following the closure of some traditional generation in Scotland, and with increasing levels of intermittent generation connecting to our network, SSEN has been working closely with fellow transmission operators, industry and working groups and wider stakeholders to review the Black Start processes and procedures to update network restoration methods.

The GB wide strategy for Black Start restoration involves creating multiple power-islands across GB which are then linked through a 'skeleton approach' where the high voltage transmission network is re-energised to link these power-islands. This approach pre-supposes that there is sufficient regional generation, to be shared across the six transmission zones, distributed throughout GB.

Across the six GB zones there is variation in the restoration times, caused by the differing network topology, availability of generation and the amount of demand. This variation is minimised by the skeleton approach, distributing available energy across the country.

Going forward, as the penetration of renewable and HVDC based technologies continues to increase in Scotland, there will be a need for investment in tools such as **synchronous compensators**, which will enhance system operability in the Scottish regions in a black start scenario.

Other potential options to help improve restoration timescales include:

- In the short term, **reviewing and using existing infrastructure more efficiently** along with continued training and exercising activity to ensure an efficient response.
- In the medium term, **new supply options could be explored**, including generation and interconnection, in Scotland specifically with the ability to black start themselves.
- In the long term, as decentralised generation and Distribution System Operator models (DSO) develop on the network, **secondary back up generation** that can connect and supply power early in the restoration process once a restoration has been initiated could be explored, if technically achievable and economically viable.

Scottish peak demand for electricity is approximately 5.1 GW at present. The total transmission connected generation in 2019 is around 11.6GW, consisting of a mix of conventional and renewable generators. During the early stages of black start restoration, it is not currently possible to access the full capacity of generation and the output is limited by water reserves, weather conditions and nuclear safety considerations. The System therefore has to be adapted to deliver black start recovery improvement and enable operation of a future network with more diverse energy sources.

iii) Telecommunications Barriers

As we increasingly transition to a more digitally interconnected society, the importance of delivering strong, and long-lasting telecommunications support becomes increasingly important from a networks resilience perspective during power outages.

As copper lines are replaced by fibre, the UK's power network can no longer rely on traditional UK telecommunications methods (historically via analogue phones) which last for several days during a power outage. Mobile networks have limited backup battery storage in the result of power failure (traditionally only lasting a few hours) and signal issues continue to cause difficulties in some parts of our rural network in the Scottish Highlands and islands.

Traditionally, electricity transmission and distribution networks have used telecommunications at centralised control centres to manage remote switchgear, obtain network information, communicate with field operatives and safely manage the network; playing a critical role in maintaining safe and reliable electricity supplies. Without reliable telecoms support, control centres visibility of network issues and the ability to manage faults can become impaired.

Networks also need to prepare for the development and transition of 'Smart Grid' functionalities, including the expected increase in Electric Vehicle usage and distributed generation (taking a whole system approach to the UK's energy needs). Increasing the level of flexibility on the UK's distribution networks means that there is an increased requirement for networks telecoms systems to facilitate the transfer of network data at real time in order to balance the grid. As Distribution Network Operators (DNOs) transition to become Distribution System Operators (DSOs) they will become responsible for communicating with large volumes of smart grid devices, which will require increased use of the radio spectrum.

Strategic telecommunications considerations will be vital during this period such to maintain availability, resilience and cyber security and as a result electricity networks will require increasingly complex telecommunications needs to successfully manage this.

The rapidly changing landscape and the existing demands associated with management and visibility of aging technologies means that investment in new telecommunication equipment, back-up power, and access to additional bandwidth as the internet of things increases in importance, will be required to ensure that the electricity network remains safe, secure and reliable.

iv) Regulatory Barriers

While the above resilience priorities are firmly on SSEN's radar, and work continues to progress solutions alongside stakeholders, industry and working groups, network companies must also be mindful of the fine balance that needs to be struck with the cost of future network investment for GB bill payers vs anticipating when this investment will be required to meet customer need. This balance forms a key part of network companies' strict licence obligations with the energy industry regulator Ofgem, and all decisions from a networks investment perspective must be agreed through regulatory process.

As Ofgem begins to lay the ground work for the next RIIO price controls, it is clear that the next price control is going to focus on reducing costs for consumers whilst continuing to deliver a reliable, safe and secure network system that supports the transition to a low-carbon future. This focus on cost reduction may present some challenges in helping to address the issues highlighted above, therefore it is key that network companies, government and the regulator continue to work closely to discuss resilience measures and align on the delivery of priorities for the benefit of GB consumers and the UK's economic infrastructure.

We are also concerned that Ofgem is continuing to progress with the extension of competition in onshore transmission in the absence of a clear legislative framework for the next price control; which introduces further regulatory uncertainty for future transmission investment.

Opening up the GB transmission network to competition would create a 'patchwork quilt' environment where large parts of critical national infrastructure are under different operation. This will fragment responsibility, undermine accountability, delay fault response and risk security of supply.

SSEN believes that competitive models have their place if the policy, objective and impact are all known and are demonstratively positive to the GB consumer and wider society. However, given the criticality of transmission infrastructure to the resilience of the UK's social and economic infrastructure, we believe that its application to key transmission projects is not fully understood at present and would likely result in several unintended consequences that are clearly at the detriment of consumers and society.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?
Working closely with other network operators, decision makers, Ofgem, wider industry partners, and resilience working groups (such as the Scottish Energy Advisory Board, National Grid, the Energy Networks Association, The Electricity Task Group; a sub-group of the Energy Emergencies Executive Committee, The Emergency Planning Manager's Forum and the Scottish Utilities Contingency Planning Group) is hugely important to bring resilience issues to the forefront and discuss how best to address barriers for the future security of the network.

While some barriers to the electricity network's resilience are still to be overcome (as outlined in some circumstances above) as we move to an increasingly interconnected and digital age, the discussions that are taking place within these organisations and working groups are actively seeking solutions and ways to overcome key issues. However, policy and regulatory support from government, Ofgem and decision makers may be required in some cases to address some of the issues identified.

The NIC may find it useful to also engage with these groups as it further progresses the resilience work stream.

Thank you for providing the opportunity to input into the scoping stage of this consultation. Should you wish to discuss any of the points covered above in further detail, or would like to arrange a meeting, please contact [contact details redacted].

National Infrastructure Commission: Resilience study scoping consultation

Network Rail Response

Introduction

Network Rail would like to thank the NIC for the opportunity to input into the proposed scope for their infrastructure resilience study. Network Rail would welcome 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.

Network Rail also believes that this study should seek to clarify who the UK infrastructure should seek to improve resilience for and help to understand the reasons why infrastructure resilience needs to be improved. Is this a case of maintaining economic performance, getting commuters and goods to where they need to be? Is this a case of ensuring quality of life? Or is this a combination of multiple factors?

Network Rail looks forward to outputs which provide recommendations specific enough for it to action and enable change in the transport industry and foster cross-sectoral collaboration.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Before establishing a series of questions on resilience, Network Rail believes that we must first establish what 'good' resilience means. From this point we can establish what level of resilience the UK infrastructure needs and the point at which the value of investing in resilience starts to become unfeasible. The questions below can broadly be grouped into five categories:

The Future & Scenario Planning

1. What are the key resilience issues which currently affect the national infrastructure?
2. Where do the key interdependencies between the UK's infrastructure providers lie?
3. What types of exceptional event (natural or man-made) should the UK infrastructure, and the transport network specifically, be resilient to? For example:
    i. Weather/Climate Change, Coastal flooding and shoreline management, Power supply issues, Network incursions (from air, land, or water), and low probability / high impact events such as earthquakes
4. Further to the above, what are the levels of service that UK infrastructure is expected to provide in the case of an exceptional event?
    i. How do we expect the frequency and impact of these events to change in the long term?
    ii. What are the circumstances in which it becomes right to temporarily close infrastructure in order to minimise risk or provide better service overall (For example, during climate change induced extreme weather events)?
5. How can we successfully future-proof our infrastructure? For example, ensuring technological compatibility across sectors which may be implementing digital infrastructure changes at different rates, or by planning for the impacts that the introduction of new technology may bring (e.g. connected autonomous vehicles).
6. How can we ensure resilience/disruption management plans in the face of exceptional events are rigorous (for example, in the case of catastrophic power failure, how do we ensure that the correct system architecture is in place to supply Category 2 responders)? Is some form of stress testing required, for example?

Cross-Sectoral Responsibilities

1. How do we define different 'sectors'? Should there be a distinction between Network Rail and Highways England, as the providers of rail and road transport infrastructure respectively, or should these constitute a single 'transport' sector, for example.
    i. Is there currently adequate cross sector planning to improve infrastructure resilience, for example, across transport, housing, and utilities?
    ii. What needs to be managed at a cross-sectoral level and why?
    iii. Who is accountable for managing cross-sectoral risks and what are the limits of their accountability?
    iv. To what extent should different sectors (and areas within the transport sector) be able to support each other's objectives?
    v. Should transport providers set targets for network availability and, if so, how should this be managed?
2. How do the Transport and other sectors integrate their data systems with DAFNI to ensure that future infrastructure planning achieves the best outcome?

Financial Constraints

1. How do we ensure that there is sufficient investment in infrastructure to maintain and improve resilience?
    i. How do we ensure that the business cases for improvements to resilience are able to consider their long-term potential to avoid economic loss as opposed to the economic uplifts given by enhancement schemes?
    ii. How do we assess the relative criticality of assets across Modes and Sectors to allow for the correct distribution of funding?
    iii. What is the role in funding of asset owners vs central Government? HMG's "User Pays" principle results in overly commercial decisions on spending. Users i.e. the general public already pay for safety/security through general taxation and should not therefore pay again for services that are, by definition, critical to civilian life.
    iv. What is the long-term impact on resilience of short-term affordability constraints?
    v. How do non-state organisations handle HMG protectively marked information in a cost-effective way?
    vi. How will Government incentivise organisations to invest in ensuring resilience to climate change when the funding cycles are short term (5 years)?

Information and Best Practice

1. How do we ensure that the workforce of infrastructure providers are equipped with the right skills to be resilient when the introduction of new technologies requires a change in the tasks they carry out?
2. How should UK infrastructure engage with the public when events we have not protected against occur?

Data and Systems

1. How does the increasing reliance on digital technology affect the resilience of the UK infrastructure?
2. Should a documented architecture for critical assets (both physical and system) and their enabling utility supply (power, fuel, water, telecoms) be developed?
    i. Is configuration management employed on critical systems? Without fully understanding the end to end system architecture it becomes difficult to assess the impact – and therefore resilience – of the addition or removal of assets and interfaces to the whole system.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

We believe it would be of value to prioritise:

1. What scenario should each sector be resilient to, given that the needs of each sector may differ to some extent?
2. Is it possible to define and implement a consistent framework when assessing resilience?
3. Further to the above, is it possible to implement appraisal method of resilience issues across different sectors, including the distinction between safety and economic appraisal methods?
4. Clarifying the accountabilities of each infrastructure provider in the context of cross-sectoral resilience and establishing where, if needed, the lead accountability is given. For example, in modelling how changing coastline conservation policies / erosion / sea levels may affect the transport network
5. Analysing where the key interdependencies between different infrastructure sectors lie.
6. Defining the expected level of service/resilience is key to NR being able to develop robust, ambitious resilience plans.
7. A plan for how organisations should ensure that their approach to resilience is adaptive, for example, in light of climate change, changing technology, and changing demands upon service.
8. A clear plan for how organisations can share knowledge both cross-sector and between HMG and non-state organisations to ensure mutual benefits to resilience (for example, in combination risks of transport (Roads / Rail) and Flood Risk)
9. The investigation of multi-modal and multi-sectoral interactions, interoperability and their effects.
10. An analysis of how HMG currently, and can in the future, incentivise spending on resilience by private companies, for example, through tax breaks.
11. How do we ensure in an increasingly politically devolved world that network accountabilities remain appropriately engaged and funded?
12. How do we ensure that devolved administrations and agencies such as those in Wales work in concert, providing a coordinated resilience policy across the whole of the United Kingdom?

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

1. It should be acknowledged that different sectors, and different stakeholders within each sector, may have different incentives which could provoke competition between organisations or hinder open discussion if not acknowledged.
2. There needs to be a political architecture mapping out accountability for specific sectors.
3. There needs to be a consistently applied appraisal framework across sectors. Some specific appraisal inconsistencies which currently occur may include:
    i. Economic appraisal has been a long-standing input to transport and other infrastructure investment decision making, and cost-benefit analysis is an important component of economic appraisal.
    ii. The purpose of cost-benefit analysis within an appraisal is primarily to distinguish between different options in terms of their value-for-money.
    iii. Estimates of costs and benefits are based on forecasts of future economic conditions and are therefore subject to significant uncertainty (and are almost always partial in coverage as some welfare impacts cannot be robustly quantified and climate change impacts are uncertain).
    iv. Uncertainty can relate to costs and benefits, and because a probability cannot be assigned to uncertain events, it cannot be quantified.
    v. Within a single sector, the decision-making risk associated with uncertainty can usually be managed because significant uncertainties are likely to be consistent across the options (for instance, the link between economic growth and transport demand).
    vi. A risk of comparing benefit-cost ratios across different sectors is that establishing a common baseline for uncertainty will be challenging. Failing to achieve a common baseline will reduce the extent to which different BCRs are comparable, and therefore the quality of information available for decision makers.
    vii. The assumptions made in appraisal may differ across sectors
    viii. The current approach may not always recognise the benefits of investing in adapting the infrastructure now to avoid the costs of disruption and improving resilience in the future.
4. Policy decisions can exacerbate risks to resilience, for example, choosing to transport aggregates out of the peak district by rail only.
5. Communication between infrastructure providers will need to be more joined up than they are currently if cross-sectorial resilience is to be pursued more closely.
6. Any proposed solutions may need to involve cross-governmental co-ordination in addition to individual sectors where policy decisions need to be made.
7. Given the geography and complexity of our individual systems (transport, energy, water, & digital) and the multiple interdependencies within and between systems, practically assessing hotspots, trigger points and resilience levels and expected levels of service may prove challenging.
8. How the infrastructure network deals with interoperable data and data sharing across sectors (though we understand this to be being addressed by the Centre for Digital Built Britain)
9. There may be time and resource considerations both to the whole UK infrastructure as well as differing constraints between sectors.
10. Different sectors may also have a different understanding and application of HMG Security Policy Framework with reference to information classification and handling.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Network Rail has, and where able continues to, work with other infrastructure providers such as DEFRA and the National Grid. It also has informal working relationships with other infrastructure providers of the Transport Sector, such as Highways England.

However, being largely outside of Network Rail's funding and usual remit, this form of working relationship is undefined and we are not clear on our role and aims in cross sectoral collaboration.

Our collaborative relationships tend to be more successful when it is within the bounds of one particular department as opposed to spanning several.

National Infrastructure Commission

Resilience Study Scoping Consultation

Introduction

United Utilities Water Ltd provides water and wastewater services to nearly seven million people in the North West of England supplying 3 million households and over 200,000 business premises. It is one of the eleven statutory water and sewerage undertakers in England and Wales. We manage over 40,000km water supply pipes and 72,000km of pipes and sewers linked to our water and wastewater treatment works and other associated infrastructure. We're committed protecting and enhancing the environment, and we are proud of our four-star rating in the Environment Agency's environmental performance assessment. This is the highest rating that the Agency awards; we have held it for four consecutive years and are one of only two water companies to do so. We were also one of only two water companies to achieve the highest ratings for resilience in Ofwat's recent initial assessment of business plans.

We welcome the opportunity to inform the Commission's development work in relation to national infrastructure resilience and provide short responses to the consultation questions below.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

There are a number of areas where we believe the National Infrastructure Assessment could provide guidance on resilience that would greatly enhance the planning and collaboration by sectors and organisations. In particular we think resilience standards and national policies are areas worthy of consideration.

National standards – There are very few national standards relating to resilience which leads to something of a 'postcode lottery' in terms of risk exposure. We use customer research to explore consumer perceptions of acceptable risk in terms of some of the resilience issues we manage such as water quality, loss of water supply, sewer flooding or pollution events. But the risk to our service is in itself exposed to risks from dependencies such as the power network, telecommunications and transport. We have little or no information on the relative risk that each of those dependencies impose upon our assets and hence onto our service. It would help our planning if (a) minimum standards of resilience by sector were applied that would allow us to at least not exaggerate the risk and (b) relative risk levels were reported by sector at sufficient detail to enable us to accurately assess our risk. Our view is that the National Infrastructure Assessment should review the interdependencies across infrastructure sectors and consider whether the setting of national resilience standards is appropriate across the board or in some cases such as for specific sectors or for specific events such as flooding.

Customer expectations - Any change in standards potentially entails cost for customers. Our customer research takes a broad approach with multiple different techniques applied to gain insight into customer's views. We agree that reliance on a single approach such as Willingness to Pay is inadequate particularly given that resilience is one of the most complex topics to explore with customers. It would be helpful for the National Infrastructure Assessment to consider what constitutes best practice in testing customer appetite for resilience. In particular, what balance needs to be struck between hard measures that provide a semi-permanent resilience to shocks but potentially at higher cost and how much is reliance on an ability to bounce back quickly acceptable? After major events, there is often a political reaction to ensure "this

never happens again" which is an unrealistic expectation. It would be helpful for the National Infrastructure Assessment to support a national debate on what good resilience looks like.

Impact of policies – We are concerned that some Government policies are contrary to the provision of a resilient water and wastewater service. We are aware that the remit of the National Infrastructure Commission is limited but it has to be acknowledged that the infrastructure sector does not exist in a bubble, it is impacted by external factors and we think it would be helpful for the NIA to highlight where policy is contrary to the resilience ambitions of key national infrastructure. An example of this is planning policy, guidance and building regulations on water and energy efficiency in new homes. In order to spur house building, these regulations have been loosened in recent years which to our view is a short term measure that diminishes our ability to provide a sustainable and resilient service in the long term. There is a question over who pays. At the moment the costs of more efficient homes are passed on to the home buyer where it could be argued that some of the benefits are to the wider customer base. We think there is a case for the NIA to consider which policies could be considered to be counter to the provision of resilient utility services and if an alternative approach was adopted how costs could be shared more effectively to ensure all interests are treated fairly.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

We consider the issue of national resilience standards to be the key issue but this can't be addressed without considering our second point which is the customer acceptability of those standards.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

There are a number of barriers that make cross-sectoral resilience planning more difficult:

- Security concerns – Probably the biggest barrier to cross-sectoral resilience planning is concern about security. We and other utility providers are reluctant to share detailed information about the vulnerability and criticality of systems with others due to the risk that the further this information is shared the higher the risk that it will fall into the hands of those who have malicious intent. What data that has been shared tends to be sanitised to remove information that would be useful to those who might seek to disrupt infrastructure services which limits its value to those who wish to use it for legitimate purposes.

- Benefits framework – The lack of a standard benefits framework for non-financial resilience benefits makes it challenging to justify investment needs particularly where different sectors or organisations are seeking to collaborate on a single solution. It would be a great benefit for the NIA to consider the merits of a standard benefits framework for assessing resilience needs and to propose how a national framework might be developed particularly to consistently incorporate natural and social capital benefits in decision making.

- Data standards – Differences between sectors and organisations about data quality and data structures makes it challenging to readily share information to support joint decision making. Development of consistent data standards would be helpful to facilitate collaboration.

- Planning cycles – Sectors planning cycles and funding mechanisms are all different so gaining consensus on approach, timing and governance is difficult. For example, Water Resources Management Plans, Water Industry Natural Environment Plans, River Basin Management Plans and Water Business Plans all work to different timetables. This is exacerbated when trying to work

across industries. A national framework for undertaking jointly funded resilience investment would help bring organisations together and smooth over differences in approach.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

We think that great strides have been made to overcome sectoral barriers in the area of incident response. We work very closely with other responders such as police, fire and other lead responders to incidents such as local authorities, working together under the Civil Contingencies Act of 2004. The Cabinet Office have promoted a protocol for joined up working, the 'Joint Emergency Services Interoperability Programme' which promotes models for shared situational awareness, joint working and joint decision making. These models have been embedded into our incident management processes. We regularly take part in joint exercises with other responders which have been very helpful in developing joint working practices that have benefitted the public during real events.

Another area where we think different sectors work well together to deliver additional resilience is in power supply. The shift towards local generation has given us opportunities to generate a source of income from wind turbines, solar panels and combined heat and power sites. But as a major power user we also work with the power companies to help balance the load on the power system by using power when other demands are low or even by shifting to generators. We gain from lower prices and the power system gains headroom providing additional resilience. Those same generators are then also available as emergency backup should we lose power, adding to our service resilience.

Q1: What are the key questions that the next National Infrastructure Assessment (NIA) should answer about resilience?

The key questions in relation to resilience are:

- Is there understanding of the nature of resilience and of the need to place it at the centre of infrastructure planning? Is the impact of digital systems on wider infrastructure fully understood?
- Will the next NIA deal with the wider societal risks as well as the economic risks?
- Are we able to commit the necessary levels of investment to have contingency plans in operation to protect a core set of identified critical networks and to maintain the technical integrity of a complex inter-dependent system on which society depends across the infrastructure silos?
- Can we provide the necessary incentives/requirements for public and private sectors to work together? Is a new organisational framework operating at several levels necessary?
- Is there is a system of regulations, standards, targets, cross-sectoral modelling and regular exercises in place to promote infrastructure resilience across different sectors? Who organises and sets these?
- Are there collaborative mechanisms in place for central government, the devolved administrations, local government and the relevant industries which enable the rapid restorative response which characterises resilience?

The next National Infrastructure Assessment needs to develop ideas put forward in the first Assessment published in July 2018. While the recommendations outlined last year indicate a new approach towards addressing the lack of a long-term infrastructure strategy and a move away from siloed decision making in infrastructure sectors, the topic of the resilience within the 2018 NIA is addressed primarily from the perspective of climate-related events such as drought or flooding. In an increasingly interconnected world, resilience is a much larger concept. Essentially, failure in sectors and cross sectors can and will occur. The only issue is frequency of the incidents and whether we are resilient enough to avoid unacceptable consequences. New networks of digitally connected infrastructure present unintended vulnerabilities and unforeseen cascade effects which need to be first: investigated; understood; planned for; and anticipated. Enhanced digital connectivity facilitates the development of smart infrastructure and while it enables more efficient management and maintenance it also carries more risk. The concept of "resilience" is very different to "reliability" - **the essence of resilience is rapid recovery**.

The threats to which our complex inter-dependent systems must be resilient are both diverse and changing. Some - extreme weather events - are predictable while others - cyber threats, sabotage, political or industrial upheaval and solar storms - are random. Foreseeable trends such as driverless vehicles, decentralised energy systems, as well as integrated digital control structures (both at a domestic level and within systems such as gas, water and electricity) underline the need for effective resilience planning. Although equally important, the concept of resilience needs to be understood separately from the discipline of emergency planning. Emergencies are exacerbated by insufficient resilience planning. For instance, Government views loss of electricity for seven days as being a possibility, while industry believes this may be optimistic for some scenarios. Resilience must be addressed across all sectors to deal with a situation of: no communications (even radio); no digital infrastructure; no internet provision; no water; no sewerage; no fuel; and; no payment systems. The probability of catastrophic failure may be low, but the NIC might need to lead a public debate on the acceptability of this risk or alternatively set out the level of resilience required for national infrastructure.

Resilience planning is not just about assessing current risk but also involves anticipating future developments. Effective resilience planning needs to be dynamic and to involve on-going dialogue. There needs to be a regular review of standards, collaboration, modelling, targets and testing. What good resilience looks like now, may be very different in 20 years' time as new technologies, interdependencies and complexities develop. Both the current NIA and this scoping study place emphasis on the economic impacts of resilience but the social impacts also need to be considered. For example, care homes may not have the resilience infrastructure which hospitals have but they also care for vulnerable people. The concept of resilience needs to be prioritised, and this new thinking must be implemented by new organisational frameworks, backed by the required levels of investment.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Some priority issues which need to be addressed are:

- the need to increase understanding of resilience in the context of digitally connected infrastructure and the interrelationships between elements of this infrastructure;
- the educational and cultural shift needed to embed the concept of resilience so that it is designed into the system;
- the creation of suitable structures which will enable communication and dialogue across the public and private sectors to enable them to exchange information and experiences; and
- the establishment of incentives and flexible governance structures which will prioritise resilience issues.

The importance of digital system resilience is well understood by the NIC and these issues are covered in the Infrastructure and Digital System Resilience Final Report published in 2017. One of the recommendations of this report is that "modelling, event simulation and workshops to understand interdependencies should be introduced at an early stage in the infrastructure planning process". This report also emphasises the role of data and advocates better sharing of data across organisations to facilitate a collaborative and cross sectoral approach. The IET endorses this approach, but this is just one element in what will have to be a major push to educate different levels of government, industry and the wider public on the importance of infrastructure resilience.

One of the key aspects of resilience within an increasing inter-connected system is an understanding of the level of disruption from failure of just one element. A trivial sounding example could be the resilience of a smart lock or a series of such locks in buildings. Would a loss of power render it opened or closed? Does it still work or only if the mobile phone which operates it has battery life? If so, what is the dependency on available digital communications, both locally and nationally? Is there a manual override function (which is usable on a practical level) and should measures be built into the product to embed greater resilience? These are the important practical questions which need to be considered when products and services increasingly rely on more complex relationships between different sectors and supply chains. In future the concept of "resilience by design" ought to be as familiar as the idea of "safety by design".

The central role of any government is the identification of issues of priority and the establishment of structures, mechanisms and dialogue which will enable these priorities to be dealt with. Many of the issues in respect to resilience are already recognised but are currently tackled within "siloes". The next NIA needs to confront this fragmented response. Fortunately, suitable governance structures for tackling resilience are starting to emerge. While in the past energy planning for resilience focussed on major industrial installations, the focus now in our service led economy is on major metropolitan areas. The emergence of the role of a Chief Resilience Officer in cities such as London, Glasgow and Manchester, and global bodies such as the "100 Resilient Cities" network are encouraging trends.

Resilience planning at local level is vital but is also needed nationally. On the top tier, leadership by the NIC and the involvement of the Cabinet Office is welcome but the emergence of new bodies such as the Scottish Infrastructure Commission could be an opportunity to embed resilience thinking within the devolved nations. Could it be argued that the concept of Scotland as a self-contained resilient nation assists the national resilience of the UK? As exemplified in the well-known large-scale disruption in Lancaster in 2015, help is needed from outside and a nation which is a network of semi-self-contained resilient cells may be a model to aim for.

There may not be technical solutions to avoid all risk, but diversity may ensure a supporting infrastructure to ensure that there is a supporting infrastructure to enable resource availability to overcome loss at least at a local level of operation.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

- Barriers on data sharing exist both within and between specific sectors. Particularly in the case of digital technology and infrastructure bodies, there are also problems of communication in terms of language, organisational culture and time scales.
- Thinking must be re-orientated to focus on consequence rather than cause.
- The concepts of inter-dependency and resilience need to be considered right from the initial planning stages.
- There is an argument that data itself must be considered as an infrastructure component. The way in which it is managed has consequences for resilience.
- Resilience planning has an international as well as a national dimension.

It should be noted that internal barriers to effective knowledge sharing exist in specific sectors, not only between sectors. The regulation of the electricity industry for example, places specific restrictions on the ability of key industry participants to share data, including data/ knowledge of relevance to wider system resilience. Privacy laws and "Chinese" walls put in place for regulatory reasons in the context of commercial market development, also segment infrastructure where there is widespread disruption of common elements (e.g. the backbone of the internet; the backbone Transmission network in electricity). In areas where no explicit restriction on data sharing may exist, a lack of appropriate cross sector knowledge and forums represents a barrier. The approach developed by the NIC study should set out a framework within which cross-sectoral interdependencies can be identified and objectively evaluated/ measured.

One of the major barriers to addressing resilience is that the way in which the issue is currently considered. Resilience can no longer be thought of in sectoral silos as technology becomes more embedded into complex systems. Up to now, the Government focus on resilience and contingency planning has very much been on the cause of major incidents, rather than the consequences. This approach doesn't recognise interdependencies and potential cascade effects, some of which may not be anticipated. A potential "fix" for a cause, may go on to create a host of more subtle vulnerabilities with different, but equally disruptive consequences. Hence the need for on-going dialogue and continuous dynamic cross-sectoral planning.

Resilience thinking needs to be embedded into the planning and design of infrastructure right from inception. The Arup report – Future Cities: Building infrastructure resilience noted that in New Orleans after Hurricane Katrina in 2005, infrastructure such as the sewerage system remained operational as it had an independent energy supply which allowed the city to be pumped of floodwater. This example of forward thinking paid dividends decades after the initial decision.

Lack of initial integrated planning will create problems but so too will a failure to invest in information management. The need for standardised data files at building level ought to be matched by data available on a city-wide level. There is an argument that data itself must be viewed as part of the infrastructure of smart cities. The problems in relation to promoting greater efficiency through data-driven decisions include: lack of common standards, poor data quality, lack of familiarity with data-led innovation and resistance to open data.

This consultation has explicitly excluded from review issues in relation to Brexit but issues of national resilience cannot be viewed in isolation without regard to the wider political and international framework. For instance, in Northern Ireland, the electricity system is part of an all-Ireland network and the UK has inter-connectors with Ireland, France and (by 2021) Norway . Data centres can be located outside the UK. It can also be argued that the UK's continued participation in projects such as Galileo and Copernicus ought be viewed in the context of resilience planning. Effective resilience planning embraces a spectrum of targets, modelling, standards, protocol and dialogue from a local level through to an international one.

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Monday 1st April 2019

Statutory consultation on National Infrastructure Commission Resilience Scoping study

Dear Sir,

Thank you for the opportunity to respond to the National Infrastructure Commission's *Resilience Study Scoping Consultation* published last month - please find on the following pages below a series of responses from NeuConnect to each of the four consultation questions.

By way of context, NeuConnect is a fully privately-financed £1.4bn interconnector that will create the first direct link between UK and German networks, allowing 1.4GW of electricity to flow in either direction. We have received initial UK regulatory approvals that allow participation in the OFGEM Cap and Floor regime for electricity interconnectors, with construction work on the project planned to start in January 2021.

By connecting two of Europe's largest energy markets for the first time the project will help deliver a more diverse, resilient and sustainable electricity supply in the UK, while also helping to lower costs for consumers. We therefore believe NeuConnect will play a crucial role in the UK's future energy security and strategic infrastructure needs.

Should you require any further details on the NeuConnect project or our consultation responses that follow further below, please do not hesitate to contact me.

Yours Sincerely,

David Inglis
Chief Executive Officer
NeuConnect Britain Ltd

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

The resilience of UK infrastructure is directly influenced by the resilience of UK energy networks which act as the crucial 'enabler' to power the UK and support its vital infrastructure. In this context, we define 'energy resilience' as the capacity of the network to withstand disturbance (for example climate change, major incidents, political or policy changes) in order to continue to deliver efficient and affordable energy supplies to consumers and industry.

The UK energy market itself faces a wide range of challenges that will impact its own future resilience and security of supply. The Government's own figures[1] show that projected energy demand is expected to increase by 2035, with rapid increases and advances in technologies such as Electric Vehicles and Data Centres driving consumption.

However, potential delays to the UK's nuclear build programme and phasing out of coal plants will create a potential 'gap' in meeting future demand. Equally, recent challenges with the financing of major new energy schemes (such as the Swansea tidal project or Hitachi nuclear plans) highlight that the need for large public subsidies is an ongoing challenge to future energy policy.

As a further example, a growing focus on using 'green' energy in order to meet national and international climate change targets means the UK will generate more power from renewable sources which are by nature intermittent, therefore raising further challenges to security of supply.

Against this backdrop of rising demand but challenges in securing and generating new energy, there is a broad consensus that increased interconnection will play a crucial role in improving the resilience and security of supply of the UK energy market, while also helping drive down costs for consumers.

By connecting into cross-border energy networks, electricity interconnectors have the ability to access wider renewable generation capacity, providing an effective way of managing the fluctuations and intermittencies of any one source of power. Using NeuConnect as a specific example, the new link will allow surplus wind power from northern Germany to flow into the UK – this Germany wind power is countercyclical to UK wind power, so there are considerable benefits from a 'balancing' point of view and/or managing intermittencies.

There is also an 'immediacy' to interconnectors that allow them to react far more quickly to 'system stress' or major incidents compared to other forms of energy generation. This immediacy also extends to maintenance, repair or replacement situations where an interconnector can be up-and-running far more quickly than, for example, a flooded or damaged major energy plant.

In this sense, interconnectors are not only resilient in their own right, they can also act as a resilient 'back up' to other systems at times of stress, failure or repair.

Finally, as predominantly privately-financed projects, interconnectors also sidestep the need for large public subsidies meaning the significant resilience benefits they offer do not come at the expense of the public purse.

In energy-specific terms therefore, the next National Infrastructure Assessment should continue to endorse increased electricity interconnection with Europe and third countries as a means of maintaining and increasing the resilience not just of the energy market but all parts of UK industry.

In addition, the National Infrastructure Assessment should also consider potential changes to the policy or regulatory landscape that may impact the energy market and electricity interconnection. As an example, the ongoing review and potential changes to the Capacity Market will have a material impact on the delivery, operation and viability of current and future interconnector projects.

Therefore, along with recognising the continued importance of electricity interconnection to the resilience of UK industry, it is also important for the National Infrastructure Assessment to guard against regulatory or policy changes that may impact the effectiveness or viability of continued electricity interconnection.

[1] UK's draft National Energy and Climate Plan (NECP)
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/774235/national_energy_and_climate_plan.pdf

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

As a crucial 'enabler' to the delivery and resilience of many other projects and sectors in UK infrastructure, the UK's energy and electricity market should be given clear priority in the resilience study.

More specifically, electricity interconnectors should be prioritised given the clear benefits they offer in meeting the UK's resilience needs. Interconnectors have the ability to 'balance' the energy system and respond instantaneously when the network is affected by disturbances such as a major storm or high-demand events. This instantaneous response helps prevent major power outage scenarios, therefore maintaining resilience.

In addition, as outlined in Q1, the energy and electricity market face a number of future changes and challenges which should also be taken into account when considering the wider resilience of UK infrastructure as a whole.

The ongoing Capacity Market review is also a good example of an issue which may have clear implications directly for the UK energy and electricity market, and also indirectly for the many other sectors and industries in UK infrastructure that rely on a secure, resilient energy and electricity supply.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

As outlined in Q1, there is a clear cross-sectoral interdependency between infrastructure and the energy and electricity market – indeed, the UK Government's own Industrial Strategy cites infrastructure as one of its '5 foundations'[2], noting the need for *"clean, affordable energy"* as part of its infrastructure ambitions.

As part of this, the UK continues to be a net-importer of power, with interconnectors providing 6% of the UK's electricity in 2018, and the UK Government planning the development of at least 9GW of additional interconnector capacity as part of its broader energy policies.

So, the UK's infrastructure and energy ambitions - and the direct links between them - are clear. However, there appears to be limited awareness or understanding of how changes to energy policy or the regulatory landscape may impact the wider resilience of UK infrastructure.

The UK's participation in the EU Internal Energy Market (IEM) together with Ofgem's 'Cap and Floor' regime have both created the right policy and regulatory landscape for electricity interconnection to develop and grow. However, both face potential challenges and limitations that may impact the UK Government's ambitions for continued electricity interconnection.

Brexit first of all, is a clear challenge to the UK's continued participation in the Internal Energy Market – while the UK Government have been clear on their desire to remain part of the IEM post-Brexit, this is not necessarily a view that is reciprocated in the EU and there continues to be a lack of certainty about what will happen next. This is therefore a clear barrier or 'knowledge gap' that needs to be addressed in the wider context of energy and infrastructure resilience.

In terms of Ofgem's 'Cap and Floor' regime, while this has opened the door to increased electricity interconnection there remain clear limitations that need to be addressed. In particular, the current regime presents barriers to 'new entrants' to the interconnector market – it is these 'new entrants' that offer the benefits of broadening the UK's energy supply (therefore increasing resilience) and creating

[2] https://www.gov.uk/government/publications/industrial-strategy-the-foundations/industrial-strategy-the-5-foundations

more competition (therefore helping drive down costs) so there are clear advantages in addressing and removing the barriers that are in place.

Ofgem have recognised this[3] and have called upon individual projects to submit 'variation' requests to the current Cap and Floor regime where clear consumer benefits can be demonstrated. However, along with project-by-project engagement on this issue, the National Infrastructure Commission adding its collective industry voice to this issue would be an important step towards addressing the barriers that are currently in place.

In summary therefore, the UK's continued IEM participation will allow electricity interconnection to continue, while changes to Ofgem's Cap and Floor regime will allow further new entrants to the market – the net result will be continued electricity interconnection, greater competition in the market, and a greater variety of supply leading to increased resilience for the energy and infrastructure sectors. Given the clear benefits, we believe that both issues warrant inclusion in the National Infrastructure Assessment.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The Ofgem 'Cap and Floor' variations issue highlighted in Q3 is a good example of a 'live' process in which barriers to resilience are in the process of being overcome.

In this context, we define 'barriers' as regulatory issues that disincentivise the delivery of crucial infrastructure projects, especially 'new entrants' to the market and/or privately funded proposals. Indeed, Ofgem have acknowledged that *"certain aspects of the default regime may be less suitable for some types of financing solutions"* and have therefore called upon individual projects to submit 'variation' requests to address this.

NeuConnect is currently engaged in this process and is arguably the first privately-financed electricity interconnector to set out what changes are needed to Ofgem's current regime to remove these existing barriers. NeuConnect's involvement therefore has the potential to create an important precedent that will open the door to further privately funded 'new entrants' to the interconnector market, helping deliver the benefits of greater competition, more choice and improved resilience.

As noted in Q3 though, while NeuConnect can make important representations from an individual project point of view, engagement on this process from industry-wide bodies like the National Infrastructure Commission would also be a helpful and important intervention to help remove existing barriers.

[3] https://www.ofgem.gov.uk/sites/default/files/docs/cap_and_floor_regime_variations_open_letter.pdf

NIC: RESILIENCE STUDY SCOPING CONSULTATION

Over the course of the last six months, 100 Resilient Cities (100RC) has been coordinating with the National Infrastructure Commission to explore ways in which learning points from our network can feed into the NIC Resilience Study.

As part of our ongoing mission, 100RC helps cities around the world become more resilient to the physical, social, and economic challenges that are a growing part of the 21st century. We do this by engaging with cities to help understand and bring shape to the shocks and stresses to which they are vulnerable, and to support the design and implementation of ambitious strategies addressing these shocks and stresses.

We are proud to play a role in the important journeys our cities take, and recognise the significant amount of effort and ownership that each of them take in the work.

Introduction

On Friday 22nd March, 100 Resilient Cities (100RC) hosted an in person/virtual workshop to coordinate feedback to the recently released NIC Resilience Study Scoping Consultation from resilience representatives from Bristol, the Greater London Authority and Greater Manchester. We were also grateful for attendance from the NIC, who were able to provide valuable context to the discussion.

The feedback presented herein is an aggregation of feedback provided on the day, and subsequently by individuals who attended the session. It also includes wider observations provided by 100RC drawn from their experience of practicing urban resilience across the globe.

In preparation for this workshop, the Greater Manchester team additionally collated written feedback from wider city representatives; this is included, question by question, at the end of this document.

In addition to this document, each of the participating cities may also provide feedback directly to the NIC through other channels.

We would be pleased to engage further with the NIC in all subsequent areas of the study and look forward to opportunities to do so.

Individuals who attended the session were:

Bristol

- ~~Rob Gilmore~~[name redacted], Senior Programme Manager, Growth and Regeneration Directorate
    - Note that ~~Rob~~ [name redacted] is not formally a member of the Bristol Resilience team

Greater London Authority (GLA)

- [name redacted]~~José Reis~~, Senior Policy Officer, Urban Resilience

Greater Manchester (GM)

- [name redacted]~~Karl Astbury~~, Senior Policy Advisor
- [name redacted]~~TBC~~

NIC

- [name redacted]~~Emily Anderson~~, Policy Advisor

100RC

- Lina Liakou, Managing Director EME
- John White, Associate Director EME

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

- Definition What do we mean by resilience within this context; is it a broad concept or something specific that we think we might be able to measure?
- How do we factor in climate change and longer term (timescales) thinking?
- How do we know if infrastructure is resilient, are there specific targets (KPIs) or thresholds?
- Drought and availability of water and flooding are important focus areas for London
    - The current NIA (2018) limits resilience to weather in the form of flooding and droughts. Is this what we mean by resilience?
- Questions around resource scarcity should be a priority inclusion.
- How does digital resilience play into the wider topic; more and more historically 'physical' infrastructure is becoming more dependent upon digital operations – are we properly framing the risk of the reliance upon digital technology in terms of its ability to impact delivery of key infrastructure services?
- Concept of 'build back better'; it's a good idea, however typical UK based insurance approaches are largely predicated upon build back the same – fit for future purpose?
- How do we achieve integrated investment models across infrastructure types?
- How do we account for high impact low probability events; how robust is the planning for these events considering their potential impact?
    - There is a challenge here in that regulators are putting high expectations on infra providers to keep bills the same – which can inhibit investment on long tail events.
    - If you increase costs to consumer to improve resilience in one area are you reducing their resilience (financially) in another area?
- Is the goal to develop infrastructure that can withstand an increasing variety and magnitude of shocks and stresses (i.e. infrastructure with a primary objective that overrides all others), or to develop an integrated approach to infrastructure planning that focuses equally on the amelioration of these shocks and stresses (i.e. infrastructure design that trades primary outcomes with secondary benefits for a greater overall outcome)?
- Over what timeframe are resilience goals being framed; and how do you/we expect the needs for and threats to this infrastructure to evolve within this timeframe?
- How can we better integrate non-financial benefits into infrastructure planning and cost benefit analyses?
- What are the objectives of national infrastructure? For example; to facilitate the seamless movement of people and goods across the country, or to create an environment in which the movement of people and goods over large distances is needed less.
- How can we better frame the financial equation for national infrastructure? One of the primary challenges in resilience is that:
    - The individuals who are asked to pay for 'greener' infrastructure are rarely the ones who reap the rewards of the additional investment.
    - The individuals who suffer most as a result of a lack of investment in 'greener' infrastructure are the ones powerless to influence the way it is built.
- What is the role of city leadership in terms of influencing infrastructure resilience; Could cities that have devolved powers could do more?
    - What is the role of sub regional government?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

- Establishing the levels of service/thresholds that cities need to set in terms of individual infrastructure components and as a system.
    - Should these thresholds vary depending on the environment?
    - Should areas with greater output receive greater investment.
- Digital, and the lack of regulatory framework around it, the opportunities it presents and also the unknown risks as we continue to build digital into our infrastructure.
- Definition Establishing a clear and consistent working definition of infrastructure resilience.
- Spatiality & governance Challenges of aligning infrastructure needs and investment plans to deliver city needs. Cities have limited control over the decision making process of national infrastructure providers – national investment plans and decisions are not always necessarily aligned with city goals.
- Spatiality & valuation Multiple infrastructure providers who frequently operate on a difference geographical footprint – this can be a challenge for place based resilience.
- Exploring new investment models that recognise the total value of a project; challenges in locating and securing finance for long term transformative projects – who will provide this investment?
- The study would benefit from being open to cross sector, cross silo recommendations; against what future scenarios is resilience is sought? Infrastructure is one of many systems that interacts with people, environment and place.
- Sustainability Addressing environmental concerns, monetising the value of blue green infrastructure in every single investment decisions.
- Spatiality Disconnect between the location of infrastructure assets and the location of the people who benefit from them; what this means in terms of financing and transfer of resilience value.
- Creating a regulatory environment that incentivises the private sector to design and implement more sustainable, resilient, climate sympathetic solutions.
- Valuation of resilience Developing a better approach to business case development for resilience infrastructure; mapping how value is created, moved and realised as a result of making more resilient choices and using this information to drive better decisions.
- De-coupling national infrastructure decisions from short term political cycles. Short term incentives and performance cycles are a primary impediment to more resilient thinking.
- Systems perspective Looking at how to explore infrastructure choices from a 'whole system' perspective.
- Good governance. Co-ordination models required for resilient cities. People live in urban areas/cities which are the hubs where infrastructure converges, where demands are increasing and where interdependences between infrastructure assets are increasing.
- Ageing assets The benefits of ensuring that new infrastructure that is provided between 2020 – 2050 is resilient compared to a business as usual scenario. The study should explore how well designed and resilient infrastructure can ensure that the gross public investment in economic infrastructure of between 1.0% and 1.2% of GDP (ie the NICs fiscal remit) in each year between 2020 and 2050 can be focused on new infrastructure investments rather than maintenance of existing (victorian era) and ageing assets designed for a different scenario of the future.
- The National Infrastructure Commission has launched a new partnership programme to help cites plan for the future. This is exploring the different way that cities can produce integrated infrastructure plans. There is an opportunity to ensure that a resilience lens is applied to these partnership and to explore lessons for the next NIA.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

- Knowledge sharing is a real barrier; there are ad-hoc workshops and working groups etc, but these are bolted on, not built in.
- Everyone recognises that their approach needs to be cross sectoral but are still acting primarily from an individual perspective.
- Lack of understanding of both basic and complex interdependencies between infrastructure organisations and assets:
    - These interdependencies surface even in a simple workshop; this evidences how little providers understand about each other's domains.
- There has been some reluctance to share data from some utility companies (commercial sensitivity?)
- A shared definition of resilience
- General value of information sharing; cost/benefit
- Lack of alignment between price reviews and needs / benefits.
    - Are resilience consideration built into price reviews?
- Short term individual/department focussed performance and incentivisation models.
- A risk averse political culture. Considering the rate with which significant change it needed (think infrastructure gap, population growth, resource shortages, overshoot day etc.) it is impossible to conceive that this change can be implemented within our current political climate. We must be more ambitious, become more comfortable with risk.
    - The cost of not acting, or acting too slowly is far greater than the cost of getting things wrong on the way.
- A lack of a common language to describe/quantify resilience benefits is prohibitive of these benefits being 'traded' in infrastructure design (think carbon trading on a wider scale).
- Infrastructure has become so tightly coupled / complex over history
- For water infrastructure the water company plans ahead to 2050 but then works back on 5 year cycles - with downward pressure on bills.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

- London Resilience Group has been working on these aspects for a while, modelling responses to potential types of hazard. They host round table workshops on interdependencies in resilience.
- Mayor of London has a high level infrastructure group.
- Working more closely with the GM Combined Authority to improve collaboration more regionally.
- GM has an infrastructure advisory board, brings key players together to discuss; this has been formalised into a strategic advisory board.
    - Decision makers to come together to find solutions at a place based level
- Website called mapping GM; developed in 2015, shares social & physical infrastructure, has become key to some approaches to public consultation. Facilitates dynamic consultation with the population. Looks at the clean air plan and how transport choices affect that. Has grown out of its original remit.
    - https://www.gmcameetings.co.uk/meetings/meeting/642/joint_gmcaagma_executive_board
    - https://mappinggm.org.uk/gmodin/#os_maps_light/11/53.5069/-2.3201
    - https://www.greatermanchester-ca.gov.uk/media/1715/greater-manchester-infrastructure-framework-2040.pdf
- New York City (NYC) parks department green roof programme; This department has identified that one of the solutions it is responsible for (green roofs) provides benefits that several other departments are accountable for (stormwater management, reduction in heat island effect, improvement in air quality, increase in biodiversity, reduction in species loss, creation of public spaces). In trading with these other departments, the NYC parks department has significantly reduced costs to install a green roof over the last five years – they have traded the benefits they can provide for budget from other departments.

ADDITIONAL WRITTEN FEEDBACK PROVIDED BY GREATER MANCHESTER

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

- A lack of infrastructure resilience arguably manifests itself in adverse impacts e.g. loss of power supplies or sewer flooding. The impact is felt in specific places and communities and therefore infrastructure resilience is context specific, with each place offering its own unique 'resilience ecosystem'. An essential question is how we can deliver integrated and resilient investment that aligns with the urban resilience needs of a city/at a local level (e.g. an aspiration to be carbon neutral). This may require the Study to assess how local composite risk analyses are fed meaningfully into infrastructure investment decisions with a clear understanding of how risks to a place are created, mitigated or managed, and how developments affect communities' exposure and vulnerability to risk. Resilience solutions then need to be protected and not value engineered out of work on site. Practical example: a number of studies available from contingencies.agma@manchester.gov.uk including the evidence base for a number of GMCA strategies and plans and research led by external consultancies including Arup.
- A *resilience* dividend is possible if infrastructure investment delivers social, economic and physical benefits from a single investment. A key question is therefore how we achieve integrated investment models across infrastructure types and multiple agendas, addressing multiple risks and cross-cutting issues. A core component of this is securing the 'bankability' of, and recognising the resilience value of, co-benefits such as those achieved through integrating blue and green infrastructure into physical infrastructure projects. Conventional methodologies for investment decisions typically take defined categories of financial and economic benefit into account and investments may not represent best total value with an opportunity for value creation and co-benefit identification being lost. Looking to capture the wider benefits could harness new partnerships, new delivery models and provide resilience benefits. Practical example: a number of studies available from contingencies.agma@manchester.gov.uk including the evidence base for a number of GMCA strategies and plans and research led by external consultancies including Arup and Arcadis.
- In the aftermath of disasters, the regulatory and insurance frameworks promote a return to normality (return to 'as was') and pre-disaster operational states, rather than promoting the UNISDR globally agreed concept of 'build back better'. This latter concept is concerned with learning from events to improve risk prevention and mitigation. There is some information about this approach at: https://www.unisdr.org/files/53213_bbb.pdf. Practical examples include infrastructure recovery following Storm Eva 2015.
- Within the current approach to risk assessments in the UK civil contingencies, the community risk registers have significant risks sat in the 'top left' of the risk matrices i.e. high impact, low probability events. These tend to include issues such as reservoir flooding and the approach to resilience often involves proactive risk management and regulation/enforcement activity. Investing in emergency planning and response for a catastrophic failure is challenging given the low probability. The study could explore the robustness of planning in this area since failures would cause destruction across multiple infrastructure types. Practical example: the adequacy of planning for high impact low probability events has been raised in an international peer review, Greater Manchester https://uscore2.eu/downloads/Uscore2%20-%20Greater%20Manchester%20-%20Salford%20-%20Peer%20Review%20Feedback%20Report.pdf.
- With the global context for risks changing considerably to include significant future change and challenge (https://www.jbs.cam.ac.uk/faculty-research/centres/risk/publications/multi-threat/global-risk-index-2019/) e.g. climate change, cyber risk, urban growth, changing demand patterns etc. this Study could address how fundamental changes to existing, as well as new, infrastructure are delivered at the necessary scale and pace to keep communities safe. 'Business as usual' or even using key

'moments of change' such as town centre redevelopments, is probably insufficient to address the scale of predicted future challenges.

- Although the Study has chosen not to adopt a definition of resilience, resilience should be broader than defence of infrastructure against external risks in order to maintain current operational performance or service levels. Whilst infrastructure can be subject to shocks such as cyber-attacks and stresses such as ageing infrastructure coupled with increasing demand, it can itself cause shocks such as power loss or stresses such as a high carbon footprint due to driving an increased demand for electricity or generation of e-waste through a high turnover of hardware.
- The need for digital resilience should be explored as a key topic within the Study. Work in Greater Manchester has suggested that the opportunities afforded by new technologies are also accompanied by risks that are not fully understood and this is echoed by the World Economic Forum which suggests that new instabilities are being caused by the deepening integration of digital technologies into every aspect of life, see https://www.weforum.org/reports/the-global-risks-report-2019.
- There is also an important issue about digital resilience in the face of power cuts or digital outages. In those instances the need for mobile based back up will be critical for businesses and households (which will need to be fast enough to serve as that back up) e.g. how will we make our connected homes function (indeed actually be able to enter them) when fixed internet goes down? There needs to be much more integrated thinking on the interdependencies between fixed and mobile connectivity moving forward to ensure our connected society is resilient. To address this there could be a Universal Service Obligation for mobile with minimum connectivity speeds which is the same as fixed (10Mpbs) so everywhere has at least 4G connections.
- We know that resilience is important to all Infrastructure Providers but can we find a new/better way to address interdependency resilience. What is the potential to generally improve the cost and quality of our delivering infrastructure by working closer together. Clearly, sharing data is one way - there will be others.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

- The Study should be open to cross-silo, cross-sector, cross-agenda considerations. This is the cornerstone of a resilient approach. Although the Study is choosing not to adopt a definition of resilience, in order to be resilient to the magnitude of future challenges, the Study needs to consider against which future scenarios resilient sought and how infrastructure plays a role as one system amongst the many that interact in the urban environment. Including considerations around people, environment and place is important in determining co-benefits and the resilience value that infrastructure can add. In particular, addressing environmental concerns and monetarising the value of including blue and green infrastructure in every physical infrastructure investment decision should be a core part of building a resilient future. Understanding and building digital resilience is also as important, with digital infrastructure being arguably untraditionally pervasive, with society not having caught up with the speed and implications of tech growth and with cyber-attacks being just one part of digital resilience.
- The Study should explore new investment models that enable infrastructure investment to recognise and leverage the total value of a project, including how to incentivise the development of sustainable, resilient urban infrastructure. This should recognise current challenges in locating and securing funding for long-term, transformative projects where a return on investment may be realised only in the medium to long-term.
- The Study should address the challenges of aligning infrastructure providers' investment plans to deliver a city region's resilience ambitions, recognising the challenges faced by local governance structures in trying to create resilient places but having limited control over the decision-making processes of multiple infrastructure providers. Equally, local, place-focused governance structures have limited control over aligning investment by different infrastructure providers to achieve integrated, place-based resilience ambitions.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

- The Study could seek to explore potential benefits from regulatory price reviews being aligned to enable greater cross-sectoral planning and/or all regulators building resilience considerations into statutory price reviews and adopting common resilience standards.
- Information sharing to identify single points of failure, interdependencies and cascading impacts. Practical example: https://uscore2.eu/downloads/Uscore2%20-%20Greater%20Manchester%20-%20Salford%20-%20Peer%20Review%20Feedback%20Report.pdf.
- The challenge of measuring resilience and defining and valuing good resilience.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

- During resilience studies in Greater Manchester, it has been proposed that long, linear infrastructure offers opportunities for integrative approaches across different administrative areas and between different stakeholders.
- Greater Manchester, in partnership with 100RC, is exploring the use of tools and techniques for project design which consider:
    - The resilience qualities of a project and how they might be enhanced
    - The ability of projects to address multiple shocks and stresses
    - The contribution of a project, including through its direct and indirect impacts, to the resilience of a place (e.g. adding resilience criteria to bid assessment or a resilience filter to fund allocations)
    - How resilience value can be amplified or embedded at each stage of the project design over the lifetime of the project to assess how decisions enhance, evolve or erode resilience value
    - The importance of infrastructure owners, stakeholders and customers not simply viewing resilience in terms of their own risk reduction and cost benefits but also in terms of the resilience of the city as a whole.

Resilience Study Consultation
National Infrastructure Commission
Finlaison House
15-17 Furnival Street
London
EC4 1AB

1 April 2019

Dear Sirs,

SUPPLY CHAIN RESILIENCE INCLUDED WITHIN RESILIENCE STUDY SCOPING CONSULTATION

Thank you for your invitation to contribute to your Resilience Study Scoping Consultation.

I note that the study's Terms of Reference excludes 'the security of supply chains' but I would urge you to reconsider as the UK will not be able to build resilient infrastructure without a resilient supply chain.

It is imperative that the UK continues to have an adequate quantity and quality of suppliers (consultants, contractors, manufacturers etc.), who tend to predominantly be small and medium sized organisations and ensure that these suppliers contain a diverse and highly skilled workforce to meet future infrastructure requirements.

I would be pleased to meet you, along with British Water's Chairman, Chris Loughlin, to discuss these points further and look forward to hearing from you.

Lila Thompson

Chief Executive

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Q1: What are the key questions that the next National Infrastructure Assessment (NIC) should answer about resilience?

We recommend that the NIC consider the water regulator Ofwat's work on 'resilience in the round', its support for the establishment of regional catchment management hubs and 'social contracts' in order to help address the following questions:

1. How do we ensure we attract the necessary skills into the UK water industry in order to ensure future security of supply?

   It is well documented that the water industry has an ageing workforce (15% of water sector workers are over the age of 55); lacks diversity (4% of the workforce identify themselves as Black & Minority Ethnic, BAME; 12% of staff identify themselves as having a disability and 83% of the industry is male dominated. Ref: Energy & Utilities Skills presentation at Women in Water on 27 November 2018.

2. What workforce skills are needed to build towards resilience?

3. What barriers exist for the current UK supply chain to meet future infrastructure requirements? E.g. does the current 5 year Ofwat regulatory cycle hinder or enhance collaboration/innovation?

   British Water has found that an estimated 40,000 skilled workers leave the water industry towards the end of a five-year Asset Management Programme (AMP) as the industry transitions from one AMP cycle to the next. Ref: HM Treasury Report *Smoothing Investment Cycles in the Water Sector*, July 2012.

4. What could be done to support the supply chain in helping to build resilience?

   The model for government supported 'water partnerships' overseas and Scotland's Hydro-Nation Strategy should be explored to help ensure innovations from the water industry are tested and adopted much quicker and best practice shared more widely. At present, each water company conducts their own innovation trials which is inefficient, limits collaboration and therefore impacts on building resilience.

5. What best practise in these areas could we learn from other sectors and internationally?

   Scotland's Hydro-Nation Strategy and international 'water partnerships' hubs should be explored to examine any best practice in order to help build a sustainable supply chain.

6. How will a UK withdrawal from the European Union impact resilience? There is a need to ensure suitable legislation is in place to secure sustainable infrastructure.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Questions 1 and 3, and 4.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other barriers to addressing resilience emerging from cross-cultural interdependencies?

1. British Water would recommend that the interdependence between water, food and energy be considered in this study including the contribution of bio-fuels to build resilience.

2. British Water would also recommend a coordinated approach across government departments to help ensure resilience.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependence or other causes, have been addressed or overcome?

1. The Industrial Strategy does not cite water as a key area of focus. We would recommend that all government departments / key stakeholders obtain a better understanding of how water underpins every aspect of infrastructure and the supply chain is a significant factor in building resilience.
2. The Industrial Strategy highlights 'people' as one of its five key pillars – ensuring a diverse, highly skilled workforce is key for the future.

AECOM's Response to Resilience Study Scoping Consultation

National Infrastructure Commission

1 April 2019

About AECOM:

AECOM is a global network of experts working with clients, communities and colleagues to develop and implement innovative solutions to the world's most complex challenges.

Delivering clean water and energy. Building iconic skyscrapers. Planning new cities. Restoring damaged environments. Connecting people and economies with roads, bridges, tunnels and transit systems. Designing parks where children play. Helping governments maintain stability and security.

We connect expertise across services, markets, and geographies to deliver transformative outcomes. Worldwide, we design, build, finance, operate and manage projects and programs that unlock opportunities, protect our environment and improve people's lives.

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1. What are the key questions that the next National Infrastructure Assessment should answer about resilience?

What definition and framing of 'resilience' can bring more stakeholders into the discussion and help catalyse effective action?

A fundamental challenge for the NIA will be establishing an effective working definition of resilience that reflects evolution of the construct that has occurred over recent years. While resilience was long considered in terms of withstanding challenges, a more nuanced view has become increasingly normalised, including the following elements:

- Resilience is not only about bouncing back to the status quo, but rather it should consider the need to adapt and evolve over the long term.
- Efforts to improve infrastructure resilience through engineering and technocratic responses must also be accompanied with a focus on addressing chronic environmental (e.g. climate change) and social (e.g. fuel poverty) stresses that can influence infrastructure systems.
- An 'all-hazards' approach that focuses on building common capabilities that improve preparedness, response and recovery, no matter what shocks and stresses are encountered.
- Those with a stake in critical infrastructure should consider how resilience investments can do more than just help maintain functioning in emergency situations. Such investments should also seek to contribute to a higher quality of life for UK residents in good times by enhancing economic, environmental and social outcomes.
- In addition to built-in redundancy, infrastructure planning needs to prioritise flexibility and avoid path dependencies, ensuring that design allows us to cost-effectively adapt networks and systems in response to new information such as changing consumer preferences, technological advancements and climate change projections.
- Infrastructure should be planned, delivered and operated with the end user experience in mind. Human behaviour during extreme events is a key consideration in terms of how this influences infrastructure vulnerability and resilience.

What are the system resilience implications of the energy transition that will be required to meet national carbon reduction targets?

Meeting UK carbon reduction targets is of critical importance, but this will require significant transition in the energy sector. AECOM has been working actively in this space; for example, by advising clients such as the Greater London Authority on intelligent energy integration for decentralised energy projects. If the overall resilience of the system to environmental shocks and demand fluctuations is to be maintained, careful, staged management of this transition will be required. Important lessons can be learnt from other jurisdictions such as the Netherlands.

How can stronger linkages be established between resilience efforts in the infrastructure sector and best practices in climate adaptation?

The Committee on Climate Change (CCC) oversees the National Climate Change Risk Assessment (CCRA) and National Adaptation Programme, providing guidance about priority risks and areas where adaptation efforts need to be increased. There is a need to increase the pull-through of this and other guidance into the work of infrastructure sector organisations.

Acknowledging year-on-year rising temperatures and a greater frequency of very hot days, more attention should be given to the impact of heat on infrastructure, and the potential solutions to reduce these impacts (such as the greater use of heat-resistant materials and components).

2. What issues should be prioritised in the resilience study?

Linkages between economic infrastructure and the smaller scale built environment

While the remit of the National Infrastructure Commission covers economic infrastructure – namely transport, energy, water and waste water, flood resilience, digital connectivity, and solid waste – emerging technological trends require the interfaces with the smaller scale built environment to be considered in more detail. For example, fully smart energy systems will allow two-way flows involving 'prosumers' and novel business models by combining energy use and production at the building or community scale. Additionally, measures to mitigate flood risk at the scale of individual developments achieved through sustainable drainage systems (SuDS) may not provide adequate resilience if larger scale mitigation measures have not been implemented. Therefore, resilience of certain large scale infrastructure may become highly interdependent with that required for buildings and community scale systems.

Conversely, if sufficient attention is paid to resilience at smaller scales, then the need for increases in capacity of larger scale infrastructure can sometimes be avoided completely. For example, SuDS can be designed so that surface water discharge to the mains wastewater systems is completely avoided. Another example is 'private wire' micro-electrical grids including energy storage, which can be designed to avoid the need for reinforcement of the local distribution network to increase capacity.

The human face of resilience

Infrastructure is not an end in itself – it is planned and developed to serve people and communities. As such, greater regard to be given to the needs of the businesses, communities and individuals, and how these needs can be better accommodated in infrastructure resilience planning. This includes providing more genuine opportunities to input into planning processes, as well as more listening to understand the formal and informal ways in which infrastructure users ensure their own resilience to disruptions and adapt to evolving challenges. AECOM has supported this need through development of the UNISDR Disaster Resilience Scorecard for Cities, which has been used by cities in the UK (e.g. Manchester, Stoke-on-Trent) and around the world to support more inclusive discussions around resilience challenges and opportunities.

Climate resilience and natural capital

While there is general consensus on the need to address the threat of climate change to our critical systems, infrastructure resilience planning must give better regard to lower likelihood but catastrophic consequence events, ensuring that contingency plans are in place. For climate change, such an event could be sea level rise significantly higher than current projections, which the IPCC has acknowledged remains possible due to feedback loops and uncertainties around the melting rate of polar ice caps. Through movements such as London National Park City there is an increasing understanding of how strengthening natural capital and ecosystem services can cost-effectively improve the resilience of our urban systems to climate change and the natural hazards it is expected to exacerbate, such as flooding and heatwaves.

Cyber resilience

Cyberattacks from perpetrators hostile to Britain present a truly existential threat to infrastructure service delivery, as well as protective infrastructure that is critical to our survival. As part of AECOM's partnership with Rotterdam, Netherlands in the Rockefeller Foundation's 100 Resilient Cities (100RC) programme, the very real threat of cyberattacks crippling vital coastal defences was identified as a priority risk. While this specific risk may not be as pronounced in the UK, the general message around cyberattacks as a vector for causing large-scale disruptions to electronically-controlled infrastructure (e.g. trains, pumping stations, telecommunications) is highly relevant to the UK. The potential for rapid developments in quantum computing technology to seismically shift the cyber security landscape must also be treated as a serious possibility.

Financing and measuring resilience

There is growing momentum within the banking, insurance and infrastructure sectors efforts to finance resilience investments using innovative mechanisms, such as resilience bonds. Achieving this requires objective methods for measurement of resilience, which is a notoriously difficult construct to quantify, largely due to the lack of a widely accepted definition and its cross-cutting nature. A range of organisations have sought to develop frameworks for this purpose, but most have struggled to achieve the rigour required to support investment decision-making. More explicit direction and support from Government could help catalyse breakthroughs both in resilience measurement and finance. This should include consideration of the role of well-established constructs in infrastructure planning, such as discount rates (see Question 3 for further commentary).

Interdependencies and cascading consequences

AECOM supports the NIC's stated focus on cross-sectoral interdependencies and welcomes increased efforts to understand these interdependencies. However, the likelihood of diminishing returns should be acknowledged. Given the sheer complexity of our physical, social and environmental systems, a practical approach should be taken in which the desire for further analysis is not used defer practical actions that can be taken now.

3. Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Disconnect between climate adaptation planning and segments of the infrastructure sector

As noted earlier, the multitude of different approaches to understanding and responding to climate risks being developed and implemented across the infrastructure sector has led to some confusion and inconsistency. Risk appetite also varies tremendously, which affects the extent to which organisations and sub-sectors can collaborate on resilience efforts. There is a need to increase the pull-through of best practice guidance from organisations like the CCC into the work of infrastructure sector organisations.

Civil Contingencies Act 2004 (CCA)

The CCA was once a world-leading piece of legislation but is now 15 years old and no longer reflects the evolving view of resilience. While it remains effective as a coordination mechanism for emergency response organisations, there is a need to bolster aspects relating to community resilience and other proactive measures to avoid disasters. It could also increase emphasis on the role of businesses in emergency response.

Use of discount rates in infrastructure planning and decision-making

The long-established practice of using discount rates in the economic appraisal of infrastructure projects can result in significant underestimation of the value of resilience investments. This is particularly problematic for investments relating to climate change, which are intended to future-proof infrastructure to threats that are increasing in significance over time, thereby increasing the value of the investment, rather than diminishing it.

4. Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

'Resilience in the round' in the water sector

The UK water sector has taken a leading role in promoting a more cohesive approach to resilience planning. This is evidenced in Ofwat's publication 'Resilience in the round', which notes the range of interconnected threats facing the sector, many of which are not immediately under water companies' control. It also acknowledges the linkages between operational resilience (i.e. the ability of infrastructure, and those who operate it, to withstand disruption) with financial resilience and what it calls 'corporate resilience' (i.e. strong, adaptive governance).

Within the sector, Thames Water has been a leader through its adaptation pathways approach to network and supply resilience planning. The approach considered system interdependences and 81 different future scenarios to highlight where future network planning decision points may lie and where a switch to an alternative approach (i.e. pathway) may be required. As noted at Question 1, these types of approach are critical for avoiding path dependencies and allowing cost-effective adaptation of networks and systems in response to new information.

Regional partnerships

The UK is also home to a range of innovative partnership organisations that facilitate information sharing between organisations with a role to play in the resilience of our infrastructure. In the area of climate resilience, examples include the *London Climate Change Partnership* and Glasgow City' Region's *Climate Ready Clyde*. While the direct impact of these partnerships can be difficult to quantify, they present a critical mechanism for linking the disparate stakeholders whose decisions influence the resilience of each region, often catalysing new kinds of collaboration.

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National Infrastructure Commission Resilience Study Scoping Consultation

Consultation 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, Ofwat and CCWater.

WRSE was originally formed in 1996 following a recommendation from the Monopolies and Mergers Commission which suggested there should be better regional co-operation when it came to sharing water. Since then it has developed a series of regional strategies which have informed the individual companies' Water Resource Management Plans (WRMPs) and identified how water could be shared and moved around. More information on WRSE can be found at www.wrse.org.uk

WRSE's strategy published in spring 2018 (From Source to Tap: The south east strategy for water http://www.wrse.org.uk/wp-content/uploads/2019/01/From_Source_To_Tap.pdf) looked across a range of future scenarios, considering different population growth forecasts, climate change impacts, customer demand patterns, drought severity and levels of environmental protection.

It identified that the south east region alone is facing a potential public water supply deficit of between 1,000 million and 2,600 million litres of water per day by 2080. This broadly aligns with the National Infrastructure Commission's (NIC) National Infrastructure Assessment, which recommended that 4,000 million per day of water needs to be made available across England by 2050 to provide resilience against severe drought – with the South East and East regions needing the greatest amount of additional capacity under all scenarios.

The approach taken by the NIC in its first National Infrastructure Assessment to assessing the cost of a severe drought to the wider economy and society, for the first time, highlighted the stark contrast between investing in resilience to avoid a severe drought and the cost of emergency measures being deployed - together with the wider social and economic consequences. Its recommendations have led to the six water companies that make up WRSE setting ambitious long-term targets for both leakage and per capita consumption and have been incorporated into the WRSE's modelling to identify the strategic regional water resource infrastructure needed to meet the challenges of the future.

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 WRMPs 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. 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.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

As highlighted in our introduction, the first National Infrastructure Assessment (NIA) clearly highlighted the cost of a severe drought on the wider economy and society. This is in line with its remit, to 'support sustainable economic growth across all regions of the UK, improve competitiveness and improve quality of life' and should continue to be the key objective of the next NIA. WRSE's objective is to develop a regional multi-sector resilience plan that will identify the future water resource infrastructure and demand-side interventions to secure the long-term resilience of water supplies across the region – considering future population growth, climate change and tightening environmental standards. It will contribute to the NIC achieving its objectives and we intend to develop it in-line with future recommendations made by the Commission.

We welcome and support the NIC's recognition that 'intersectoral' aspects of resilience is a key question which it is ideally placed to address. Identifying dependencies between sectors and developing solutions that benefit multiple sectors will be part of the WRSE's regional resilience plan so an increased focus by the NIC in this area will be beneficial. This will not only be important in terms of a systems-based approach for more effective resilience but may well also shift the economics of various interventions and levels of resilience which are best value if the benefits extend beyond a single sector.

We hope that this work extends to looking across key Government policy areas and considers the infrastructure, or other interventions, needed to deliver key long-term strategies including the Industrial Strategy and the 25-year Environment Plan. This will be important to ensure that all infrastructure sectors are supporting the Government's wider objectives and will also identify any potential mis-alignment between policy areas.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Below we detail a number of areas which we believe should be addressed through the resilience study.

1. Define what good resilience looks like

As identified in the consultation scoping document, resilience has a broad nature. Further consideration needs to be given to how to assess the value of resilience and what the appropriate mix/scalability/adaptability/vulnerability of infrastructure and other interventions is, which goes beyond simply increasing headroom capacity to deliver the optimum level of resilience. It must be recognised that different types of options have unique vulnerability signatures so further consideration of what mix of infrastructure types will provide the best balance between risk/vulnerability and resilience is required.

2. Move from least cost to best value planning

As WRSE has shown in its latest strategy 'From source to tap' the future is uncertain, and this uncertainty gives rise to a range of potential future water resource scenarios. This highlights the importance of taking an adaptive planning approach and the value of incremental and/or scalable

options which can adapt to changing circumstances and information. To achieve this, we need to move beyond assessing options primarily from a least cost perspective to a better assessment of best value – that considers the wider social, environmental and economic benefits. This includes more work around achieving the right balance between hard and soft infrastructure. We consider that to achieve this there is a need for all utility/infrastructure regulators to have access to and align with best practice resilience thinking to inform their regulatory approach. A more common and consistent approach should apply not just to resilience frameworks but also to best valuation of resilience investments, which should take better account of broader criteria such as natural capital and economic valuation techniques – and the principles set out in the 'Triple Dividend' thinking on resilience www.gfdrr.org/sites/default/files/publication/The_Triple_Dividend_of_Resilience.pdf

The current legal and regulatory framework supports the delivery of national water and sewerage infrastructure, however the framework for deciding what national infrastructure is required and by when is less effective. Regulators and companies are well versed in making these decisions within company areas, but the sector is less successful at driving forward these longer-term decisions as the primary focus is typically on the short-term, lowest cost to customers. If the current approach continues, there is a risk companies will not invest in the new infrastructure required to deliver long-term resilience and instead continue to take short-term decisions at a potentially higher future cost to society at large.

3. Enhanced stress testing

The resilience study could usefully consider how stress testing at sector and cross sector level could be enhanced to better assess levels of resilience. This could be effectively done at regional level and we would welcome the opportunity to work with the Commission to further develop this important area.

4. Cross-sector collaboration

Increasing collaboration will be essential to achieving this. This includes joint/cross sector resilience planning – as proposed in the WRSE regional plan; and funding/regulation for single interventions with multiple cross sector resilience benefits. There is a need for a more comprehensive, systems-based approach to planning and developing resilient water resources. The resilience study could develop a framework to support a consistent approach being taken across the country.

5. Understand how customers and society value resilience

We need to better consider and understand how customers and society more broadly value resilience. Research carried out by water companies has generally shown that customers value resilience differently if they have experienced a service failure or incident. Therefore, it is essential that we better explore customer views on high consequence/low probability events to inform our assessment of best value. We must also recognise that people may take a different view when responding as a 'customer' to when they respond as a 'citizen' and the resilience study could usefully explore key differences between the two.

6. Understanding the enablers of resilience

There are a number of issues that sit around the edge of traditional resilience thinking but are essential to enable delivery which need further work in order to understand their relative importance. They include:

- skills/capacity of the workforce and supply chain
- support for innovation

- trust and institutional structures which may impact levels of trust
- the need for regulatory alignment (across regulators) and identification of existing barriers within regulation and conflicting objectives of different regulators.

7. Consider the balance of the 4 Rs

Water companies take a risk-based approach to planning; however, we will never achieve zero risk. Therefore, it would be useful for the resilience study to consider what is the right balance across the 3 preventative components of the 4Rs - reliability, redundancy and resistance and what risk remains that will need to be addressed through response and recovery. Further work is needed to address this and better co-ordinate response and recovery both within and across sectors.

8. Identify forward-looking metrics

The identification of appropriate forward-looking metrics that are systems-based and cross sector will be important to better measure improvements in resilience. Many current metrics are backward looking, performance-based metrics and we believe there is value in rebalancing this with more forward-looking condition/probabilistic metrics which are beyond functional.

9. Monitoring and reporting progress

Given the scale and nature of the resilience issues faced for essential utility services and the scrutiny infrastructure providers receive, particularly when service fails, the resilience study could usefully consider whether the Commission or another organisation should provide an ongoing oversight function. We believe that this could provide real benefit in identifying and sharing best practice, to advise, monitor and assess progress against national infrastructure resilience objectives.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

The emerging work on cross-sector interdependencies has already begun to highlight some potential barriers to addressing resilience. This includes:

- Regulatory barriers and conflicting regulations that challenge our ability to address resilience at both sector and multi-sector level - for example the ability of water and energy companies to consider the respective benefits/economics of water/energy efficiency
- Enabling investment in resilience – inconsistencies exist between and across regulators, the WRMP and PR19 processes being a current example
- Alignment between approaches for understanding and planning for uncertainty – this is linked to the point above as different regulatory process do not always work together to enable investment in resilience
- Being able to demonstrate the value of resilience – current approaches are very restrictive. The lack of regulatory guidance and commitment to natural capital and the other six capitals limits the ability for infrastructure providers to assess and deliver best value
- Metrics limit understanding and the evidence to support timely investment – all but two of Ofwat's common performance commitments are measures of backward-looking performance
- Timing of different sectors planning cycles and the planning horizons they cover. For example, the LEPs are required to produce local industrial strategies for Government by March 2020 which will cover the period up to 2030. The regional resilience plan being

developed by WRSE will be produced in 2023 and looks some 60 years ahead, so ongoing iteration between plans will be required.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The work carried out by WRSE to date has been largely focused on increasing the resilience of public water supplies and has not explicitly addressed the needs of and interdependencies with other sectors. The regional multi-sector resilience plan will address this by considering the specific water requirements of key sectors and the role of water in achieving planned industrial growth across the region as projected by the Local Economic Partnerships. As our work progresses, we will continue to make the Commission aware of barriers that emerge and how we address them.

Arup response to NIC resilience study

ARUP

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Arup think the key questions the next Assessment should answer include:

Why is resilience important? Is it understood by all decision makers? Is there a common understanding of the importance of current and future resilience by all stakeholders, and in all the economic infrastructure sectors?

What are the key areas that the United Kingdom should focus on to deliver a transformational change in how infrastructure is planned, designed, delivered, operated and maintained? This should be considered across assets, finance, people, governance and regulation. It is critical to be more resilient, both to known shocks and stresses, but also to the unknowns, or surprises. The City Resilience Index (CRI)[1], developed by Arup and the Rockefeller Foundation, provides an excellent starting point for a holistic assessment of what matters for cities, to adapt, survive and grow in the face of shocks and stresses. The CRI, and work led by Arup, Stockholm International Water Institute (SIWI) and others to develop a City Water Resilience Approach[2], demonstrates the importance of identifying a range of holistic goals, sub-goals and indicators, not seeking a single measure for resilience. The soon to launch British Standards Institution (BSI) City Resilience Guidance also highlights the need for stakeholders and infrastructure sectors to work together. Arup recognises that the National Infrastructure Commission (NIC)'s remit is not directly aligned with 'cities'. However, cities can be a useful lens through which the interconnectedness of infrastructure systems can be viewed.

How can an approach be developed that both recognises the range of shocks and stresses that the United Kingdoms' infrastructure may face, and the need for infrastructure systems to have the characteristics that will help them to recover from surprises? It is widely understood that there is no 'silver bullet' – resilience of infrastructure systems will require a range of policy instruments as well as financial and customer driven incentives. Both outcome-based approaches, i.e. those that 'measure' resilience, such as downtime and recovery time, and attribute-based approaches, i.e. those that look for qualities or behaviours present in resilient systems, will be relevant to the NIC's needs. There will also need to be a recognition of the balance of tension between short-term priorities impacting infrastructure, and the long-term outputs and priorities.

For existing infrastructure systems, what are the interventions that are 'threat agnostic' and how should they, be it physical, digital, or community-based, be prioritised? **Who** is responsible for prioritising these interventions, and how can the NIC influence decision-makers towards the right decisions for resilience?

Is there a clear remit to align resilience of critical infrastructure with the importance of climate mitigation that recognises that solutions that achieve both are likely to deliver more total value and achieve a "resilience dividend"? Promoting a total value [3] approach to infrastructure solutions (capturing social, economic, environmental as well as financial) can create new opportunities, and provide evidence of the benefits realised from these opportunities.

[1] City Resilience Index - https://www.arup.com/perspectives/city-resilience-index
[2] City Water Resilience Approach - https://www.arup.com/perspectives/how-can-we-build-more-water-resilient-cities
[3] Total Value approach to infrastructure - https://www.arup.com/perspectives/publications/research/section/making-the-total-value-case-for-investment-in-infrastructure-and-the-built-environment

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Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

What
We believe the NIC should start by focusing on areas where there are gaps and conflicts in the way different sectors approach resilience. One of these is a robust understanding of the importance of national policy, including future financing models, and its ability to incentivise changes in practice. The Organisation for Economic Co-operation and Development[4] (OECD) report and ongoing work by the Resilience Shift[5] (in preparation) are both relevant to this, but some bespoke work for the UK context is needed.

We also think the study should explore resilience in the round, rather than being led by specific threats such as climate change or terrorism (whilst being compatible with work by the UK Government committee for Climate Change and the Adaption Sub-Committee and the Cabinet Office). This will encourage measures and a framework, across the infrastructure sector that transcend individual risks, and provide direction on system attributes that enhance systems no matter what, demonstrating the value of resilience.

Where
There needs to be an increased understanding of infrastructure as globally inter-connected systems, and a need to have a common understanding of performance. The NIC is uniquely positioned to develop a framework that allows different infrastructure sectors to work towards such a shared understanding.

The NIC should consider the right scale for action, and consider UK-wide, national, city region as well as local, resilience forum level. Consideration should certainly be given to existing and planned differences in approaches to resilience across different regions and devolved administrations of the United Kingdom.

Who
The NIC is in a unique position to engage and identify key stakeholders, from national government, regulators, devolved administrations, city leaders, private sector and end users in delivering more resilient infrastructure for the long term. In doing this the NIC will be in a position to make recommendations on how roles on resilience should be defined.

When
It is important to recognise both short-term responses to resilience, as well as considering it as part of long-term planning. Planning for each is often influenced across the infrastructure sector by variations in market, policy and regulation. One area where this is apparent is the different regulation and timescales across different infrastructure sectors. For example, considerations of resilience in the water and energy sectors are different as they operate with different regulators, with different and non-aligned regulatory price review and quality control periods.

One big opportunity is to capitalise on the major transitions, such as the move towards low carbon and more digitally connected systems, taking place across the infrastructure sector. The NIC should focus on understanding how the UK can utilise these opportunities to embed resilience policy and regulation, to enhance future resilience, and to ensure that new or unintended vulnerabilities are not created. This was explored by Arup and University College London (UCL) in an NIC report on the *Resilience of Digitally Connected Infrastructure*[6]. This report specifically looked at the ability of digitally led infrastructure systems to be robust, and to recover from incidents they face. The NIC is in a position to help set out a golden thread, providing a common framework for systems to talk to each other across industries and markets.

[4] OECD - http://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf
[5] Resilience Shift - https://www.resilienceshift.org/
[6]Resilience of Digitally Connected Infrastructure https://www.nic.org.uk/wp-content/uploads/CCCC17A21-Resilience-of-Digitally-Connected-Infrastructure-Systems-20171121.pdf

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Arup is a host institution for the Resilience Shift[5], a global not-for-profit initiative focussed on shifting practice in the planning, design, delivery, operation and maintenance of critical infrastructure. In 2017, the Resilience Shift undertook some qualitative benchmarking as to what the current landscape looks like, to articulate the change that is needed. This included identifying barriers to considering interdependencies in practice, and the findings are available in the report *Understanding the landscape*[6]. Barriers identified included the question of 'who pays vs who benefits', and the difficulties in terms of procurement in working beyond fairly narrow boundaries, and lack of clear tools and approaches to help identify interdependencies.

Codes and standards present a barrier as they are currently mainly asset or sector specific and provide guidance for specific known hazards such as flooding. There is less codified guidance around dealing with interdependencies between systems, and in decision making which creates uncertainty. These are both very important aspects of infrastructure system resilience. This could be explored further by the NIC and would support cross-sectoral decision making and investment. There is also an opportunity to capture reliable data and make it widely available which could facilitate resilience across sectors. This is starting to be addressed through several initiatives, including one by the Open Data Institute (ODI)[7], as well as by the Data & Analytics Facility for National Infrastructure (DAFNI)[8], that are helping advance this challenge.

Barriers are even present within sectors where they are not dealing with interdependencies. This highlights the need for a common understanding of what resilience is, and what is an appropriate level of resilience for UK infrastructure. Arup's Levels of Service review[9] for the NIC found that there is no consistency across, road, rail, electricity, gas etc. and emphasised the importance of the role of regulation of economic infrastructure in ensuring long term resilience. Therefore, there needs to be an evolution in the mechanisms in regulatory framework to allow for long-term solutions, such as decarbonisation, that facilitate resilience.

From recent engagement that Arup has been connected to, including a *'Tools and Approaches for resilience'* workshop hosted by the Resilience Shift, we believe that an increased focus on resilience at the point of project delivery is needed. This includes construction, where lean approaches, value engineering, and capex driven decision making can be in tension to the long term, systems thinking that will drive resilience measures. This should be further explored in terms of how policy can ensure that whole life costs, *total value* and system thinking are driving decision making throughout.

[7] Resilience Shift - https://www.resilienceshift.org/
[8] Understanding the Landscape - https://resilienceshift.org/wp-content/uploads/2018/06/The-Resilience-Shift-Understanding-the-Landscape-June-2018.pdf
[7] Open Data Institute - https://theodi.org/project/sharing-engineering-data-for-the-public-good/
[8]DAFNI – Digital Communications Infrastructure Models https://www.dafni.ac.uk/about/
[9] Arup/NIC Levels of Service https://www.nic.org.uk/publications/review-of-uk-levels-of-infrastructure-service/)

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Climate-resilient Infrastructure report - the Organisation for Economic Co-operation and Development (OECD)
http://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf
Climate resilience is one of the more advanced aspects of infrastructure resilience. It is important to recognise that climate resilience is necessary but not sufficient for holistic resilience in an uncertain future.

Best practice in specific sectors Resilience Shift primers - The Resilience Shift
https://www.resilienceshift.org/grantees-primers/ www.resilienceshift.org
A global initiative to build resilience in practice, these primers will present a number of real world examples of implementing resilience in practice, identifying the drivers/levers in different sectors.

Lessons from Superstorm Sandy in New York
The implementation of resilient infrastructure in the recovery from Superstorm Sandy demonstrates best practice in post-disaster recovery funds, following an extreme event. There are multiple published examples (Chapter 17 of this World Bank document[10]) however, the challenge for the NIC is to demonstrate the values in making such changes in advance.

City Water Resilience Approach (CWRA) in Hull - Arup, The Rockefeller Foundation, The Resilience Shift and Stockholm International Water Institute (SIWI)
https://www.resilienceshift.org/wp-content/uploads/2019/02/CWRA_CCR_Hull_spread.pdf
The CWRA helps cities plan and implement actions to build resilient urban water systems. A critical first step in this process is understanding the local water system, and the factors that contribute to or detract from resilience.

The new British Standard for city resilience BS 67000
https://www.bsigroup.com/en-GB/our-services/events/2019/city-resilience-launch/
The standard will provide guidance to stakeholders across infrastructure sectors (and beyond) about the key steps that will support building resilience in a city. It provides an approach to assessing a city's maturity of practice to support capacity building.

OurWater online collaboration tool to build urban water resilience - The Resilience Shift
https://www.resilienceshift.org/publication/watershare/
OurWater has been developed to address the growing need for tools that can help cities share information between different stakeholders and visualize complex interactions. Transferring learning between sectors is likely to be largely transferrable to other sectors.

The United Nation's Sustainable Development Goal's
https://www.un.org/sustainabledevelopment/
These should be used as a framework for 'what matters' and be an essential part of any conversations about resilience.

Design with water - Arup
https://www.arup.com/perspectives/publications/promotional-materials/section/design-with-water
Arup's approach looks at the benefits of placing a re-integrated water cycle at the heart of sustainable planning, design and delivery.

City resilience strategies globally – 100 Resilient Cities and partners
https://www.100resilientcities.org/strategies/
The City Resilience Strategy is one of the core tools that propels 100 Resilient Cities members through the process of building resilience. The strategy unites people, projects, and priorities, and surfaces crucial new solutions so that cities can collectively act on their resilience challenges and create call to action.

[10]World Bank http://documents.worldbank.org/curated/en/583011538651181032/pdf/130474-PUB-PUBLIC-document-date-9-20-18.pdf

Emailed to: resilience@nic.gov.uk

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

1 April 2019

Dear Sir/Madam,

National Infrastructure Commission: Resilience Study Scoping Consultation

I write in response to the National Infrastructure Commission Resilience Study Scoping Consultation.

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 2017 we received 172,865 initial contacts from complainants and resolved 92,110 complaints.

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.

Ombudsman Services has, for the last year, been going through a transformation process that is built upon the principles of customer first and digital first. We have:

- a new brand and new tone of voice that ensures accessibility and that interactions are simple, clear and inclusive, with no jargon;
- undertaken significant research and emersion as part of our brand work and consulted all customer groups – consumers, regulators and other stakeholders;
- a new website that has been built with clarity, accessibility and customers in mind; and

- a new case management system which provides an improved experience for consumers and businesses. This delivers a more direct relationship between the consumer and business about the complaint and provides greater transparency and trust in the system. We can also use the system to promote early resolution of complaints through Facilitated Case Resolution.

General comments:

We welcome the opportunity to provide comments to this resilience study. By operating in a range of sectors we think we can provide a unique insight into some of the issues that might affect resilience per se, however, we would also like to propose widening the discussion of resilience to look at consumer resilience. We think looking at consumer resilience is important in order to build public trust and confidence in how infrastructure is built, managed, maintained and changes with new technologies.

We believe building trust with consumers today is essential if consumers are going to trust the changes and innovations of tomorrow, for example, sharing of their data to look at how infrastructure needs to work best for consumers, helping to change consumer behaviour in terms of the transport they use, the amount of energy they consume and when – which will become crucial as electric vehicles are rolled out more widely.

Answers to the specific question raised:

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

We fully appreciate the importance of looking at resilience in infrastructure and considering key questions such as building resilience to attract investment, the actual building and maintaining of physical networks and hardware and protecting against major events such as cyber security risks or political uncertainty. However, we also think it is important to factor into the study the importance of building public (consumer) trust and confidence in infrastructure by consciously designing infrastructure with the public in mind. This will help to manage public expectations, engage with the public in a meaningful way when issues arise and provide a focus and mindset with businesses to resolve issues quickly and fairly for the public.

We think it is pertinent to consider the following points as part of the next National Infrastructure Assessment on resilience:

<u>Consumer resilience - how to build public trust and confidence in infrastructure resilience?</u>

Building public trust and confidence in the resilience of infrastructure and the sectors involved is key. From our experience of operating in three sectors relevant to resilient infrastructure – energy, communications and parking, we think this can be achieved by:

- Consciously designing structures and systems for the public. Having data and insights around what the public wants, is complaining about and the impact on the public is key. Ombudsman Services is in a unique position, we have data and insight into what consumers complain about, what they are saying, how they feel and what they think is fair and reasonable.

- Ensuring that there is skills resilience within organisations, for example, appropriate ‘soft’ skills to communicate effectively with the public, especially when things go wrong. Keeping the public and customers informed about what is happening, manage expectations and fixing things quickly, including providing compensation/redress for customers are crucial. We have worked with organisations and companies within all our sectors to help them build soft skills resilience.

Organisational resilience

Wider organisational resilience is important to look at, not only to ensure that businesses are viable but also that businesses are not undertaking unnecessary and inappropriate risks or practices. We have seen these situations in other sectors such as the financial sector but also in the tendering of new contracts and on-going contracts around infrastructure.

We agree with the suggestion in the consultation paper around stress testing sectors or geographical regions but also think it is worth considering stress testing individual organisations or specific structures such as public tendering and procurement exercise. In the energy sector there have been a number of energy providers that have gone into administration over the last couple of years. We have developed modelling based on the:

- type of complaints we received from consumers about those companies in the last six months before going into administration – how those complaints changed and what they were about; and

- use of text analytics to gain invaluable insight into what consumers are saying/feeling when they make their complaint to us.

We think this modelling gives a good indication around where energy providers are stressed in providing services to consumers and the quality of consumer care. We do have the ability to run energy providers through that modelling.

There is also the interesting mix of public and private resilience in business practices. For example, if infrastructure resilience is affected by a cyber security attack, sever weather damage such as flooding, or businesses running large infrastructure contracts going into administration then generally these events are in the public domain and action is taken in a way that is communicated to the general public. However, from our experience we know that quite major resilience issues affecting businesses happen in a more private setting. For example, we know that a number of businesses in the sectors that we operate in have had significant problems in the past when they have updated and changed billing platforms. Although this will get limited public attention it can affect tens of thousands of consumers and impact trust and confidence in new technology and resilience of infrastructure. We think the importance played by stakeholders within a sector working together needs to be emphasized in these situations. So, we will know what the issue is because of the complaints from consumers that we see, as will Citizens Advice. By working with companies, regulators and other stakeholders we can help to resolve consumer detriment and ensure the customer journey is as straightforward as possible in these more private situations of resilience failure.

Sustainable and environmental resilience

Just as important is the resilience of infrastructure in terms of being sustainable and environmentally friendly. For example, the advancement in technology such as smart road networks, electric vehicles and even driverless cars if planned in the right way in terms of infrastructure should be seen as positive in terms of improving the lives of consumers and help the Government meet decarbonisation targets.

Looking at some of the sectors that we operate in, such as energy, telecoms and parking by working with organisations, regulators, companies and consumer bodies then data and insights could be collected and used to join up different sectors. For example, by having data around where people park, the journeys that are made and at what times could feed into road management, placing charging points for electric vehicles and joining up different forms of transport.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Along with the more traditional approach of looking at resilience in terms of systems and hardware we think that the three broad areas outline in our response to question 1 merit inclusion in the resilience study. However, if we to promote one above the others it would be consumer resilience.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

We think that it is important for different sectors to work together to share data, insights, knowledge and enhance policy development to improve resilience and consciously design with the public in mind. However, it is fair to say that currently individual sectors work together without really engaging with other sectors. Yes, there are groupings where different stakeholders come together for example, the United Kingdom Regulators Network (UKRN), the Essential Services Access Network and various policy groupings, however, this is more about sharing good practice and not about working together in a more joined up and proactive manner.

One possible way to provide more common ground between different sectors is if the focus on resilience is deliberately widened to include consumer resilience. As technology advances and more sectors are linked in the provision of services to consumers then it seems a natural hook to begin joining sectors up with a common goal and language.

It is interesting to note the National Audit Office (NAO) report on Regulating to protect consumers: Utilities, communications and financial services markets. The NAO found that regulators are working to address a number of common challenges for consumers, including affordability concerns, service failures and challenges for vulnerable consumers. However, regulators have not been specific enough in defining the overall outcomes they want to achieve for consumers. They also find it difficult to manage the trade-offs they face between competing objectives in protecting consumers, for example, some measures to promote a competitive market have negatively impact on vulnerable consumers.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

We think there are snippets of examples that can be built upon to increase the chances of resilience issues being overcome by different sectors working together. For example:

- The work that the UKRN has done on looking at consumers in vulnerable circumstances and, in particular, Ofgem and Ofwat working together on vulnerability and the Priority Services Register.

- At Ombudsman Services, because we are in a unique position of working across a range of sectors, we have been well placed to establish and facilitate workshops on vulnerability. We were approach by communication providers, following Ofcom introducing new requirements through their General Conditions requiring communications providers to publish policies and procedures which set out how services are delivered to customers in vulnerable circumstances, for help and advice on the best way forward. In response, we have set up a vulnerability working group to facilitate discussion over key issues and to look at good practice. We have invited guest speakers from Citizens Advice and from other sectors, such as energy, to discuss some of the challenges experienced by people who are vulnerable.

- In the energy sector we have developed what is known as 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 provider that are causing concern or consumer detriment, issues that are appearing and most importantly what action is to be taken and by which organisation. This approach really helps to horizon scan what is happening across a whole sector but is also very proactive in looking to act in a preventative way as opposed curing the problem once it is established. We think that a similar approach can be taken in other sectors, for example, we have been discussing with Ofcom and the Ofcom Consumer Panel how this might work in communications, but it could also be looked at in water and rail. The interesting piece is then looking at how this model might be used to join up different sectors.

- We also think the proposed changes to the Competition and Markets Authority (CMA) focus to place protecting the economic interests of consumers as their paramount duty could be an opportunity to help join up sectors where consumer resilience is not being met. Indeed, the recent Citizens Advice super complaint on the loyalty penalty to the CMA and the CMA's response looked at a number of sectors.

Please do not hesitate to contact us if you would like further information regarding our response. I am meeting with Sir John Armitt to discuss the consultation on reviewing the future of regulation in infrastructure consultation and also this resilience scoping study on Tuesday 2 April.

Yours sincerely,

Matthew Vickers
Chief Executive and Chief Ombudsman

For more information regarding this consultation response please contact:

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Committee on Climate Change

Independent advice to government on building a low-carbon economy and preparing for climate change

Resilience Study Consultation

National Infrastructure Commission

Finlaison House

15-17 Furnival Street

London EC4A 1AB

1st April 2019

The Committee on Climate Change (CCC) welcomes the NIC's Resilience Study and will be pleased to contribute and advise on climate change relevant aspects as the Study develops. In answer to the Commission's questions:

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

An assessment of resilience needs to go beyond calculating risks. We have an increasingly rich understanding of the risks to UK infrastructure but the resilience of these systems is mediated by their interaction with people and organisations, with the natural environment (including engineered green infrastructure), and cyber systems.

- How can resilience be defined? And how is it being defined for the NIA? We would encourage the NIA to consider the:
  - robustness and reliability of infrastructure (i.e. ability to cope with a wide range of conditions and hazards);
  - redundancy of service delivery (of a particular system e.g. multiple routes, but also redundancy of service delivery methods e.g. flood warning via digital mobile phone message, and analogue siren signal transmitted via long wave radio); and,
  - response and recovery of individual assets, but also of entire networks/system, and consider the role and interaction with communities that rely on multiple infrastructure services.
- How can resilience (both process and objectives) be effectively monitored?
- What level of resilience is needed across the UK? Is this question answerable? Is this/should this be geographically homogeneous?
- What sort of approaches can/should be used?
- What metrics and indicators are needed?
- Where should the focus on policy and investments (in physical infrastructure and in supporting social and ecological resilience) be in short and longer term?
- What are the impacts of lock-in on resilience decisions? E.g. comparisons between resilience included from the outset of new infrastructure/infrastructure decisions or

should infrastructure be designed to be upgraded cost-effectively as the climate changes.

- What are the synergies between built environment and infrastructure, including the interplay between grey infrastructure and natural capital (green and blue infrastructure)? E.g. how can improving resilience of wetlands in estuaries reduces the need for costly sea walls.
- Are there trade-offs between different types of resilience? E.g. resilience to climate change versus resilience to economic shocks?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

A priority will be to assess resilience across the whole system - incorporating social, organisational, environmental, physical and digital dimensions.

In the CCC's 2017 progress report we noted a number of gaps in evidence where we were unable to fully understand the levels of adaptation/resilience to climate change:[1]

- Nationally Significant Infrastructure Projects (NSIPs) are taking into account future risks from flooding and sea level rise. However, less account appears to be taken of other climate hazards, where the impact of climate change is less certain but could be significant. It would be interesting for the resilience study to assess how NSIPs should take account of all climate hazards and any examples of good practice.

- The scale of investment needed to tackle the issue of surface water flood risks is yet to be addressed. Evidence suggests a significant and increasingly severe lack of capacity in the sewer network to deal with heavy rainfall. There is very little consistent data available at a local level (some areas have better coverage of this than others) that provides a detailed understanding of the interactions between drainage systems owned and maintained by different Risk Management Authorities and third parties and hence there is not a shared understanding of local flood risk on which to make informed decisions in partnership.

- There is limited evidence on transport infrastructure resilience - data regarding overall resilience of ports and airports are lacking, and variability in annual delay data on roads and rails means it is not possible to assess robustly whether this is a result of adaptation actions of other factors.

- There remains a lack of evidence available to assess the resilience of the digital and ICT sector and that of interdependencies and cascading effects. The CCC's CCRA3 research project 'Interacting Risks' is aiming to map interdependencies between the built environment, infrastructure and natural environment.

[1] CCC (2017) *Progress in preparing for climate change.*

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

A survey of 17 Local Resilience Forums (LRF) commissioned by the ASC in March 2017 re-iterated previous findings from the CCC's 2014 report. LRF coordinators felt that there was reluctance from some utility and telecommunication providers to share information about their infrastructure due to commercial sensitivities. A few of those interviewed also stated that access to data on Critical National Infrastructure was restricted, and that this was a barrier. Telecommunications were cited by four interviewees, out of the sample of 17, as being particularly challenging to engage with, as they did not prioritise engagement with LRFs.

There is also a general lack of common standards of resilience that we are aware of. The Cabinet Office rejected the CCC's 2015 recommendation to confirm that the services provided by all critical national infrastructure are now resilient to a 1-in-200 year flood event (in line with the Commission's recommendation to deliver a nationwide standard of resilience to flooding with an annual likelihood of 0.5 % by 2050 where this is feasible). The CCC had asked that the Cabinet Office agree, for a wider range of climate risks, sector resilience standards that are in the national interest and see that they are implemented. Nonetheless, the National Flood Resilience Review has looked at the vulnerability of some infrastructure sectors for a 1-in-a-1000 year flood event as a de facto standard of protection (but did not look to the longer-term risks or cover surface water flooding). Common standards of protection could help with investment planning, and help emergency planners better understand the potential for service disruption arising from assets in an area.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

HS2 Ltd. has assessed the risks faced from climate change impacts on interdependencies, such as the rail network, electricity supply, and ICT. This included an analysis of the locations at highest risk along the HS2 route. Engagement with infrastructure operators helped to identify key interdependencies. It is not known whether the assessment of interdependencies included both resilience of the new infrastructure and the new stations. It is important that there is a consideration of the whole system when assessing interdependencies.

Institute and Faculty of Actuaries

Resilience study scoping consultation

IFoA response to National Infrastructure Commission

5 April 2019

About the Institute and Faculty of Actuaries

The Institute and Faculty of Actuaries (IFoA) is a royal chartered, not-for-profit, professional body. We represent and regulate over 32,000 actuaries worldwide, and oversee their education at all stages of qualification and development throughout their careers.

We strive to act in the public interest by speaking out on issues where actuaries have the expertise to provide analysis and insight on public policy issues. To fulfil the requirements of our Charter, the IFoA maintains a Public Affairs function, which represents the views of the profession to Government, policymakers, regulators and other stakeholders, in order to shape public policy.

Actuarial science is founded on mathematical and statistical techniques used in insurance, pension fund management, investment and increasingly in other areas where actionable insight needs to be obtained from data. Actuaries provide commercial, financial and prudential advice on the management of assets and liabilities, particularly over the long term, and this long term view is reflected in our approach to analysing policy developments. A rigorous examination system, programme of continuous professional development and a professional code of conduct supports high standards and reflects the significant role of the profession in society.

Institute and Faculty of Actuaries

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

5 April 2019

Dear Mr Crossman,

IFoA response to NIC Resilience study scoping consultation

The Institute and Faculty of Actuaries (IFoA) welcomes the opportunity to respond to the National Infrastructure Commission's Resilience scoping study consultation. Our response reflects the views of the IFoA's Finance & Investment Board and Risk Management Board, together with those of our Infrastructure Working Party.

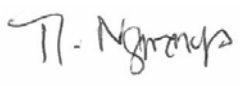
The IFoA welcomed the announcement of the first National Infrastructure Assessment (NIA) as a much-wanted long-term assessment of the country's infrastructure needs that would be "joined up", would seek to achieve political consensus, and would reduce uncertainty for infrastructure investors. We are pleased that the next NIA will be enhanced by material on the vital subject of resilience, reflecting the views of stakeholders in response to this consultation.

Actuaries' work on infrastructure projects is mainly carried out from the perspective of project investors or lenders, for insurance companies, pension funds, investment firms and ratings agencies. A small number of actuaries also work for infrastructure projects directly, or for their suppliers or advisers. The profession also has a long-standing joint working party with the Institution of Civil Engineers on the risks in infrastructure projects, as evidenced by this response.

Reflecting this actuarial expertise, we have focused on the first two consultation questions and omitted those on cross-sector interdependencies.

If you would like to discuss any of the points raised in this response in more detail, please contact Matthew Levine, Policy Manager (matthew.levine@actuaries.org.uk).

Yours sincerely,



Marjorie Ngwenya
Immediate Past President, Institute and Faculty of Actuaries

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

In infrastructure projects it may sometimes be necessary to incur an extra capital cost to achieve increased resilience. Whether the extra cost is appropriate will depend on the severity of the consequences of a failure of the project – the greater the consequences for society, the more justification there may be for the extra spending. However, seeking to spend more to achieve greater resilience could make the difference between a project passing or failing tests of financial viability. Sometimes it may be possible to build options into the design of the asset and delay spending money on increasing resilience until the nature of an emerging risk becomes clearer.

The IFoA acknowledges that judgement will always be necessary in making such decisions. **It would be extremely helpful if the National Infrastructure Assessment (NIA) could help sponsors consider their options about investing in resilience in the context of their individual projects**. The NIA could include evidence and analysis based on the results of the NIC's resilience study, including examples of where resilience has effectively been built into infrastructure and why it was successful, and conversely where it has failed and why. The NIA could also provide clarity on how resilience can be measured, how its financial costs can be weighed against quality of life impacts, and how to prioritise those impacts. Meaningful resilience measures are grounded in potential variations from a base case, so it is important that the base case is comprehensive, including all key parameters and assumptions.

The **timescales** for which it is desirable to build in resilience need to be carefully considered. For example, is it worth spending extra money now, to mitigate a threat that is not expected to occur in the next 20 years but is thought to have a significant chance of occurring in the following 30 years? Or, is spending the money now potentially a bad use of resources, since the asset may well be overwhelmed by new threats that could arise in the next 20 years?

The NIA could also include material that will **help project development teams to respond to important questions from those making decisions on developing or sponsoring the project**. Examples of such questions include:

- Does the project development process allow sufficient time and access to others' experiences to achieve a reasonable degree of resilience?
- Has there been a sufficiently imaginative exploration of a wide range of possible scenarios throughout the asset's expected lifetime? Are the usage forecasts as soundly-based as possible, including changes in the future of work arising from increasing use of artificial intelligence?
- What are the main risks which could threaten the continuance of the project during commissioning, construction and after the asset comes into operation? Does the length of the development and construction phase bring added risks due to unexpected developments? How vulnerable is the project to financiers or construction firms backing out?
- How long is it likely to be before these risks become quite likely to materialise? Are there early warning indicators which will be able to detect this?
- What steps are being recommended to mitigate these risks as far as possible?
- Have all avenues for achieving greater resilience, including those at no significant extra cost, been fully explored?
- Will it be recommended that extra capital should be spent in order to provide greater resilience and, if so, what is the justification for doing so? Can this extra cost be justified if it results in greater public spending?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

To help sponsors, we suggest **the study should identify different kinds of resilience and key project risks, and assess the ways in which each form of resilience can mitigate each of these risks**. Some forms of resilience may also allow opportunities to be taken, for example adaptability.

In work carried out with the Institution of Civil Engineers, we have identified the following broad categories of resilience, all of which can be built in to a project from the outset to a greater or lesser extent:

1. Disaster recovery - The ability for an asset to return to its previous state after a disaster, without substantial further expenditure. An example would be the use of fire-resistant materials in the construction, or the installation of back-up generators.
2. Strength to withstand more extreme conditions - Assets could be made stronger and more likely to survive e.g. storms which become more severe over time. We note that building for expected worsening of storms during the design life is not resilience but base case design. Resilience is building for (even) more future severity than we expect.
3. Future expansion - The scope to expand in order to meet unforeseen increased demand. An example is designing metros in megacities, where future required capacity is very uncertain. It may be good practice to build in high capacity from the outset as building only modest capacity could cause serious problems if future expansion is needed while maintaining operations.
4. New legal requirements – Even if there is no immediate likelihood of such changes, for example on safety or protection of the environment, it may be worthwhile for the designers of a project to go beyond current legal requirements. Otherwise, there could be unanticipated extra cost, such as the extensive and expensive safety requirements imposed on the Channel Tunnel after the project was agreed.
5. Adaptability - Designing an asset so that it can quite easily be converted to an alternative use if necessary. For example a hospital or prison could be designed with the aim that it might eventually have to be converted to an outpatient clinic or rehabilitation centre.
6. Flexibility – Designing for a degree of flexibility in an asset's use, without much extra cost. This could include designing for major maintenance or asset replacement while maintaining operations.

We have also identified some of the main downside risks which can be mitigated by resilience measures:

1. Irreparable damage to physical structures due to natural events or mistakes in construction.
2. Premature obsolescence due to e.g. technological developments or changing customer expectations, which cannot be accommodated within the structures, or not without prohibitive cost.
3. Increased competition from external developments which mean that the structure or service is no longer used to the extent originally envisaged.
4. Over-forecasting of usage, meaning that the asset is not financially, socially or environmentally viable once it comes into operation.
5. Under-forecasting of usage, meaning that in order to meet demand, further substantial expenditure is required which might have been much less had the asset been designed originally on the basis of correct forecasts.
6. Changing social needs which mean that the asset is no longer needed. For example, a hospital may not be required if more people can be treated at home.
7. Risks associated with third parties, for example contractor bankruptcies or investors pulling out before construction is complete.

Achieving maximum resilience is a highly desirable goal, subject to the concerns we have mentioned about justifying capital spending. We therefore recommend that **decision-makers should always be required to address resilience specifically and report on it**, when a project is authorised to proceed.

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submitted via email

To Whom it May Concern,

I would like to take this opportunity to participate in the National Infrastructure Commission Resilience Study Scoping Consultation. I am making this response as an individual.

I will first provide some context to my interest in participating. I have international experience in professional practice and in research, providing a unique perspective on civil engineering, construction, resilience and sustainability. Over the past two years I have directed the Construction Engineering Master's degree programme at the University of Cambridge. The course is a unique two-year, part-time degree for senior professionals (predominantly from the UK architecture, engineering and construction industry). I also consult on resilience and sustainability projects and have a particular interest in disaster risk reduction. I am a lead member of the Technical Advisory Group for the Resilience Shift – a five year programme funded by Lloyds Register Foundation and hosted by Arup, with the goal of facilitating a shift towards resilience in critical infrastructure sectors: http://resilienceshift.org/faqs/

The comments below are some brief reflections on the consultation questions rather than comprehensive responses. I hope this will add a useful perspective to the wider feedback garnered through your consultation process.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

- Are there "headline" indicators that can be used to compare performance across sectors?
- Are there fundamentally different considerations for different sectors that need to be acknowledged?
- What are "systemic" and "long-term" resilience considerations versus component-centric and short-term?
- What are investment priorities for building national infrastructure resilience?
- What are critical barriers associated with governance?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

While I understand the hesitancy to define resilience too narrowly and too early, I believe there is a need to establish some clearer boundaries about what is "in" and what is "out". The study's Terms of Reference go some way to address this. However, creating a common language and understanding would help limit criticism (and possible confusion) arising over a concept that has not been articulated clearly. Resilience needs to have meaning so that stakeholders can directly engage.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

In 2018 I supported a small research project on this topic. I include below an abstract for a paper that will be presented at ICONHIC 2019 (the 2nd International Conference on Natural Hazards and infrastructure: https://iconhic.com/2019/). This provides a brief summary of the findings of the research, which highlights current "state-of-play" for modelling infrastructure interdependencies.

Title: Infrastructure system management – understanding and advancements in the methods and approaches for interdependency analysis

Authors: S. O'Brien, K. MacAskill, University of Cambridge

Abstract: Today's society relies heavily upon complex national and international infrastructure systems. It is widely accepted that our infrastructure systems are vulnerable to a range of threats and risks. One such risk is the interdependent nature of infrastructure systems and there are current limitations in our ability to understand this risk and manage it. This paper presents a conceptual framework for categorising infrastructure interdependency analysis that was developed from an assessment of existing approaches to interdependency modelling and management. It explicitly examines characteristic traits of the methods of analysis, namely the: type of interdependency modelled, method maturity, data requirements, and computational complexity. Thirty-two approaches were reviewed and categorised. A small number of mature approaches exist that have the capability of completing detailed multi-sectoral analysis. However, there is no dominant technique for analysing infrastructure interdependency, and there is even less evidence of practical application of the approaches in industry. A significant constraint to the application and development of the analysis approaches is their computational and data requirements. Addressing these limitations should be a priority for long-term progress and value to be recognised from these approaches.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

I was recently involved in hosting a round-table workshop in Christchurch, New Zealand, which explored learning with respect to "infrastructure resilience" as a result of the reconstruction of the city following earthquakes in 2010/2011. Some reflections from this event are reported here: https://www.resilienceshift.org/reflecting-on-resilience-together-with-christchurch/. I'd like to emphasise two observations from this event. Firstly, the pre-existence of relationships between key players was an enabler for decision-making after major disruptive event. This has been facilitated in New Zealand via the Civil Defense system. Regional groups across the country help to facilitate conversations across sectors. While the Civil Defense system is based around emergencies, participants highlighted the value of forming relationships and gaining insights into other organisations that share borders within a sector, or that present an interdependency across sectors. Secondly, an organisation called Orion (an electricity lines company serving the Christchurch region) was generally held in high regard for its planning and response to the earthquakes. The company had explicitly acknowledged the risk of natural hazards in its strategic planning and had made investment decisions to mitigate this risk. Here is a link to a report which documents Orion's approach: http://www.oriongroup.co.nz/assets/Customers/Kestrel-report-resilience-lessons.pdf.

I hope that the comments and examples provided here will help in advancing the Commission's scoping study.

Yours Faithfully,

Dr Kristen MacAskill

South West Water

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19 August 2019

Resilience Study Consultation
National Infrastructure Commission
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Dear colleagues

RESILIENCE STUDY SCOPING CONSULTATION

We welcome the opportunity to provide comments as part of the resilience study scoping consultation.

Appendix 1 contains our responses to the specific questions raised in the consultation. We hope you find our comments helpful. Please contact us if you would like further detail.

Yours faithfully

[signature redacted]

Sally Mills
Regulatory Director
[contact details redacted]

APPENDIX 1

Question 1

What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Based on our experience as a utility and the results of our work looking at long-term planning, we consider the following are the key questions that the NIC should answer. We have grouped these into themes:

Framework and Policy

1. Do we understand what level of resilience and response the public and businesses are willing to accept?
2. For infrastructure providers, how well does the current regulatory regime deal with resilience investment against an uncertain future?
3. For infrastructure providers, how well does the current regulatory, financial and environmental regimes incentivise or disincentivise improving resilience when current incentives and policies are applied to day-to-day business decision making?

Cross sector opportunities

4. What are the cross-sector vulnerabilities with regard to resilience to a) short-term and b) long-term environmental, social, financial and technological resilience threats
5. What are the cross sector interdependencies? How can these be made more visible and understood?
6. Do we have adequate resilience measures or planning in place for the short, medium and long term to address cross sector interdependencies?

Question 2

On the basis of your response to question 1, what issues should be prioritised in the resilience study?

We believe **items 1,2,3 and 4** should be prioritised.

Item 1 gives information on what as society we are willing to accept with regard to resilience. Without this one cannot decide where the priorities should be. Items 2 and 3 then give information on whether the frameworks we have in place incentivise or disincentivise resilience. Item 4 then shows what the links are across sectors and in turn highlights where there are opportunities for synergy or where there may be a vulnerability.

True resilience is likely a different approach to the framework in which infrastructure and other industries operate within. We would suggest therefore **items 2 and 3** should be a key focus of the study as it is that framework which determines decision making on resilience.

For example, some of the regulators have worked hard to provide more flexibility but much of this is provided by tweaking existing regimes when actually new approaches are required. As an example, when the water industry work with partners to provide wetland treatment systems for wastewater, the permitting regime is broadly akin to that used for technological solutions when greater flexibility is required to allow for the use of natural systems and processes.

However, the current regulatory or policy regimes can also act unevenly on different sectors ranging from a high degree of regulation to lighter touch and incentive driven approaches. This creates a disincentive to partner in more resilient joint solutions at catchment levels. Better enforcement of some sector regulation, such as agriculture, is also required and would facilitate more partnership working in catchments.

This may also help in decision making. For example, there is differential regulation say in land drainage and sewerage, and this can lead to the more regulated and enforced sector trying to address problems in the wrong place based on root cause analysis, as consequences are not experienced equally.

Finally, with resilience the benefits are not always directly experienced by those paying for them (at least not proportionately) and this can create disincentives. Fair share funding approaches are needed and there are some reasonable examples of this being used by the Environment Agency for example. However, it often appears that decisions around who funds / can fund come to the fore too soon in the decision making process. **Item 4** will help understand the links between sectors but then in turn help to identify the most cost effective and resilient solutions for a catchment (unit cost of improvement) then we can look to deliver those through appropriate co-funding rather than falling back on differential regulation to drive sub-optimal improvements because there is an uncomplicated payment vehicle.

Question 3

Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Policy Barriers

- Differing planning timescales across sectors for assessing future infrastructure development- e.g. Local Plans look at a minimum 15 years, Water Resource Management Plans look at 25 years etc).
- Spatial decision making – it is not always clear who and how decisions on resilience are made spatially. For example, the alignment of plans above introduces challenges due to spatial coverage of individual sectors area of service and the prioritisation of investment across these areas but who owns what decision and how are these to be made e.g. Environment Agency is a national scale, Energy providers may be national/regional scale, Water and Sewerage providers may be regional/sub-regional scale, Local Planning Authorities at a sub-regional scale.

Data barriers

- Knowledge – each sector has a good understanding of the resilience issues facing themselves. However, cross sector knowledge and skills with regard to resilience is potentially more limited due to the requirement to understand multiple sector drivers and challenges to resilience. This is both a data and a skills gap at present.

- Different risk based approaches – different sectors will assess and view risk differently depending on spatial coverage of sectors, investment/funding cycles and availability. Therefore, in our opinion, it is hard to understand the collective resilience risk, of say, the level of reliability of information infrastructure and in turn how that could affect other sectors and their linkages.

Other Barriers

- Loss aversion/status quo bias – to meet future challenges we are going to have to work differently with the environment. This requires a different mindset, for example licenced abstractions from a whole catchment are needed if we are to maximise benefits/avoid costs to society. There is an intrinsic human behavioural barrier for maintaining the status quo/loss aversion to change which we will need to overcome if as a society we are to be smarter on how water is used in the environment.

- Collaboration costs money – working across sectors costs money. There needs to be recognition of this but also processes in place to allow those sectors who cross or have competing needs to develop cross cutting solutions

Question 4

Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been address or overcome?

Policy barriers

- Spatial decision making – the development of the regional water resource planning group is a good example of how this barrier is starting to be overcome. However, more work is still needed on who and how decisions will be made.

Data barriers

- Knowledge – in the work on Regional water resources planning, whilst there is information on water company demand forecasts, that for other sectors is lacking. This creates a barrier to planning strategically for all water users. This can be overcome through giving ownership to a body to undertake these forecasts but is currently being undertaken by some water companies as an organisation that has the inherent skills to undertake such work.

- Different approaches to risk - a good example of collaborative working exists between South West Water, Environment Agency, Torbay Council, University of Exeter and the National Centre for Scientific Research Demokritos (Greece) – this was on an EU-Circle funded project 'Effects of climate change on coastal flooding' funded from the EUs Horizon 2020 research and innovation programme. This addressed a series of questions with regard to existing and future flooding scenarios from multiple sources (tidal, fluvial, pluvial) and the impacts on infrastructure (sewer network, telecoms network, electricity network, road and rail network, residential and commercial property) to better understand the interdependencies, the direct and indirect effects for flooding and potential resilience/adaption measures. A summary of this information can be provided.

Other Barriers

- Loss aversion/status quo bias – as part of the West Country Water Resources regional group we have included a programme of work to examine 'responsive regulation'. The aim is to look at different ways water can be licenced in a catchment to deliver dual resilience benefits to the environment and public water supply. This requires all organisations to think differently on what can be possible.

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Future Water Association response to National Infrastructure Commission – Resilience Study Scoping Consultation on Encouraging

Future Water Association (FWA) is a membership organisation representing c.150 companies in the Water and Wastewater supply chain; our members employ some 40000 people across the UK. We are a non-political organisation working collaboratively with clients, regulators, academia, Government and other key stakeholders in the sector.

The Association has a focus on innovation, education, skills and engagement, by bringing together companies and organisations from across the sector through a diverse membership, including utilities, tier 1 contractors, equipment suppliers, manufacturers, innovators, academia, insurers, investors, data & cyber specialists. Future Water helps to drive a collaborative approach to sector wide challenges and we strive to work with professional bodies, research organisations and trade associations throughout the sector. With SME's making up over 70% of the membership and a focus on innovation, Future Water sits at the heart of the debate on creative thinking and brings in a cross-sectoral dimension to our work, through our hosting of the UK Society for Trenchless Technology (UKSTT) and close relationship with Energy Utilities Association and Pipeline Industries Guild.

Our aim is to shape the future of water and push innovation towards a business as usual operation for utilities. An important part of our focus is Water Dragons, a 'Dragons Den' style initiative, operating for more than ten years, which has brought hundreds of innovations into the sector and put them in front of the utilities. Future Water has established an innovation hub to lead the organisation's activities and also to directly engage with regulators including OFWAT, helping to drive innovation across the sector in consultation with the regulators. The work of the innovation hub is augmented by the more recent Intelligent Water Management group which is exploring how to bring 'systems framework' thinking into urban water management.

FWA view of Resilience

The FWA understands that at the heart of resilience innovation is a broad-based concept that ranges from incremental improvement of existing ideas and practice, to discoveries that produce counter-intuitive changes to our paradigms that produce benefits to society. The FWA agree with the definition of innovation that was set out in the recent Treasury Consultation (https://www.gov.uk/government/consultations/encouraging-innovation-in-regulated-utilities) and would also add that from practical experience of members innovation could also include novel application of ideas from one sector to another, innovative extraction of insight from existing data that can be usefully actioned and holistic joined up thinking across traditionally separate inter-sector boundaries (e.g. capturing excess flood water and utilising for non-potable demand). This final sentence sums up innovation in a resilience context.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Infrastructure delivery depends on Innovation and a dynamic, active supply chain – Future Water Association would like to see:

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- Supply chain resilience as a key factor in the study – especially as supply chain companies work across sectors, support and drive innovation, help to deliver much of the infrastructure outputs. The supply chain also brings critical knowledge and skills to infrastructure – so how resilient is the supply chain?
- Are the regulators helping to drive resilience and innovation? Will this study draw on the outputs of the HM Treasury Consultation described above?
- The NIC should ask about how resilience issues are viewed across the different sectors, for example the economic regulator for water published a document 'Resilience in the Round' https://www.ofwat.gov.uk/wp-content/uploads/2017/09/Resilience-in-the-Round-report.pdf challenging the sector to examine Corporate, Financial and Operational resilience – have the regulators of the infrastructure sectors a coherent and coordinated view on resilience?
- Linked to the 'regulators' point the study should ask 'is the current system of regulation helping or hindering resilience'
- Is resilience understood as a system? Are all the interdependencies between infrastructure sectors mapped out?
- What skills will be required in the future? How resilient is the workforce?
- How can AI, VR systems help and support a more resilient approach to infrastructure management and delivery? Is this evolving dynamic properly understand?
- Is Innovation seen as a key component of resilience and is it being encouraged?
- Being Water specific – the largest part of the sectors asset is water & wastewater networks – the underground assets, how can the performance of these be maintained, developed and improved?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Future Water Association believes that the issues that need prioritising are those that enhance the supply chain, the focus should there be around:

- Innovation especially across sectors
- Skills and especially new skills for developing technologies
- Coordination of infrastructure development across sectors
- Regulation 'good or bad'
- Underground assets – from a water perspective how can the integrity and performance of the assets be maintained, improved

Future Water Association argues that there should be a common approach to resilience across all sectors, water is a fundamental resource to the UK economy and therefore a common approach to resilience is required. The association has recently argued to both the Treasury and Defra that the adoption of systems framework thinking could have a major impact not just on the water sector, but across infrastructure.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Fundamentally yes – the key areas are:

- Innovation – there is no 'common approach' to driving innovation across the different sectors, therefore there is a mixed approach, ideas are not transferred well between sectors. Yet water is

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critical across sectors, roads and railways have a major challenges managed water and the impact it has in their systems – ideas to change the way water is managed, drained away, used as a potential resource should be encouraged through innovation;

- Best practice is not commonly passed between sectors – this needs to change;
- Common regulatory approaches to resilience – there is no common framework approach and this leads to mixed responses to the challenges;
- Sharing of data is a challenge in a GDPR and Cyber Security world – the regulators need to drive a common approach to date sharing that takes account of these areas
- Data collection is still a barrier: the internet of things does not yet apply to water and wastewater networks. Without adequate data on structure, connectivity, condition and performance it is hard to assess resilience, let alone improve it. Knowledge from management of networks such as rail, highways, oil, gas etc are key elements for the water sector.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

This is more difficult to answer – there is the Government's Industrial Strategy which is a framework to bring things together, alongside the Industrial Strategy Challenge Fund. The impact of the policy is unknown and does not appear yet to be bringing benefits. It is also apparent that resilience issues are not a key part of the strategy – this maybe an area to address.

However, there are two clear examples that we are able to cite from within our membership that illustrate how barriers to resilience arising from sectoral interdependencies can be overcome:

1. Most of our energy, water and telecommunication infrastructure lies beneath the Nation's highway infrastructure. Because of increased traffic loadings it is becoming more common for buried pipes to deteriorate, fracture and burst, and for cable networks to become stressed and fail. To maintain them it is necessary to excavate down within roads and footways – leading to traffic disruption and community inconvenience, so unsurprisingly local authorities are restricting the ability of utilities to effect repairs. The answer as we have seen through our UK Society for Trenchless Technology membership is to innovate and develop new methods of undertaking repairs without digging up roads. Alongside this we are seeing the development of asset location and management data techniques that are bringing our mapping and visualisation of asset condition into the 21st Century. But this is being entirely driven by supply chain innovation rather than being driven by corporate and regulatory leadership. This is an area that the NIC could very usefully put some energy behind.

2. Flood resilience and the need to provide flood protection to more than 5 million homes in the UK has been blighted by affordability issues for many years. Local Authorities and the Environment Agency simply do not have the funds to protect all of these homes from flooding using flood resilient infrastructure alone. The supply chain has once again shown its ability to be innovative by devising local ways to protect individual properties from flooding using property flood resilience measures. The industry has gone further and collaborated with the Insurance Industry and Government to create a code of practice that will ensure high standards of installation and flood resilience at an affordable cost for all of those properties for which major flood resilience schemes are not practical.

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Although the Consultation set out to exclude the supply chain from this review, the fact is that the supply chain is absolutely key to achieving resilient infrastructure in the UK – both in terms of creating the ideas to achieving it, to chasing funding, to delivering it. Government is not a leader in this respect but an enabler and if there was one key message to come out of this exercise, is that we must really value the knowledge and expertise that exists in the supply chain and nurture and harness it through good infrastructure governance, rather than Governments being seen to be driving this. The Future Water Association is committed to speaking on behalf of the Nation's water infrastructure supply chain businesses and enabling its skills, innovations and entrepreneurialism to flourish and are delighted to offer our advice and support to the NIC.

Final Comment - Future Water Association would like to see greater cooperation and coordination of regulatory functions among the regulators. Such an approach would drive resilience and focus priorities, for example focusing on bringing IT/Telecoms infrastructure up to current standards across the whole country, this would greatly help to support the digital revolution which is beginning in the water sector but which needs to accelerate.

There also needs be consideration of shocks, for example Brexit, will it affect the UK – yes but how is not yet clear, however, potential events like this must be part of resilience thinking.

Future Water Association through its Innovation Hub and Intelligent Water Management Group is happy to elaborate on any of the above.

Kind regards,

Paul Horton
Chief Executive Officer – Future Water Association

UNIVERSITY OF CAMBRIDGE
Department of Engineering

CSIC Cambridge Centre for Smart Infrastructure & Construction

RESPONSE from the Centre for Smart Infrastructure and Construction (CSIC), University of Cambridge

To

NIC Resilience Study Scoping Consultation

Introduction to CSIC

The Cambridge Centre for Smart Infrastructure and Construction (CSIC) was launched seven years ago to transform the future of infrastructure through smarter information to secure better decision-making. As an Innovation and Knowledge Centre funded by EPSRC, innovate UK and industry, CSIC's principal role is to advance research in Smart Infrastructure and create impact and resilience for infrastructure owners, operators, designers, and contractors through tried and tested technology-ready solutions.

CSIC has an established pedigree in employing world-leading research to transform infrastructure and construction. We develop cutting edge sensing and data analysis models to provide a powerful platform for delivering data to enable smarter, sustainable, resilient and proactive whole-life asset management decisions, both during construction of new infrastructure and for existing assets. Our technologies and tools have been tested and proved on some of the largest live civil engineering projects in the UK, including London Underground station upgrades and the Thames Tideway Tunnel.

The creation and maintenance of a robust, resilient and affordable infrastructure – one that is fit for purpose in a growing economy – is key in enabling our economy to thrive. However, without a strategic, government-led, cross-sector approach to caring for our infrastructure, we run the risk of over-investing in some areas while neglecting others that are in need of attention, or risk failing to address economic and societal needs. The complexity of the landscape in this area calls for a coherent strategy and integrated programme of action.

Smart Infrastructure - the combination of the physical with the digital - will be a key element of any coherent strategy. Digital Infrastructure may vary from sector to sector, but it shares a similar anatomy comprised of three basic layers (data management, sense making and decision making) all connected by communication, with data as the key. It is the overlay of this model onto physical infrastructure that makes it 'Smart'. Smart Infrastructure is a global opportunity worth £2trn-4trn[1]. It has the potential to transform the way we manage our infrastructure, build resilience into our assets and use our existing infrastructure more efficiently. Benefits include:

- Better understanding of existing infrastructure leading to increased capacity, efficiency, reliability and resilience
- Enhanced service provision despite constrained finance, resource scarcity and short supply of greenfield sites
- More efficient design and delivery of new infrastructure, providing improved whole-life value

Both new and existing infrastructure can be 'Smart'. While major new infrastructure projects are taking place in the UK, for example Crossrail, Thames Tideway and HS2, these only represent a fraction of our current infrastructure portfolio, much of which is now at an advanced stage of maturity. It will often be more cost-effective to add to the overall value of existing infrastructure via digital enhancements than by physical enhancements. Digital enhancements can increase productivity by transforming existing infrastructure with focused, information-based interventions for maintenance and renewal.

Universities, and in particular the UK Collaboratorium for Research in Infrastructure and Cities (UKCRIC), will play a crucial role in the research, development, and knowledge transfer of new and innovative 'Smart' technologies

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Consideration needs to be given to what 'resilience' should mean in the context of national economic infrastructure. Typically, this can be described as how our infrastructure assets and systems can be prepared for uncertain future events. These can be in the form of shocks or sudden events (such as severe storms, flooding or terrorist attacks) and more gradual changes (such as demographic change, climate change, changes of usage requirements).

Critical to this, is the ability to answer the question 'what if' – for example, What if the asset is flooded? What if a nearby, linked asset fails? What if loading on the asset changes? Exploring the answers to such questions enables us to understand which assets and asset systems are more critical, and to transform current practice from a reactive position to a proactive one, with the ability to respond to different potential future scenarios embedded in our planning and management of infrastructure.

Hence an understanding of future hazards and disruptions which could affect assets and systems is critical to assessing and delivering resilience. This includes:

- identifying what the future scenarios (or combinations of future scenarios) are that could develop and impact our assets/asset systems;
- considering the timescale over which such scenarios will develop and relative severity over time
- how these scenarios will affect the assets/ asset systems;
- what specific actions may therefore be needed to address the resulting vulnerabilities during the lifetime of the assets.

The particulars of vulnerability will vary from asset to asset, depending on factors such as location, use, age, etc. Therefore, a framework approach will be needed which can be applied to individual assets or systems, rather than a single national interpretation.

One such approach has been developed by the Cambridge Centre for Smart Infrastructure and Construction's work on 'futureproofing UK infrastructure' (Masood et al, 2016 https://www.icevirtuallibrary.com/doi/full/10.1680/jinam.15.00006).

This considers both the futureproofing requirements, and how this interacts with the activities of infrastructure management – as responsibility for resilience needs to be placed somewhere in the organisation, and embedding this within the 'business as usual' management activities can ensure that action is taken (see fig below, from Masood et al 2016). This can be thought of as embedding 'resilience thinking' into asset planning, delivery and management.

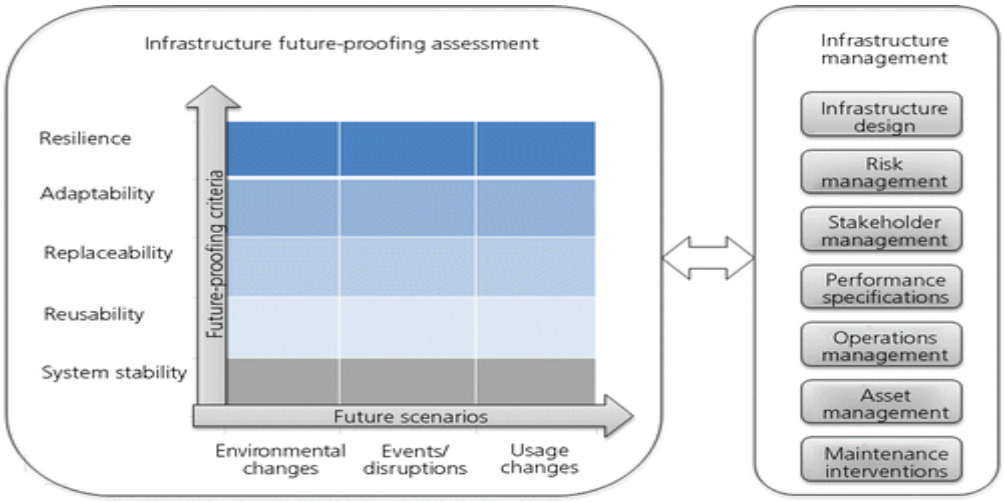

Fig 1 - Model for future-proofing-considered infrastructure management [Masood et al, 2016]

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

In order for a national study of resilience to be meaningful, the scope of consideration needs to be defined in some way, and the desired benefits to be achieved by addressing resilience – as resilience requires investment, at either the planning and delivery stage of an asset's life or during use (or both). The figure below (from Masood et al 2016) provides a framework for future-proofing of infrastructure portfolios.

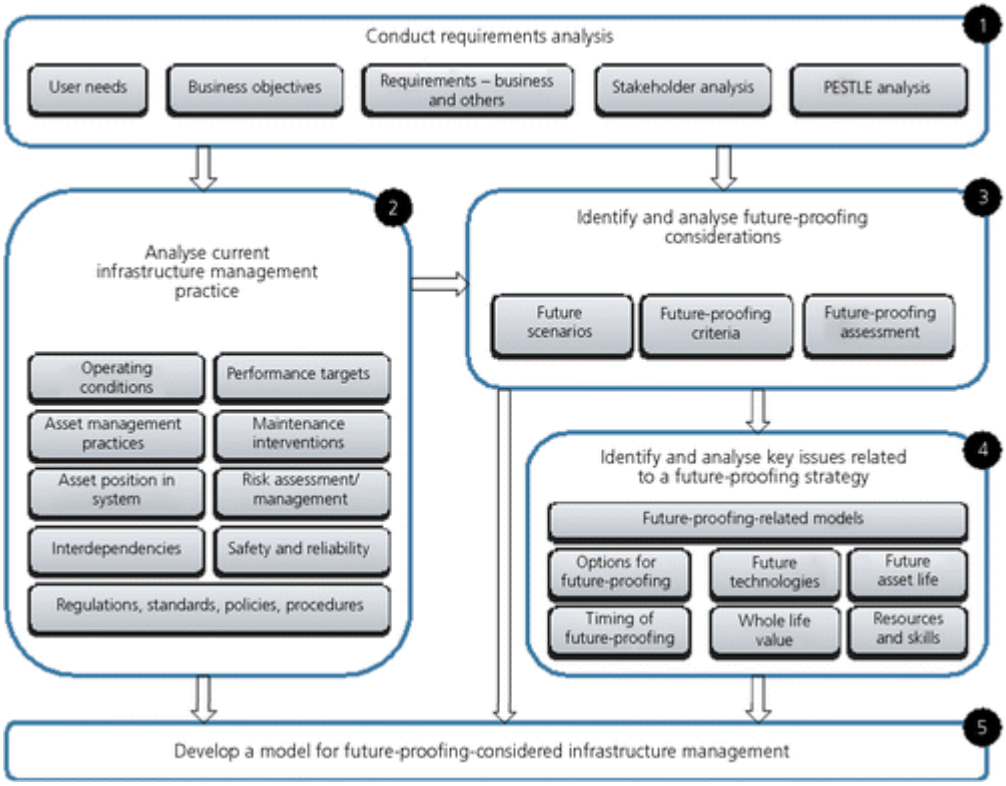

Fig 2 - A framework for future-proofing of infrastructure portfolio. [Masood et al, 2016]

It is vital to identify and analyse key issues to be addressed as part of a national infrastructure resilience strategy. For example, the following questions will help in identifying and analysing such issues related to a resilience strategy:

- What resilience models and strategies are relevant for an infrastructure?
- What are the options for resilience?
- How are asset operational lifetimes being affected?
- What is the whole life value in resilience?
- What is the best timing for investments in resilience? (design, construction, during life (and at what point))
- What future technologies are relevant and going to impact on an infrastructure?
- How can such technologies be used in improving the resilience of the infrastructure?
- Why invest in such technologies?
- What organisational resources and skills are required to implement resilience actions?

Critical to successful assessment and implementation of any resilience strategy is an understanding of assets that are actually performing now. In order to predict future performance under a set of circumstances that have been developed using future scenarios, we need to have the capability to capture the performance of assets accurately, i.e. a model/digital twin of the asset that we can trust (otherwise any future results are worthless). For this model to be built reliably, actual data is required. If the data is not available, it should be obtained using appropriate deployed sensing and monitoring systems.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

There are a number of barriers to addressing resilience, both across sectors and more endemically.

Between sectors, there is a lack of clear mapping and understanding of infrastructure inter-dependencies and the resulting vulnerabilities. For example, utility 'corridors' which could be affected by flooding or embankment failure resulting in loss of multiple infrastructure services; dependency of one key infrastructure on another, for example, water pumping stations and power and/ or flood resilience.

Lack of systemic sharing of information on vulnerabilities / dependencies of one infrastructure system on others – e.g. the 2007 Walham Substation & Mythe Water Treatment works flooding, which left 50,000 people without power for up to 5 days and 350,000 people without water for up to 11 days. (http://news.bbc.co.uk/1/hi/uk/6912650.stm)

Work carried out by ITRC (www.itrc.org.uk/) and DAFNI (www.dafni.ac.uk) seeks to address this, but can only be as good as the data provided. Hence, further efforts to develop a 'resilience and interdependency mapping' for infrastructure assets must be a priority. This should focus both on quality of data available, and the need to share that data between different sectors. In developing this, it is important to focus on the mutual benefits of sharing such data, in order to encourage contributing parties to be open and transparent about the level of data they hold and its accuracy. Highlighting any lack of data should be seen as a positive step towards finding and filling the gaps, rather than a stick to beat organisations with.

It would also be helpful to develop a 'resilience index' to enable a common assessment of infrastructure asset vulnerability which can then be shared between organisations.

At an asset-specific level, there is a lack of systemically collected and curated data to enable condition assessment and degradation modelling. This is part because there is a lack of experience in this area, with occasional visual inspections being the traditional approach to monitoring assets. This is beginning to change, but typically there is resistance to setting up such data collection approaches as this is seen as an upfront cost, rather than being assessed with a 'whole life value' approach. Such an approach will pay dividends in the long run, with condition-based asset maintenance and management becoming possible, and hence reducing spend and extending asset life.

Some examples of what infrastructure resilience assessment and inclusion in infrastructure management would contain are included in the following:

- To what extent is an infrastructure resilient in the face of environment changes e.g. effect of increasing daytime heat on railway tracks?
- To what extent is an infrastructure resilient in the face of disruptions due to e.g. flood, snow, wind, cyber attacks, etc?
- To what extent are assets adaptable in the face of increasing usage demands?
- To what extent are current (sub) assets replace able in the face of (the pose of) significant failures necessitating such replacements?
- To what extent are assets reusable, e.g. can piles be reused when converting an office block to a large residential building or vice versa, in a congested city?
- To what extent are current asset management practices applicable in the face of (significant disruptions / future scenarios.
- To what extent are current performance targets for key infrastructure applicable in face of environment changes / future scenarios?

Evidence submitted on behalf of the Centre for Smart Infrastructure and Construction by:

Dr Jennifer Schooling
Director CSIC

the professional body for
whole life management of physical assets

The Institute of Asset Management

National Infrastructure Commission

1 April 2019

To Whom it may concern,

The Institute of Asset Management is pleased to respond to the National Infrastructure Commission Resilience study scoping consultation.

Introduction

The Institute of Asset Management (the IAM) is the international professional body for asset management professionals. The IAM develops asset management knowledge and best practice and generates awareness of the benefits of the asset management discipline for the individual, organisations and wider society. Established in 1994, the IAM has a network of over 22,000 people in 158 different countries. The IAM seeks to ensure the widespread understanding of asset management and the value of good practice for society. Our knowledge projects, publications and services promote a considered approach to the achieving long-term value from physical assets in every organisation, whether large or small, private, public, governmental or not-for-profit. We often collaborate with other organisations and professional bodies. We support individuals and organisations in professional development to demonstrate capability in asset management.

We have addressed the first two questions posed in the Resilience Scoping Study Consultation and our responses are included on the following two pages.

Your faithfully

Kirsten Bodley

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Chief Executive

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Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Technology in Asset Management and its relationship to resilience

There is great benefit from the growing "digitalisation" of the national infrastructure. Intelligent monitoring and the application of predictive analytics coupled with understanding the critical interfaces and interdependencies between infrastructure systems is central to asset management decision making and resilient provision of services. Intelligent monitoring covers not only the performance and degradation of assets and infrastructure systems but also the external environmental factors and the users and uses of infrastructure.

We believe the NIC should explore how the implementation of intelligent monitoring would support a better understanding of current resilience and the interdependency between sectors. To what extent can intelligent monitoring be a basis to model resilience of the national infrastructure and hence consider the effects of asset interventions on future resilience?

The NIC may wish to consider whether the development of this understanding (including associated data gathering, analysis and visualisation of results) would best be provided through an independent body operating across sectors.

This increasing capability in intelligent asset monitoring provides positive benefits in decision making around operations, maintenance and capital works planning and delivery. This also introduces a dependency of asset systems such as rail, energy and water organisations, not only on telecommunications infrastructure, but also the data warehousing and associated analytics platforms necessary to give these insights. The NIC study should seek to understand the resilience of these intelligent solutions economically and physically and the way in which their failure or maloperation may impact on the economic operation of energy, water and transportation networks. This might extend to an examination of cyber security issues.

Skills and Competence in Asset Management and its impact on resilience

Consideration should also be given to the provision of skilled asset managers and other specialists to ensure the capability and competence necessary for a national resilient infrastructure grows in line with economic and social needs. If we do not equip our people and businesses with the emerging digital skills, we cannot have a resilient UK economy based on this new available intelligence. To what extent are academic courses and formative post graduate training and apprenticeships keeping pace with the required provision of resilient infrastructure and a resilient capability to deliver it?

Aligned to this capability is the retention of knowledge and learning in the field of resilience and resilient infrastructure. We need to ensure that knowledge of value to the nation is not only captured but curated and made available to infrastructure organisations; for example, the knowledge created through the development of high speed rail routes could be collated and curated through the High-Speed Rail College. The NIC should question how this may be achieved, respecting commercial confidentiality and addressing IP issues.

There is often a focus on reducing the cost of implementation of a new asset to meet short term spending targets. While Value Engineering aims to reduce the costs for the delivery of an appropriate asset, it often seems to result in assets with little opportunity to support capacity growth and which face longer term increased costs due to requirements for enhanced maintenance and improvements as business needs change.

The NIC should explore the extent to which decision making at asset creation stage adequately addresses future needs for resilience (including whole life affordability, demand growth and potential adverse events).

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study

The NIC should place priority on the following aspects:

To achieve a truly resilient infrastructure, creating a change in the level of understanding of asset management principles amongst the leadership across many organisations and in Government must be prioritised.

The focus on long term value (e.g. economic, social, environmental, financial value), and how the infrastructure asset base contributes to this value, is central to effective decisions about critical infrastructure.

Understanding the risk of failing to meet objectives, understanding how to capitalise on opportunities to generate additional value over the long term, and prioritising the allocation of resources accordingly is not only desirable - it is essential if we are to meet the needs of the nation now and in the future. The digital revolution is allowing the capture and analysis of immense quantities of data; Asset Management professionals need to be equipped to use this resource to reveal new truths. The ability to ask the right questions, to determine what needs to be measured and to harness the potential benefits of machine learning are fundamental – while also ensuring that the data informs competent decision making, underpinning the provision and maintenance of resilient infrastructure.

Priority should be given to exploring how this understanding and competence is being developed and then embedded within infrastructure organisations and in government.

Understanding the role of digital infrastructure in the proper realisation of a resilient and robust national infrastructure should be a priority. This should address availability, capability and capacity issues especially in areas of lower population density where the availability of telecommunications networks to support other national infrastructure resiliently may be more problematic. In addition to understanding the telecommunications aspects, particular priority should be applied to determining the dependency of infrastructure on the underpinning software and analytics platforms – considering their vulnerability to malicious activity or the economic issues surrounding rapid progress in technology and obsolescence in this field.

Introduction

The Digital Framework Task Group (DFTG) is a group of experts representing a diverse group of interests across industry, academia and the public sector, convened by BEIS and co-ordinated by the Centre for Digital Built Britain, in support of the National Infrastructure Commission's (NIC) Data for the Public Good report. A full list of members and their affiliations forms Appendix 1. The DFTG's remit is to steer the successful development and adoption of the information management framework for the built environment, which will be a key enabler of the National Digital Twin (NDT)

The DFTG welcomes this consultation which it believes supports our central philosophies that:

1. Digital twins of physical assets can and are helping organisations to make better-informed decisions, leading to the improved outcomes of financial savings, improved performance and service, and better outcomes for business and society per whole-life pound;
2. Creating an ecosystem of connected digital twins – a National Digital Twin – opens the opportunity to release even greater value, using data for the public good.

We note that the overwhelming proportion of the UK's future physical assets or infrastructure are already in existence rather than being in planning and construction phases.

Q1: What are the key questions that the next National Infrastructure Assessment (NIA) should answer about resilience?

We note three types of risks which arise from an increasingly interdependent infrastructure system which the NIC may seek to assess and address through the next NIA:

1. Physical Interdependence
2. System interdependence
3. Societal interdependence

These interdependencies are considered in turn below.

Physical interdependence

It is often the case that infrastructure assets (such as pipes and cables) occupy the same physical space in constrained environments, as illustrated in Figure 1. As a result, damage to one asset can result in multiple system failures. A notable example was road damage in the Lake District in 2015 when damage to the A591 south of Keswick also affected the electricity supply. The DEFRA Flood Resilience Review of 2016 sought to review and address these issues.

Figure 1: Multiple infrastructure assets are typically co-located

System interdependence

In addition to the physical proximity of individual assets, entire local or regional infrastructure systems can be interdependent and vulnerable to cascading effects. A well-documented case study is the Lancaster floods following Storm Desmond in 2015, where electricity failure led to the jamming of the emergency services phone lines and cessation of railway services, which might otherwise have provided a safe means of exit from the town.

The challenge of cascading effects is illustrated in the Figure 2 below, showing part of Carlisle during the flood event of 2005. The flooding of roads has left several buildings, shown in purple in the lower central part of the image, isolated from other services. In the same way, the flooding of the sewage works and power station in the top left of the image will have left their own constituencies without key services. These interdependencies could all be modelled as part of the flood protection prioritisation and risk management processes.

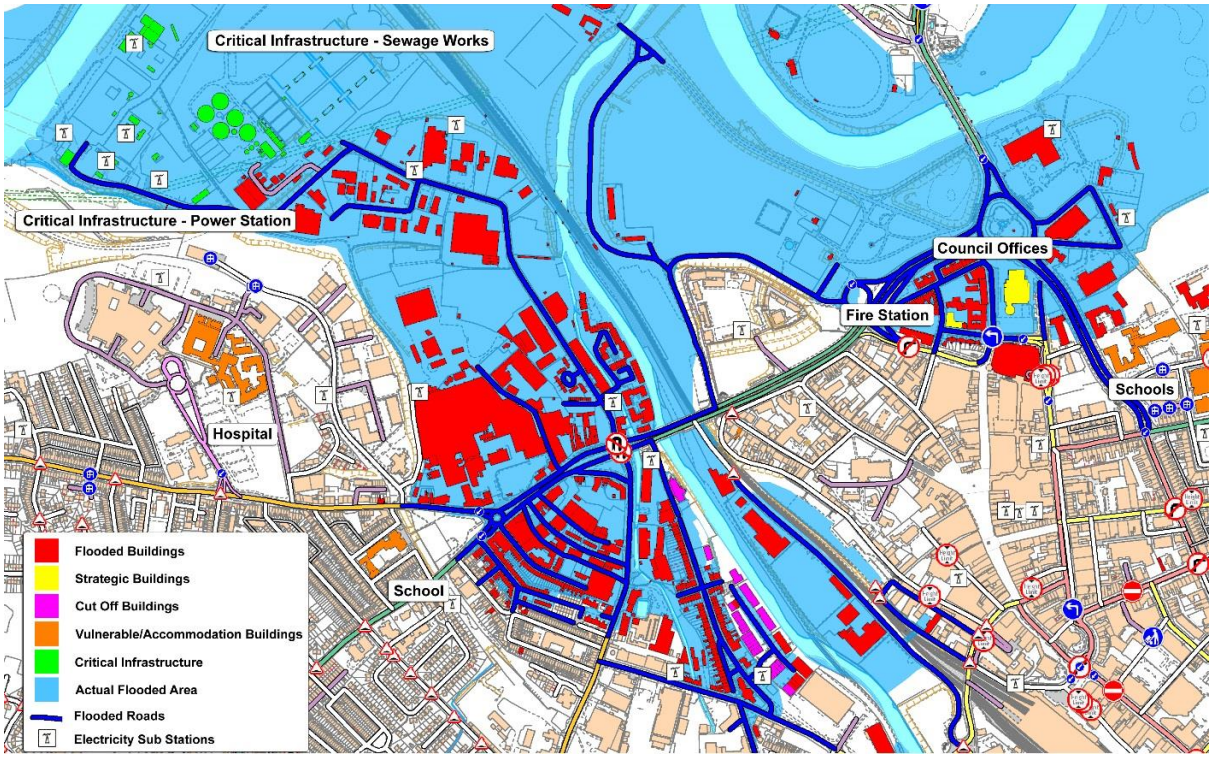

Figure 2: System interdependence, illustrated by the 2005 Carlisle floods

In addition, increasing and wide-spread access to real-time information gives affected people the means to respond to asset, service or system failures, resulting in increased knock-on demand for neighbouring or related systems. For example, the Battersea Park trackside fire near Waterloo in July 2016 resulted in overcrowding of Victoria and Clapham Junction stations rather than just on the lines affected by the fire.

Societal interdependence

The impact of a single critical asset failure can have far-reaching impacts beyond the system or network of which it is part. For example, the Cockermouth bridge collapse in 2015 impacted the population severely when several roads were closed (Figure 3) forcing travellers to take long diversions to cross the valley; Figure 4.

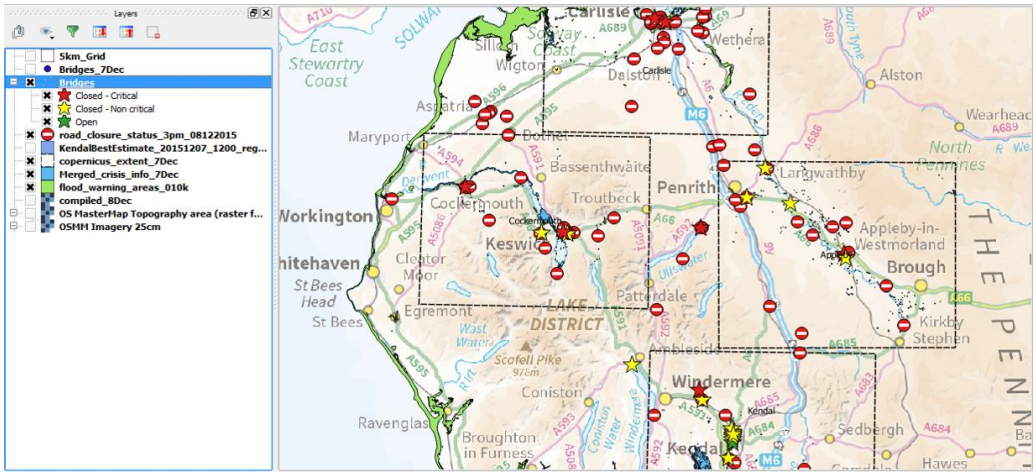

Figure 3: Impact of the closure of the Memorial Garden Bridge in Cockermouth in 2009

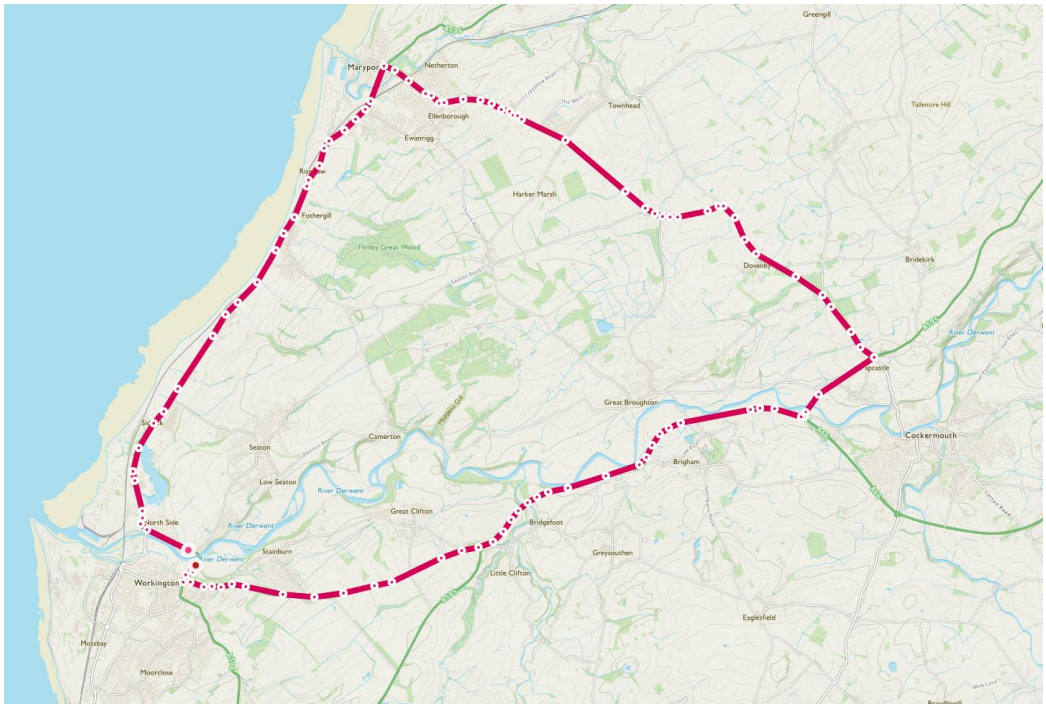

Figure 4 Diversion Following Cockermouth Bridge Collapse

During the same flood event the Tadcaster bridge over the River Wharfe (Figure 5) was damaged, impacting transport, utilities, communications and power services. Retrospective academic research suggests that the bridge failure might have been predicted by increased satellite monitoring.

Figure 5 Ordnance Survey Data Showing Tadcaster and the bridge over the River Wharfe

Analysis of the road (or other) network can reveal which assets or intersections will have the greatest impact on population movements, freight volume or business activity. With such information, an increased

monitoring regime and appropriate contingency measures can be prioritised put in place to prevent or minimise harmful disruption.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

The NDT, together with the framework on which it is based, will enable more resilient use, operation, maintenance, planning and delivery of national and local assets, systems and services.

An information management framework for the built environment is required to enable the effective management of information that is fundamental to the creation of the NDT. The DFTG recognises that information relating to infrastructure will need to be managed in conjunction with a risk management process, but that is the second half of the equation. Building the case for an information management framework should also ensure that systems-based resilience is part of the mandate for change.

Based on the notion of 'data for the public good', strong founding principles to guide the NDT and its framework through development subsequent use have been published. The nine values at the heart of the framework are known as the Gemini Principles which asset owners, civic and industry leaders in the built environment are being urged to embrace. They are also being tested through a collection of trials of which the DFTG is aware.

The DFTG welcomes review of the principles, their adoption and the trials which will test and develop them.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Members of the DFTG and its associated working groups are aware of the significant challenge in the cross-sector change programme that will be required to create the framework to enable an NDT and a more resilient and productive infrastructure system.

The Gemini Principles note that the challenges reach beyond technology to include:

- Data management and making sense of information from different origins and with varying age and levels of assurance;
- The challenges of security and privacy;
- Different perspectives of data ownership and value.
- A mix of privately and publicly owned institutions and regulatory regimes

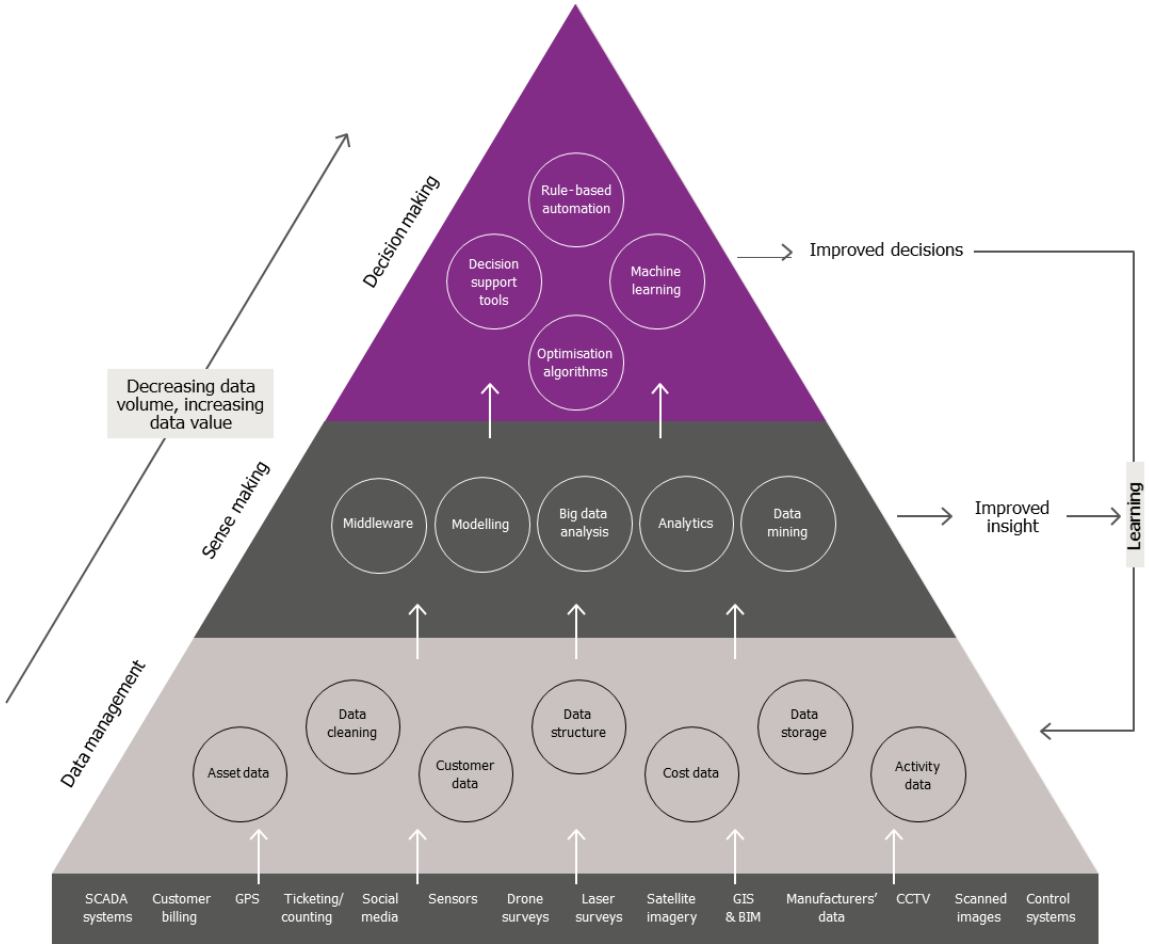

Figure 6: Information Value Chain

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The DFTG is itself one example of a cross-functional group addressing the barriers to sectoral interdependence. Its members have been involved in a number of other groups and activities, including:

The UK Infrastructure Transitions Research Consortium (ITRC): this is a collaboration of seven universities and over 50 partners from infrastructure policy and practice. ITRC's research provides concepts, models and evidence to inform the analysis, planning and design of national infrastructure (NI).

Energy Data Taskforce: . The Taskforce will deliver recommendations for how industry and the public sector can work together to reduce costs and facilitate competition, innovation and new business models in the energy sector, through improving data availability and transparency.

Project Iceberg: This collaboration between OS, the Future Cities Catapult and the British Geological Survey identifies numerous examples where data exchange between utility sectors has resulted in better outcomes that fundamentally increase the resilience of the systems they cover.

National Underground Assets Group (NUAG): Established in 2005, NUAG was designed to address issues of transport network interference from maintenance of buried infrastructure (energy, water, waste). Additional benefits were identified around event/incident management, system-of-system impacts, and safety of life. Recommendations were carried forward in a new BSI PAS (256). However, the project was prematurely closed through a lack of clarity of objectives compared to the resourcing available.

The ODI (Open Data Institute) is researching the means of breaking down barriers to data sharing where there are multiple stakeholders involved. Examples include:

- https://theodi.org/article/uks-first-data-trust-pilots-to-be-led-by-the-odi-in-partnership-with-central-and-local-government/
- https://theodi.org/article/uks-first-data-trusts-to-tackle-illegal-wildlife-trade-and-food-waste/
- https://theodi.org/article/lloyds-register-foundation-and-the-odi-launch-data-initiative-to-make-our-railways-roads-and-power-stations-safer/
- https://www.resilienceshift.org/

Appendix 1 – DFTG Members

Michael Barrett	Cambridge Judge Business School Professor of Information Systems & Innovation Studies Director of Research, Fellow of Hughes Hall
Barry Blackwell	Government Liaison
Alexandra Bolton	Centre for Digital Built Britain (CDBB) - Deputy Director
Ant Burd	BSI - Head of Sector, Built Environmen
Amelia Burnett	Centre for Digital Built Britain (CDBB) - Head of Engagement (Maternity leave
Kate Parsley	Centre for Digital Built Britain (CDBB) Head of Engagement (Maternity cover)
Ian Dabson	Infrastructure and Projects Authority (IPA) Commercial Specialist (replacing Alex Lubbock)
Alex Lubbock	Infrastructure and Projects Authority (IPA) Head of Digital Construction and Manufacturing for the IPA
Mark T Enzer	Mott MacDonald - Chief Technical Officer, DFTG Chair
Peter El Hajj	Mott MacDonald Infrastructure Advisory, DFTG Programme Manager
Matthew Evans	techUK CEO/ Executive Director
Mark Girolami	Alan Turing Institute (ATI) Programme Director for the ATI – Lloyd's Register Foundation Programme in Data-Centric Engineering
Alan Wilson	Alan Turing Institute (ATI) CEO

Amit Mulji	Alan Turing Institute (ATI) Strategy Support Manager
Fergus Harradence	Construction Leadership Council (CLC) Deputy Director
Sarah Hayes	National Infrastructure Commission (NIC) Senior Regulatory Advisor
Emily Keaney	UK Regulators' Network (UKRN) Head of Children's Research at Ofcom (replacing Rachel Wright)
Rachel Wright	UK Regulators' Network (UKRN) Director (replaced by Emily Keany)
Anne Kemp	UK BIM Alliance/Building SMART Fellow & Technical Director

Resilience study scoping consultation

Date: 1st April 2019

National Infrastructure Commission

Introduction to Jacobs

Jacobs is a global leader in the professional services sector; delivering solutions for a more connected, sustainable world.

Jacobs provides a full spectrum of services including scientific, technical, professional, construction and programme management, for wide variety of infrastructure clients.

With a business heritage of over 150 years in the UK, Jacobs is currently delivering some of the country's most challenging infrastructure programmes; from major transport works, such as HS2 and Crossrail; to flooding and wastewater projects, such as Tideway and TEAM2100; nuclear new build work at Hinkley Point C and Bradwell; to national security programmes with the British Navy and the UK's nuclear submarine programme. Our 10,000-strong UK team is providing technical expertise to help address some of the most critical issues around mobility, resiliency and security, whilst helping benefit the communities we operate in to build the UK's future prosperity and competitiveness as a nation.

Jacobs is keen to engage with the National Infrastructure Commission during this scoping exercise and hope the cross-sectoral experiences we can draw upon from our broad programme portfolio in the UK (and globally) will support and provide useful data points for the development of this important study.

Q1 – What are the key questions that the next National Infrastructure Assessment should answer about resilience?

As preface to this question, we have three general points to raise:

- There have been many studies on resilience over the last decade, but each has typically focused on resilience in the traditional way. For example, the impact of floods and extreme weather on our cities. It is becoming increasingly apparent, however, that resilience of our national infrastructure is being tested by the wider emerging risks associated with technology, cybersecurity, society, geopolitics, a changing environment and economics.
- It is also becoming apparent, that the siloed approach of the UK's infrastructure development, has now resulted in an infrastructure system with an emergent interconnectivity and mutual dependency, that is poorly understood. We now have an infrastructure nexus/ ecosystem that lacks strategic intent and consequently lacks resilience both in the short term and long term.
- Taking this further within the context of resilience, the continuing lack of interconnected planning is limiting the resilience options of the future, in short, our national systems are becoming more fragile.

Given the above we believe the following are key questions that should be included in the next National Infrastructure Assessment:

Key Question 1 – Is the UK infrastructure resilient to the emerging risks associated with changes to technology (including cyber and cybersecurity), society, geopolitics, environment (including climate change) and economics?

Key Question 2 – Do we need to change the current infrastructure planning and investment approach in order to ensure resilience of our interconnected infrastructure and prevent decisions in one sector reducing resilience of our national infrastructure system?

Key Question 3 – Recognising we have an emergent interconnected infrastructure in the UK, albeit created in an uncoordinated way. What steps do we now need to take, to build upon our existing infrastructure to create a resilient national infrastructure, with strategic intent?

Q2 – On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Priority Issue 1 – The development of a common approach across all infrastructure clients/ government departments, that recognises the need for all to consider the common risks of changing technology, society, geopolitics, environment and economics on future infrastructure development;

Priority Issue 2 – Recognising that the world has changed, what are the new roles needed of infrastructure clients and infrastructure investors; we currently have an approach dominated by legacy organisations;

Priority Issue 3 - Understanding the way in which digital innovation and cyber can add value, increase connectivity, but also detect and mitigate risks in a more effective manner

Q3 – Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Specific Barrier 1 – The continuing siloed development approach to infrastructure and the consequential lack of understanding of sectoral/departmental interdependencies. The big opportunities from our perspective, come from cross sector working.

Specific Barrier 2 – Despite the long-term infrastructure needs of the UK, we still make investment decisions based on departmental preferences, rather than looking for the most advantageous blend of investors, delivery organisations and government representatives.

Specific Barrier 3 – Many ‘value for money’ decisions continue to be dominated by short term ‘cost’ review as opposed to TOTEX value to the nation.

Specific Barrier 4 – The lack of resiliency standards within the UK. For example, Resilience standard 1 (which could show resilience to environmental related risk), right through to Resilience standard 5 (which could show resilience against the technology, society, geopolitics, a changing environment and economic risks). By adopting a common standard this would likely enable linkage to consistent asset management approaches across our infrastructure and enable us to see if connected infrastructure has consistent resilience, this would enable weak spots to resilience to be identified.

Specific Barrier 5 – The lack of commitment to infrastructure decision-making during periods of political uncertainty or sensitivity; leading to policy inertia and the deferral of major infrastructure projects during critical periods (nuclear new build, major rail, airport capacity); resilience of infrastructure governance is a critical part of infrastructure resilience.

Q4 – Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Examples in which barriers to resilience issues have been overcome/ addressed include the following:

- All parties work together in delivery of infrastructure, as per the guidance of Project 13 approach – Examples we are working on include TEAM2100 with the Environment Agency. Imagine the power of a Project 13 approach between infrastructure clients within a city environment?

- In major project delivery (such as London 2012 Olympic & Paralympic Games) in which all parties worked together around a common masterplan to deliver a successful project. From what we observe, this project delivered successfully to bring a resilient solution to this whole area of London.

- Some of the schemes we are working that bring this approach related to major development activity: These include:
    - National Western Centre in Denver, Colorado, USA.
    - The Oxford – Cambridge Arc development, UK
    - The Thames Tideway Tunnel in which many different sources of infrastructure investment (blended finance) were brought together to provide a resilient infrastructure investment. By mixing investment from numerous sources in a connected way, so much more can be achieved.
    - The London Gateway projects, including the Rochester Riverside development, in which seed investment from the UK government (SEEDA), was used to unlock development at this Brownfield site.

Further Information

For further information on the points made in this submission or a more detailed discussion on infrastructure resilience please contact:

[contact details redacted]

Yorkshire Water's response to the National Infrastructure Commission Resilience Study Scoping Consultation

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

How well do the current economic regulatory regimes in the UK for key infrastructure promote and encourage resilience (e.g. in design, in considering interdependent infrastructure systems, in the management and operation of assets, or in response/recovery)?

In the water sector, our funding is predominantly linked to the delivery of environmental and consumer regulatory outputs (e.g. phosphorus schemes, lowering leakage, etc). There are significant cost efficiency pressures in achieving these regulatory outputs under the economic regulatory regime which has a strong emphasis on comparative past cost data. Using historic cost data means that the current or future costs of climate change impacts and associated resilience measures are not accounted for.

This is of particular importance when considering that resilience expenditure is needed to address both acute (one-off interventions) and chronic (many small interventions over years) needs. It is easier to make a regulatory business case for acute needs, but much less so for the chronic needs, especially whilst still meeting short term capital delivery efficiency targets.

Therefore a key question for the NIC study should be how to adequately fund and incentivise resilience measures and how to offset long held and ongoing pressures to reduce costs and reduce redundancy and thus resilience.

A second area for consideration is that the current regulatory regime for most environmental quality compliance schemes does not include or consider climate change impacts; it is highly focussed on the current water environment and does not account for how that environment is and will be affected by a changing climate. The current regulatory regime also does not consider broader environmental impacts, for example the carbon and energy costs associated with chemical use (and associated transport movements) or process energy needs.

A more agile regulatory regime could also consider the role of dynamic consenting/permitting in achieving cost-efficient resilience. For example, real-time river quality monitoring allowing sewage treatment works to discharge more during times of high river flow (and thus dilution)

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.

Another important question for the NIC to consider is the role of standards in achieving resilience. There are defined Cabinet Office scenarios through which infrastructure operators are expected to maintain service, however these are not statutory or embedded in planning policy or other regulatory mechanisms. Standards could be a valuable mechanism in achieving a known, understood level of resilience. However, any resilience standards would have to be agreed with customers and would need to reflect differing levels of risk in different areas of the country, and the networked nature of many infrastructure systems. Standards would need careful consideration as to how they

are set, how they are funded and how differing resilience levels across the country and across sectors are accounted for.

For example, customers in Yorkshire enjoy a high degree of resilience to drought and the risk of water supply interruptions which is mainly as a result of significant infrastructure investment following the 1995/96 drought. Other areas of the country do not maintain such high levels of drought resilience. What would be the level of investment required to raise drought resilience for all customers to the same level of the most resilient providers, and would that be appropriate across the country? For example, do customers want the same level of resilience as we deliver in Yorkshire for drought, and how would this be funded? These are questions that are currently being considered through the work that Defra / EA are leading on the national framework for water resources, and the role that regional groups have in water resources planning, which will assist the NIC in this study.

A further area for consideration is how to tackle future skills shortages across the infrastructure sectors. The study could explore future resource gaps in key sectors against a backdrop of increased infrastructure investment and an aging workforce. The Commission could investigate how gaps are planned to be offset or not, by training and education policies and the markets ability to fulfil future right-skilled resource needs.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

How the regulatory regime can be adjusted to adequately fund and incentivise resilience, including how to account for current and future climate change impacts in environmental permitting and the role of dynamic consenting.
Addressing inter-generational fairness.
The role of standards in terms of setting standards and embedding them within regulatory regimes.
Skills shortages.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

The current focus on competitive markets as a solution to cost pressures and to stimulate innovation is worthy of debate so that data is freely valuable and shared. For example, Resilience Direct is only available to the emergency planning community, but a secure national data sharing platform would enable much more than emergency planning.
There is a need for a national flood risk asset register that is open access and which includes NFM and SuDS assets so that different authorities have one central location for storing this information, and are able to interrogate it in order to develop plans, maintenance regimes, identify potential partnership opportunities etc.
A lack of national climate impacts mapping eg future flood risk maps, future sea level rise and coastal erosion maps.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

I don't have any case studies to hand but suggest that partnerships are a great way to overcome these barriers, but that partnership working comes with its own challenges, not least of which are how to deliver them in our current regulatory regime, how to account for shared benefits and how to fund them.

The National Infrastructure Commission
4th Floor, Finlaison House
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EC4A 1AB

1 April 2019

To whom it may concern

Nichols response to the National Infrastructure Commission's resilience scoping study consultation

Introduction

Nichols provides creative expertise on large iconic programmes, complex capital projects and business change initiatives, operating in a wide range of industries, particularly infrastructure, energy and transport.

Over the last 44 years we have worked on various projects and programmes, including carrying out strategic reviews of England's highways for the Government, leading a project assessment of HS2 and reviewing the Nuclear Decommissioning Authority's capabilities.

Delivering infrastructure investment efficiently and effectively is vital to ensure that taxpayers and end users get more for less. Our work, particularly for clients in the decommissioning sector, has taught us that it is also essential that infrastructure is resilient and sustainable. Such an approach will ensure that infrastructure of all kinds leaves a positive legacy for future generations and benefits everyone - de-risking investments, improving efficiency and protecting the planet.

Question 1 – What are the key questions that the next National Infrastructure Assessment should answer about resilience?

A key question, which will determine costs, is about which resilience risks should be designed or built in by general long-term engineering standards (for example for nuclear hazards which present communication vulnerabilities of all kinds), and which, in specific cases, can be left for sector judgement and management. Various studies on crisis response to incidents suggest widely varying approaches.

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Registration no. 2930116

Question 2 – On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Identifying a consistent, integrated methodology for examining the cases described which cover technical, economic and presentational issues should be prioritised. This will allow learning between sectors to enhance security and avoid unnecessary costs from practices which have grown up without comparator scrutiny.

Question 3 – Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Yes, there are areas of unclear responsibilities in spatial geography. For example, Rail and Ports are subject to specific legislated Counter-Terrorist security regimes to prevent attacks at key locations. Roads are not subject to such legislation; so a new cycle lane could be installed alongside Parliament without consideration of whether it could be utilised for a vehicle attack (which occurred in 2018). There are various other examples too sensitive to record in this note.

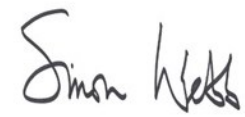
Question 4 – Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Yes, the UK nuclear industry's response to Fukushima led to the development of some novel techniques such as Severe Accident Analysis workshops and operator-led Emergency Response planning. These techniques kept the cost of the infrastructure improvements under £1bn compared to the many £bn spent in some other countries with nuclear plants.

Given our experience in this space we would be delighted to meet with you to discuss our response in more detail in order to inform your work developing a framework for considering national infrastructure resilience.

We would be delighted to discuss this further with you. If you would like to contact us we can be reached at 0203 826 6217 or by email at nichols@fieldconsulting.co.uk

Best wishes



Simon Webb
Director, Nichols

1 April 2019

Sir John Armitt CBE
Resilience Study Consultation
National Infrastructure Commission
Finlaison House
15-17 Furnival Street
London EC4A 1AB

Nominet response National Infrastructure Commission Resilience Study Scoping Consultation

Dear Sir John,

This is Nominet's response to the National Infrastructure Commission's (NIC) scoping consultation on its proposed infrastructure Resilience Study.

The Commission is right to emphasise the importance of reliable and robust critical national infrastructure, fit for the 21st century. This is particularly the case in the context of an increasingly interconnected world, with more services contingent on online connectivity. The need for stability is arguably greater in many key respects than it was even a decade ago.

We also note the Commission's comments around the reach of these challenges. The provision of key services can be dependent on any number of third-party activities, from the provision of cloud-based services, to mobility of physical assets, and most notably digital and mobile connectivity. As our utilities, transport and telecoms network become increasingly sophisticated, policymakers must take a holistic approach to resilience, to ensure these services can be provided reliably and without disruption.

As such Nominet welcomes the opportunity to respond to this scoping consultation.

We believe that Nominet has particular insight to offer in this regard. For 20 years, Nominet has run the .UK top level domain infrastructure, developing expertise in the Domain Name System (DNS) that now underpins sophisticated network analytics used by governments and enterprises to mitigate cyber threats.

More broadly Nominet is driven by a commitment to use technology to improve connectivity, security and inclusivity online. We support initiatives that contribute to a vibrant digital future and we continue to explore applications for a range of emerging technologies including new tools to support the deployment of autonomous vehicles, and the dynamic allocation of the mobile spectrum that underpins much of our critical national infrastructure.

Nominet's comments in response to the NIC's scoping phase questions are set out below.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Nominet supports the Commission's initial thinking on key resilience questions, in particular the need to address cross-sectoral interdependencies as being central to its programme.

To date much of our thinking around the critical national infrastructure has focussed on specific institutions, rather than systems themselves, and third-party dependencies that arise from them. The Commission's approach needs to focus on elements of often common vulnerability across services.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Nominet supports the key issues the Commission identifies, namely our skills and knowledge base, public expectations of resilience, and 'stress tests' of sectors, areas and organisations. The Commission's research might also focus on areas that present systemic risk or dependencies – for example the provision and concentration of cloud-based services.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Nominet would note a potential concern around the range of previous assessments, audits and questionnaires, from regulatory and compliance bodies, that may overlap considerably with the Commission's study. In some cases, this has had the unintended consequence of duplication of work that neither benefits respondents or regulatory body concerns.

Nominet has argued previously for the need to use existing wording and tools - to ensure respondents have clear and consistent requirements. We believe that the NIC may have a potential coordinating role in enabling such an approach, by virtue of taking a view of infrastructure challenges that coordinates and cuts across regulation in specific sectors.

This would also help industry to compare findings over time and ensure that any learnings or improvements are comparable with previous assessments. The Commission is uniquely placed to assess these challenges on such a holistic basis and should be ready to overcome any obstacles identified from its scoping exercise to do so.

We also note an additional concern around cross-jurisdiction dependencies.

In some cases, critical components of UK infrastructure may be dependent on third-party services or resource that falls outside of regulators' jurisdictions. It is important that the NIC not be blind to such risks that cut across sectors and national borders, and importantly that the approach the NIC recommends is proportional to risk to resilience, rather than the visibility of the risks. It is important that any approach does not overburden one component of UK infrastructure while others fall

outside the NIC's remit altogether by reason of ownership, scale or the location of company registration.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Nominet does not identify any such cases as noted in our response to Q3. However, we believe that the NIC is well placed to coordinate such work and handle, for example, data that might be potentially sensitive or not for wider exposure while making open and transparent recommendations to Government.

I hope these comments will be of use to the Commission in establishing the scope of its study. Nominet continues to support the NIC's work to ensure the stability of our critical national infrastructure, and we look forward to offering further insights at the projects second phase later in 2019.

If we can be of any further assistance, please do not hesitate to get in touch.

Yours sincerely,

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1st April 2019

National Infrastructure Commission: Resilience Study Scoping Consultation

Drax Group plc (Drax) owns and operates a portfolio of flexible, low carbon and renewable electricity generation assets – providing enough power for the equivalent of more than 8.3 million homes across the UK. The assets include Drax Power Station, based at Selby, North Yorkshire, which is the country's single largest source of renewable electricity. Drax also owns two retail businesses, Haven Power and Opus Energy, which together supply renewable electricity and gas to over 390,000 business premises. Through our generation assets we are actively helping to contribute to the UK's security of supply though providing balancing and ancillary services which allow the UK's energy system to operate safely and securely.

We welcome the opportunity to help inform the scope of the NIC's Resilience Study and have focused our response on the UK's security of supply for electricity.

Under the UK's Climate Change Act, and more stringent obligations under the Paris Climate Agreement, the decarbonisation of the UK's energy system must continue. We believe that it is likely that the majority of this decarbonisation will be provided by the continuing rollout of intermittent renewables such as offshore and onshore wind and solar increasingly replacing traditional thermal plant such as coal and gas. It is important that the continued rollout of intermittent renewables does not compromise system security in the UK's energy system.

We believe that the NIC's resilience study should focus on two important aspects within the UK's energy system to test robustness as a result of an increase in intermittent renewables, namely capacity and system needs.

<u>Capacity within a decarbonised energy system.</u>

As the rollout of intermittent renewables increases the UK will be increasingly reliant on the weather to generate electricity. For periods where the sun isn't shining, and wind isn't blowing there will need to be sufficient capacity on the system to ensure that demand can be met. In the UK we have the Capacity Market (CM) which helps to ensure this demand is met however following its suspension in late 2018 this security of supply is at risk. We believe that NIC should investigate the effects of a long suspension of the CM on security of supply.

Whilst we recognise that there is a need to deploy some interconnection in the UK, we believe that an approach which relies too heavily on interconnection puts the UK's security of supply at risk. All interconnected countries are undergoing the same transition to a decarbonised energy system as the UK and exposes the UK to risks in these countries decarbonisation policies. For example, during the cold snap in 2018 the UK-France interconnector was actually exporting from the UK into France during the coldest period due

to an increasing reliance on electricity for heating in France pushing wholesale prices up in comparison to the UK[1]. These problems will be more pronounced given the French government has committed to reducing the share of nuclear power in the French grid from 75% to 50% by 2025 giving greater exposure to intermittent renewable generation.

Analysis from Aurora has shown that as the amount of interconnection rises, each additional interconnector contributes progressively less to security of supply due to saturation effects as interconnectors connected to similar countries will begin to compete with each other[2]. Therefore, whilst we believe there is value in some interconnection on the system, we believe the NIC should assess the affect of high levels of interconnection on security of supply and take into account the effect of interconnection on system needs, as explained below.

System needs within a decarbonised energy system.

National grid is responsible for ensuing that the national transmission is operated within a number of defined technical limits to ensure its safety and stability. These include:

- *Frequency response*: The national transmission system must maintain a stable system frequency of 50 Hz. Frequency response is a change in generation or demand to counteract changes in system frequency.
- *Inertia*: Inertia determines how quickly frequency will change when there is an imbalance between generation and demand; the greater the inertia, the slower the change in frequency.
- *Voltage control*: Reactive power (measured in MVAr) is used to control voltage. Generation, demand and network equipment (such as transformers, overhead lines and cables) can either generate or absorb reactive power. These contributions need to be kept in balance to keep the voltage at the right level. Voltage is a local property of the system so requirements vary from one region to another.
- *Black start*: Black start is the service used to restore the system in the unlikely event of a partial or total shut down. To restore power, National Grid needs generation capable of starting up without external power supplies, energising the transmission system and supporting the reconnection of demand.

Some of these system needs are procured by National Grid through a combination balancing services markets, bilateral contracts and the Balancing Mechanism. National Grid has historically been reliant on thermal generators such as coal or gas fired power stations to provide these services as they can increase or decrease electrical output in response to the demands of the transmissions system. Other services, such as inertia, are provided for free by large thermal generators and as such are not ascribed the correct value. There is a risk that underinvestment in these services risks jeopardising the resilience of the network.

As the UK continues to decarbonise it is crucial that Britain's power system retains and replaces a degree of flexible, dispatchable technologies which can provide these services such as pumped storage hydro and biomass in contrast to technologies which cannot provide these services such as interconnection. To enable this, a long-term strategy on ancillary services and system resilience needs to be developed by National Grid and Distribution System Operators. Among other potential improvements, this should involve creating a regulatory framework that incentivises the System Operator to act in the long-term interest of consumers by developing a procurement approach that offers the necessary

[1] https://www.drax.com/press_release/beast-east-exposes-reliance-french-interconnector/
[2] https://www.auroraer.com/wp-content/uploads/2018/05/Aurora-Press-New-study-Energy-Security-in-an-interconnected-Europe-240518.pdf

financial certainty for providers and investors. We believe there is value in the NIC assessing the best approach to this.

By focusing on these two issues, we believe that a clearer picture will emerge as to the security of supply in the UK's energy system, which is a vital aspect of ensuring resilience in the UK and we would welcome the opportunity to discuss these issues in further detail with the NIC.

Yours sincerely,

By email

Karl Smyth

Group Head of Policy and Government Relations

Drax Group plc

19 August 2019

SGN Response to NIC Resilience Study Scoping Consultation

SGN welcomes the opportunity to respond to this consultation. SGN manage the network that distributes natural and green gas to homes and businesses across Scotland and the south of England. We deliver a safe, secure and reliable gas supply to 5.9 million customers. Our response will cover four main areas we have identified as key to the future resilience of our network – weather & climate, whole system solutions, cyber security and workforce.

- **Weather & climate** - Ensuring our gas network remains resilient is a priority for us as we move into our next price control period, RIIO-GD2 which will run from 2021-26. With almost all of our 74,000km of pipeline underground, it's very rarely affected by bad weather and our ongoing programme to replace our old metal gas mains with modern plastic pipes means on average a customer will only experience an unplanned interruption to their gas supply once every 140 years. Despite this we are working to ensure the increasing frequency of extreme weather events - which is expected as a result of climate change - does not impact this level of reliability. We want the opportunity to bring forward interventions should we identify potential failures as a result of environmental changes that would have a high societal impact.

- **Whole systems solutions** - As we transition to a future low carbon energy system, considering whole energy system solutions, could increase resilience compared to solutions which rely heavily on a single energy vector. Utilising the storage capabilities of the gas networks is increasingly being recognised as a key aspect of a whole systems approach to decarbonisation which could reduce the amount of investment needed in the electricity network to meet peak demands. We believe this study should consider how whole energy system solutions can deliver a resilient low carbon energy system that meets climate change targets at least cost and lowest disruption for customers.

- **Cyber security** - Cyber is a growing threat to the resilience of our gas networks and other infrastructure. The threat of disruption to our customers and our business is continually evolving and it's why our Board has identified cyber risk as our number one corporate risk. Continued capability improvements will be required for us to continue to successfully manage this growing threat, and we therefore welcome it is part of the scope of the resilience study.

- **Workforce** - A skilled workforce is just as important to our network's resilience as the quality and condition of our pipes. We invest significantly in our workforce through training, apprenticeships and up-skilling to ensure they continue to operate competently, safely and flexibly. However, our age profiles indicate that we will inevitably lose significant numbers of our most experienced employees through retirement over coming years. Over and above this, our churn rates have increased over recent years, too, particularly in the South of England where there is effectively 'full employment', upward pressure on wages, and increasing competition for the skills and competencies our employees possess. To meet these challenges and maintain workforce resilience, we will need to continue to invest heavily in our workforce into the future through large scale recruitment of apprentices and trainees and the upskilling our existing employees, and encourage retention by providing competitive salaries and other terms and conditions.

Our answers to the specific questions are outlined below. If you have any questions on the points raised, or would like to arrange a meeting to explore any of them in more detail, please don't hesitate to get in touch with our Policy Manager James Higgins via james.higgins@sgn.co.uk.

Answers to specific consultation questions

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

We have identified four key areas as key to the future resilience of our network – weather & climate, whole system solutions, cyber security and workforce that we believe should be considered for the next National Infrastructure Assessment (NIA).

Weather and climate

We believe the next NIA should consider whether infrastructure can effectively deal with the harshest of weather. Climate change could mean extreme weather events such as 2018's 'Beast from the East' happen more frequently and there is a need for us is to ensure our gas network is resilient and able to keep our customers safe and warm even during such events. The Beast from the East event in 2018 tested us, but our preparation and resilience meant our gas network was able to meet up to 80% of energy demand in our regions during the storm. The fact our gas network infrastructure is almost entirely underground means it is very rarely affected by bad weather in the way that above ground utilities are. As a result of this, GB customers on average experience an unplanned outage to their gas supply only once every 140 years.

As we plan for our next price control we are identifying any additional actions or resources that may be required to maintain this level of resilience. An action we have already undertaken is to purchase 750 metres of flood barriers ready for deployment to ensure our pipes and equipment remain safe during flood conditions. We are waiting to hear back from Government regarding which bridges in our network area are at highest risk from flooding, and where an alternative pipeline crossing could increase resilience. This follows the Tadcaster bridge collapse during storms in December 2015 which interrupted gas supplies. There is also a need to ensure regulatory frameworks do not prioritise short term outcomes over investments to ensure long term resilience.

Whole systems solutions

While decarbonisation in line with Government climate change targets is a key priority for the energy sector, it will be imperative our future low carbon energy infrastructure continues to allow peaks in demand to be met in an affordable way. Currently, our gas network allows us to meet the extreme winter peaks in heat demand – which are more than four times larger than peak electricity demands – in an affordable way as a result of its ability to store vast amounts of energy and quickly release it when needed. Across heat, power generation and transport, gas has an important role to play as part of an integrated low carbon energy system. As an example, small back up peaking power plants connected to the gas distribution networks are increasingly being used to provide vital support to the electricity grid at peak times and when intermittent renewables are not available.

We believe the next NIA should consider how whole energy system solutions can deliver a future resilient low carbon energy system which meets climate change targets at least cost and lowest disruption for customers.

Cyber security

As the consultation document highlights, cyber-attacks are a growing threat to the resilience of our gas networks and other infrastructure. The threat of disruption to our customers and our business is continually evolving and it's why our Board has identified cyber risk as our number one corporate risk. We have multiple, major initiatives in progress to help protect us from cyber-attack. We were one of the first utilities to achieve Cyber Essentials accreditation - a government security scheme recommended to help protect against common cyber-attacks. We also became the first owner of Critical National Infrastructure (CNI) to migrate 100% to the cloud. However, we recognise continued capability improvements will be required for us and other infrastructure networks to continue to successfully manage this growing threat. We therefore welcome that this is an area included as part of the terms of reference for this study, and believe the NIA should consider any further actions that may be necessary.

Workforce resilience

Finally, we believe the NIA should consider the importance of a skilled workforce to maintain infrastructure resilience. We see our skilled workforce as just as important to our network's resilience as the quality and condition of our pipes. We currently have over 3,700 highly skilled and flexible employees but our age profiles indicate that we will inevitably lose significant numbers of our most experienced employees through retirement over coming years. Over and above this, our churn rates have increased over recent years, too, particularly in the South of England where there is effectively 'full employment', upward pressure on wages, and increasing competition for the skills and competencies our employees possess. To meet these challenges and maintain workforce resilience, we will need to continue to invest heavily in our workforce into the future through large scale recruitment of apprentices and trainees and the upskilling our existing employees, and encourage retention by providing competitive salaries and other terms and conditions.

The relatively low level of graduates and apprentices taking up core STEM (science, technology, engineering, maths) subjects is a recognised problem that could impact our future skills pipeline. We are working with partners to encourage more young people to explore STEM opportunities and careers. We also have an award-winning apprenticeship programme as well as coaching and development programmes to train and upskill our existing colleagues. All of this will be key to ensure we have the right people, with the right skills to ensure we have a resilient network into the future.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

As outlined above, we believe the resilience study should consider four areas: 1) the ability to cope with the British weather and the increasing possibility of extreme weather events as a result of climate change 2) the evolving cyber security threat 3) the importance of a whole systems approach to deliver a resilient future low carbon energy system at least cost and 4) lowest disruption for customers and workforce resilience.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

We are supportive of whole energy system outcomes but there is a tendency to bind thinking on whole system outcomes to the electricity system. This definition has inadvertently created a barrier to evaluating and working towards whole energy system outcome opportunities for cross-sectoral issues. An example of this is in the joint Ofgem/BEIS Smart Systems and Flexibility Plan which only covered electricity. The whole system outcomes approach is about delivering energy to the end consumer in the most convenient, efficient and resilient manner whilst recognising the need for decarbonisation and the potential disruption in delivering decarbonisation.

A whole system approach needs to consider electricity, heat, transport and waste. It should look to derive a system that integrates delivery of energy, energy efficiency and decarbonisation at least cost. For heat there are multiple routes and, in our view, no single solution. We believe the right approach is likely to include a blend of waste to gas (bioSNG), biomethane, hydrogen, dedicated heat and dedicated hydrogen networks.

Considering whole energy system outcomes when making energy infrastructure investment decisions could allow capacity issues to be resolved more cost effectively, for example, by utilising the storage capabilities of gas networks to reduce the amount of investment needed in the electricity network. Network companies should therefore be incentivised to enable these solutions in an impartial way, and promote the enabling innovation.

We would firstly encourage Ofgem to evaluate whole system outcome opportunities within its own approach. To fully remove the barriers to a whole system outcomes approach, however, Ofgem's vires and the respective Acts of Parliament (e.g. Utilities, Electricity and Gas Acts) need to be considered. These Acts contain duties, such as an obligation to supply gas or maintain a connection, that may impede an alternative whole system outcomes solution.

Finally, we need to recognise that there are financial and organisational barriers. Developing a whole system outcomes approach extends operational activities. Such extensions have a direct cost and their success is highly inter-dependent with multiple parties, as such they have a higher risk of not progressing or not providing a direct payback to the company compared to other sector specific projects. This needs to be recognised when promoting whole systems outcomes.

It is in consumers interests that these barriers are overcome, and RIIO-2 should look to bring about a change in business as usual and the current regulatory structure to enable a whole systems outcome approach. The requirement to reduce the current barriers in the regulatory and licence framework will take time, but the process of change should start as soon as possible.

In the meantime, in the RIIO-2 price control period there are many whole system benefits and outcomes that could be realised through the design of specific incentive mechanisms. It is important to recognise that whole system outcomes need to be directly incentivised because they are typically non-core and high-risk projects where the financial benefits may accrue to multiple parties. However, the key benefit should be the delivery of a resilient energy system where different parts of a future lower carbon energy system can support others to ensure resilience.

National Infrastructure Commission

Resilience Consultation

Answer to Question 3

Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Yes, protectionism of data appears to be a substantial impediment to enable cross-sectoral resilience. Where data are publicly shared or made available in other ways (e.g. subscription), the digital infrastructure can share awareness of resilience threats.

As an example, consider the how flood resilience has been addressed through data sharing. The Environment agency deployed water level sensors on most of the UK water courses. However, only recently the readings of these water sensors were made available through a push strategy, to community potentially affected by floods in the areas of the sensors. This came through the Gaugemap[1] project that associated a twitter account to each of the water level sensors and tweeted alert signals to their followers whenever the level was to reach critical levels. This is a way of making resilience tangible to population of flood prone areas.

The digital layer helps the population resilience to failures originated in the physical water infrastructure (intended as the natural and built assets along the water courses in Britain and Ireland). However, the open-loop nature of the interaction, that is, there is no direct action on the physical infrastructure from the digital layer, creates a circuit breaker that prevents the two sectors to interact in a potentially dangerous way. In fact the lack of a direct feedback loop from the digital to the physical infrastructure reduces the complexity of the system increasing its predictability, hence the possibility of engineering it with reduced uncertainty.

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[1] https://www.gaugemap.co.uk

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National Infrastructure Commission – Resilience study scoping consultation

Response from the Met Office

Authors: Tom Butcher (Head of Industry Consultancy), Jodie Wild (Government Transport Manager) and Kirsty McBeath (Senior Stakeholder Relationship Manager)

Date: 1 April 2019 v1.0

The Met Office is the UK's National Meteorological Service, a Public Sector Research Establishment and an Executive Agency of the Department for Business, Energy and Industrial Strategy. We are responsible for monitoring and forecasting the weather and conducting scientific research to support, develop and improve these capabilities. In addition, the Met Office Hadley Centre provides up-to-date robust scientific advice to Government on climate variability and change to inform policy development and decision making.

In addition to services provided to Government we provide weather and climate services to a number of different industries. These services help customers to manage weather related risks and opportunities so businesses can operate safely, efficiently and profitably.

Weather and climate change pose risks for infrastructure across all timescales and should be an important consideration in planning investments into new technologies and assets.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

The Met Office welcomes the cross-cutting and long term perspective being advocated by the Commission and the recognition of the importance of resilience to environmental hazards in both the interim report and your 2017 report on the subject. One of the key questions that NIC should continue to raise through the next NIA is: **how resilient is UK infrastructure to current weather variability and future climate change?**

It is important that resilience to changing climate risks is built through a joined-up and strategic approach that takes account of both existing and future infrastructure requirements. Infrastructure design needs to ensure that new assets are not only resilient to extreme weather events, such as those seen in recent years, but also the impacts of future climate variability and change. Conversely, understanding of longer term changes in risks can better inform the use of weather information today.

Weather and climate information can inform all stages of the infrastructure lifecycle: from government policy, to asset design, build, operations and end of life. The Met Office works in partnership with governments and industry across each of these stages to bring together multi-disciplinary expertise. For example:

- We work with a range of industry customers on understanding how weather impacts on the operation of their assets and tailoring short-range forecasts to manage day to day risks.
- We are currently working closely with partners such as the Environment Agency (EA) and the Centre for Ecology and Hydrology (CEH), where our seasonal forecasts are being used to inform their Hydrological Outlook.
- The UK Climate Projections (UKCP18), produced by the Met Office Hadley Centre Climate Programme and supported by BEIS and DEFRA, have been developed in close partnership with government and industry stakeholders. UKCP18 is an expansive toolkit that enables industry and governments to explore the possible impacts of climate change to inform government policy, infrastructure design and organisational strategy.

Different types of infrastructure are vulnerable to different weather types. For example, UKCP18 highlights that the 2018 UK summer heatwave is likely to become the norm by the middle of the century. This could have wide ranging implications across a range of sectors. For instance, the water sector is impacted during heatwaves through exceptionally high levels of demand; trains may have to slow down to account for the expansion of rail tracks; and the energy sector has to cope with higher than normal levels of electricity demand as a result of increased usage of air conditioning systems.

We have previously undertaken a piece of work to characterise hazards for the energy sector[1] that can be applied to support consistent decision making across the industry. This approach could be extended for other sectors which will have different vulnerabilities.

Beyond this, more could be done to understand inter-sectoral dependencies. For example, highly renewable dependent energy networks must be designed to be resilient to periods of extreme demand coupled with low wind speeds and cloudy conditions. Uptake of electric vehicles could exacerbate this demand, or provide more flexible energy storage across the network, depending on the extent to which they are integrated in a smart manner.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

The Met Office and our customers are increasingly interested in data which can help us to understand risk, of which the hazard is only one component. We have good access to geospatial hazard data for weather and climate hazards, however the data covering exposure and vulnerability can prove more difficult for us to access. The specific datasets needed for this depend on the question being asked, however they often relate to infrastructure (such as the location of key assets), population data or land use.

We have found that poor curation of data significantly impedes its use, particularly when that use is for purposes other than that for which the data were originally collected. Data about risk exposure or vulnerability is often collected with little or no geospatial data, which limits the extent to which it can be reused to generate additional benefit. Encouraging the inclusion of geospatial data and high-quality metadata in more datasets would support improvements in the understanding of infrastructure vulnerability and inform better risk management.

For example, the Met Office are currently working with Highways England to analyse the granularity and expanse of roadside observation data against meteorology to better understand how numbers of observations would impacts on road maintenance and decision making. However poor-quality location data in the road sensor dataset has created additional work, in addition to further interdependencies and questions that will need to be investigated to realise the further value of this area of work. Similar issues have been experienced when working with for example rail fault data and electricity network fault data. We would therefore strongly support actions to raise the general awareness about what “good” datasets look like, and efforts to meet a minimum standard to ensure reusability. This would enable the UK to get better value from the investment that goes into collecting data and help to inform better decision-making for infrastructure management.

[1] http://www.imeche.org/policy-and-press/energy-theme/enabling-resilient-uk-energy-infrastructure

Resilience study scoping consultation

A cross-engineering sector response to the National Infrastructure Commission's resilience study scoping consultation on behalf of the Royal Academy of Engineering and Institution of Civil Engineers

April 2019

Introduction

We welcome the opportunity to respond to the National Infrastructure Commission's resilience study scoping consultation. This is a cross-engineering sector response on behalf of the National Engineering Policy Centre, developed by the Royal Academy of Engineering and the Institution of Civil Engineers, an example of the increasing collaboration between engineering institutions. We would be pleased to explore with the NIC possible solutions to the issues and barriers highlighted in this response.

The UK needs an infrastructure that is as adaptive, flexible and resilient as it can possibly be[1]. Resilience is a system-wide issue because infrastructure is interconnected, so the system-wide consequences of any disruption may be far more important than the local effects. We welcome the NIC's focus on resilience, and agree that it is vital to consider interdependencies between sectors and the risk of cascades of failure across sectors, and the importance of rapid recovery following failure. **Systems engineering approaches**, based on good evidence, are required to address resilience at the level of the system.

Infrastructure is interconnected most visibly through the reliance of one system on another system. For example, the flood protection system is reliant on the electricity system for pumping water. Systems are interdependent as part of overall process flow – for example, rail needs road or urban transport for passenger dispersal at rail termini. Systems are also interdependent as users migrate from one system to another in the event of failure, such as when telecommunications systems or data networks are subject to heavy local demand if transport systems fail. All sectors are dependent on electricity and increasingly on the internet. For example, many water supply systems rely on pumps and almost all water treatment requires electrical energy. Historic flooding events have demonstrated the cascading effects of progressive infrastructure failure[2].

Resilience is a **time-dependent** issue, firstly in sustaining an adequate level of resilience during an asset's life and secondly, that in the event of a failure, time to recovery is acceptably short. There may be some trade-off between these two, for example, a lower level of resilience may be tolerable if the recovery time is short enough. In particular:

> (a) infrastructure systems need to be resilient for at least their whole design lifetime, so the ability to predict, prevent, detect and repair failures, to do preventative maintenance, to understand the implications of upgrades or of introducing additional interdependencies are all at the heart of resilience. This is particularly critical for new technologies, where long-term properties may be uncertain or where digital components, protocols and maintenance knowledge may change or disappear.
>
> (b) time-to-recovery – a one minute interruption to the water supply to London may be insignificant, whereas a one day interruption could cause major problems and a one month interruption would be catastrophic.

Reconfiguration and retrofitting of infrastructure will be needed to increase resilience, as well as flexible and new infrastructure. Resilience is therefore "an important driver of demand"[3].

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[1] Royal Academy of Engineering (2017) National infrastructure Assessment - Response to the National Infrastructure Commission's call for evidence.

[2] See for example, Royal Academy of Engineering, IET and Lancaster University (2016), *Living without electricity: one city's experience of coping with loss of power*.

[3] ICE (2016) *National Needs Assessment* www.ice.org.uk/news-and-insight/policy/national-needs-assessment-a-vision-for-uk-infrastr

Many of the examples given in this response are taken from individual sectors such as the water sector, but the issues transcend all branches of economic infrastructure.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Definitions of resilience : How are the different infrastructure providers currently approaching resilience? Are they defining it in a narrow way, for example, the resistance of infrastructure to stress, or including wider elements such as avoidance and recovery?

Measurement of resilience : What metrics do different infrastructure providers use to measure resilience? Is resilience monitoring used as a means of driving improvement?

Dealing with future uncertainties: How do key uncertainties related to a changing natural environment[4] as well as fast-paced developments in new technologies and in new delivery and service models affect approaches to resilience? Will historical methods for ensuring resilience need updating[5]?

Impact of disruptive technologies: How can the consequences of disruptive technologies be better managed to support resilience policy objectives rather than undermining them? Or would this stifle innovation?

Understanding infrastructure interdependencies: How well do we understand infrastructure interdependencies? In what way are interdependencies between infrastructure sectors changing and/or growing?

Levels of resilience: What should be the desired level of resilience? What is the right balance between the costs of increasing resilience and the benefits of avoided disruption? For example, is the recommended resilience standard for flooding reasonable? Could there be adverse **unintended consequences** of introducing targets for levels of resilience?

Approaches to resilience: How can better resilience be achieved?[6] Are there tensions or trade-offs, for example between flexibility/adaptability and resilience, or between resilience and efficiency, for example?

Economic and social value of resilience: What is the case for investing in resilience and the evidence for this? How can quantification of potential for disruption and systemic risks help to justify the case for investment?

Cooperation between infrastructure sectors: Where is better cross-domain collaboration between infrastructure sectors needed to improve resilience? How can cross-domain collaboration feed into effective systems engineering approaches? How can system planning be improved as a result of better collaboration? How can system operators collaborate to improve incident management?

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[4] ICE's 2016 National Needs Assessment highlights flood risk, temperature fluctuations (especially heatwaves) and shortages of water as key issues impacted by climate change which will affect the UK's need to respond to improve resilience. For example, as rainfall becomes less reliable, the water supply system could be more likely to fail for a significant period - weeks or even months - if reservoirs reach minimum supply levels and there is insufficient rainfall to replenish them.

[5] For example, water systems have generally attempted to have a balance of different types of resources to provide greater resilience, such as pumps in boreholes, reservoirs, water reuse plants, or desalination plants.

[6] For example, is it through greater redundancy or using standby facilities on a temporary basis while accepting higher failure rates?

Stakeholder engagement: To what extent do infrastructure operators engage with customers (end users) to manage resilience? What other stakeholders influence infrastructure resilience such as spatial planners and urban designers? To what extent are they engaged in building resilience?

Public/consumer opinion: What level of resilience is acceptable to the public? How much are consumers willing to pay for a given level of service?

Reducing demand: What methods of demand-side reduction[7] can be adopted, for example, through resource efficiency, technology or encouraging lower usage? What impact will they have on demand and therefore on resilience requirements?

Accountability: Where should responsibility for resilience lie? Should it be with individuals or service providers, or some combination?

Incentives for improving resilience: Do commercial or regulatory incentives – to maximise profit or minimise the regulated asset base – work with or against total system resilience? What regulatory instruments are required in order to enhance resilience, for example, information sharing?

Regional variations: In what way do the differing geographical and demographic challenges influence the requirement for resilience and approaches to resilience?

Policy and funding context/devolution: What is government's role and how can it work best with industry and the public to support improvements to resilience? What role should regulators play? How does devolution affect policy and funding solutions?

Skills: Where are new skills needed in design and planning, regulation and policy, operation and maintenance of infrastructure, and in cross-domain collaboration, to deliver better resilience? How does the introduction of new technologies and automation affect the blend of skills required? How can education address skills requirements?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Definitions of resilience: Resilience may be defined in a very narrow way – for example, the resistance of infrastructure to stress - so that action to improve resilience is also narrowly focussed. This, however, may miss the wider elements of resilience, including avoidance and recovery. Avoidance can be important, for example, where a particular infrastructure element is dependent on other infrastructure, a common instance being the dependence of a pumping station on grid electricity. Avoiding this dependency by, say, installing a local generator, improves resilience. Equally it may be more cost effective to accept occasional infrastructure failure but have a really good system in place to recover. Resilience also encompasses people-centred aspects such as reporting, crisis management and business continuity[8]. There is a danger that by taking a too narrow view the most cost-effective approaches to improving resilience may be missed.

Approaches to resilience: There are a number of questions in relation to how resilience should be approached, including the following:

[7] ICE's 2016 National Needs Assessment projects a UK population of 75 million by 2050 and increased energy demand from 900 TWh/year to 1200 TWh/year, while other projections show increased numbers of elderly or disabled people and increasing concentrations of urbanisation.

[8] Royal Academy of Engineering (2018), *Cyber safety and resilience: strengthening the digital systems that support the modern economy*, https://www.raeng.org.uk/publications/reports/cyber-safety-and-resilience

- How well is the relationship between resilience and efficiency understood? To what extent has resilience been compromised - for example by the removal of redundancy - in a drive for infrastructure 'efficiency'?
- Where should additional resilience be located in the overall system, and how can systems engineering approaches inform this?
- How can new informatics and modelling capabilities inform decision-making?
- How can monitoring be used as a leading indicator of shortfalls in resilience?
- How can the consequences of failure be limited and restoration capabilities be accelerated, given that some failures are inevitable?

Dealing with future uncertainties: There are likely to be many changes with significant implications for infrastructure, including:

- the UK's transition to a low-carbon economy
- adoption of connected, autonomous vehicles
- adoption of smart infrastructure
- growing interconnectedness of physical infrastructure with digital systems
- demographic change
- climate change.

These will all affect the nature and size of the demand for infrastructure, the nature of the interdependencies, the types of risk and consequently the approaches to resilience.

The impacts of disruptive technologies may not be consistent with policy and societal objectives. For example, UBER is cheap and convenient for passengers but in London, it has driven a rise in the number of vehicles on the road and an increase air pollution, which is counter to TfL and government policy. Thus the consequences of disruptive technologies will need to be better managed to support resilience.

There is more to be done to understand extreme events and how they might affect infrastructure. For example, the *2016 National Flood Resilience Review*[9] demonstrated that possible maximum rainfall events may have been underestimated by between 20% and 30% across the UK.

Understanding infrastructure interdependencies: As an example of growing interdependence, the transition to a low carbon energy system over the next thirty years will have major implications for the built environment and digital infrastructure, as well as the infrastructure that transmits and distributes energy. An economy based on the internet of things will be much more able to deliver energy as a series of services rather than a commodity, with potential for greater customer satisfaction and lower costs, but it could also expose the nation's critical energy system to systemic failures.

As more and more infrastructure depends on software systems that are connected to networks, the consequences of a cyberattack must be a major consideration. A cyber attack may well be designed to affect multiple systems simultaneously. Physical and cyber safety, security and resilience must be treated as a fundamental system design issue from inception and must be kept under constant review throughout the lifecycle of assets.

Cooperation between infrastructure sectors: An improved capability in systems engineering for infrastructure decision-making and for the management of system interactions urgently requires improved collaboration between infrastructure sectors so that resilience is addressed at system level. Processes will need to be designed to

[9] Cabinet Office and Defra (2016), *National flood resilience review*, https://www.gov.uk/government/publications/national-flood-resilience-review

transgress traditional silos, disciplines and domains, bringing together decision-makers and practitioners in design, delivery, operation and maintenance with thought-leaders in research and new technological capabilities. The challenge is to engage stakeholders in the decision-making process continuously, routinely and transparently. Organisations themselves need to be resilient and have a culture of learning. Data sharing will ensure better management of interdependencies.

Incident management also requires greater cooperation between system operators. This is particularly vital where cascade failures affect operators, each with limited bounds of control. Understanding and communications between systems operators is limited, but there is potential to improve cross-system performance through more consistent operating standards and strengthened operating protocols. This could include better links between transport jurisdictions – for example, TfL and Highways England – between modes, and between infrastructure system types.

Confident projections and certainty in policy and funding: Effective resilience across the economic infrastructure sectors cannot occur without the right policy and funding/financing approaches. It is important to understand the adverse implications of a lack of policy and funding certainty on achieving resilient infrastructure.

Increased resilience comes at a cost and may not be financially viable without state support of one kind or another. There will be limits on the extent to which government and the public are likely to be willing to pay for resilience, and this needs to be traded off against the acceptability and cost of inevitable failures. Understanding the **economic and social value of resilience** will be important for justifying the case for investment. The benefits of redundancy and surplus capacity must be properly valued. For example, a cautious approach to resilience may lead to surplus capacity that is built but not used and will need to be justified.

Measuring and setting levels of resilience : Ways of undertaking measurement and benchmarking of resilience to improve its provision and quality in a strategic way require investigation. along with consideration of how those responsible for delivering or maintaining resilience should make use of benchmarks and set levels of resilience.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

The following section discusses the barriers and, for some of the barriers, suggests possible solutions:

A lack of systems integration monitoring: a key issue is how infrastructure systems are integrated or even how such opportunities are identified. Appointing a body or individuals responsible for systems integration across sectors might serve to improve resilience and plan for mitigation or solutions to issues as they occur, as well as exploiting opportunities. Potential problems could be overcome by:

- Providing a forum for communication between sectors, and building a business case to inform financial decision-making which might act against improving resilience if taken in isolation or on the basis of self-interest.

- Matching integrated users and owners with each other's funding streams or cost savings. For instance, introducing water efficiency methods may be more costly than increasing supply for a water company but the savings to wastewater from reduced treatment costs could be shared in order to overcome that cost.

Insufficient joining up of stakeholders, even within sectors: For example, resilience to flooding can be approached from many different angles and is governed by a wide range or responsible bodies and other stakeholders. Despite efforts by Defra and the Environment Agency, and its counterpart in other devolved administrations of the UK, there is a lack of a national framework for flood risk management with a common agreement on standards. This means that not all the measures to improve the resilience of communities are being exploited. In particular, the failure to implement *Designing for Exceedance*[10] means that opportunities to improve the resilience of communities to surface water flooding in urban areas is being missed. This is due to the lack of a joined-up approach between water companies, local lead flood authorities and local authority drainage departments. Current plans to implement Drainage and Waste Water Management Plans provide an opportunity to address this however.

A lack of frameworks for sharing data: Data sharing has been poor throughout the sector for a variety of reasons, including 'siloing' of the different infrastructure sectors, a lack of mechanisms and institutions to enable trusted sharing of data in a controlled way[11], commercial sensitivities, a lack of business model, an inadequate legal framework and the fragmented nature of the supply chain. Individual companies may even take different approaches to data management within different departments.

A lack of relevant data: Relevant data, for example, on faults, delays and disruptions is not being collected in a form which enables interpretation and statistical analysis of failures.

A lack of benchmarking for resilience and sharing of best practice: an organisation with an international perspective, such as the OECD or a similar organisation, could introduce resilience benchmarking for infrastructure.

Insufficient focus on resilience by regulators: Each national regulator could appoint a person to lead on infrastructure resilience and related interdependencies, accept a duty of resilience and work with other regulators in a more joined-up way. Resilience audits could be considered as part of the reporting requirements to fulfil licence obligations. The activities of regulators and the National Cyber Security Centre need to be more integrated.

Insufficient knowledge or understanding of resilience: The need for diverse redundancy may be overlooked or misunderstood.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The Environment Agency's recently published version of its ***Long Term Investment Scenarios***[12] includes analysis of the knock-on effects of flooding on infrastructure systems in England. This is an example of good practice.

The ***Defra Property Level Flood Resilience Roundtable***[13] has brought together professional bodies, the insurance sector, contractors, consultants, and representatives of flood risk management authorities. This is a good example of cross sector working and has enabled good progress to be made on improving the resilience of the existing

[10] Ciria, *Designing for exceedance in urban drainage - good practice (C635)*.

[11] Royal Academy of Engineering (2018), Towards trusted data sharing: guidance and case studies.

[12] Environment Agency (2019), Long-term investment scenarios (LTIS) 2019

[13] *DEFRA Property Level Flood Resilience Roundtable. See for example 2017 End-of-year 1 report*.

building stock to flooding. Demonstration projects have been successfully completed and new industry guidance is due for publication later this year. It is anticipated that this will play an important part in enabling affordable market-led flood insurance to be delivered for property after the end of Flood Re.

Emerging **data sharing initiatives** within energy, built environment and engineering sectors, such as those being led by the Digital Framework Task Group and the Energy Data Taskforce, are beginning to address the lack of data sharing frameworks[14,15,16].

The **Grafham Water Treatment Works resilience project**[17] aimed to mitigate the effect of a major outage to the Water Treatment Works. It involved significant reuse and adaptation of existing assets with resulting cost savings and required collaborative working between the project team and the operator, Anglian Water.

The **Resilience Shift Initiative**[18] is a global initiative that aims to catalyse implementation of resilience within and between critical infrastructure sectors, taking it from theory to practice. The initiative was discussed at a session at ICE's Global Engineering Congress[19] in October 2018.

[14] Centre for Digital Built Britain and the Digital Framework Task Group published the Gemini Principles in December 2018. Bolton A, Enzer M, Schooling J et al. (2018), *The Gemini Principles: Guiding values for the national digital twin and information management framework*.

[15] Energy Data Taskforce, https://www.gov.uk/government/groups/energy-data-taskforce

[16] Sharing engineering data for the public good, https://theodi.org/project/sharing-engineering-data-for-the-public-good/

[17] ICE (2019) Grafham Water Treatment Works resilience project

[18] Resilience Shift

[19] ICE (2018) GEC 2018: The Resilience Shift, Day Four

[name redacted] – please see below the WRE response to your consultation questions. Please let me know if you have any queries

Regards

[name redacted]
Water Resources East
[contact details redacted]

For more information about WRE and to see the latest developments visit the website here

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

- Dependencies between the power and water industries, taking account of deep uncertainty in future energy scenarios (FES) and the future balance between water supply and demand. This includes water demand for the public water supply, agriculture, manufacturing, power and environment sectors
- Dependencies between the water industry, the environment and irrigated agriculture
- How to increase resilience in the natural systems upon which the water industry depends for water supply and wastewater treatment (water recycling). In particular, any work in this area should attempt to address the issue of how hydro-ecological baselines will evolve under the influence of climate change and what the cost will be of "defending" pre-climate change conditions. The current natural environment programme (NEP) is a significant cost driver in water company business plans

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

- Techniques for multi-objective planning (see Q4 below) and adaptive planning
- Regulatory approaches for incorporating both in water company (and other) business plans. Given the work of the "National Planning Framework" and the funding that Ofwat has made available for the development of regional strategic solutions, it is important that a framework for applying these techniques is developed and tested quickly

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

- WRE experience shows that water resource planning expertise in sectors other than the water industry is sparse. Similarly, water sector knowledge of the resilience requirements of other sectors is equally poor. This lack of mutual appreciation is a significant barrier to cross-sector working. A tendency for "silo" working is the underlying issue. For the water industry,

this is driven by a model for economic regulation that is wholly focussed on water company customers

- The lack of funding in key non-public water supply sectors for work on water resource planning and resilience is also a significant barrier. To address this, it is recommended that the funding which has been made available for work on the regional strategic options is used to assess the requirements of all sectors with a dependency on reliable, affordable and sustainable water supplies
- Related to the above, there is a lack of appreciation of the efficiencies to be gained from effective cross-sector working, or of the threat of equivalent compounding risks. In the absence of this, there is little incentive to direct funding and other resources into this area. As a minimum, case studies showing the benefits and/or risk are needed

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

- The WRE is pioneering cross-sector water resource planning work on resilience. The multi-objective robust decision making (MO RDM) approach which is used by the WRE allows different sectors to work together to develop water resource management (and resilience) plans. While originally applied for long-term strategic planning, the MO-RDM approach is now being used at catchment level to promote a more local approach to these issues. This includes building resilience to flood and drought.

Question 1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Question 2: On the basis of [answer to question 1] what issues should be prioritised in the resilience study?

Our impression is that, to date, planning and investment in infrastructure and resilience is done at sector level with limited input from, and consideration given to, the other infrastructure sectors and their interdependencies.

The key questions on the resilience of each sector should therefore be designed to determine how resilient each sector is and how this can be quantified in terms of the services they deliver to people. Once this is done a more informed discussion about interdependencies can take place. So, in our view, priority one should be working out the resilience of each sector, priority two should then be to put these together to work out the interdependencies and risks.

Within the water sector, a lot of work has been done on contingency planning for the potential scenarios associated with leaving the European Union and have included, for example, dealing with transport disruption issues. This work builds on wider resilience planning within the water sector primarily to tackle weather related events interrupting services like, for example, the Beast from the East last year or severe droughts.

The assessment of risks, and the consideration of broader aspects of resilience within the water sector has largely been driven by the water industry regulators and government. In September 2017 Ofwat published 'Resilience in the Round', this document considered what resilience means to the water sector and outlined what it might look like in practice. The expectation has been that the water companies incorporate a 'systems' based approach to resilience in all their planning and, to do this successfully, the companies need to understand the constituent parts.

Water companies publish their draft water resource management plans, which set out their proposals for ensuring the resilience of their water supplies over the next 25 years or longer. These plans are subject to public consultation and extensive customer research. This approach to longer term planning is also being adopted for drainage and wastewater management in the future. While statutory responsibility for water resources planning is currently at the individual company level, Defra and the regulators are now directing the companies to work more collaboratively at a regional level and within a national planning framework which facilitates the exploration and delivery of more strategic infrastructure development in the future.

Water companies, as part of the five yearly Price Review process, also publish their draft business plans which provides an opportunity to set out their planned investments for the next five years. As part of this process the companies are again required to engage with their customers to understand their priorities and preferences. This includes their preferences and willingness to pay for different service levels, including expenditure to secure greater resilience to known challenges around climate change and population growth.

These planning processes provide a level of transparency and customer engagement that does not appear to be replicated elsewhere in other sectors at present. It is, however, still work in progress as the draft business plans submitted for the Price Review 2019 did not tend to set out the service levels or resilience in a particularly consumer relevant way and it therefore makes it difficult for someone to easily understand the company's current and

planned for levels of resilience. It is also worth noting that while long-term resilience planning is a statutory requirement for water resources management, the longer-term resilience of other aspects of company operations and systems are not currently as well understood or planned for.

From our perspective, a good understanding of resilience is essential for planning purposes and would seem to be the minimum necessary within each sector, before any cross-sectoral interdependencies can be explored. The primary questions should therefore be to understand to what extent each sector considers and plans to achieve resilience in the broadest terms, what level of resilience is determined as acceptable and how and, importantly, to what extent customers and stakeholders are involved and influence those planning decisions. Once this work has been done, then the logical next stage seems to be to ask how each sector's approach is mapped at the geographical/regional level and then nationally. This should expose any good practice or potential gaps in the overall planning process and control.

Regional planning has the benefit of being able to consider the specific regional characteristics and risks associated with maintaining infrastructure and associated services, and co-ordinating what action is needed to address these risks. It also helps to expose where inconsistent or incompatible service levels have been set in different sectors. For example, there is no point having water assets that are resilient to 1:200 year return periods if they are dependent on communication equipment that is only protected to a 1:10 level. Regional planning might also help with wider stakeholder engagement as this is often geographically structured, for example local authorities.

NIC should look to ensure that the approach across the country is consistent, appropriately integrated and efficient, and that any good practice is shared and spread. We would also suggest that NIC adopts an outcomes based approach which considers the resilience of services provided by assets, rather than the resilience of the assets themselves. Ideally, we would wish to see:

- Clarity of current resilience levels
- The involvement of consumers exploring acceptable current and future service standards
- These points feeding into further work to understand cross sector interdependencies.

National Infrastructure Commission's Resilience Study – National Grid Response to Scoping Consultation

Energy is vital to the UK economy: our society depends on it. From the warmth, light and technologies that we rely on at home, to powering commercial and manufacturing enterprises across the UK. Resilient, secure, reliable and affordable energy is essential. Over the next decade investment will need to be made in the UK energy sector to maintain resilience, and help transition towards a lower carbon energy system in an affordable and sustainable way.

National Grid is one of the UK's biggest infrastructure providers, owning and managing the energy networks that deliver gas and electricity to communities and businesses across the UK, as well as the interconnectors which connect the UK to diverse pool of energy across the English Channel. We recognised that there is an ever-growing interdependence between the different infrastructure sectors, with energy and communications playing a greater role in areas such as the future operation of transport, infrastructure networks and other essential services (emergency services, healthcare and food supply etc). The pace of technology change and sectorial decarbonisation, amongst other developments in society and the energy landscape, are enhancing the reliance on energy for society and businesses.

As the boundaries between sectors become increasingly blurred and cross-sector dependencies increase, ascertaining collective resilience for essential services and being able to ensure these relationships are both understood and accommodated for in our holistic understanding of UK resilience is key. In the future, cross–sector dependence is likely to increase, as technology continues to bring together infrastructure and services and to provide users with the benefit of integrated goods and services. However, in doing so, it will become increasing complex to establish the overall resilience of these goods and services (and the infrastructure which underpin them). Resilience will need to increasingly be assessed across sectors, and in a compatible and consistent way.

The National Infrastructure Commission (NIC) is uniquely positioned both in remit and scope of this study to address cross-sectorial challenges. Establishing a framework which is both; applicable across sectors and that has sufficient depth to be interpreted and applied to individual sectors by their experts, would be a positive step towards future (cross-sector) resilience assessment and assurance.

If future resilience approaches are to be advocated by business and society, then greater levels of information provision are required to end users (or their representatives) on these cross-sector dependencies to gauge their opinion on the appropriate resilience levels. This would provide a greater understanding of the networks, assets and services that make our national infrastructure resilient to sudden shocks and stresses that would otherwise impact our day-to-day lives.

We recognise that infrastructure resilience reaches beyond our assets and is underpinned by the expertise of our workforce and UK labour market. These factors should also be considered in the Study's exploration of infrastructure resilience.

We are very happy to support the NIC's development of case studies, e-pilots and analysis of infrastructure systems to correctly identify the necessary actions to improve future resilience. We would value an opportunity to meet and discuss the content of this submission, when appropriate.

nationalgrid

Consultation Question Responses

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Through consultation with industry on the future resilience of the electricity system, we believe the following questions are pertinent to the National Infrastructure Commission's Resilience Study;

- How do we ensure national infrastructure remains resilient in the future, when considering evolving economic, technological, environmental, social drivers, and emerging threats?
- How do we ensure the dependence of society and business on infrastructure is clearly understood and recognised? how can we address the falling timescales that disruption can be tolerated in the future, due to decarbonisation and technological advances expected?
- What is a realistic future timescale over which national infrastructure providers should plan for collective resilience assessment, action and assurance?
- How do we ensure cross-sector dependencies are well understood across; the sectors contributing to the delivery of dependent services? and the businesses and society using them?
- What considerations are required to allow resilience to be interpreted consistently across sectors, to ensure that resilience actions are compatible?
- What recommendations can the National Infrastructure Commission's Resilience study make on a guiding cross-sector framework/set of guiding principles for establishing future resilience assessment/measures?
    - How should this account for mitigative and restorative actions for identified disruptive events?
    - How can these measures be applied broadly across infrastructure sectors, yet remain applicable to individual sectors and businesses?
- How can a resilience framework adequately account for cross-sector dependencies, both for business' and society's needs today and those likely to manifest through future trends (e.g. technical, environment, social, economic drivers)?
- How could such a framework ensure that resilience of specific services, that span multiple sectors, is consistently assured, avoiding an overall drop in level of resilient service by 'weak links'?
- What cross-sector action is required by businesses, regulators, policy makers and government to exact such a framework?
- How will factors of commonality across sectors, such as the need for appropriate cyber security be accounted for? Will the next National Infrastructure Assessment (NIA) make recommendations to ensure cyber security is coordinated effectively?
- How will evolving infrastructure threats be accounted for? How will their evolution be flexibly accommodated in any resilience assessment, measures or framework established via this resilience study?
- With estimations that one-third of UK electricity is set to be produced by offshore wind farms by 2030, is there enough electricity interconnector capacity to cope with the growing intermittence of renewables and to dynamically balance the surplus/deficit of renewable energy (across Europe)?
- The UK's existing LNG infrastructure strengthens the resilience of the gas sector through by diversifying supply sources and by providing a flexible tool to respond to supply and demand changes. Is UK LNG going to be an attractive destination for LNG in an increasingly competitive global market without more robust government support? Do we have the right infrastructure in place to support anticipated levels of gas-fired generation? How do you ensure the right level of storage capacity during a stress event?
- Infrastructure companies are required to maintain a sufficient workforce to respond to any situation. This requires the right skills and competitive labour market to be available in the UK. How should the National Infrastructure Assessment (NIA) address this specific requirement about labour market and workforce resilience required to deliver the resilient infrastructure?

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

The on-going ability for our national infrastructure to support UK society and business, and to protect the UK economy in all circumstances should be a central consideration for this resilience study. A focus on the future resilience of our national infrastructure and the essential services it supports (emergency services, healthcare, food chain supply, movement of goods and energy services) would provide the most value from the National Infrastructure Commission's Resilience Study. This, combined with appropriate resilience assessments and measures that span all sectors, would help promote enduring resilience solutions.

We believe, the following should be priorities in the resilience study;

- Defining the scope of resilience (via a definition for resilience or otherwise) is important to the study. Ensuring that all sectors and businesses are thinking in similar terms is necessary, given that any principles, guidance or framework agreed for measuring resilience across sectors may require further interpretation by respective experts to establish what it means for their specific sector / business.
- The time bounds of the study's definition of 'the future' must be clearly defined.
- Critical interdependencies between industries and sectors need to be highlighted and understood as a precursor to establishing how this may evolve under future scenarios.
- Clear future pathways/scenarios of national infrastructure development should be established that consider the evolution of sectors within scope. This will help the study to ascertain how future resilience needs may differ from today, including (any changes in) the critical interdependencies between sectors that may influence this.
- Joint approaches to ensure resilience of systems that have acknowledged cross-sector dependencies must be established, fully supported by regulators and market authorities.
- Establishing future resilience measures and levels of service will help to consistently understand how resilient our collective future national infrastructure will need to be. We believe the National Infrastructure Commission are ideally placed to establish an overarching framework for this collective future resilience approach, which should be interpretable/applicable to individual sectors and/or businesses. Determining resilience levels by service rather than sectors should be considered, given increasing interdependency.
- In establishing future resilience measures, the UK's future business and societal needs, along with expectations of service from sectors within scope, should be considered. Focus is needed for continually evolving areas such as technology, where use of and dependence on infrastructure from multiple sectors to deliver is increasing. This requires engagement with (representatives of) society and business to achieve so they can advise resilience requirements from the services they want and need.
- Differing resilience requirements of geographically disparate elements of business and society should be considered (i.e. do cities that have a significant impact on gross domestic product has the same infrastructure resilience requirements as rural areas, and will this change as technology reliance increases?).
- The unintended consequences of the introduction of (internet) technology has the potential to impact multiple infrastructure providers independently or consequently. A key focus area should be to establish effective cyber security approaches to achieve resilient systems that span multiple sectors. Technology has a key role in our future and should be enabled through clear resilience focus in its implementation.
- Government and policy should consider resilience requirements, when legislating for all future technologies and infrastructure. This should extend (but not limited) to; smart infrastructure, critical services (emergency services, health, energy and water), defence, labour markets and workforce resilience.
- Resilience considerations should span beyond the physical infrastructure; a competitive labour market is required, and to support our workforce resilience, education, training and apprentices to deliver resilience.
- Technology developments that can enable society to continue in exceptional circumstances should be a consideration - prioritising essential services for society such as; warmth, shelter, food and drink, access to health care etc. For example, in a future cashless society, the ability to allow transactions to be cached locally at point of sale should communication fail might allow service to society to be maintained.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

The Energy Research Partnership and National Grid have undertaken some cross-sector mapping from the perspective of electricity system in their study of the 'Future Resilience of the UK Electricity System'[1], however this would need to be replicated by all sectors considered under the scope of any resilience study to understand the total number of interactions across the collective sectors, and their criticality. These will likely be different for each industry or sector considered, making assurance of cross-sector dependency challenging and a likely, but unintended barrier to addressing (future) resilience.

Below are some of the main areas we perceive to be barriers to establishing cross-sector resilience;

- No detailed assessment of infrastructure cross-sector dependencies exists today, nor any assessment of how these may change with future trends in respective infrastructure sectors.
- There is a lack of a consistent framework or guiding resilience principles and measures across sectors that allows for consistent comparison of resilience capability that would allow to identification of resilience best practice and improvement opportunities.
- Resilience in different sectors may not currently have common priorities i.e. safeguarding lives, welfare and the economy could be some high-level cross-sectorial goals.
- Greater alignment of regulators and market authorities is needed to account for interactions across industries, to provide the appropriate direction (and incentive) for cross - sector resilience collaboration.
- There is presently an absence of national forums to establish, manage and govern resilience pertaining to interactions across sectors.
- Legislative and policy direction is required to support decisions between industries.
- Establishing sustained and regular data communication channels between industries would allow the establishment of collective resilience, any identified risks (likelihood and consequence) from perceived resilience shortfall, and improvement actions.
- A Siloed approach to licencing, codes, standards, market requirements currently exists, which do not prioritise cross- sector interactions and consequences across industries.

[1] http://erpuk.org/project/future-resilience-of-the-uk-electricity-system/

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

National Grid are keen to collaborate across sectors to manage resilience challenges that are associated with; the resilience of our own sector, other sectors that our infrastructure resilience could impact, and the impact of other sectors on the resilience of the electricity and gas sector. Interdependence could drive individual sectors and businesses to make themselves resilient to this dependency – for example, communications businesses could establish their own sustained power supplies to avoid dependence on energy networks. However, overcoming these barriers in a cooperative way is possible through coordination, and could alleviate costs associated with independent sectors/ businesses developing their own independent solutions.

There is precedent within the energy sector for overcoming cross-sector barriers through genuine collaboration. Following significant flood events in the 2000's, National Grid and the Distribution Network Owners worked collaboratively via the Electricity Networks Association and with representation of the Environment Agency to develop targeted flood resilience levels. Through legislation and regulatory alignment, we have invested to protect sites with highest risk to floods, therefore protecting supplies for interdependent infrastructure and communities. In exacting this approach at individual sites, we further engage with the Environment Agency to align where possible our proposals with the overall flood resilience needs of the areas.

Proactive collaborative work to address present and future resilience of regional infrastructure exists today. National Grid collaborates through initiatives such as the Greater London Authority's London Resilience Forum, which is one component of the Mayor's Infrastructure High Level Group, focussing on addressing the London Plan from an infrastructure perspective. However, further coordination at a national level is required on the topic of infrastructure resilience planning.

There are many pieces of work currently being undertaken in the energy networks sector which would provide useful input to the broad discussion topic of infrastructure resilience. The Energy Research Partnership's 'Future Resilience of the UK Electricity System'[1] identifies several the challenges and focus areas outlined in this consultation response, whilst the CIGRE Power System Resilience Working Group will be continuing their work into resilience definition and measures in parallel with the National Infrastructure Commission's Resilience study. Existing work within the sector, within other sectors or across sectors, can provide useful reference points for this proposed study and ensure that collective efforts are maximised. Some examples of cross-sectorial resilience consideration already in the public domain that might be relevant to this study include the 100 resilient cities project[2] and the City Resilience Index[3].

[2] https://www.100resilientcities.org/
[3] https://www.arup.com/perspectives/city-resilience-index

Gatwick Airport response to the National Infrastructure Commission's Resilience Study

Introduction

1. Gatwick Airport is the UK's second largest airport. It serves more than 230 destinations in 74 countries for 46 million passengers a year on short and long-haul point-to-point services. Gatwick is also a major economic driver and generates around 85,000 jobs nationally, with 24,000 of these located on the airport. The airport is south of London with excellent public transport links, including the Gatwick Express and the recently upgraded Thameslink service, and is part of the Oyster contactless payment network.

2. Gatwick Airport welcomes the opportunity to respond to the National Infrastructure Commission's Resilience Study. Within our response we will focus on four key areas in relation to resilience at airports – runway slots, surface access, power and airspace. The fundamental issue linking these four resilience challenges is a lack of spare capacity across UK infrastructure, which undermines the country's ability to recover when things go wrong.

3. Gatwick Airport is supportive of an industry-led approach to resilience and we play an active role in the Industry Resilience Group (IRG). Resilience plays a major role within our future planning - of the key airfield projects at Gatwick Airport from 2018 to 2022, six have resilience as part of the reasoning why they are being taken forward. The total list of key projects is listed below:

	Projects	**Primary purpose**
Airfield	Runway resurfacing	Asset stewardship and resilience
	Boeing Hangar	Commercial revenue
	Lima taxiway extension	Resilience
	Rapid exit taxiway	Capacity and resilience
	Pier 6 extension	Service quality
	Push and hold stands	Resilience
	Additional remote stands	Resilience
	Flood mitigation	Asset stewardship and resilience
Terminal	Check-in and bag drop	Service quality
	CTA/domestic bag reclaim	Service quality
	Departure lounges	Service quality and commercial revenues
Operational efficiency & resilience	ATC technology and process improvements	Asset stewardship and resilience
Surface access	Rail station	Service quality
	Bus and coach facilities	Service quality
	Car rental	Resilience
	Road improvements	Service quality and resilience
	Car parking	Capacity

Source: "Gatwick Airport: Draft Masterplan 2018", Gatwick Airport, October 2018, p55

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

4. As pointed out above, the NIC should focus on increasing the UK's infrastructure capacity in order to improve resilience.

5. With regards to runway slots, particularly in the London network, the lack of spare capacity at airports across the system is a major obstacle to resilience. With most airports running at, or close to, their maximum capacity, there is little flex in their ability to quickly recover their own operations in face of disruption. Further, when facing more significant disruption, aircraft are often forced to divert to airports outside the London system and even as far away as mainland Europe, as there is no room to accommodate them at a London airport.

6. Therefore, Gatwick supports the government's policy that all airports should make the best use of existing runways to increase capacity and provide system-wide resilience. The NIC should, alongside the Department for Transport's Aviation Strategy, should focus on the mechanisms, policies and support required to help deliver additional capacity across UK aviation.

7. Gatwick is the world's most efficient single runway airport, with resilience provided by a standby runway which operates when the main runway is not operational for any reason, such as during maintenance. As part of our draft masterplan, we have consulted on bringing the standby runway into routine use alongside the main runway, to create potential for an additional 10 to 15 air traffic movements (ATMs) per hour. The standby runway would be used for departing aircraft only, but the system of runways should increase the airport's resilience. We are due to publish a final masterplan later this year.

8. Surface access to airports is a key area of focus in relation to resilience. Again, we would ask the NIC to consider whether the lack of spare capacity in the current main line railway network and the strategic road network undermines the UK's capability to accommodate expected growth in international passenger travel and freight movement without compromising resilience. Secondly, the NIC could assess how the unique role of airports as multi-modal interchange hubs, as highlighted in the government's Aviation Strategy, is reflected in road and rail investment and resilience strategies. Thirdly, how the government's transport strategies and policies are sufficiently integrated between air, maritime, road and rail to ensure that surface access to ports and airports is adequately prioritised.

9. Airspace should also be viewed as a key national asset. Gatwick Airport strongly supports the government's plans for modernisation of UK airspace. Improving airspace capacity and resilience, in particular in the airspace around London and the south east, are key enablers for future aviation growth, for reducing noise and for making the airspace more resilient. It is clear that government leadership is key to galvanising the cross-industry support necessary for airspace modernisation to succeed.

10. Most UK Infrastructure depends on a resilient power network, which again requires sufficient spare capacity to accommodate increased demand, particularly in face of greater electrification of vehicles. We would urge the NIC to consider the capacity and resilience of the UK's power networks as part of its work.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

11. As outlined above, we believe the resilience study should prioritise how the UK can best create spare capacity in runway slots, surface access, airspace and power networks in order to enhance resilience across the airports sector.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

12. The NIC should look at how spare capacity can be created across UK infrastructure, but particularly with regards to runway slots, surface access, airspace and power networks – all of which may require bold policy decisions and funding for new development. This is not just an airports issue, but the planning system should be set up to facilitate the increase of capacity across UK infrastructure required to enhance resilience. The government should also provide guidance and support to airports looking to grow, acknowledging their vital role as transport hubs.

13. Passengers and staff need to access airports 24 hours a day, 365 days of the year, in particular via rail and the strategic and major roads networks. On the road network, addressing peak period congestion and resilience in terms of incident management is a key priority. This should take account of the benefits of Highways England's Smart Motorway programme, and should be reflected in funding proposals that directly support surface access to ports and airports. Current funding commitments for rail only maintain the current aging assets to existing performance levels and do not adequately reduce the average age of key assets or improve resilience. This is essential to provide a reliable network.

14. Greater sharing of data regarding peaks in activity at ports and airports would help the rail industry and government better consider the benefits of a 24 hour railway. Increasing rail mode share for access to airports is closely linked to the availability of train services matched to an airport's hours of operation. Funding levels for ongoing railway maintenance and asset renewals are not sufficient to reduce the regular, planned closures for maintenance work that affect the availability of rail access to airports between 22:00 and 06:00. In the south east region, even with increased investment, renewals are not keeping up with the age of assets. Network Rail confirm that in the south east 14% of track is life expired and around half has less than 20 years life left, one fifth of high-voltage cabling is over 60 years old and two-thirds of signalling will be life expired within 15 years.

15. As demand for electricity increases, not least through a greater uptake in the use of electric vehicles, it is crucial to assess this in relation to resilience. As detailed in question 4 below, Gatwick has future-proofed its own power requirements, but only through the purchasing of capacity it does not currently need in order to ensure resilience is built-in. The NIC should consider if this is the most efficient way in which to provide resilience.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

16. In Gatwick's draft masterplan, we explored ways to further increase the capacity potential of Gatwick as well as improving its operational efficiency and resilience. One such scenario was to use the standby runway more routinely, thereby increasing capacity and easing reliance on the single main runway. This is in line with the

government policy of making best use of existing runways, and a final masterplan exploring three scenarios for growth will be published later this year.

17. Network Rail's focus on investment in the Brighton Main Line, including the approach to single, longer, planned blockades has wide reaching economic benefits and reduces the need for regular overnight closures that are detrimental to airport surface access. The use of new techniques such as the Mobile Maintenance Train, and use of bi-directional signalling means that maintenance takes less time and can be performed safely while a reduced service is operating alongside, without closing a line completely.

18. As part of the delivery of the M23 Smart Motorway Project, Gatwick Airport as a key stakeholder initiated a joint working group with Highways England, Network Rail and local highway authorities (Surrey and West Sussex) to co-ordinate the programme of traffic management around other, potentially conflicting work. Having Network Rail present avoided the main road and rail access to Gatwick being disrupted at the same time. Gatwick was also able to advise Highways England when the network may be particularly busy around the airport, so avoiding potential safety and congestion issues.

19. Gatwick Airport's Power Strategy ensures that sufficient power is available at the right time and in the right place to support the sustainable growth of the airport over the next 25 years, taking into account the changing dynamics of the electricity supply market. There is currently scarcity in electricity capacity, which will only worsen without adequate investment to take account of future demand. Until recently Gatwick had a site capacity of 29MVA (Mega Volt Amp), but in November 2018 this was increased to 40MVA and in April 2019 to 52MVA at site level. This ensures continued operation of the airport until at least 2028, including EV (electric vehicle) demand even under a high uptake scenario. This is based on benchmarking, capacity forecast model outputs, and independent forecasts of EV growth.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Climate Change and Systemic Collapse

Humanity faces a large number of challenges in future decades including increasing population leading to increased competition for dwindling resources and climate change. These challenges could lead to 'collapse of civilisation' i.e. the complex system of exchange of good and raw materials, energy, food and water would be susceptible to *shocks* or many even collapse altogether.

"Often, too, we have not fully assessed the indirect or systemic risks, such as those affecting international security – even though, as the UK's first national climate change risk assessment found, these could be far greater than the direct risks like coastal flooding. Assessing the threat of climate change today demands a more coordinated, more sophisticated, more holistic approach."

Rt Hon. Baroness Anelay of St Johns Minister of State, UK Foreign and Commonwealth Office[1]

Even without climate change the human race faces many problems in the coming decades. With climate change there are a growing number of people in academia and politics who consider these factors along with climate change could lead to the collapse of 'civilisation' by the end of the century:

"Humanity just won't be able to cope with the world we are heading for."

Prof Peter Stott, Met Office Hadley Centre[2]

Collapse of civilisation is a near certainty within decades

Paul Ehrlich, President of the Center for Conservation Biology at Stanford University[3]

If we don't take action, the collapse of our civilisations and the extinction of much of the natural world is on the horizon

David Attenborough[4]

It is time we consider the implications of it being too late to avert a global environmental catastrophe in the lifetimes of people alive today.

Professor Jem Bendell, Professor of Sustainability Leadership University of Cumbria[5]

Collapse will not be driven by a single, identifiable cause simultaneously acting in all countries, it will come through a self-reinforcing complex of issues

Dennis Meadows, Professor Emeritus Of Systems Policy at the University of New Hampshire[6]

In fact, one of the main lesson to be learned from the collapses of the Maya, Anasazi, Easter Islanders, and those other past societies [...] is that a society's steep decline may begin only a decade or two after the society reaches its peak numbers, wealth, and power. [...] The reason is simple: maximum population, wealth, resource consumption, and waste production mean maximum environmental impact, approaching the limit where impact outstrips resources

Jared Diamond, Collapse: How Societies Choose to Fail or Survive[7]

Unlike many apocalyptic prophesies that have arisen over the years these risks have valid scientific and socio-economic basis.

In a media landscape saturated with sensational Science stories and "End of the World" Hollywood productions, it may be hard to persuade the wide public that real catastrophes could arise as unexpectedly as the 2008 financial crisis, and have a far greater impact.

Martin Rees, UK Astronomer Royal[8]

The risk of a systemic collapse before the end of the century therefore has probability that cannot be ignored in current planning.

Although current planning takes into account direct affects of climate change under H++ scenarios the indirect risks due to cross-sectoral interdependencies are not taken into account.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Nuclear Power

The nuclear industry is unique in the danger it poses from systemic shocks or collapse. Without of power supply, fresh water and human expertise it creates the risk of reactor core meltdown and/or a spent fuel fire which could release massive amounts of radioactivity with catastrophic results.

It is reasonably foreseeable that a systemic shock occurs resulting in loss of essential services such as power and/or water supply could result in core meltdown and/or a fire in the spent fuel pond. Even if such a catastrophe is averted doing so will lead to diversion of scarce resources to maintaining a nuclear power plant that is no longer able to supply electricity. This would be even more problematic if the systemic shock results in systemic collapse.

A 1997 report for the NRC by Brookhaven National Laboratory found that a fire in a spent fuel pond containing the last core could render about 188 square miles uninhabitable, cause as many as 28,000 cancer fatalities, and cost $59 billion in damage (not including health costs) [9] even for a low release faction.

It should be noted that for the stage 1 and stage 2 consultations it was proposed that the spent fuel would be stored on site in a second cooling pond. The figures from the Brookhaven report for a full pool with a high release faction are 2790 square miles uninhabitable, 143,000 cancer fatalities and $566 billion in damage.

A study by the staff of the Nuclear Regulatory Commission (NRC) analysed a “loss of coolant” accident at the Peach Bottom nuclear plant in Pennsylvania. One scenario resulted in a fire of the spent fuel rods and the release of radioactivity that the study finds would lead to more than 17,000 cancer deaths, 9,400 square miles of evacuated territory (nearly twice the area of East Anglia) and more than 4 million people displaced long-term. (The first number uses the usual low-dose risk coefficient of 0.05 per person-Sv.)[10]

It is reasonably foreseeable that a systemic collapse occurs and the Geological Disposal Facility (GDF) is not completed or we do not have the resources/ability to move the spent fuel from Sizewell to the GDF. Dry stores of nuclear fuel have a limited lifetime.

A number of power plants, nuclear included, have experienced chloride stress corrosion cracking of austenitic stainless steel piping that has been exposed to a salt air atmosphere where concentration can occur after a period of 30 years or less. This is well short of the anticipated 100 year storage requirements that have now been placed on spent fuel storage casks.

US Department of Energy, 2011[11]

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

There is a problem if risks from specific infrastructure (e.g. Nuclear Power Plants) are ignored by the NIC. Although indirect risks should be taken into account in the safety assessment for nuclear power stations[12] this has not been done. The NIC should ensure that adequate analysis of risk resulting from cross-sectoral interdependencies are undertaken by specific projects.

No attempt has been made to quantify the risk of systemic shocks or collapse. This may be a difficult or even impossible task. However, if the risk cannot be adequately assessed it should not be ignored and steps should be taken to ensure the safety of nuclear power plants and spent nuclear fuel.

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[1]The Rt Hon. Baroness Anelay of St Johns Minister of State, UK Foreign and Commonwealth Office, Climate Change A Risk Assessment (http://www.csap.cam.ac.uk/media/uploads/files/1/climate-change--a-risk-assessment-v11.pdf)

[2]Climate change made UK heatwave 30 times more likely – Met Office , The Guardian, 6 December 2018 (https://www.theguardian.com/world/2018/dec/06/climate-change-made-uk-heatwave-30-times-more-likely-met-office)

[3]Paul Ehrlich: 'Collapse of civilisation is a near certainty within decades', The Guardian, 22 March 2018 (https://www.theguardian.com/cities/2018/mar/22/collapse-civilisation-near-certain-decades-population-bomb-paul-ehrlich)

[4]David Attenborough: collapse of civilisation is on the horizon, The Guardian, 3 December 2018 (https://www.theguardian.com/environment/2018/dec/03/david-attenborough-collapse-civilisation-on-horizon-un-climate-summit)

[5]Deep Adaptation: A Map for Navigating Climate Tragedy IFLAS Occasional Paper 2 (http://www.lifeworth.com/deepadaptation.pdf)

[6]Apocalypse Soon: Has Civilization Passed the Environmental Point of No Return? Dennis Meadows, professor emeritus of systems policy at the University of New Hampshire, Scientific American, 23 May 2014 (https://www.scientificamerican.com/article/apocalypse-soon-has-civilization-passed-the-environmental-point-of-no-return/)

[7]Jared Diamond, *Collapse: How Societies Choose to Fail or Survive*, Penguin Books, 2011, chapter "The world as a polder: what does it all mean to us today?"section "One-liner objections", page 509 (ISBN 978-0-241-95868-1).

[8]Denial of Catastrophic Risks, Martin Rees, Science 2013 (http://science.sciencemag.org/content/339/6124/1123.full)

[9]A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants, Brookhaven National Laboratory, 1997 (https://www.nrc.gov/docs/ML0822/ML082260098.pdf)

[10]Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor, US Nuclear Regulatory Commission, October 2013 (https://www.nrc.gov/docs/ML1325/ML13256A342.pdf)

[11]Life Prediction of Spent Fuel Storage Canister Material, US Department of Energy (https://neup.inl.gov/SiteAssets/FY%202011%20R%20and%20D%20Abstracts/12-3117_Ronald%20Ballinger.pdf)

[12]Safety Assessment Principles for Nuclear Facilities 2014 Edition, Office of Nuclear Regulation, 2014 (http://www.onr.org.uk/saps/saps2014.pdf)

Dear [name redacted]

On behalf of Lloyd's Register Foundation please see below our response to your current consultation. Sorry this is slightly late.

Our response is based on the findings of our *Foresight Review of Resilience Engineering* see: https://www.lrfoundation.org.uk/en/publications/resilience-engineering/

That review led to establishing the *Resilience Shift* see: https://www.resilienceshift.org/

Please do let us know if you would like to follow up on any aspects of our response.

Best wishes

[name redacted]

Director of Research, Lloyd's Register Foundation

[contact details redacted]

Lloyd's Register Foundation, 71 Fenchurch Street, London EC3M 4BS, UK

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Lloyd's Register Foundation response to NIC consultation questions

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

Which sectors of the UK infrastructure have the lowest resilience? Where should the UK (public and private sectors and international partners) prioritize short and long term effort to improve resilience.

With the term "infrastructure" we apply a broad definition: This includes built infrastructures (e.g. bridges, roads, railways, pipes and pumping stations); distributed supporting systems (e.g.telecoms, transportation and electricity); human resources to manage and keep systems in function; and distributed primary infrastructure systems such as health care and food and water supply which provide critical services.

Public preparedness for living through times where the infrastructure is not delivering services at a predetermined level needs to assessed. (Social unrest is a major risk element in this respect.). Measures required to compensate for any lack of preparedness should be identified.

The assessment should also examine the dependencies between publicly and privately held assets and services, and within and between critical infrastructure sector where cascading effects become important. Finally the assessment should examine the international nature and dependencies of the nation's infrastructure resilience. Shocks and stresses are easily propagated internationally and the UK cannot be resilient if its international networks and dependencies are not resilient.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Our *Foresight Review of Resilience Engineering* identified the priority areas to be resilience in the private sector and within and between the globally networked critical infrastructure sectors vital to maintaining life (food, water, power, healthcare, transportation).

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Our review identified four areas:

Governance: incentives, standards and rules, law and finance

Capacity building and engagement: professional development, publications, communication and public engagement

Data and supporting tools: shared datasets, modelling and simulation, decision support

International and global scale networks: studies of global systems, supply chains, knowledge networks.

These are the key focus of the *Resilience Shift* founded by LR Foundation in partnership with Arup.

In practice we see a need for sectors to meet and work closer together to achieve a better understanding of interdependency which may lead to improved capacity to function in times of shock and stress.

We also see a need for closer cooperation between the public sector and the private sector. Private asset owners, finance and insurance are sectors are important in this context although having different roles.

The cross sectorial interdependencies and the understanding of these are seen as one of the most critical elements to be worked on to improve on resilience.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

There are numerous lessons learned from case studies in many parts of the world. Hurricane Sandy and Fukishima are well documented and – as highlighted in our *Foresight Review* – it is important to understand what goes right in such circumstances as well as what goes wrong, to identify ways and means to improve and measure resilience. In particular the public preparedness for stressful situations. There is much to learn from examples in Japan, and other countries such as small island states and countries which have made steps to improve resilience such as New Zealand, Singapore and Switzerland. Some companies are more resilient than others and lessons can be learned from those in the private sector who have withstood shocks or who have built systems with the redundancies and flexibilities to maintain function during shock. For example, he Maersk cyber attack, whilst devastating for the company at the time, provided lessons in how to bring a company back into full operations in a relatively short time scale.

Common approaches and methodologies which eventually will be reflected in international standards is a key to assess and improve on resilience in a practical and efficient way. It is recommended that NIC build on and reflect the achievements made by global networks.

The *Resilience shift* would be very pleased to share its achievements and along with the NIC.

Airport Operators Association response to the National Infrastructure Commission's Resilience Study Scoping Consultation

Introduction

1. Founded in 1934, the Airport Operators Association (AOA) is the national voice of UK airports. We are a trade association representing the interests of UK airports, and the principal such body engaging with the UK Government and regulatory authorities on airport matters. The AOA's members include over 50 airports and 160 Associate Members, made up of companies representing a wide range of suppliers in the aviation industry.

2. The AOA is an active member of *Sustainable Aviation*, the UK coalition of airports, airlines, aerospace manufacturers, air navigation service providers and key business partners that sets out a collective and long-term strategy to ensure a sustainable future for UK aviation. The industry is committed to making a positive contribution to UK society and its economy, and meeting the need for air transport whilst minimising its environmental impacts.

3. The AOA is also an active member of the Infrastructure Operators Adaptation Forum, initially launched and funded by the Environment Agency and Defra.

4. Rather than specifically answering the four questions laid out in the scoping consultation, the AOA will, in this paper, briefly highlight some of the interdependencies, related to resilience, which are of the greatest concern to UK airports, and where the National Infrastructure Commission (NIC) may want to focus some attention. Each paragraph will begin by highlighting where existing Government effort is concentrated.

Interdependent Resilience Issues

5. For the AOA, there are three main strands of cross-sectoral, systemic and long-term issues which could benefit from further resource, policy development and understanding. The first of these would be focus around a changing Climate and the need for infrastructure to be coordinated in their adaptation to that ever-changing external environment. The second area of focus relates to existing interdependent resilient issues with physical infrastructure. The third strand relates to the quickening advance of technology which brings with it, its own challenges on new types of users of airspace, airspace modernisation and cybersecurity.

6. The Department for Environment, Food & Rural Affairs is responsible for the Climate Change Adaptation Reporting Power (ARP)[1], under the 2008 Climate Change Act. This power enables national infrastructure organisations to report to the Government how they are adapting their operations to mitigate and prevent disruption brought about as a result of Climate Change.

    a. All sectors and organisations report in their own ways, but they collectively use the Infrastructure Operators Adaptation Forum (IOAF) as a vehicle for sharing best practice and exchanging knowledge on adaptation. The Forum was previously subsidised by the Environment Agency and Defra: this funding has since been scaled back. The AOA believes that the facilitation of cross-sector discussion, reaching agreement on mutually beneficial research/practical projects, and keeping all sectors up-to-date with adaptation developments is a vital function. A function which will only grow in importance as the effects of Climate Change are felt more widely across our infrastructure. The IOAF needs to be adequately resourced. NIC involvement in the IOAF, as a steward and sponsor of the forum, could be a

[1] https://www.gov.uk/government/consultations/climate-change-adaptation-reporting-power-plans-for-the-third-round

method of ensuring the NIC's engagement and oversight of climate adaptation efforts, while also lending the group the resource and gravitas it needs to function more effectively.

7. The resilience of the UK airport system is inextricably linked to the fundamental issue of capacity. Mitigating the impact of an event is often challenging, given current capacity constraints, particularly in the South East of England. While the Department for Transport has an existing policy statement for airports to make best-use of existing capacity[2], this can only take the UK airport system so far. Further capacity will be necessary to provide optimum air transport network resilience in the coming decades; the National Infrastructure Commission could examine how that capacity would be best delivered.

8. While the Department for Transport has existing policy workstreams on all modes of transport, better surface access to airports in particular can help build resilience into the national transport system. However, how the railway network and strategic road network can offer adequate resilience for expected growth in international passenger travel and freight movement is crucial. This complementary resilience would ideally be addressed by a high-level of integration between the government's air, maritime, road and rail strategies. In absence of this, it is suggested that the NIC examine the resilience of airports in their role as transport interchange hubs, linking road, rail and air networks.

9. The Centre for the Protection of National Infrastructure (CPNI) is currently the lead Government agency developing standards for counter-drone technology. Unmanned aerial vehicles more broadly have great economic and social potential for the country. However, this benefit needs to be balanced with the risk of malevolent and inadvertent disruption utilising new technologies like drones. The Aviation sector has been quite publicly exposed to this risk at the end of 2018 and early 2019, but other infrastructure sectors are vulnerable to this.

    a. In developing climate adaptation plans and operational resilience plans more broadly, it is often difficult to tangibly include risks which have yet to mature or are not fully understood. There is policy space for the NIC to examine some of the resilience-related issues which are brought about by future innovations in unmanned aircraft: including the near-future prospect of urban air mobility, and the increasing use of cargo or delivery drones. Understanding how future innovations and changing transportation options will affect resilience issues would be useful for organisational planning. There is currently limited incentive for companies to invest in this sort of research unilaterally; the NIC could assist with furthering this understanding.

10. The Department for Transport (DfT) and the Civil Aviation Authority (CAA) are currently co-sponsors of the airspace modernisation process due to be completed during the 2020s[3]. The modernisation of the UK's airspace is long overdue and gives attention to a neglected part of the nation's critical national infrastructure, our invisible infrastructure in the skies. Airspace modernisation should enhance the resilience of the aviation sector in the UK, enabling increased flexibility and capacity for a range of contingency and business-usual operations.

    a. As with drones and other emerging air technologies in paragraph 9, there remains a challenge as to how future advancements will be integrated into the UK's airspace. Numerous organisations are progressing with the idea of an Unmanned Traffic Management (UTM) system which could manage the operation of drones and urban air mobility. The redundancy and resilience of such a system, how it relates to existing Air Traffic Management (ATM) and how both of these systems might account for further developments, such as spaceplanes, has not been fully explored. The NIC could examine these future interdependencies and how they might affect current operational and adaptation planning.

[2] https://www.gov.uk/government/publications/aviation-strategy-making-best-use-of-existing-runways

[3] https://www.caa.co.uk/Commercial-industry/Airspace/Airspace-Modernisation-Strategy/About-the-strategy/

11. The Civil Aviation Authority currently oversee an industry-led initiative entitled the Industry Resilience Group (IRG)[4]. As a result of the disruption at Gatwick and Heathrow over the holiday period in 2018, the IRG has begun the development of a Mass Diversion Protocol. The protocol would be triggered in an instance of serious disruption at a major UK airport, such as a drone sighting, extreme weather events or a cybersecurity situation with air traffic control. The protocol sees airports and airlines volunteer landing slots for diverted aircraft to use in an emergency event, bringing more coordination and resilience planning to a usually more ad-hoc process.

For further information, please contact AOA Policy & Public Affairs Officer Jeff Bevan on 020 7799 3171 or jeffbevan@aoa.org.uk

[4] https://www.caa.co.uk/Consumers/Guide-to-aviation/Improving-resilience-for-UK-airports-and-airspace/

Resilience Study Consultation - National Infrastructure Commission
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Email: resilience@nic.gov.uk

3 April 2019

Resilience study scoping consultation

EDF Energy is one of the UK's largest energy companies with activities throughout the energy chain. Our interests include nuclear, coal and gas-fired electricity generation, renewables, storage and energy supply to end users. We have over five million electricity and gas customer accounts in Great Britain, including residential and business users.

EDF Energy welcomes the opportunity to comment on the National Infrastructure Commission's (NIC) resilience study scoping consultation. Our comments address issues relevant to the electricity system, which faces the challenge of maintaining its resilience through the transformation to a truly low-carbon system. This transition is already in progress but has much further to go and the long-term focus of a National Infrastructure Assessment provides an opportunity to consider some aspects of this resilience challenge.

Many of the potential issues are already well understood and/or are the subject of detailed study within the electricity industry. In addition, there are existing forums to exchange information on climate change adaptation issues and seek common approaches to maintaining or improving resilience to identified consequences of the future changing climate.

We recognise that the NIC will not wish to duplicate existing work; however, we have identified two cross-sectoral areas where we believe that the NIC could potentially make a valuable contribution in its proposed study**.** These are impacts on the electricity system from decarbonisation of other sectors and industries and interdependencies between gas and electricity networks.

Our response to the NIC's specific questions is set out in the attachment and I confirm that this letter may be published on the National Infrastructure Commission's website. Should you wish to discuss any of the issues raised in our response or have any queries, please contact Natasha Ranatunga on 07875 112 981, or me.

Yours sincerely,

Guy Buckenham
Head of Generation Policy and Regulation

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Attachment

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

The electricity system faces the challenge of maintaining its resilience through the transformation to a truly low-carbon system. This transition is already in progress but has much further to go. There are many elements to it, including:

- A rapidly changing generation mix with greater reliance on intermittent sources of generation;
- Increased interconnection potentially leading to greater reliance on imports;
- A greater use of decentralised energy resources, often subject to more decentralised control, increasing the challenges of maintaining the stability of the system and leading to a more distributed approach to system operation, as evidenced by the potential development of Distribution System Operators;
- Changes in the way that electricity is consumed with an increasing focus on demand side participation in the market and new sources of demand such as electricity vehicles; and
- Climate change itself will have many impacts on the availability of generation and on patterns of demand.

In some cases, the potential impacts of these factors are already fairly well understood; in other cases, this is less so.

Existing control measures to ensure the resilience of the electricity system have served us well up to now. The next National Infrastructure Assessment should help to provide assurance that they will continue to do so throughout this transition.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Many of the issues identified in the answer to Question 1 are already well understood and/or are the subject of detailed study within the electricity industry. However, we see two key cross-sectoral issues where the NIC could potentially make a valuable contribution in its proposed study**.** These are the impacts on the electricity system from decarbonisation of other sectors and industries and the interdependencies between gas and electricity networks.

Decarbonisation of other sectors and industries

Electrification is expected to provide the means of decarbonising other sectors of the economy. Although the most significant examples are the increasing take up of electric vehicles to decarbonise transport and the use of heat pumps to decarbonise heating**,** other changes may also become important, such as the potential use of electrolysis to produce hydrogen. These changes could have big impacts not only on total electricity demand but also on the location and timing of demand, which in turn will have consequences for the requirements on both generation and networks. They may also necessitate changes in the way that the system is managed. There may also be other implications; for example, patterns of behaviour in vehicle charging may have impacts on road use.

Interdependencies between gas and electricity networks
There is likely to be a loss of diversity in electricity generation through the 2020s, with the UK becoming increasingly reliant on "real time" interconnector imports of both gas and electricity to manage events like last year's "Beast from the East" weather episode. This could result in a lower level of system resilience, compared to the past and current situation where we retain coal stockpiles in stations and nuclear fuel held in reactors, providing stores of firm power.

In addition, the supply of gas to gas-fired CCGT power stations creates an interdependence between the electricity and gas systems. Great Britain's CCGT fleet will become increasingly important for resilience as existing coal stations close; although the total volume of gas demand for generation is likely to fall, the peak gas demand on low wind days will not reduce in the same way and may well increase

The "Beast from the East" weather episode in February/March 2018 demonstrated the increased risk that in the event National Grid Gas had to call a Gas Deficit Emergency (command & control); then 'firm' users would be disconnected, with CCGT generation plant as the largest gas demand coming off the system first, which could lead to increased pressures on the electricity system. Both of these trends merit further review of the implications for resilience. We understand that BEIS is considering whether to undertake a study on these interactions, which we would welcome.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

We have not identified any specific barriers to addressing resilience emerging from cross-sectoral interdependencies.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

The energy industry continues to engage and co-operate on a voluntary basis in the development of system-wide arrangements to assess, mitigate and manage risks which, if not addressed, can impact on overall system resilience and ultimately impact on consumers of electricity and gas.

An example of this is generating companies working through Energy UK to exchange information on climate change adaptation issues and seek common approaches to maintaining or improving resilience to identified consequences of the future changing climate. The fora that these issues have been addressed within include the Infrastructure Operators' Adaptation Forum; the Energy

Emergency Executive Committee (E3C); the JEP Water Working Group; Defra's Abstraction Reform Advisory Group; and the National Water Resource Steering Group.

EDF Energy
April 2019

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National Infrastructure Commission
Finlaison House
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Monday, 1 April 2019

National Grid System Operator response - Resilience study scoping consultation

Dear Sir/Madam,

We welcome the opportunity to respond to the Resilience study scoping consultation from the National Infrastructure Commission.

Who we are:

As the operator of Great Britain's gas and electricity transmission networks, National Grid System Operator sits at the heart of the energy system. We make sure Great Britain's gas and electricity is transported safely and efficiently from where it is produced to where it is consumed. We ensure supply and demand are balanced in real time, and we facilitate the connection of assets to the transmission systems. We work with our customers and stakeholders to shape the future of the energy market, providing insights and analysis. We also facilitate changes to commercial frameworks to accommodate new technologies and ways of working, while considering how our own role should evolve over time.

On 1st April 2019, National Grid will set up a new, legally separate company to carry out our electricity system operator (ESO) function within National Grid Group. Facilitating holistic, whole system outcomes is one of our four key roles as an ESO moving forwards. As we tackle the key energy challenges ahead of us, we expect to see greater interactions between gas and electricity markets, along with the heat and transport sectors. Our privileged position as the GB gas and electricity system operator continues to be of significant value to industry, as we bring insight that cuts across both fuels. We have drawn on insight and data from both the GSO and ESO in this response, to give a deeper understanding of the technical and system challenges of decarbonising heating, whilst being technology neutral.

Executive Summary

- Decentralisation, Decarbonisation and Digitalisation will all help to create a different energy network to the one we use today. The paradigm change in how everyone will use this future network will potentially require significant alterations to how we as the System Operator operate to ensure the future resilience of Great Britain's energy networks.
- As we set out in our annual Future Energy Scenarios reports, there are several potential energy futures for the UK, particularly when we look out towards the 2050s. Our concern for future resiliency planning is if this process takes a preferential view of different emerging technologies and the associated requirements energy networks will have in future, which will potentially exclude alternative options that could provide greater consumer benefits.
- At present, there are several potential energy futures for the UK which will all present different opportunities at all levels of energy use. The interplay between the GB's existing gas and electricity networks, which will be impacted in different ways by the decarbonisation of heat and transport, mean that we must consider future resilience and changes to the energy network at all levels, from a Whole System Thinking perspective, so that we do not ignore the interdependencies in fuels and between sector actors that will underpin our energy future.

Our Response

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

A central question to the future resilience of the UK's energy network will be the impact of the three D's: Decarbonisation, Decentralization and Digitalisation. As the System Operator, we have already begun to examine how these issues interact with regards to resilience as seen in our 2018 Innovation Strategy report[1].

As the System Operator, we support the development of all three strands, however all pose considerable questions for future resilience, that interact across heating, transport, energy, data protection etc. These issues will become apparent not only at the national network level, but will also impact upon distribution networks and, as devices become smarter and household relationships with the network become more reciprocal, these issues will also become apparent in the home.

The interdependencies across these various factors are also impacted by the various energy futures that currently face the UK. As set out in our annual Future Energy Scenarios, (which set out four of several potential scenarios) the role of Government policy will increasingly impact on the energy future we find ourselves in by the 2050s[2]. Future resiliency therefore needs to be integral to our future energy planning, regardless of the energy policy direction and decisions of the current and future governments.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Whole System Thinking

As National Grid System Operator, we believe that whole system thinking is needed to fully understand the UK's future energy needs and therefore the future impact on resiliency. Given the potential energy futures still open to the UK, we strongly encourage that any question of resiliency in the energy sector not consider the issue in a vacuum, given the interaction between a number of sector actors at both the national and distributed networks level.

On electricity, the Electricity System Operator has begun to analyse these issues more clearly in our Facilitating Whole Electricity System Outcomes report[3].

Network interdependencies

Beyond the need to think about the interaction between various sector actors and the interdependence of National and Distribution Networks, there are also considerations to be made relating to the interdependence of GB's gas and electricity networks. For instance, the decarbonisation of heating will have a significant impact on demand for GB's gas network, at a similar time that electricity generation is expected to grow from renewables, potentially requiring a more significant role for gas fired power stations to maintain security of supply.

Decarbonisation of transport will also have a significant impact on our future resiliency planning, depending on the extent to which hydrogen is adopted as the preferred fuel for commercial and domestic vehicles, as this will require the GB gas network to change composition and flexibility.

Cyber Security & Data Protection

As we increasingly decentralise and digitalise the energy networks in this country we will begin to create a smarter, more flexible grid, capable of allowing consumers to both recipients and generators of energy simultaneously. As this process continues however we will see increasing risks in the energy network regarding cyber security and data protection, as we will see the transfer of far more data, particularly at the DNO level of information relating to the individual's use of smart devices in the home. The addition of so many devices into the energy network could also require greater enforcement of cyber security standards, to ensure that potential threats to the grid are limited.

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[1] Page 5, 2018 Innovation Strategy - National Grid System Operator
[2] Page 24, 2018 Future Energy Scenarios report - National Grid System Operator
[3] Facilitating Whole Electricity System Outcomes - National Grid Electricity System Operator

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

As we move into the 2030's and further we will begin to see significant changes to the energy networks as we embrace Decarbonisation, Decentralization and Digitalisation. Continued resiliency will be significantly impacted by existing knowledge barriers, particularly which policy decisions will be taken by government and the increased importance of data to maintain balance in supply and demand across both gas and electricity. Looking out to the 2050s these barriers will become less tangible, as our annual Future Energy Scenarios report[4] highlights, through its four scenarios, increasing uncertainties in how energy consumption will change in future, will require different innovations and technologies to ensure future resiliency.

Decarbonisation of Heat

Whilst the decarbonisation of energy has been an early success in moving towards the Government's 2050 climate change targets, the pathways for the decarbonisation of heat and transport remain less clear, particularly beyond the 2030s. For instance, as highlighted by our Future Energy Scenarios (FES) 2018 document[5], and related System Operator publications which have looked at realistic and achievable heat decarbonisation pathways, they will all have interactions with choices made in sectors of the economy other than heat. For example, both hydrogen and biomass could be used to decarbonise industry and transport, and the pace of transport electrification will influence available network and generation capacity for electric heating. Similarly, the use of energy vectors like hydrogen could enable flexibility actions across fuels. Consequently, a whole energy system approach, that considers cross sector and cross fuel impacts, is crucial to ensuring infrastructure changes are planned efficiently and corresponding resiliency requirements are addressed as needed. As a result, Government decisions on the future of gas and heating policy will have significant impact both on the future pathways for heat decarbonisation, but also on the future resiliency requirements for both the Electricity and Gas networks.

Decarbonisation of Transport

Similar to the issues facing the future of heat, the decarbonisation of transport will fundamentally change how we ensure resiliency in future, as the policy and technology direction of change will require significantly different responses from an operational standpoint to ensure resiliency. As set out in our 2018 FES report[6] there are a number of future scenarios for transport, given the current development of both electricity and hydrogen technologies for the purposes of decarbonisation. Both solutions will require different solutions from the network, as electricity will require greater flexibility and smarter use of generation in order to match charging behaviour from consumers, whilst hydrogen powered vehicles will require a greater decarbonisation of the current gas network to meet demand. How we meet future resiliency needs will fundamentally depend on which of these technologies becomes the predominant solution for commercial, public and household transport, or as is likely to be the case, the extent to which these solutions are adopted simultaneously.

Future of Data

With the ever-increasing decentralisation and digitalisation of the UK's electricity networks, the role of data and the reliable sharing of information between generators, network operators and consumers will become increasingly complex as we move towards a de-lineated model for consumption and generation[7]. Changes to Data flows will have a significant effect on consumers, as it will significantly alter their ability to engage in energy markets and trading. From an operational standpoint data will also play a significant role as the sharing of data and protection of personal information will both play a critical part in the successful operation of the system, by providing us with a much clearer picture of where and when supply will need to match demand across the country.

[4] National Grid System Operator, 2018 Future Energy Scenarios report
[5] Page 39, 2018 Future Energy Scenarios report - National Grid System Operator
[6] Page 83, 2018 Future Energy Scenarios report - National Grid System Operator
[7] Page 39, 2018 Future Energy Scenarios report - National Grid System Operator

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

As Great Britain's System Operator (SO), we're at the heart of our nation's energy system, which gives us early visibility of the increasing changes to the grid. We therefore have the responsibility as well as the opportunity of addressing those challenges in the best way for our customers and consumers. Through innovation, we're finding new ways to improve how our electricity and gas systems are operated, both now and in the future.

Our innovation portfolio features a novel range of projects funded by Ofgem, through the Network Innovation Allowance (NIA)[8] and the Network Innovation Competition (NIC)[9]. This funding gives our business, and the people who work with us, the freedom to develop ideas in a way that wouldn't be possible in normal business operations. Below we have set out a number of examples:

Embedded Generation

One of the most significant advances in the use of renewable energy sources in this country over the last two decades has been the introduction of small scale renewables, in the form of small wind turbines and rooftop solar panels. These small generators have not only increased the low carbon generation capacity available to deal with the UK's energy needs but have also allowed local communities to play a more active role in the energy that powers them.

Whilst this advancement should continue to be championed, it has required us to change the way we operate the network to ensure continued resiliency, given the different generation profile of renewables to traditional forms of generation based on environmental factors. To help improve our understanding of how and when these low carbon forms of generation will appear on both the national and distribution level networks we have worked closely with the Met Office, Reading University and the Alan Turing Institute to establish forecasting models, which will allow us to better track the availability and efficiency of these low carbon sources in greater detail.

Vector Shift & RoCoF

With the increase of renewable generation, we have seen issues with the adoption of mains protection systems, leading to an uneven adoption of mechanisms like Rate of Change of Frequency and vector shift, potentially undermining the stability of the grid.

In response to this National Grid ESO, alongside Ofgem and the Distribution Network Operators, have worked closely to resolve these resiliency issues[10], through an accelerated vector shift change programme, to update existing protection mechanisms and ensure consistency across all levels of generation, regardless of size.

We would welcome the opportunity to further discuss with the National Infrastructure Commission how we can further support the Resilience study. For further information or discussion please contact Michael McLaughlin in the first instance at michael.mclaughlin3@nationalgrid.com

Yours sincerely

Duncan Burt
Director of Operations, National Grid System Operator

[8] Network Innovation Allowance
[9] Network Innovation Competition
[10] Page 38, 2019 Summer Outlook - National Grid System Operator

HR Wallingford
Working with water

English flood & coastal erosion risk management: resilience mix priorities for infrastructure

[name redacted]

4th April 2019

Westminster Energy, Environment & Transport Forum Seminar

Infrastructure resilience mix priorities for Flood & Coastal Erosion Risk Management

Everydayness

1. Multiple priorities
2. Community 'voice'
3. 'Green' works well here

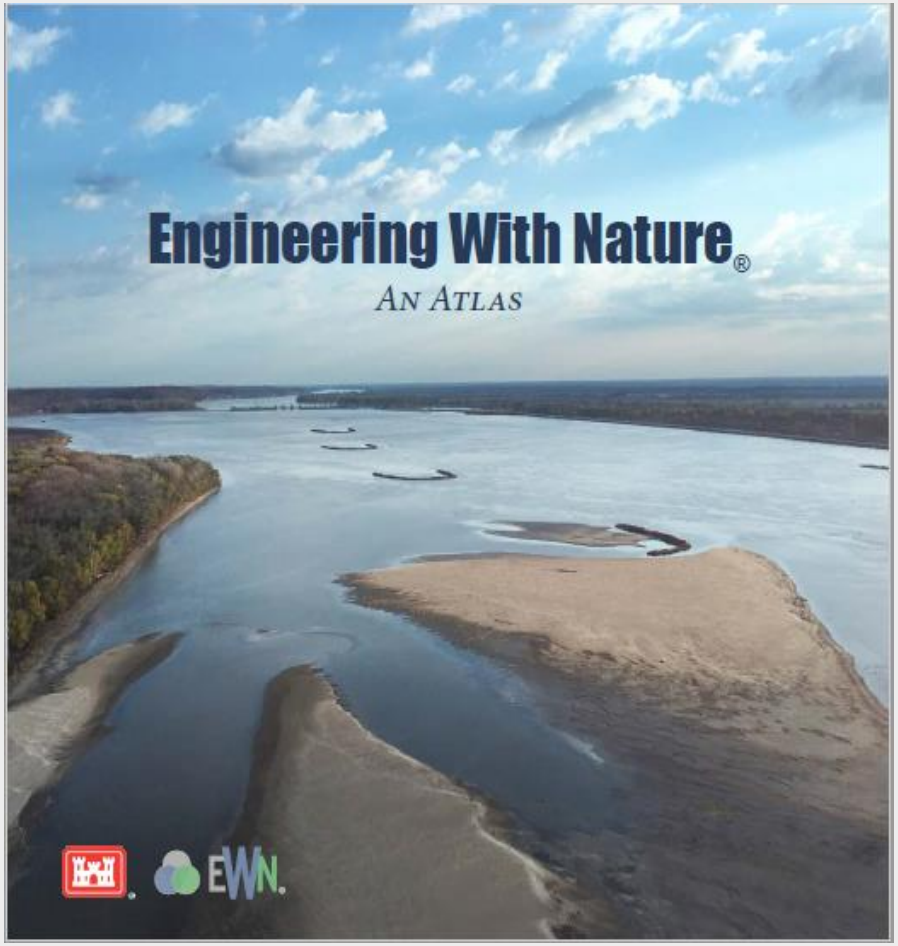
Surviveability

1. Must deliver risk reduction
2. Design for 'bigger
3. Often needs 'grey'

Recoverability

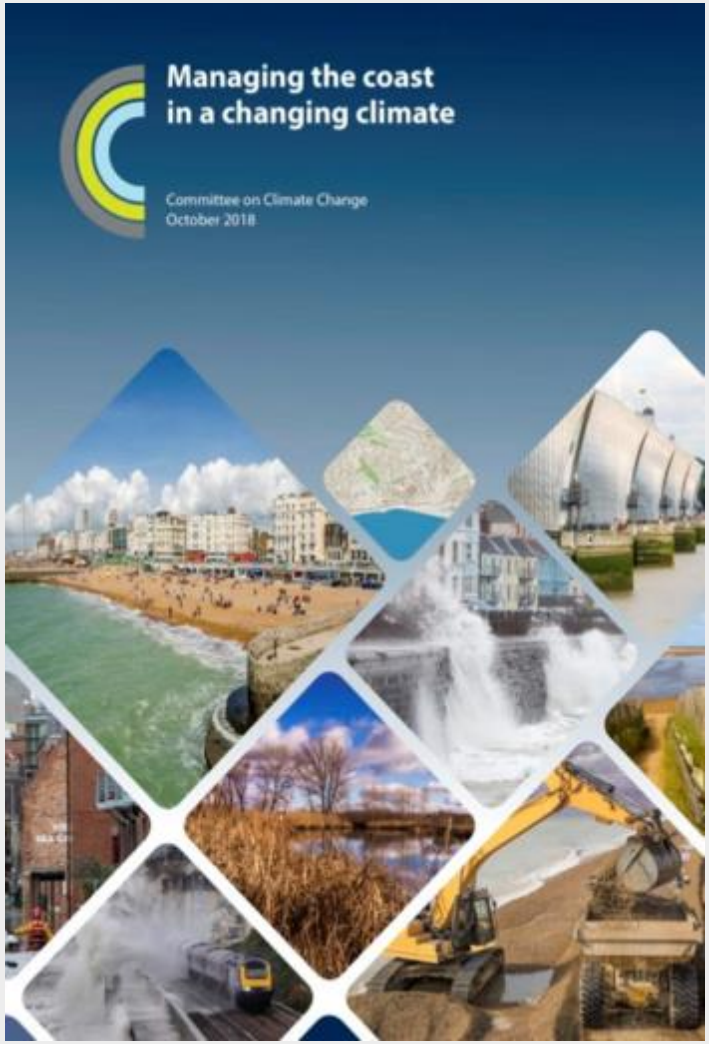
1. Speed of recovery
2. Replacing vs. adapting to change
3. Transformation opportunities

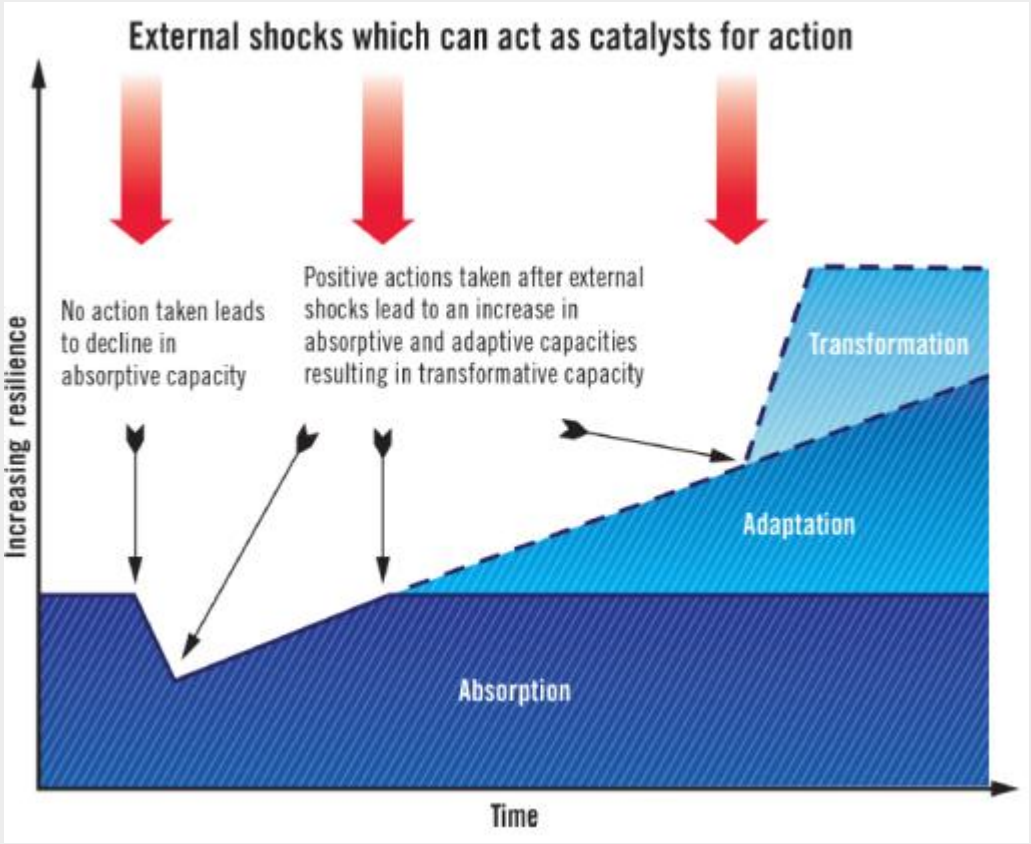
Everydayness



Surviveability

Recoverability: Thinking about adaptation & transformation





Lumbroso et al (2017) Enhancing resilience to coastal flooding from severe storms in the USA: international lessons. Nat. Hazards Earth Syst. Sci., **17**, 1357–1373.

Conclusions

1. Move away from obsession with a single “design event” to multiple design points, including design for exceedance
2. Recognise the multi-objective potential for infrastructure in communities
3. Find ways of adopting robust but adaptive solutions including nature-based elements

UNISDR (2017) Build Back Better – implementing Priority 4b of the Sendai Framework for Disaster Risk Reduction 2015 - 2030

HR Wallingford
Working with water

English flood & coastal erosion risk management: resilience mix priorities for infrastructure

[name and contact details redacted]

4th April 2019

Westminster Energy, Environment & Transport Forum Seminar

EnvC WGREAD 14/19

Response to the National Infrastructure Commission's Resilience Study Scoping Consultation

5 April 2019

About Energy UK

Energy UK is the trade association for the GB energy industry with a membership of over 100 suppliers, generators, and stakeholders with a business interest in the production and supply of electricity and gas for domestic and business consumers. Our membership covers over 90% of both UK power generation and the energy supply market for UK homes. We represent the diverse nature of the UK's energy industry – from established FTSE 100 companies right through to new, growing suppliers and generators, which now make up over half of our membership.

Our members turn renewable energy sources as well as nuclear, gas and coal into electricity for over 27 million homes and every business in Britain. Over 730,000 people in every corner of the country rely on the sector for their jobs, with many of our members providing long-term employment as well as quality apprenticeships and training for those starting their careers. The energy industry invests £12bn annually, delivers £88bn in economic activity through its supply chain and interaction with other sectors, and pays £6bn in tax to HM Treasury.

Energy UK welcomes the opportunity to respond to the National Infrastructure Commission's (NIC) proposed Resilience Study Scoping Consultation. Currently, a level of resilience in the UK electricity generation industry is ensured by the combination of a generating plant capacity margin, geographical diversity of generating plant (together with a national transmission network) and diversity in generation technology. Because of this, the electricity supply system is robust against individual plant failure and, in the last decades, electricity generation has demonstrated a consistently high level of resilience to potential disruptions from extreme events. Provided that these key factors are maintained over the next 20 years, this intrinsic 'robustness' is not expected to change.

Our response largely focuses on the historic and future water requirements of thermal power generation plant for cooling purposes, which even as we decarbonise our energy supply, and in particular electricity generation, will continue to play an important part of the generation technology mix for the foreseeable future. This plant will not only be providing a back-up role during times of system stress, but the gas-fired electricity generation will also continue long-term to provide an essential role in meeting our energy needs, especially at times of low renewable energy output.

Response to consultation questions.

Q1: What are the key questions that the next National Infrastructure Assessment should answer about resilience?

The power industry's dependence on, and interconnectedness with, other components of national and local infrastructure is a source of risk. Access to water for cooling is one of the key traditional drivers for thermal power station location[1] but others, such as fuel routeing (i.e. the supply of gas to gas-fired power stations), transmission or distribution network capacity and geographic distribution of demand, may also present different potential vulnerabilities and therefore either allow or prevent particular resilience measures.

[1] The use of water for cooling by thermal power plant leads to improved thermal efficiency compared with alternative cooling methods such as air cooling. A reliable water supply is therefore vital to ensure freshwater cooled plant can deliver their full market potential for energy production, meet the conditions of Capacity Market contracts or provide flexible grid balancing capacity.

A key goal of the power industry is to ensure that the supply of electricity to consumers, including industry and other sectors, remains robust in a potential future (under climate change) where river flows are impacted more significantly by prolonged periods of low flows and or drought meaning that water quality and availability is consequently reduced.

It is also key not to overlook the importance of the distribution network, which needs to be robust in order to ensure supply to consumers, even when the sector is resilient to potential power generation under-supply to the grid. A greater use of decentralised energy resources, often subject to more decentralised control, increases the challenge of maintaining the stability of the system and leading to a more distributed approach to system operation, as evidenced by the potential development of Distribution System Operators.

At the same time, the electricity system faces the overarching challenge of maintaining resilience throughout the transformation to a truly low-carbon UK economy. The impact on the electricity system of such a transformation manifests in two ways: firstly, maintaining security of supply under a rapidly changing generation mix with greater reliance on intermittent sources of generation, and; secondly the increased demand on generation and networks from the decarbonisation of other sectors and industries.

Q2: On the basis of your response to question 1, what issues should be prioritised in the resilience study?

Energy UK considers there to be three key cross-sectoral issues where the NIC could potentially make a valuable contribution in its proposed study: access to water; the impacts on the electricity system from decarbonisation of other sectors and industries, and; the interdependencies between gas and electricity networks.

Access to water

As indicated above, access to reliable water supply (in terms of both quality and quantity) is key to ensuring the future resilience of the thermal, and therefore, the whole energy generation sector. Accordingly, as Defra progresses measures to address issues associated with the current water abstraction arrangements set out in the England and Wales Abstraction Plan launched in December 2017, and in particular the move to a catchment-based approach, it is vital to understand and recognise the sector's dependence in this respect; past investment decisions that have been made in water-dependent infrastructure assets (including associated developments such as transport and energy networks); as well as potential future investments.

Forecasts for the freshwater needs of electricity generation in the future are variable. They show that in the long-term demand could increase or decrease depending on the future electricity generation technology mix, the uptake of Carbon Capture Use and Storage (CCUS), the future location of new generation plants and the cooling technology used[2]. The power generating sector has engaged in the development of policy measures that may affect the availability of water to the thermal power plant in areas where there is, or is projected to be, water scarcity and/or drought (See answer to Q4).

Decarbonisation of other sectors

Electrification is expected to provide the means of decarbonising other sectors of the economy. Although the most significant examples are the increasing take up of electric vehicles to decarbonise transport and the use of heat pumps to decarbonise heating, other changes may also become important, such as the potential use of electrolysis to produce hydrogen. These changes could have big impacts not only on total electricity demand but also on the location and timing of demand, which in turn will have consequences for the requirements on both generation and networks. They may also necessitate changes in the way that the system is managed and result in other implications; for example, patterns of behaviour in vehicle charging may have impacts on road use.

[2] Environment Agency water supply and resilience and infrastructure Environment Agency advice to Defra

Interdependencies between gas and electricity networks
The supply of gas to gas-fired CCGT power stations creates an interdependence between the electricity and gas systems. Great Britain's CCGT fleet will become increasingly important for resilience as existing coal stations close; although the total volume of gas demand for generation is likely to fall, the peak gas demand on low wind days will not reduce in the same way and may well increase.

The "Beast from the East" weather episode in February/March 2018 demonstrated the increased risk that in the event National Grid Gas had to call a Gas Deficit Emergency (command & control); then 'firm' users would be disconnected, with CCGT generation plant as the largest gas demand coming off the system first, which could lead to increased pressures on the electricity system. Both of these trends merit further review of the implications for resilience. We understand that BEIS is considering whether to undertake a study on these interactions, which we would welcome.

Q3: Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?
In a strongly competitive market, as is the case for the UK electricity market, resilience measures that are beneficial (from a cost-benefit perspective) are expected to be commercially rewarded and their implementation can therefore be expected to be market-driven, both over the lifespan of an existing fleet, as well as for new plants (with resilience measures preferably occurring at the plant design, planning/ consenting and permitting stage). As with any other investment decisions, electricity generating companies derive the optimal timing for the implementation of beneficial resilience and adaptation measures by evaluating their net present value over different timeframes.

A barrier to the timely implementation of actions to increase resilience might however arise from the high uncertainty intrinsic to the future developments in the energy markets, as well as in the anticipated changes to key weather parameters driven by climate change. The evolution of the electricity market over the next decades is particularly uncertain with National Grid's Future Energy Scenarios (covering GB) only providing possible scenarios, rather than accurate forecasts of the future generation mix.

One of the greatest risks to the current operation and development of future plant at existing and new power station locations is due to water abstraction reform/resilience planning initiatives. These have been identified by our members as: reduced ability of power generating plant to deliver their full market potential for energy production, meet Capacity Market contracts or provide flexible electricity grid balancing capacity; and reduced capability and value of existing and historic generation sites for future development.

Notwithstanding the above, in England and Wales, after a review of the principles of water rights allocation, the UK Government decided to move from a "top down" approach to water abstraction reform using new primary legislation, to a catchment-based "bottom up" approach (as set out in the England and Wales Abstraction Plan launched in December 2017). Under this initiative, the influence of catchment partnerships potentially dominated by water companies (with public water supply statutory obligations) and focussing on local scale issues is a particular concern which could lead to less strategic governance of abstraction reform. Changes to water availability for thermal power plant due to the consequences of such regulatory developments are much harder to predict than the consequences of weather variability and (imperfectly understood) climate change. Regulatory uncertainty of this kind could pose a barrier to the implementation of appropriate adaptive measures.

Individual generating companies may have resilience, continuity or contingency plans to mitigate the effects, but to a certain extent, resilience for generation is dependent on other sectors and the regulators. A further barrier to implementing resilience measures lies therefore in the uncertainties about interdependencies with other stakeholders and their adaptation plans. Risks to generators from climate change, cannot be viewed in isolation from risks to other parts of national and local infrastructure (power transmission and distribution networks, water infrastructure, transport infrastructure, etc) as many of these risks are regulatory and indirect.

Regulatory and policy uncertainty are also barriers to the resilience of the wider electricity system. The sector is characterised by relatively large investments with long pay-back times, which means that stability and clarity in regulatory requirements are important to avoid damaging investor confidence and consequently deterring investments from taking place. Furthermore, regulatory frameworks need to be set on a reasonable and effective basis so as to incentivise the development and maintenance of a cost-effective, decarbonised and secure generation fleet.

To give an example, the Planning System has been known to present potential barriers to the development of certain projects which might otherwise increase the overall resilience of the electricity system. In response to a recent consultation[3], Energy UK called for BEIS to consider raising the threshold level for electricity storage projects within the Nationally Significant Infrastructure Project (NSIP) regime to ensure the planning and decision-making process is proportionate to the potential impacts of each project. This ask was made in relation to storage projects using electro-chemical technologies such as lithium-ion batteries. The retention of such electricity storage projects over 50MW within the NSIP regime may ultimately deter investment given the prohibitive fee structure for this size and scale of project and the increased time and resources required to progress via this consenting mechanism; adversely impacting build out of electricity storage in the GB market and, ultimately, energy security.

Even more pressing, the Capacity Market annulment continues to have an unprecedented impact on energy market participants and has created an unstable and uncertain policy environment. As highlighted in earlier questions, in an increasingly decarbonised electricity system with greater reliance on intermittent sources of generation, it is vital to protect the resilience of the system by procuring capacity among a wide range of technologies to ensure the security of supply. With Capacity Providers facing ongoing financial pressures due to the absence of capacity payments, Energy UK has called for Government to continue to address this as a priority, so as to avoid failure to deliver capacity and ensure the security of supply.

Both examples highlight how a lack of forward-thinking or clarity on policy decisions can result in the deferral or cancellation of new generation and of investment in improvements to existing generation. Consequently, the most effective policy action to secure the resilience of the electricity system is for Government to provide the earliest possible clarity on any future requirements for generation plants and confidence in the stability of confirmed policy decisions (for example, by setting out a timetable for any future reviews on progress and additional measures that provides adequate notice to operators and investors).

The generation sector is also dependent on the UK Government and the relevant economic and environmental Regulators for the delivery of the 'state-of-the-art' climate projection data to be used to inform impact assessments. If the data is missing, or available data is deemed expired, then there can be a barrier to the identification of a sufficiently robust mitigation strategy for that risk. For instance, there is currently a lack of data on future river flow data compatible with future water management strategies and climate change against which to test individual power station cooling water requirements.

Q4: Are there any examples in which barriers to resilience issues, arising from sectoral interdependencies or other causes, have been addressed or overcome?

Adaptive capacity in the UK electricity generation industry is ensured currently by the combination of a generating plant capacity margin, geographical diversity of generating plant (together with a national transmission network) and diversity in generation technology. Because of this, the electricity supply system is robust against individual plant failure and, in the last decades, electricity generation has demonstrated a consistently high level of resilience to potential disruptions from extreme events.

[3] Energy UK Response to BEIS consultation on electricity storage planning proposals - 25 March 2019. Available here: https://www.energy-uk.org.uk/publication.html?task=file.download&id=7091

Provided that these key factors are maintained over the next 20 years, this intrinsic 'robustness' is not expected to change.

Back in 2017, for example, the Environment Agency led on a national review of the resilience of electricity generation to drought and drought-related conditions. Undertaken through collaboration with Defra, BEIS, National Grid, Energy UK and electricity generators, the review assessed freshwater-cooled power stations in England and Wales and the impacts of drought and low flows in rivers on individual power station output. The study concluded that the risks to electricity supplies caused by foreseeable droughts are low at the present time, due to the severe and extreme drought scenarios falling within the range of operational risks that the System Operator typically plans for; it is therefore highly likely there should be sufficient generation available to meet electricity demand for the majority of the time.

Energy UK and its generating companies participate in a number of fora which seek to exchange information on issues around interdependencies and which seek common approaches to maintaining or improving resilience to identified consequences of the future changing climate.

For example, Energy UK represents the power industry at the Infrastructure Operators' Adaptation Forum, which exists to support and challenge national and local climate change policy on matters related to infrastructure and the National Adaptation Plan. The cross-industry representation coupled with Regulators and the UK Government should enable a more integrated and evidence-based approach to be adopted. This should provide the opportunity to learn of existing and new approaches to adaptation, to access knowledge and information in support of adaptation, and to highlight the potential to reduce vulnerability to points of dependence on other systems.

Energy UK also participates in the Energy Emergency Executive Committee (E3C). E3C and its associated task groups exist to support and foster effective engagement by the UK, Scottish and Welsh Governments, Regulators (HSE and Ofgem) and industry (energy networks, power and gas producers, suppliers etc.,) to facilitate collaboration on issues relating to energy sector resilience. All participants commit to engage and co-operate on a voluntary basis in the development of system-wide arrangements to assess, mitigate and manage risks which, if not addressed, can impact on overall system resilience and ultimately impact on consumers of electricity and gas.

A further example is the power industry's involvement with Environment Agency's National Framework Senior Steering Group for water resource planning in England. This group had been established in response to pressure from Defra and Ofwat to establish a more effective and better integrated regional planning system for water resources. With representatives from the main users of water in and from rivers, lakes and aquifers, the main deliverable of this collaborative initiative will be a report that articulates the challenges facing the water industry and other water users, and sets out expectations of the water industry and others at a national and regional scale. This will then feed into the regulatory process and water companies/regional groups can use it to shape their future plans. The power sector is a major user of water across the UK, and the Senior Steering Group provides the opportunity to highlight the essential contribution that water makes to the generation of UK electricity and allows all stakeholders to understand how future water management proposals will impact on future electricity production.

On a regional scale, Energy UK has been a partner in the Water Resources East (WRE) project: a cross-sectoral project led by Anglian Water working with input from the energy, agricultural, water supply and environmental interest groups. The WRE mission is to work in partnership to safeguard a sustainable supply of water for the East of England, resilient to future challenges and enabling the area's communities, environment and economy to reach their full potential. Climate change, population growth and abstraction reductions mean that the risk of water shortages will be even greater in future, unless we take action now. WRE pioneered a new, collaborative approach to water stewardship. The project worked to create a multi-sector long-term water resource strategy, which balances affordability and reliability with sustainability and environmental stewardship.

Energy UK had provided input on the potential impacts of water shortage on the power sector, and is currently deciding its future involvement in the second phase of the project.

Energy UK also attends the EA's National Drought Group (NDG) whose purpose is to ensure that a common picture is held across stakeholders and their communication messages reflect the scale of impacts and the actions we are all taking. The workplan for the group involves specifically looking at interdependencies between the water and energy industry, therefore Energy UK sits on the group to ensure that risks to the power sector are not misrepresented.

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Energy Networks Associations response to the National Infrastructure Commission's Resilience Study Scoping Consultation

5 April 2019

The UK's electricity and gas networks

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.

Our energy networks are recognised around the world for their strong track record of safely and securely providing the UK with the gas and electricity it needs in three key areas:

1. Trusted performance - UK energy networks are amongst the most reliable in the world and are recognised for their leading performance that meets the needs of all consumers, whether they be domestic or business. The average gas customer will experience an unplanned interruption once every 140 years and 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.

2. Reduced costs & increased investment - Network costs are now 17% lower than they were at the time of privatisation and are projected to remain flat, and in some areas fall, into the next decade. The UK's energy networks have attracted some £100bn of investment since 1990. They are forecasted to invest £45bn between 2017 and 2023.

3. Delivering innovation - Network companies have spent a total of £99m across 928 projects through the Network Innovation Allowance, and supported a total of 1,735 innovative projects across all innovation funding mechanisms. Independent research carried out by Pöyry has shown that innovation projects by local electricity Distribution Network Operators (DNOs) could deliver up to £1.7bn of benefits by 2031.

Understanding this track record of our energy networks since privatisation in 1990 is key to understanding the role that our energy networks can play in helping the Government meet its decarbonisation targets and the objectives of the Industrial Strategy and Clean Growth Strategy. As regulated monopolies that are publicly and directly accountable to the energy regulator, Government and Parliament through a price control system, acting as an important lever of public policy.

Introduction

ENA welcomes the invitation to respond to this scoping consultation because it highlights the importance of ensuring we maintain resilience as we transition to a smarter, cleaner and more efficient energy system. It will help to identify potential barriers and strengthen our understanding of the opportunities and interdependencies between different sectors within the economy.

For Britain's energy networks, 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 these events.

Even during extreme weather, energy network companies demonstrate their resilience by keeping the lights on and ensuring households stay warm and safe. As temperatures plummeted nationwide during last year's 'Beast from the East' storm, Britain's 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%. As always, the gas network companies focused on ensuring the most vulnerable members of the public received the support they needed.

The regulatory framework managed by Ofgem has enabled energy networks to make vital investments in strengthening their resilience against the impacts from such major external events. 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, electricity and gas network companies have invested proactively to improve the resilience of the networks against the impact of storm and flood conditions. As extreme weather events become more common due to climate change or cyber threats grow, this may require approaches to maintaining resilience.

Energy network companies rigorously assess and monitor the potential risks to the networks, with mitigations in place to manage these risks. Each network company has comprehensive business continuity and emergency plans to ensure an effective response in a range of scenarios. The networks work together to carry out research, share best practice and plan for emergencies, through regular ENA committees and task groups. These activities focus on the highest priority risks such as the electricity network companies' Flood Protection Programme, which has been underway for 10 years.

Beyond this, the energy networks also work with Government, Ofgem, industry and society to prepare for issues and manage threats. ENA's Cyber Security Taskforce brings together the Department for Business, Energy and Industrial Strategy (BEIS) and the National Cyber Security Centre share information about increasingly sophisticated cyber-crime threats and to discuss barriers to maintaining resilience. Such cooperation is vital on issues as wide-ranging as energy system outages and restoration, telecommunications and the increasing digitalisation of our economy.

Q1. What are the key questions that the next National Infrastructure Assessment should answer about resilience?

The National Infrastructure Assessment (NIA) performs an important service to the UK by making a clear, long-term assessment of the UK's infrastructure and providing certainty for the public, industry and investors. The NIC's interim report highlighted the important transition underway to a low-carbon energy system and its initial recommendations in this area were very much welcomed. It made clear the importance of Government, regulators, industry, the public and others working together to continue to address the top priority issues and threats to UK infrastructure through until 2050.

As our energy system rapidly transforms, there are some key questions which should be answered to ensure we can continue to maintain the level of resilience that the public is accustomed to. Energy networks play a key role in a system with increasing decentralisation, digitalisation and decarbonisation. As a sign of the pace of change, the networks have connected close to 30 GW of distributed energy resources such as solar PV and wind power to the grid since 2007. Similarly, close to 100 biomethane plants are connected to the gas grid and providing low-carbon gas for heating and transport.

The next NIA should build on its initial findings and recommendations relating to a low-carbon energy system, which focused on renewable electricity generation, energy efficiency measures and heating options such as hydrogen and heat pumps. It should explore how these vital low-carbon technologies are part of an energy system which is increasingly interconnected with sectors including transport, waste and water. Further, how resilience can be maintained in this new era amidst growing threats such as cyber activity and extreme weather events, while continuing to keep costs low for the public.

Q2. On the basis of your response to question 1, what issues should be prioritised in the resilience study?

The rapid transformation of our energy system raises critical questions about how both electricity and gas networks can be used to maximise resilience. ENA believes developing the future energy system requires a 'whole system' approach to policy, regulation and market design, and similarly to resilience.

This approach is based on the principle that increased co-ordination and integration of innovation in our gas and electricity networks is the quickest, cheapest and most effective way of meeting our decarbonisation goals. For example, during periods of peak energy demand, the gas networks can quickly release vast amounts of stored energy. In fact, at peak times 61% of power and over 80% of heat and power is delivered by gas through the network. If our power, heat, transport and waste sectors are all interdependent then so must the solutions to their decarbonisation.

In future, there will be increasing amounts of intermittent renewable energies on the grid, higher up-take of electric vehicles and more households adopting new smart technologies. While this presents challenges for planning and operating the network, it also provides new opportunities to manage the grid smarter and more efficiently. For example, by developing a smart grid it is possible for flexibility services from smart energy technologies to be used to match supply and demand at a local network level, while gas networks can continue to provide unique flexibility and storage capabilities with new low-carbon gases.

Two industry-wide ENA projects are helping to answer some of these important questions. The Open Networks Project, which has been underway for two years, brings together stakeholders from across the industry to lay the foundations for a smart grid in Britain. The recently launched Gas Decarbonisation Pathways Project is providing a blueprint for the role of gas in a 2050 energy system. As we add new amounts of green gases such as biomethane and hydrogen to the network for transport and heating, we need to consider what measures, standards and protocols may need to be updated to maintain resilience.

As we move to this smarter energy system, we will need to build on traditional approaches to managing resilience (security firewalls and physical barriers such as fences) with leveraging the latest digital technologies. Energy networks are already using new technologies such as robots and drones to monitor and inspect the networks against environmental or physical risks. These modern techniques to managing resilience also benefit the public as they minimise disruption. To enable this to continue, sufficient investment in innovation must be enabled by the regulatory framework, RIIO.

Finally a skilled workforce underpins the resilience of our critical electricity and gas network infrastructure. It is vital that the Government and regulators continue to support initiatives which help to develop the science, technology, engineering and maths (STEM) skills needed by the energy networks in the future. It is particularly important that we invest in the development of these skills in girls and women, and that the UK has access to STEM talent from outside of the UK beyond Brexit. This is likely to continue to be a challenge into the future and must be addressed effectively to ensure resilience within a rapidly changing energy system.

Q3. Are there specific (eg. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sector interdependencies?

Increasing external threats to resilience are not unique to Britain's energy networks and present similar challenges for all major infrastructure asset operators. As the electricity and gas networks are the backbone of the UK's critical infrastructure, they are relied upon by much of our commercial industry, telecommunications, and transport and water operations. It is therefore vital that any barriers and issues are considered carefully and comprehensively as part of the NIC's recommendations to Government on future resilience and that policy and regulatory frameworks are aligned with these recommendations.

The Government and regulators of major utilities sectors should provide clearer strategic direction on how interdependent sectors can work together on resilience to deliver value for the public and the wider economy. In line with this, planning for emergency scenarios across sectors should be developed on the same underlying assumptions to ensure consistency, especially where there are interdependencies. For example, this approach is vital in addressing the wide variety of views regarding the extent and impact of climate change on critical national infrastructure.

Further, Government, regulators and industry should work together to align priorities and find solutions to challenges as wide-ranging as energy system restoration and increasing digitalisation. For example, as copper lines are replaced by fibre the UK's electricity networks can no longer rely on traditional, reliable telecommunications methods during power outages – this presents challenges for transferring data across the network to manage the system and for using mobile phone networks with limited back-up battery. Strategic communications considerations are vital to maintaining availability, resilience and cyber security.

ENA's detailed analysis shows that the greatest threat to the electricity networks is adverse weather including flooding and gradually increasing temperatures, both driven by climate change. Electricity network assets have very long lives, typically operating for between 30 to 80 years, which makes it vital to plan for potential but sometimes unknown impacts. It is a

priority for energy network companies continue to develop their understanding of threats from climate change and undertake resilience measures to protect the networks against them. At the same time, energy networks are continuing to strengthen their resilience against increasingly sophisticated cyber attacks. Sensitive data about specific assets must be protected and remain secure.

It is essential that energy networks continue to receive allowances via the regulatory framework to handle uncertainty about future risk and respond quickly and cost-effectively when needed. By collaborating across sectors and where there are interdependencies, it will be possible to maximise the value of investment into resilience measures to deliver value for the public and the wider economy.

Energy networks have innovation in their DNA after years of delivering low-cost innovation projects which benefit the public and help deliver on the Government's low-carbon policies. Boosting innovation in resilience will be increasingly vital to manage growing stresses and threats. As an example, a Network Innovation Allowance project led by National Grid Transmission Operator is studying how distributed energy resources such as solar PV, energy storage and electric vehicles could be used to help restore the electricity grid in a low probability, high impact incident. Until now, Black Start, the name for the restoration process, has relied upon starting large grid-connected generators. Another example is UK Power Network's Automatic Power Restoration System, which enables the local electricity network to reconfigure and heal itself to keep the lights on.

Finally, ENA believes that resilience is reliant on each part of the system being individually resilient. All critical public services should have comprehensive contingency plans and back-up generation in case the energy networks experience a major incident outside of their control, including councils, hospitals and water companies. All regulatory frameworks, including RIIO, must allow sufficient flexibility to deal with short-term risks arising from climate change-driven extreme weather events or cyber attacks. This ensures companies are empowered to act quickly, at the lowest cost to the public.

ENA contact details

If you have any questions on the points raised in this response, please contact Casey Sattler, Policy and Stakeholder Engagement Manager, Energy Networks Association by email to casey.sattler@energynetworks.org.

UKCRIC CN Response to NIC Resilience Study Scoping Consultation

This response has been prepared by [name redacted] on behalf of the UKCRIC Co-ordination Node.

1. What are the key questions that <u>the next National Infrastructure Assessment</u> should answer about resilience?

Highly Resilient economic infrastructure is a systemic pre-requisite for the realisation of NIC strategic objectives. If resilience is not prioritised, the normal operations of economic infrastructure will be disrupted with greater frequency, intensity, scale and duration. The impacts of which, will adversely affect any aspects of society or the economy that is enabled either directly or indirectly by products and services produced by economic infrastructure (i.e. all of it). Therefore, failing to make resilient economic infrastructure a core priority jeopardises the long term feasibility of all other strategic NIC objectives.

Therefore, although not explicitly stated in the NIC strategic objectives, the success of the NIC depends on ensuring that the UK's economic infrastructure is intrinsically resilient. Therefore, the resilience of economic infrastructure must be made an explicit priority for the next National Infrastructure Assessment (NIA), all future NIC special studies and all NIC work in reviewing HM Government progress on implementing all previous NIC recommendations.

Moreover, the net impact of all NIC recommendations on the resilience of the UK's economic infrastructure must be explicitly considered at every stage of both NIA and special study methodologies. To be fit for purpose, the NIA methodology must be capable of producing a set of recommendations that both boost the resilience of economic infrastructure and support the realisation of NIC strategic objectives.

The questions regarding resilience that the NIA (and NIC special study) methodologies must be capable of answering are:

1. What does the NIC mean when it applies the concept of resilience to economic infrastructure?
2. What impact does the resilience of economic infrastructure have on the feasibility of NIC achieving its strategic objectives?
    a. What are the wider societal impacts of economic infrastructure with low resilience?
3. How intrinsically resilient is the UK's economic infrastructure at present?
    a. Which current practises increase intrinsic resilience?
    b. Which current practise decrease intrinsic resilience?
4. How will the NIC ensure that it systemically identifies, analyses and understand the root causes of low systemic resilience and selects interventions that systemically address root causes? (rather than diagnosing and treating symptoms on a sector by sector level.)
5. What are the strategic challenges and trends of greatest significance for the future resilience of the UK's economic infrastructure?
6. How has the need to increase (or at the very least not reduce) the resilience of the economic infrastructure system been explicitly included at all stages of the NIA process?
7. What is the expected net impact of any specific recommendation on the overall
    a. Resilience of the economic infrastructure system?
    b. Capability of the economic infrastructure system to enable NIC objectives?
8. In making these recommendations, have any trade-offs been made between 8a and 8b? If so, on what basis? What are these? And why are they necessary?

2. On the basis of your response to question 1, what issues should be prioritised in the resilience study?

The current Resilience Study is an opportunity to lay the groundwork for the above by prioritising:

1. A clear conceptual framework for economic infrastructure and supporting narrative to illustrate:
    - The purpose of economic infrastructure is ultimately to an enable the desired outcomes society expects
    - The interdependent mechanisms by which economic infrastructure fulfils this purpose
    - The total societal value (direct and indirect) uniquely enabled by economic infrastructure
    - The sheer scope, scale and complexity of interdependencies between Economic infrastructure sectors, and the importance of these to the normal operations of economic infrastructure.
    - Economic infrastructure is a complex interdependent network of networks, in which all networks have at least one continuous and absolute interdependence with at least one other, and no infrastructure product or service is produced by a single sector in isolation.
    - Economic infrastructure is interdependent with the dynamic external context within which it is embedded.
    - The total societal value of making economic infrastructure resilient (i.e. reducing the frequency, intensity, scale and duration of disruptions to the normal operations) and the society-wide opportunity cost of failing to do so (i.e. not prioritising resilience)

2. A clear and consistent conceptual model of resilience characteristics.

The NIC must be consistent in the way it integrates resilience into all aspects of its work, and be capable of effectively communicating, in any given context, which elements of resilience it is focusing on and why. A conceptual model for resilience that captures the following key points is required:

- Resilience is the intrinsic characteristic of a system that determines the extent to which a system is adversely effected by any given disruptive event. The greater the intrinsic resilience of a system, the lower the likely scale, intensity and duration of disruptive impact resulting from any given hazard or other cause of disruption.
- Resilience is not a fundamental property of assets, rather it is dynamic emergent property of interdependent systems. Resilience varies interdependently with underlying system characteristics, particularly those described by Rinaldi in the interdependence dimensions Coupling and Response Behaviour, State of Operation, and Infrastructure Characteristics. Low resilience is not caused by a single party or have a single technical cause. Nor can high resilience be created or sustained by a single magic bullet, sector or organisation
- Developing, sustaining and enhancing the intrinsic resilience of any system requires long term collaborative commitment, to improve knowledge of system dynamics and interdependencies, avoid actions that reduce resilience and develop and implement a dynamic, multi-faceted, systemically targeted portfolio of actions
    - Dynamic to ensure continuous action, monitoring, review and adaptation to ensure the portfolio of interventions is fit for purpose and sufficient
    - Multi-faceted to avoid overdependence on any single intervention or intervention type
    - Systemically targeted to address the root causes of low systemic resilience, intervene at the most effective points in the system, with the most effective intervention types, at the most appropriate time

3. Building on 1 and 2 above to

- Demonstrate the total societal value of resilient economic infrastructure
- Demonstrate the impact of low resilience on the feasibility of NIC strategic objectives

  Resilient economic infrastructure is a pre-requisite for realisation of NIC objectives. The opportunity cost of low resilience economic infrastructure is a reduction in the feasibility of NIC objectives (and associated societal benefits) being realised for any given level of investment.
- Integrate resilience into the methodologies used for the next NIA and for all future special studies
- Systemically identify, analyse and understand the root causes of low systemic resilience and select interventions that build intrinsic resilience by systemically addressing root causes (avoid diagnosing and treating symptoms on a sector by sector level.)
- Champion understanding of Resilience in terms of system characteristics, interdependencies and the need for intrinsic system resilience to all potential disruptive impacts
- Identify, and communicate the significance of, the future strategic challenges to which economic infrastructure must be resilient

- Clearly distinguish between Resilience and the management of high impact low probability Risks
  Risk Management requires sufficient knowledge to all possible outcomes from a disruptive event or quantify the likelihood of that event occurring. This is often not possible in complex systems, meaning in complex systems the incertitude is better characterised, depending on the specific context, as uncertainty, ambiguity and ignorance, all of which are distinct from low probability high impact events. It is in these type of systems where aspiring to improve systemic resilience is needed.

3. Are there specific (e.g. policy, knowledge, data sharing or other) barriers to addressing resilience emerging from cross-sectoral interdependencies?

Barriers to resilience emerge not from cross-sectoral interdependencies themselves, rather barriers to resilience emerge from our insistence on managing, governing, planning, incentivising, evaluating, maintaining, valuing, regulating, owning, operating, measuring performance of (henceforth managing*) economic infrastructure as though the sectors were a collection of independent systems. Economic infrastructure is in practise a single interdependent system comprised of a network of economic infrastructure Networks. It is this fragmented management* philosophy that create erroneous assumptions regarding, and a blindspot to, interdependencies between sectors and the emergent system properties (positive and negative) these enable. Barriers to resilience, therefore, emerge not from the interdependencies themselves but from any management* practise that either ignores or makes inappropriate simplifying assumptions about the significance of interdependencies.

The extent to which a system is Resilient (or not) is an emergent property that cannot adequately be understood, measure or managed* on a sector by sector basis. Resilience needs a whole system approach to management*, or approaches at the sector level which explicitly consider impacts of sector actions on system resilience. It is the absence of such approaches, or structures, practises or institutions- that impede their development or adoption that are the barriers to action to address resilience.

Elaboration

The systemic reality is that although we manage* Economic infrastructure as though it were a collection of discrete economic infrastructure sectors, it is in fact a single complex interdependent Network of Economic Infrastructure Networks (EI NoN). It is in practise a single system because no economic infrastructure sector is capable of producing the flow of infrastructure products or services (IP&S) we associate with it in isolation from the wider EI NoN of which it is an interdependent part. Analysis by John Beckford concluded all economic infrastructure sectors have at least one absolute and continuous dependence on at least one other economic infrastructure sector. In short the entire EI NoN is what Normal Accident theorists describe as a high risk system, characterised by both complex interdependencies, and tight coupling between components. The sheer scope and scale of the IP&S produced by the EI NoN is made possible by the skilful management of interdependencies both within and between the networks of which it is comprised, and significantly interdependencies with the wider external context within which it is embedded.

However, as a direct consequence of this, the EI NoN is vulnerable to three forms of interdependence related disruption (cascade failures, escalating failures and common cause failures). These IRD can be initiated by an external disruption (e.g. a hazard), a long term external trend, an internal component failure, or an unexpected change, fluctuation or peturbation anywhere in the system, which is subsequently propagated through the system via interdependent pathways. The frequency, scale, intensity and duration of any IRD is therefore determined both by the characteristics of the event that caused it and the interdependencies within the affected system. Thus, the resilience of the EI NoN is an emergent property, resulting from interdependencies within the EI NON and between the EI NoN and the sociotechnical context within which it is embedded. To improve system resilience it is first necessary to understand the normal operations of a system in terms of interdependencies.

Appendix – Brainstorm of Key Themes considered when Compiling Consultation response

RESILIENCE AS CORE TO ALL NIC PROCESSES

- How will the NIC make resilience impacts an explicit component of all infrastructure decision making processes?
- How will trade-offs between resilience and other NIC strategic priorities be made explicit in all future NIC work?
- How will findings from this study be integrated into the methodologies adopted for the next NIA, future Special studies, and future NIC Annual Reviews
- How will the NIC explicitly evaluate the resilience impacts of all future NIA and Special Study recommendations prior to publication?
- In the light of this study, will the net resilience impacts of all current NIA and special study recommendations be re-evaluated?
- In the light of this study, will the net resilience impact of the portfolio of projects currently in the National Infrastructure Development Plan pipeline be re-evaluated?

BENEFITS OF HIGH RESILIENCE VS OPPORTUNITY COST OF LOW RESILIENCE

- Why does the resilience of economic infrastructure matter?
    - What are the benefits of highly resilient economic infrastructure?
        - Who are the beneficiaries?
    - What is the opportunity cost of economic infrastructure that is less resilient?
        - Who is adversely affected?
- How can ensuring economic infrastructure is resilient support the realisation of NIC strategic objectives?
- To what extent does neglecting the resilience of economic infrastructure undermine the realisation of NIC strategic objectives?
- What is the society-wide opportunity cost of economic infrastructure that is not resilient?
    - Can the NIC adopt this OC as a more accurate counterfactual of the impacts of not investing in resilience?

STRATEGIC CHALLENGES

- To what current and future strategic challenges must economic infrastructure be resilient?
- What short term trade-offs exist between Resilience and other NIC objectives?
    - How can the identification and evaluation of these integrated into future NIC methodologies?
- What current BAU management* practices (if any) reduce systemic resilience?
    - How can these be identified, understood, and adapted?
- What current BAU management* practices (if any) constrain actions to increase systemic resilience?
- What current BAU management* practices (if any) are known to increase systemic resilience?
- How can barriers to Resilience be identified
- How can actions that inadvertently reduce resilience be avoid?
- How can the impacts on the systemic resilience of established systems be made explicit?
- Who is responsible for ensuring that the UK's economic infrastructure system is resilient?

- What is the value proposition?

SYSTEMIC APPROACH

- How can the systemic root causes of low resilience be most effectively I Ded?
- Can these be used as leverage points to increase systemic resilience?
- At what scale(s) must actions to increase systemic resilience be targeted?
- Why does systemic complexity matter?
- a resilient economic infrastructure system cannot be created on a sector by sector basis. Likewise resilience cannot be measured on a sector by sector basis. How does
- Is the National infrastructure commission committed to a whole systems approach to understanding resilience?
- can the National infrastructure commission ensure that we do not chase magic bullets. Resilience is an emergent sociotechnical property. Technical fixes alone cannot guarantee greater resilience.
- Emergent properties?
- Dynamic properties?

CONCEPTUAL CLARITY/CLARITY OF PURPOSE

- Can the National infrastructure commission provide a conceptual model to make explicit how it characterises resilience?
- Can the NIC provide a conceptual model to illustrate the society-wide benefits of resilient economic infrastructure?
- Can the NIC adopt insights from NAT…. to characterise economic infrastructure as a dynamic complex adaptive system characterised by interdependencies within it and on the dynamic external environment
- Can the National infrastructure commission adopt a conceptual model to make explicit the full scope and scale of interdependencies present in economic infrastructure?
- Can the National infrastructure commission make explicit that the assumptions of risk management ……are difficult to justify in infrastructure systems. Therefore the management* of infrastructure for society-wide benefits requires a focus on systemic resilience rather than solely risk?
- Resilient Infrastructure systems are in the long term enlightened self interest of us all as individuals, families, communities, cities, regions, nations. No matter your walk of life, in the long term you benefit from resilient infrastructure.
- can the National infrastructure commission ensure that if adopting a framework to quantify resilience that this is explicit in stating why once to measure resilience
- How does the National infrastructure commission propose to change the terms of reference when discussing infrastructure away from the cost of action to the society wide opportunity cost of inaction? Costs benefits values oc counterfactual

TOOLKIT, MECHANISMS, INTERVENTIONS, ACTIONS

- What mechanisms are needed to ensure investment in resilience?
- What mechanisms are needed to ensure that resilience is not accidentally? Reduced in pursuit of a strategic objectives
- can the National infrastructure commission ensure that governance structures, regulatory frameworks and other management processes are recognised as parts of a resilient toolkit