**New Energy and Water Public Interest Network**

**New-Pin – Workshop 3**

# Long-run resilience in the energy and water sectors

**Are '20th century' approaches for securing resilience relevant for the citizens and consumers of the 21st?**

**How might '20th century' approaches need to evolve?**

# Discussion paper

# FINAL

**Written by Sharon Darcy with support from Judith Ward. This paper has been a collaborative effort. Sustainability *First* would like to thank all those New-Pin Network members and others who spoke to us on this topic and contributed to the case studies. Responsibility for the paper sits with Sustainability First.**

## About the New Energy and Water Public Interest Network (New-Pin)

**Background:** New-Pin brings together stakeholders active in the energy & water sectors to help secure greater focus in company, investor, regulatory & policy decisions on **long-run public interest issues.** It aims to:

- **Build understanding between the energy and water sectors and their stakeholders**. New-Pin explores areas of similarity and difference, leverages learning and identifies practical steps all actors can take that could better serve long-term public interest issues;
- **Strengthen stakeholder engagement.** New-Pin seeks to increase public participation in decisions by water & energy companies, investors, regulators and policy makers through developing lasting capacity and thought-leadership among 'public interest' advocates; and
- **Stimulate a more 'inclusive' perspective on governance.** The Network is exploring what governance in the public interest looks like for energy and energy companies.

New-Pin was established by the charity Sustainability First in 2015. The New-Pin Network is made up of consumer, environmental, citizen, academic and investor interests, a small group of energy and water companies, regulators and government departments.

Sustainability First arranges and facilitates carefully structured New-Pin workshops to discuss relevant long- term public interest issues. The process is iterative and is evolving as New-Pin becomes more established. Network members decide which topic to focus on at each workshop. Prior to the workshops, Sustainability First holds bilateral discussions with members and other interested parties to discuss what they think are the key public interest issues in that topic area and to identify appropriate case study material. Following a literature review, this information is then used to draw up a draft paper for consideration at the workshop. After the session, the paper is revised to take on board comments. All final workshop papers are placed in the public domain.

**Current and proposed New-Pin papers**

- Towards a definition of the long-term public interest, August 2015
- Long-term affordability: who should pay for our infrastructure resilience and renewal and the move to low carbon? October 2015
- Trust and confidence: what does this mean for the different stakeholders in the energy and water sectors and what can be done to build and maintain this? March 2016
- Long-run resilience: Long-run resilience in the energy and water sectors. Are twentieth century approaches for securing resilience relevant for citizens and consumers of the twenty-first? June 2016
- Stakeholder engagement for citizens and consumers and capacity building, October 2016
- Competition policy and the public interest agenda, February 2017
- Innovation and regulation: what's the problem that innovation is trying to solve and how do regulators let go without letting companies off the hook? June 2017
- Investment decisions – communities, devolved approaches & big infrastructure, Nov. 2017
- Governance in the public interest: lessons learnt and next steps, February 2018

**The New-Pin Network** Current New-Pin public interest advocate members include: Citizens Advice, The Consumer Council for Water, Green Alliance, The Centre for Sustainable Energy, Water Wise, The Local Government Association, ShareAction and The iGov Programme at Exeter University. Company members include, from the energy sector; Electricity North West, Northern PowerGrid, RWE NPower, Scottish and Southern Energy Power Distribution and Western Power Distribution; from the water sector; Affinity Water, Anglian Water and Southern Water; and PA Consulting. Regulatory members include: The Environment Agency, Ofgem, Ofwat and the Water Industry Commission for Scotland. Government representatives are: DECC, DEFRA and the Scottish Government. Other individuals with a relevant interest are from time to time also invited to Network meetings.

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## Executive summary

Resilience in the energy and water sectors is important for citizens and consumers as it is essential for economic and environmental health and personal wellbeing. It also helps ensure value for money as major failures can be costly. Approaches that seek to remove all risks to services and systems, however, would be extortionately expensive, and even then couldn't guarantee against failure. Work on resilience therefore needs to focus on managing risks.

Long-run resilience in energy and water has two elements. Firstly, it is the ability to anticipate trends in the resources and other factors that impact on services and systems. Secondly, it is the ability to withstand problems and maintain services and systems for people and protect the natural environment now and in the future. It is shaped by a number of elements including technical, social and environmental issues. These can 'frame' how the topic is seen from the public interest perspective.

There are clear differences in the approach to resilience in energy and water. As energy is nationally networked, the approach to resilience is currently largely based on deterministic standards that are fairly uniform across the country. In water, due to differences in resource levels, geographies and demand, there currently aren't really any existing underlying *national* standards in this area and the approach to resilience tends to vary on a company / catchment basis.

Traditional approaches to securing resilience have tended to be top down and supply-side focused. The emphasis has been on solid / hard, technically focused and dependable measures (although natural approaches are starting to also be used in water). However, these may not provide resource where it will be needed and at the quantity required in the future. As a result, supply side interventions may provide too much or too little security – at a cost either way.

Behavioural economic insights, tariffs and smart meters and appliances are leading to increased focus on 'softer' demand side approaches, and approaches that tackle the supply/ demand balance. Consumer or commercially focused, they can be more agile than hard engineering solutions. However, the flexibility and optionality they bring to the system may not always be as dependable or secure as supply side alternatives. Energy and water companies do a lot of work to ensure that their services are resilient but more could still be done to share lessons between sectors and mainstream good practice.

Looking to the longer-term, the resilience picture is starting to evolve, driven by two factors. Firstly, climate change can lead to shocks to the system such as severe droughts & intense rainfall. These types of extreme events are becoming more common, and as they are unpredictable, are likely to test our traditional resilience approaches of balancing supply and demand. Secondly, technological changes & advances in IT and digital communications are leading to new resilience challenges. As many of these are dependent on, and 'enabled' by electricity, they can also lead to risks to secure supplies. The Internet of Things will make this dependency even greater. The energy and water sectors face an increasing number of complex

interdependencies. In electricity, the disaggregated value chain means that there are already a large number of actors that need to work together to secure resilience. With the development of a whole suite of renewable distributed technologies, the number of interfaces in the system is increasing. In water, the rising focus on upstream issues & the need for transfers in some drought scenarios may lead to an increasing need to co-ordinate with a wider range of companies and groups, such as farmers, around resource planning.

There are also links between the sectors. Water companies use energy for pumping and energy companies use water for cooling and new approaches to increase resource capacity are often energy and water hungry. There is a growing acceptance that a holistic or 'system of systems' approach to resilience will be important. Failures in resilience don't respect operational, sector or institutional boundaries. Without a coherent cross sector approach, resilience can be undermined by the weakest link in the chain and value for money may be eroded. This poses a question for existing institutional arrangements that were largely forged before resilience challenges became an issue. Changed citizen and consumer expectations (such as the desire for continuous connectivity), accompanied by a growing scepticism with the establishment, may also impact on how future resilience is secured.

Markets may provide a faster and more flexible response to resilience than regulation, in the process encouraging innovation and diversity. They can enable the emergence of new & local actors better placed to understand and respond to local risks and tap into the desire for a community voice. However, markets can create new inter-faces that need to be managed and by their nature can be disruptive to the networks that may still be needed as back-up. As the local and regional landscape changes, new market & governance arrangements to address long-run resilience may be needed to manage the new boundaries and knock-on distributional impacts such as stranded assets. What is an optimally efficient solution within one 'boundary' isn't necessarily a resilient one if it leaves key parts of the value chain and wider system vulnerable. Fair & transparent cost allocation/ access-pricing arrangements are needed to manage such conflicts at 'system boundaries'.

Stakeholder & consumer engagement is vital to secure long-run resilience; helping to set priorities for change, increase the knowledge-base of where risks / vulnerabilities are and paving the way for quicker response and recovery when there are shocks. Companies clearly need to take the lead in engaging their own customers. However, decisions on who should bear which risks can have significant distributional impacts, so there is also a key role for Government. Elected representatives need to take an holistic view of the overall affordability of resilience programmes. Government at every level also has a role to play in terms of engaging the public on cross sector issues and playing a lead on debates around electricity dependency.

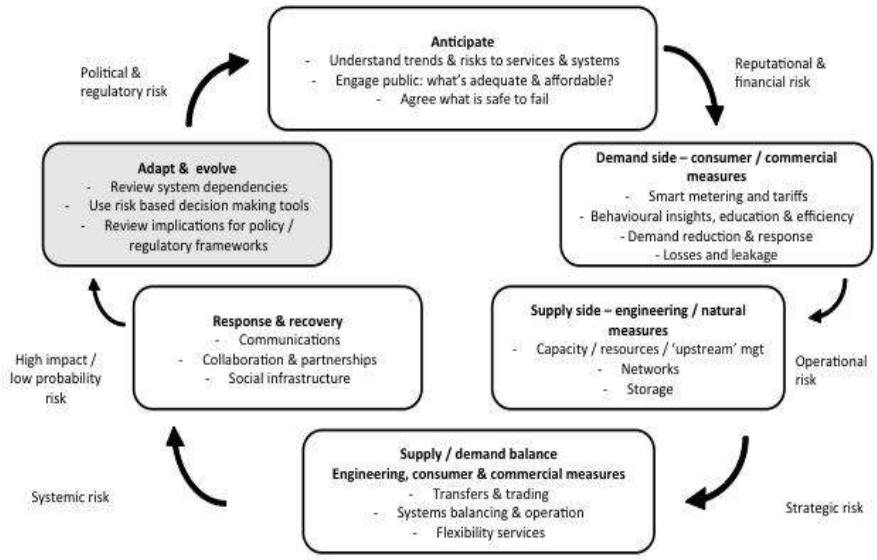
Information, and having a strong evidence base of the risks, costs and benefits of different approaches, is another important enabler for long-run security. This can help build joined-up and collaborative responses to problems and identify good practice. Standards can play a part. Given the uncertainty that exists, moving from a deterministic and universal approach to standards, as currently is the case in energy,

to a more risk based & tailored approach, and possible 'mitigated' state during shocks, may be helpful. However, there are potential distributional implications of doing this that need to be assessed in the round. Metrics for judging long-run resilience and tracking progress have a role. As there is no single resilience metric that can be used to assess future security, a suite of measures may be needed, including those that can assess cross sector performance.

Strong leadership is vital to deal with resilience, particularly in difficult areas like flooding or to prepare for droughts that can be relatively rare events. When faced by a crisis there can often be pressure to be seen to be doing something large-scale, 'hard' and visible. Moving to a situation that enables a greater plurality of both hard and soft approaches, at the local, regional and national levels, will require clear decision-making frameworks & roles and responsibility that can work across institutional and funding silos. The need for action in this area is now starting to be recognised; the new National Infrastructure Commission is good news. However, ensuring that responsibilities for resilience at the local and national level knit together is a significant task. Given the potential conflicts that could arise, especially on questions of affordability, or environmental protection, it would seem sensible to build a consensus amongst citizens and consumers as to what a cross sector set of long-run resilience principles could look like.

Diagram 1 summarises a suggested approach to long-run resilience and how this can help manage different types of risks. Given the uncertainty of climate change, securing resilience needs to be a dynamic & adaptive process. The key stage in the diagram is arguably the shaded box, when shaped by experience, services and systems (and associated regulatory / policy frameworks) adapt and evolve. It is also worth noting that in our suggested framework, demand side approaches precede supply side approaches – to maintain focus on customer centric and flexible services.

**Diagram 1: Overview of possible approach to securing long-run resilience in the energy and water sectors for citizens and consumers**




*Source: Sustainability First*

# 1 Overview

## 1.1 Objective

Resilience is a broad and complex topic. There are also some clear differences in resilience issues for the energy and water sectors.

This discussion paper does not attempt to 'solve' the issue of long-run resilience. Rather, it seeks to identify the evolving challenges that the two sectors face, from a citizen and consumer perspective. Much is clearly going on in this area. However, through discussion we have started to tease out what key new thinking is needed on this topic from a public interest point of view. As such, this discussion paper presents a fresh perspective on this topic and starts to provide an accessible and common 'language' that consumers and citizens can use to discuss these difficult issues – including from a cross sector view point.

With a locus firmly in the long-term public interest, it explores the current approaches the two sectors take to this topic to stimulate a discussion about whether, and if so how, these approaches may need to change. In doing so, it provides an opportunity for the two sectors to learn from each other, embed good practice and to see the issue in the round – from the citizen and consumer perspective.

The paper is primarily concerned with the resilience issues that are emerging in the 21st century. Giving the public a say in how best to respond to these is important. This paper is, however, only 'one half' of the equation on long-run resilience. The cost of resilience is the other half. In a sense, this paper therefore 'sets the scene' for our next discussion paper and the workshop that New-Pin will be holding on stakeholder and consumer engagement and capacity building on 19 October 2016. In that session, we will explore *how best to involve citizens and consumers in these issues, including the topic of willingness to pay for resilience*. We do not address these fundamental questions in this paper.

## 1.2 Outline of paper

**Section 2** explores the different elements that can make up resilience and puts forward a working definition for use in this discussion paper.

**Section 3** provides a very brief overview of the current resilience landscape in terms of actors, institutions and responsibilities. There is clearly much work already in train in this area.

**Section 4** of the paper summarises some of the existing approaches to resilience in the energy and water resource sectors in the areas of:

- Supply;
- Demand;
- The supply – demand balance; and

- Response and recovery.

There is also a brief note on the arrangements for wastewater. This current high level map is not intended to be exhaustive; rather the aim is to ensure that all stakeholders, regardless of their background or sector, have a common reference point. Drawing on case studies of current good practice, section 4 also provides some useful practical examples of what can be done within current arrangements – in the process providing some cross sector lessons.

Resilience is clearly an evolving issue. **Section 5** provides an overview of the major 21st century long-run resilience issues for citizens and consumers that are being driven by climate and technological change.

**Section 6** explores how 20th century approaches to resilience may need to change for the 21st. Through discussion, the following areas for change were identified: the local, regional and national landscape; the need to address cross-sector issues; and the respective roles of market approaches and / or other interventions.

**Section 7** examines from a citizen and consumer perspective how you might judge whether you have the right long-run approach to resilience in place. In doing so, it explores the 'enablers' for resilience. These include: stakeholder engagement; sharing information; standards and decision-making tools; metrics; and leadership.

**Section 8** explores the responsibilities of different actors for managing resilience issues that cross boundaries, be these physical or administrative.

**Section 9** concludes with a discussion of how to take forward future-thinking on long-run resilience issues for the water and energy sectors by creating a clearer 'public interest' focus. It suggests some high-level principles by which to guide future thinking and actions for a 21st century context.

## 1.3 Methodology

A scoping note proposing the main issues to address was circulated to all New-Pin Network members for comment. Following a short literature review, this note was then used as the basis for bilateral interviews with 16 Network members and others with an interest in resilience. The paper draws heavily on these conversations and on the case studies that have been shared with us or taken from published material. It also reflects the discussions that took place at the New-Pin workshop on this topic on 22nd June.

## 1.4 Scope

Resilience is a very broad subject. To make the discussion manageable, in this paper we therefore do not cover:

- *How* to establish what people want / are willing to pay for in the future. This will be considered at the New-Pin Stakeholder and consumer engagement workshop on 19th October 2016;

- The technical detail of existing standards or any future standards that may be discussed;
- Questions of short-run resilience and recovery (to some extent this was covered in the New-Pin workshop on Trust and Confidence in February 2016);
- How far ahead it is sensible to try to predict the future (to some extent this was covered in the workshop on long-term affordability in Autumn 2015);
- Innovation as a way of adapting standards or maintaining affordability. Although we inevitably touch on this, a future New-Pin workshop is planned specifically for this in June 2017 (and the implications for regulation);
- In energy, issues of GB self-reliance and questions of diversity of supply and dependency on imports are only touched on in passing; and
- The potential impact on resilience of the EU Referendum.

## 2. Definitions

Much focus on resilience to date in the energy and water sectors has been on the **resilience of infrastructure**. For example, in 2011 the Cabinet Office produced a guide to improving the resilience of critical infrastructure. This defines resilience as:

*'The ability of assets, networks and systems to anticipate, absorb, adapt to and / or rapidly recover from a disruptive event.'*

The Guide identifies four different aspects of resilience: resistance; redundancy; reliability; and response and recovery.[1]

The resilience of infrastructure, and its associated **technical** hardware and software, is clearly vitally important. However, it is important to ask whose resilience is being discussed. If we take a citizen and consumer perspective, **the question of what is resilience may need to be 'framed' in a slightly broader way**. From the public interest perspective, resilience may need to move beyond an assessment of long-run physical capacity plus short-run operational capability to also take on board (to some extent at least) wider systems, including environmental and social considerations. There are clearly issues of scale and scope here. However, citizens and consumers are unlikely to view resilience on a basis that is simply bounded by sector. Instead they may be concerned with the total impact that the resilience of different systems in combination will have on their daily lives and the lives of future generations.

Some of the other **wider aspects of resilience,** beyond technical reliability, that may therefore also need to be considered could include:

- Linkages within and between systems - such as the inter-dependencies between electricity and IT/communications systems or energy and water systems (see Section 5 and 6 for more detail). This is necessary if systemic risks are to be managed;

[1] *Keeping the country running: Natural hazards and infrastructure. A guide to improving the resilience of critical infrastructure and essential services*, The Cabinet Office, 2011

- Environmental / ecological resilience - primarily in terms of ensuring supplies are sustainable – for both current and future generations;
- Social / political resilience – the strength of 'social infrastructure' and the ability of communities, institutions and organisations to anticipate and cope with challenges and then 'bounce back' can vary. The ability of governance arrangements, and indeed also political and administrative systems, to be resilient in the face of long-run change is clearly also relevant here;
- Requirements, expectations and behaviours of citizens and consumers - these will not necessarily be the same.[2] For example, citizens may have something to give and a propensity to do so (eg community spirit). Consumers may have a more transactional / commercial relationship and there can be differences between consumer segments. For example, the needs of a large industrial and commercial customer may be different to those of a household customer. Indeed, what different consumers and citizens want from a resilient service and what they need, what is acceptable and what is non-negotiable, may vary from person to person and issue to issue; and
- System personnel and processes[3] - for example, the extent to which the staff of one company or organisation are able to support others during a crisis.

There can clearly be a relationship between these different aspects of resilience. For example, if social resilience increases in response to events, then spend on technical resilience measures could potentially be less.

Given New-Pin's 'public interest' perspective, and in order to reflect some of these wider factors, this paper focuses on the **adequacy of services and the resilience of the systems that underpin them**. This approach covers both operational ('opex') and capital ('capex') solutions to issues. It may therefore go somewhat wider than some other studies of the resilience of existing service providers.

The paper also concentrates on the **long-run** resilience of services and systems. Whereas short-run resilience issues may be more concerned with the reliability of the infrastructure in place and in the medium term resilience may be more concerned with the supply chain, in looking long-term, questions of sources of supply, and their flexibility, become more prominent.[4]

It is important to note, however, that short-term resilience challenges, and the response to them, can have an impact on long-term resilience. There is not always a neat division between the two. From the public point of view, there can also be a 'rolling window' between these different time frames as these services are continuously being used rather than being 'one-off' purchases.

The working definition of resilience that we propose to use in this paper is therefore:

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[2] See, *Towards a definition of the long-term public interest,* Sustainability First, August 2015

[3] *Electricity sector resilience, Resilience and society: energy infrastructure*, 26 April 2016, Sara Walker

[4] *UK Gas security, threats and mitigation strategies*, Dr Jim Watson, January 2010

*Long-run resilience has two elements. Firstly, it is the ability to anticipate trends and variability in the resources and other factors that impact on services and systems. Secondly, it is the ability to withstand problems and maintain services and systems for people and protect the natural environment now and in the future.*

The two elements are clearly connected. If we do not anticipate trends correctly, and fail to continuously refine and adapt our forecasts, it can be far more difficult to withstand problems and maintain services in the future.

# 3. The current landscape: actors, institutions & responsibilities

This Section provides a very brief overview of the current arrangements amongst actors and institutions for securing resilience in the energy and water sectors. A more detailed summary of sector specific arrangements is contained in **Annex A**.

In addition to the sector specific arrangements outlined in this Section, various actors also have wider resilience related responsibilities:

- **DECC** – The Department is responsible for the legislation on the Carbon Budgets that are required under the Climate Change Act to meet long-term emission reduction targets;

- **DEFRA** - The Department publishes five yearly Climate Change Risk Assessments and sets the parameters that companies should prepare for in terms of flood events;

- **The Committee on Climate Change (CCC)** – The Committee gives advice to the UK Government and Devolved Administrations on Carbon Budgets. The Government committed to the Fifth Budget covering the period 2028 – 2032, on 30 June 2016. The Committee also provides evidence to DEFRA on the Climate Change Risk Assessment; and

- **The National Infrastructure Commission (NIC)** – The new Commission will produce a National Infrastructure Assessment once every Parliament, setting out the strategic vision for UK infrastructure in the next thirty years & making recommendations as to how these needs should be met. It will also produce reports on specific infrastructure challenges (such as the future of 5G).

- **The Centre for the Protection of National Infrastructure (CPNI)** – The Centre oversees the national security of infrastructure and key assets in the face of threats and associated preventative security measures.

## 3.1 Electricity and gas

Historically, electricity cannot be readily or cheaply stored and therefore capacity adequacy was centrally planned until the electricity industry was restructured in

1990. In 2014, within a market framework, a new capacity mechanism marked a part-return to long-run capacity planning. In gas, British Gas was restructured in 1994 into separate trading and transportation / storage arms. Storage and transportation were in turn separated in 1997 to enable the development of a competitive and resilient storage market.

Both the Secretary of State and Ofgem are required to carry out their functions having regard to *'The need to secure that all reasonable demands for electricity are met*' and *'The need to secure that, so far as it is economical to meet them, all reasonable demands in Great Britain for gas conveyed through pipes are met.*' Ofgem must also have regard to both current and 'future' consumers but does not have an explicit resilience duty. Social and Environmental Guidance from DECC requires the regulator to carry out its functions in a manner best calculated to bring about better resilience of electricity and gas networks and infrastructure.

Ofgem also awards the licenses for the interconnectors that play a crucial role in maintaining gas capacity. The Office of Oil and Gas, which was established in April 2015, covers upstream reserves, including shale gas, and is responsible for the competitive system of license awards for on-shore and off-shore gas.

The unbundled structure of the electricity and gas industries has created specific roles and responsibilities for resilience, albeit these are disaggregated. Licensed actors have particular responsibilities to deliver and to coordinate on security of supply, as defined by statute, licences and statutory codes. Standards for reliability and security are nationally based and largely 'binary' (you are either on supply or off). Quality of supply standards are set out in statutory regulations, with defined tolerances. Delivery of long-run resilience for the end-customer is dependent on successful coordination among a number of actors across the supply chain, plus the adequacy of market frameworks. Where the market does not provide the right signals, government or the regulator steps in.

## 3.2 Water supply

The current integrated nature of the water sector means that much of the responsibility for resilience in water supply primarily sits with companies (the statutory undertakers). Standards for drinking water and environmental quality, as they impact on resilience, are set at a national level by quality regulators. However, given the differences between undertakers in terms of resources, terrain, assets, demand and incomes, standards for other aspects of resilience, beyond minimum emergency service levels, are not defined in detail and are instead determined on a company and catchment Outcome Delivery Incentives (ODI) basis. The approach to this, however, is evolving, as set out in Ofwat's new Water 2020 regulatory work. In summary, the interplay between quality and quantity issues means that the approach to standards in the water sector is therefore more nuanced and catchment-specific than in the energy sector.

DEFRA currently sets the parameters in terms of what is expected from companies in terms of drought planning (ranging from temporary use bans to rota cuts) based on

historical drought data. Companies prepare Water Resource Management Plans (WRMPs) for the Department setting out how they will manage their resources over minimum 25 year periods. Although companies are held to account on these through an annual review process, in discussion it was put to us that once DEFRA has agreed these, how companies are externally managed against them is somewhat unclear – unless there is a *significant* change in circumstances. The Water Act 2014 provides the Government with powers to direct companies on their planned levels of service. DEFRA will announce its approach to the use of these level of service powers in Autumn 2016.[5] The 2014 Act also imposed a new primary duty on Ofwat to secure resilience in the sector. How this will become embedded in practice remains to be seen but the economic regulator has signalled that innovation and markets can play an important role in achieving this.[6]

## 3.3 Wastewater and drainage

The wastewater system in England and Wales is extremely complex: ownership is split between a multiplicity of actors (including water companies, local authorities and the Highways Agency) making assigning responsibility for managing resilience challenging. An open as opposed to a closed system, it can be difficult to control the type and scale of events that may impact on the resilience of the network. The current trend towards connecting and centralising wastewater plants is likely to continue due to economies of scale.

The sewerage network has only been mapped to date where there have been historic problems. These may not necessarily be the places where future problems will occur. The transfer of responsibility of private sewers and drains outside of household properties to water and sewerage companies in October 2011, where asset condition data is even more patchy, has increased the size of the mapping exercise required in order to be able to fully anticipate issues.

## 3.4 Current and new initiatives: timelines

Given the importance of resilience in the energy and water sectors to individual, social, environmental and economic health, it is not surprising that there is currently a significant amount of work already going on in this area. Some of this is 'annual' and related to the significant on-going work that companies, regulators and government already do in this area – and some is new. Key initiatives are summarised in Table 1. In addition to those activities in the Table, regulated activities in both sectors are also subject to a regular programme of price controls where resilience planning plays a key role. As noted in 3.2, regulatory approaches in these areas are also evolving.

Some of the initiatives listed point to the increased importance attached to anticipating the trends that will impact on services.

[5] *Creating a great place to live, enabling resilience in the water sector*, DEFRA, March 2016

[6] *Towards resilience – how we will embed resilience in our work*, Ofwat, December 2015

**Table 1: Some of the key current and new initiatives to help secure resilience in the energy and water sectors**

| Actor | Initiative | Timing |
|---|---|---|
| **Relevant to both energy and water sectors** | | |
| NIC | National Infrastructure Assessment (NIA) – Recommendations | 2018 |
| NIC | NIA - Vision to 2050 | Summer 2017 |
| DEFRA | Climate Change Risk Assessment published | January 2017 |
| NIC | Process & methodology for NIA - Consultation | Ends 5/8/16 |
| CCC | Climate Change Risk Assessment evidence report to DEFRA | July 2016 |
| CCC | Annual review on progress for the Fifth Carbon Budget | June 2016 |
| DECC | Draft legislation for the Fifth Carbon Budget | 2016 |
| Cabinet Office | National Flood Resilience Review | Summer 2016 |
| Academia | Research into infrastructure inter-dependencies and associated need for governance changes | On-going |
| **Energy** | | |
| National Grid | Future Energy Scenarios. Electricity and gas ten year statements. Systems Operability Framework (Electricity) / Future Operability Framework (Gas). Network Options Assessment. Winter Review & Summer Outlook. | Ongoing |
| DECC/ Ofgem | Statement on security of supply for electricity, gas and oil (annual) | October 2016 |
| DNOs | P2 Security of supply engineering standard reform - consultation (which could see renewable and demand-side network connection standards vary between local areas) | Ends June 2016 |
| **Water** | | |
| Companies | Consultation on Water Resource Management Plans | 2018 |
| Ofwat | Consultation on PR19 methodology | Summer 2017 |
| Water UK | Twentieth century drainage project reports (40 year needs assessment for DEFRA) | Spring 2017 |
| DEFRA | 25 year Natural Environment Plan (Departmental response to the Natural Capital Committee's recommendations) | Winter 2016 |
| DEFRA and Welsh Government | Publication of Strategic Policy Statement to Ofwat (in the Autumn, DEFRA will also decide on whether to publish a National Policy Statement for water) | Winter 2016 |
| DEFRA | Announcement of approach on use of level of service powers | Autumn 2016 |
| Ofwat | Consultation on outcomes for PR19 (including proposals on resilience and balance between bespoke and common outcomes and role of comparative information) | November 2016 |
| Ofwat Resilience Task & Finish Group | Review of progress one year on | Autumn 2016 |
| Water UK | Water resources long-term planning framework reports (50 year needs assessment and strategic options appraisal for DEFRA) | Summer 2016 |

*Source: Sustainability First*

# 4. Existing approaches to support resilience

This Section briefly summarises the most significant **current** approaches to withstanding problems and maintaining services to secure resilience. For both energy and water resources, these roughly fall into the following broad headings:

- **Supply side;**
- **Demand side;**
- **Supply – demand balance; and**
- **Response and recovery.**

An open system, drainage doesn't fit neatly into the first three of these categories. In this Section, it is therefore included under a separate heading.

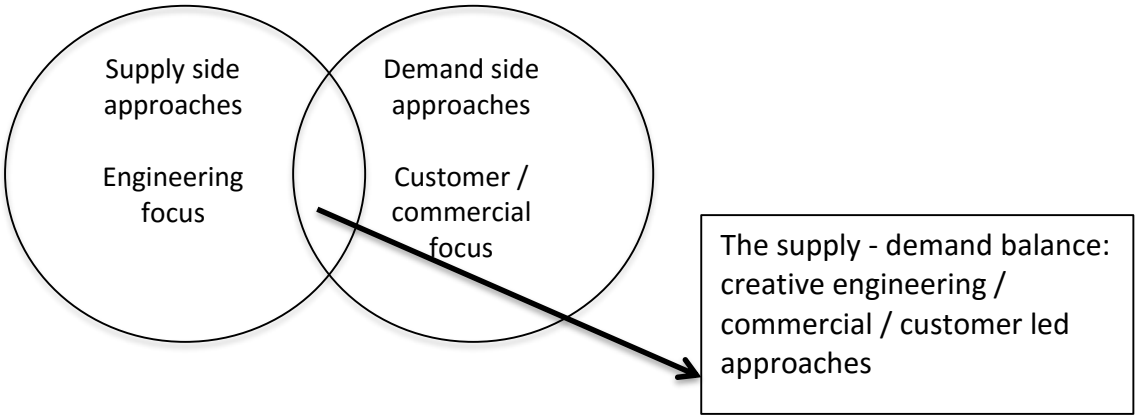
Diagram 2 illustrates the existing relationship between the supply side, demand side and the supply–demand balance for energy and water resources. The two circles have some inter-dependencies. Most obviously, the more effective demand management is, the lower the need for new resources and supply side solutions. Total expenditure (totex) approaches to costs in both sectors are starting to make it easier to choose between supply and demand side approaches. The size of the respective circles, and the intersect between them, can also each vary - both between sectors and within sectors.

At the risk of gross simplification supply side solutions have perhaps *historically* been the main focus of resilience work and these have *traditionally* had a strong engineering focus, providing solid and reliable approaches to service delivery. In the past, these approaches have predominantly led to hard solutions. This is starting to change as more natural supply side solutions are developed (particularly in water). The extent of the benefit of a specific supply side measure will in part depend on the degree of connectivity in the network. Historically, supply side solutions have involved the construction of large expensive assets with long asset lives. The opportunity cost, and frequently also planning implications, of such measures can therefore be significant. Deciding on where best to site these, so they can withstand future uncertainties and shocks, is also an issue.

Demand side solutions can be 'softer' and arguably may have a more commercial or customer-led focus and may have provided a more agile approach to resilience. As demand can clearly be variable, solutions in this area may be fragile and not be as 'dependable' as those on the supply side. However, they can potentially provide a more flexible response which can be targeted at particular problems (in a geographical area or time of day / year, for example).

Some Network members have noted that the prevailing paradigm at the moment, particularly in energy, starts with the supply side and is often top-down and centralised with the demand side focused on dealing with the short-comings / failures of the top-down system. This is starting to change and with new behavioural economic insights and communication technologies, far more focus is being given to the demand side.

**Diagram 2: Overview of existing approaches to support resilience in energy and water resources**




*Source: Sustainability First*

Resilience challenges in energy and water are not new. Ensuring that there is adequate capacity and that supply and demand are in balance is clearly vital for resilience and has always been a core task of service providers working in the water and energy sectors. However, new techniques, such as small scale storage, are starting to blur the distinctions between supply and demand side approaches.

It is widely recognised that many assets in these sectors are ageing, whether these be networks, plants or treatment works. Active discussions are underway about asset replacement programmes to ensure security of supply. The extensive investment programmes that will be required to address this point, along with the need to meet the evolving challenges outlined in Section 5, provide an opportunity to look afresh at the balance of supply-side and demand side approaches.

This Section is intended to be a high level overview to provide an informed back-drop to subsequent discussion on what may need to change. Getting people from different sector and professional backgrounds 'on the same page' and developing a common language would seem important if in the future more cross sector approaches are likely to be needed (see Section 6.2). Case studies are used to illustrate some of the good work already taking place. In writing this paper, it became clear that many thought that this good practice was often a 'drop in the ocean' of what needed to be done or was 'just pepper potted around.' Although the case studies may be familiar to the actors in each sector, they have been included to stimulate discussion on how: the different sectors can learn from each other; and good practice can be embedded and mainstreamed more widely (recognising that sometimes there may be good reasons for local differences in approach).

## 4.1 Supply side

There are broadly three different elements to supply side approaches to resilience in the energy and water resource sectors:

- Capacity / resources – is there enough resource?
- Networks – is network capacity where it is needed – and / or can the resource be cost effectively transported to where it is needed?
- Storage – can the resource be stored so that it is available when needed (eg at times of peak usage) and / or to protect against disruptions, shocks and intermittency.

### 4.1.1 Supply-side: Electricity

Issues around the potential shortage of generation **capacity,** although often picked up by the media, seldom cause black outs. Conventional generating plant is large-scale 'lumpy' investment, so prone to cycles of under-/ over-investment depending on market signals. Thirty years back, capacity adequacy was centrally planned. In today's 'unbundled' structure, security of supply and resilience are delivered through a mix of obligations within electricity market frameworks.

The closure of unabated fossil plant (EU directives) and ageing nuclear plant is leading to concerns about a short run capacity shortfall. The move to low carbon generation is also leading to resilience challenges. Electricity market reform introduced subsidies (contracts for difference) to accelerate the development of large low-carbon plant, which is growing as a proportion of capacity and of operation. However, the unexpected high uptake for Photovoltaics (PV), especially household PV, and political unpopularity of onshore wind, caused government to re-think subsidies.

The intermittent nature of renewables is leading to further resilience challenges. Lack of long-run wholesale price signals to encourage flexible investment prompted an additional subsidy (the capacity mechanism). The difficulty of storing electricity remains a challenge. **Storage** technologies are still evolving (eg in the field of the chemical science of batteries) and these will have knock-on impacts on the scale and cost of the solutions that will emerge.

**Case study – SSEPD and domestic electricity storage**

SSEPD is involved in the Innovate UK project Energy Resources for Integrated Communities (ERIC). Part of this study is investigating whether customer owned storage may increase resilience by giving Distribution Network Operators (DNOs) operational support at times of fault, or provide more support for vulnerable customers, and to build knowledge on how aggregated domestic storage combined with PV generation may develop as a commercial market.

A potential equivalent in the water sector could be the development of small scale reservoirs by farmers, growers and other landowners. However, the extent of connectivity in the sector, and the problem of mixing water with different chemical compositions, could limit the opportunities to do this.

**Transmission and distribution networks** are designed, built and operated to nationally adopted engineering-based standards and regulations, themselves rooted in underlying probabilistic assumptions on a possible supply loss (e.g. a 1 in 10, 1 in 20 system peak). These standards under-pin short-run operations (i.e. that system peak can be met) and also underpin planning for long-run resilience. The standards currently ensure there is sufficient in-built redundancy in physical network capacity that two circuits (transmission) or one circuit (distribution) can be lost in operational time-scales without a knock-on loss of supply[7].

In the medium-term, capacity challenges for the networks include modernising ageing assets, enabling network connections at the distribution and transmission levels for renewables at 'new' locations (eg the South West) and potential asset stranding. The latter may be triggered by long-run uncertainty on: the location of both generation and demand; possible major new electrical loads; and bi-directional network flows. As more renewables come on line in Scotland, and demand continues to grow South of the border, the issue of the bootstrap between England and Scotland becomes more important.

### 4.1.2 Supply-side: Gas

**Capacity adequacy** of gas supplies is potentially significant. Challenges include long-run sources of gas supply (declining UK reserves, increasing reliance for imported supplies on three interconnectors and Liquefied Natural Gas [LNG] terminals). Imports can be prone to geo-political risk and price hikes. Some commentators question whether equating domestic supplies with secure supplies is correct, and point to the potential impact of 'home-grown' risks (e.g. under-investment in new import infrastructure; lack of UK storage etc). In this context, it is important to distinguish between supply security and price security. New sources of non-conventional gas, whether this is from sources such as bio-methane or shale, still pose technical challenges. Gas **storage** is an on-going resilience discussion: the UK has significantly less gas storage capacity than other European countries.[8]

Gas **network** assets are ageing, but there has been an extensive replacement programme of the old iron gas-mains. In terms of their long-run role and resilience, there are major unresolved questions about the future for the UK gas networks. These differ fundamentally from the capacity-related resilience questions for the electricity or water networks. Faced with long-run decline in future UK gas demand (efficiency, switch away from gas for heat, less gas-fired power generation) two key questions arise for gas network resilience: first, poor line-of-sight and uncertainty about their long-run future role - unless commitments are made to adapt to potential alternatives (i.e.transport of renewable-gas, hydrogen, CCS, cable ducts etc); and second, given that gas fails 'dangerously', how to meet long-run costs of upkeep with long-run declining revenues.

[7] On radial feeders, not at the very local level (i.e where households are connected).

[8] Dr Jim Watson, op cit.

### 4.1.3 Supply-side: Water

Water Resource Management Plans (WRMPs) set out how each company is going to manage their future **capacity** requirements. However, DEFRA has noted that the WRMP framework '…. *has not fundamentally increased the resilience of water supplies in parts of the country*'[9], and is now actively reviewing their approach in this area. As the price review process also plays a key role in funding improvements for resilience and agreeing a fair price with customers, this is also evolving (see Section 3.2).

Differences between local resource levels, geographies, asset conditions and demand mean that capacity resilience challenges vary considerably between Water Resource Zones. Supply side approaches for a water company can include:

- ground water (relatively cheap as filtered by acquifers and near point of use);
- surface water (from reservoirs or rivers so in need of treatment to be pushed / pumped to where demand is);
- transfers from within the company or from another company or a third party (eg surplus from a brewery). Section 4.3 has more details on this issue;
- indirect reuse schemes (more expensive still and therefore primarily restricted to droughts. Note – in Dubai there are direct reuse schemes);
- desalination plants (Thames Water has these);
- storm water harvesting, whether upstream or in urban areas;
- aquifer recharge (Southern Water has a water 'bubble' in Worthing); and
- softer, sustainable and more natural measures such as catchment management approaches and sustainable drainage schemes.

Aquifers and reservoirs clearly provide **storage** capacity. There are significant planning issues for the latter. Farmers may of course have small private reservoirs on their land that can provide security for relatively short periods but these are unlikely to be large enough to withstand more than one dry summer, for example. The need for up-stream reform and changes to **abstraction** licenses to manage resource issues more effectively is the subject of continuing debate in the sector.

Water, unlike energy, is a heavy good and expensive to transport. Therefore, the extent to which water **networks**, even within a company area, are connected is limited. Mixing water with different chemical compositions can also be problematic. There is no national grid for water. Some areas, even with high population densities, still only have a single source of supply. For example, the Elan Valley Aqueduct is the single source of supply for Birmingham making the current scheme to introduce new network connections in the area important to enable resilience against not only resource restrictions but also to accidents / threats.

[9] *Creating a great place to live, enabling resilience in the water sector*, DEFRA, March 2016

**Case study - Wessex water grid and saving energy**

The water supply grid is a £230 million 200 kilometres plus project that will enable demand for water to be met over the next 25 years without the need to develop new resources. The eight year project, due to be completed in 2017, comprises more than 50 individual schemes across Somerset, Wiltshire and Dorset and will allow the company to redistribute surplus water to where it is needed. The grid will improve the security of supply for customers, ensuring they have two sources of supply, and meet reductions in abstraction licences required by the Environment Agency to improve flows in some rivers and protect their ecology. It will deal with seasonal or occasional deteriorating raw water quality, particularly increasing concentrations of nitrates at some groundwater sources. There is clearly water trading potential here too.

A new Optimiser control systems has been devised that will manage and optimise the transfer of water along the transfer main. It will be controlled centrally, scheduling transfers in the most efficient way while ensuring security of supply, minimising any risk of water quality issues and keeping energy costs to a minimum. Bi-directional links will maximise flexibility. This means there will be some flow reversals that result in a requirement to reduce the water pressure within the pipeline. There are plans to install energy recovery turbines within the pipeline with the power generated being used to offset power usage at the pumping stations.

*Source: Wessex Water website*

## 4.2 Demand side

There are perhaps more similarities in demand side approaches to resilience in energy and water than there are on the supply side. However, there are still some significant differences. The universal nature of volumetric charging in energy, and the smart metering programme, which can be instrumental in encouraging demand side activity, are a key current differentiator between the sectors. In water, metering is still not universal: in March 2014 only 41% of customers in England and 34% in Wales had a water meter.[10]

The dependence on secure electricity and water supplies, challenged by climate, demographic and digital factors, is increasing the interest in how demand side approaches can deal with resilience in a cost effective way. The development of new technologies and data analytics, to both anticipate trends and identify where resilience problems and solutions may be, are further increasing the interest in this area and stimulating the development of new commercial approaches. Both energy and water sectors are using insights from behavioural economics to influence

[10] *Water meters: the rights of customers and water companies,* House of Commons briefing paper, October 2015

demand, with companies like Advizzo and Watersmart providing services in this area. Smart meters can open up new approaches to resilience such as the ability to: ration flows to preserve supplies at times of shortage (recognising that there could clearly be potential consumer protection issues here); diagnose problems in network performance; or identify priority needs.

Clear links also exist in energy and water efficiency. Water heating is the second largest use of energy in the home (after space heating) so can significantly contribute to energy savings[11]. The extent to which the smart meter roll- out in energy will lead to the development of joint smart services for the two sectors remains to be seen.

### 4.2.1 Demand-side: Electricity and gas

As electricity and gas are **metered** and paid for by usage, there is an incentive on consumers to reduce their consumption to save money. In principle, this should reduce the overall demand for energy on the system and the size of the resilience challenge overall. Innovative demand side response (DSR) electricity **tariffs** are already being trialled and used with both domestic and non-domestic customers to help avoid even higher peak usage, and so support the resilience of the network (see Section 4.3). With the roll out of smart meters, these types of offers are likely to increase. Energy service packages, for example including smart thermostats (eg Hive and Nest), are now starting to develop. If smart grids and electric heat services take off as predicted, there could be even greater scope for demand side interventions to manage resilience.

Government energy **efficiency programmes**, such as home insulation measures targeted at key vulnerable groups (eg those on low incomes), have not only helped to make bills more affordable but have also made individual consumers better prepared to be resilient to cold weather. However, since the collapse of the Green Deal flag ship energy efficiency programme, there is no clear line of sight of policy in this area.

The resilience of electricity networks could be strengthened further if technical **losses** were reduced. A mechanism to encourage the management of this difficult issue was introduced in the last distribution price control (ED1).

### 4.2.2 Demand-side: Water

Although the number of homes with water meters is increasing, there are still significant differences in **metering** levels both within and between company areas. Until metering using more advanced technology is more widely introduced, the scope for **tariffs** designed to help further manage demand and increase resilience is likely to be limited. For example, when Southern Water carried out seasonal tariff trials, these proved very unpopular with customers and seen as unfair as only those with Automatic Meter Reading meters could be billed using the tariff and customers

[11] *Green Deal guidance for the water sector,* Water Wise and the EST, 2012

wanted time to get used to be being metered before new tariffs were also introduced. The company therefore decided to progress with its universal metering programme without making any changes to tariffs and continues to test the view of its customers and stakeholders on this subject.[12]

Nearly all water companies already do extensive work with their customers to **educate** them on water issues (including with schools to raise awareness of issues such as resilience) and to promote water **efficiency** through offering audits, advice, information and free or reduced cost water saving devices. It is interesting to note that in France, incumbent supplier Suez has taken this one step further and has helped to 'mainstream' water efficiency by itself selling rain water harvesting and water efficiency kits and services through national French DIY retail chains.

**Grey water** re-use systems that could help reduce demand significantly have been slow to take off. Cambridge Water (owned by Cambridge University) has installed a grey water system that is one of the biggest schemes of its kind in Europe. However, this would appear to be an exception in the UK. Such systems need an expensive network of pipes that many new-build plots would not have the space to accommodate. To be cost effective, some of those interviewed for this paper thought that they may also need to be introduced at a minimum scale of around 10,000 houses. Post the 2008 recession, many new residential developments are now below this size. There was also a view amongst some of those that we talked to that maintenance of grey water systems might pose challenges for the skills and work practices of today's generation of plumbers.

Managing **leakage** levels is clearly an important way of maximizing resilience in the water sector. Many companies are now looking at going beyond the 'economic' level of leakage, in part to 'show willing' with customers that they are also doing their bit for demand management. Companies such as Anglian Water are also using pressure management to reduce leakage further and improve the efficiency of the network. Reducing the demand for water can also help tackle sewerage network capacity issues and thus improve the resilience of the wastewater system.

[12] Interview with Southern Water, 20th May 2016

**Case study – Affinity Water: Metering, tariffs and education**

The water-metering rate in Affinity's three operational regions ranges from 42 to 93%, largely in response to the resource challenges in each area. Following an extensive consultation on its WRMP, the company found that 77% of respondents believed a compulsory metering programme should be universal rather than limited to areas of severe water scarcity only. Willingness to pay and bill acceptability studies have demonstrated clear preferences for demand management measures (leakage and water efficiency) over increasing abstraction from rivers. As a result, Affinity has designed a Water Savings Programme to help customers save water, energy and money, along with a commitment to reduce leakage by 14%.

In the company's most heavily metered Southeast region (formerly Folkestone and Dover Water), there has been a year-on-year reduction of water put into distribution and a reduction of more than 16% in domestic customer consumption. Affinity has run the following trials here to understand how meters might influence customers' behaviour:

1. Smart communications trials in Lydd. Personalised consumption information compared household usage to that of similar occupants. Identified a small impact but demand in the area was low anyway.
2. Stepped two-tier tariff. Essential use was charged at 75% standard measured tariff and discretionary use at double the standard tariff. A minimal impact on demand and customers did not respond well.
3. Retrofit water efficiency devices. Positive comments but low savings.
4. Folkestone smart meters. 6000 domestic customers had smart meters installed but the data was only used by the company to identify leakage.

The educational awareness programme includes the company's Education Centre in Bushey, which receives around 6,000 visitors each year. The team also visits 7,000 pupils each year at schools in the community, as many customers wanted to see more done to educate the next generation. Affinity Water has recruited qualified teachers on a permanent basis to reflect the company's commitment to educating future generations.

Source: Affinity Water final Water Resource Management Plan, 2015-2040, published in June 2014

## 4.3 Supply-demand balance

### 4.3.1 Supply-demand balance: Electricity

National Grid as national electricity transmission system operator is charged with (and incentivised) to keep supply and demand in the **system in balance** at all times: both in operational and in long-run capacity planning timescales. Evolution from a top-down national transmission-connected electricity system, to a more bottom-up distributed system with bi-directional flows, poses new challenges for the resilience of the electricity system at every level, both short-run and long-run. The rapid rise of

solar PV in the South West, and the constraints this has placed on the system there, has led to calls for a better understanding of trigger points for connection decisions. Taken to the extreme, in the future, each existing Grid Supply Point could become a node where supply and demand are balanced by a Distribution System Operator.

Ofgem's Smart Grid Forum Work Stream 7 on a 2030 Electricity System and GB System Architect work by DECC, ETI et al is examining some of these technical system-wide operability and resilience issues. Companies are pursuing many new initiatives to ensure an affordable long-run resilient supply-demand balance, including the need for more innovation (both technical and commercial) and greater flexibility.

**Flexibility** is important in electricity not only for deferral of new capacity building (until a clearer picture has emerged of future demand and energy patterns) but also for cost-efficient system operations, as it reduces on-going costs. Debates are currently taking place as to how much flexibility there can be within the existing engineering led paradigm for distribution network build (e.g. the P2 security of supply standard).

**Case study – SSEPD and Constraint Managed Zones**

SSEPD have introduced CMZs (Constraint Managed Zones) where network requirements related to peak electrical demand under fault conditions are met through the use of demand side response or export to grid services, provided as a managed service to SSEPD by a CMZ service provider. CMZ services are procured through the open market on a technologically agnostic basis, and the commercial contracts allow service providers to participate in other markets outside the specified CMZ service window, thereby accessing different income sources to support their business case for investment in the technology (e.g. STOR & TRIAD). CMZ solutions may include demand reduction schemes or export from generation or storage, with service requirement monitoring and signaling integrated into normal network operations.

The optionality value provided through the use of third party services creates a lower-cost solution for meeting security of supply standards locally and improving resilience of the network. This business as usual approach to resilience adds flexibility so the company can assess how demand is evolving and delay investments until there is greater clarity (capex deferral or avoidance).
Such technologies may, in future, also be used to manage network peaks where these occur rarely or for short periods of time in a given area or thermal and voltage constraints to improve asset health, benefitting the levels of service provided to customers and helping to extend asset life. SSEPD developed CMZs using totex, not innovation, funding. The company is discussing with Ofgem how to compare the outcomes from CMZs with traditional resilience solutions.

### 4.3.2 Supply-demand balance: Gas

The challenge of balancing supply and demand in gas is made more complex due to a long-run future likely to be ever-more dependent on **imports**, but at the same time physically interconnected to price-driven markets in continental Europe. This issue is outside the scope of this paper.

### 4.3.3 Supply-demand balance: Water

Water **trading** between companies as a way of addressing the supply – demand balance is still limited. Indeed, DEFRA has commented that the WRMP framework has not '*…driven a step change in how water is traded between regions*.'[13] There are clearly tensions between the benefits of market based trading (increased information and price discovery) and the draw-backs (the need to preserve resilience within region at times of drought and the benefits of collaboration and partnership arrangements across multiple agencies during times of crises). There are also some limitations on trading / interconnectivity in water (eg chemical composition) that need to be managed if different sources are to be mixed. Water UK's long-term water resource planning work is examining the supply – demand balance in the sector and addressing issues such as the cascade impacts that can occur when developing an overall approach to 'drought coherence' between donor and recipient areas. Ofwat have said that '*The resilience duty requires us and the sector to think beyond the structure and functioning of assets – to consider whole systems and services*.'[14]

Some companies are already using existing networks to develop more holistic approaches to supply – demand balance challenges. For example, Kent County Council is working with Southern Water, South East Water, farmers and growers to explore the potential for collaboration around water trading. This is also looking at the potential for a water reuse scheme to provide additional water for abstractors in the area. At the same time, the Water Resources East Anglia (WREA) network is deepening links with other water companies, farmers, the energy sector and others to work together to improve water resilience over the long-term in the region. These groups have examined the potential for water companies to sell water to businesses outside the public water supply, transporting it either through rivers or pipes, and to develop new water resources to enable this. Some are also exploring new solutions such as buying into reservoir capacity in another region.

Discussions for this paper indicated that in the past, water and wastewater plans have often been prepared 'in splendid isolation.' Through our conversations it became clear that some feel it could be helpful to take a more holistic approach to water and wastewater planning. Others thought that it could make an already complex picture even more difficult to manage.

[13] *Creating a great place to live, enabling resilience in the water sector*, DEFRA, March 2016

[14] *Towards resilience – how we will embed resilience in our work,* Ofwat, December 2015

## 4.4 Response and recovery

At the workshop there was some discussion about the need to get the balance right between 'cure' investment as part of an emergency / short-term response (eg building walls around key equipment) and 'prevention' investments (eg reviewing land use practices upstream). Concern was expressed that following a shock, much political focus was often on the former as it was visible to the public and comparatively easy to measure.

Energy and water companies are familiar with the need to manage disruptions and outages from accidents like fires (such as in the UK's most important gas storage site in 2006) and plant failures. In energy, for example, the mutual aid arrangements in the NEWSAC network help companies share generators at times of crisis. In water, the case study from Anglian below demonstrates what that company did to put in practice the lessons learned from another company that had a fire in their treatment works on which a major city was dependent.

**Case study - Anglian Water Norwich resilience scheme**

Anglian Water's long-term resilience strategy is to develop a fully integrated water supply system resilient to the effects of outages, growth, climate change and reductions in abstraction for environmental protection. In 2007, Anglian's supply system included areas where customers depended on a single treatment works for much of their water supplies. These sites were robust to process failure, but they provided little protection against the effects of a catastrophic event, such as a large fire, flood, or act of terrorism. The Norwich zone was one of these, depending on a single treatment works, Heigham, for 70% of its water; the supply for around 200 thousand people was at risk. Catastrophic loss of Heigham could lead to loss of supplies for an extended period (>3 days).

To increase Norwich's resilience, Anglian Water invested around £15m in a new stand-alone treatment works and associated supplies and transfer network. This is kept 'ticking over' with a small throughput but can rapidly be put into full use and supply Norwich in the event of a catastrophic event at Heigham. Anglian has modelled the impact of a complete outage for each of its water treatment works and has a programme of investments to fill any deficit outages would cause. The importance of resilience to our customers is reflected in two Outcome Delivery Incentives: on serviceability and interruptions to supply.

Other threats to resilience, such as the need to prepare for cyber attack and terrorist incidents, are already present. **The Centre for the Protection of National Infrastructure (CPNI)** oversees the national security of infrastructure and key assets in the face of dangerous threats and preventative security measures in regard to physical security, personnel security and cyber security.

### 4.4.1 Cyber security

Cyber security is already a growing issue of concern, and there is significant work going on to address this issue. Table 2 provides some examples of cyber attacks on global utilities in recent years.

In energy, the biggest threat could potentially come from loss of command and control over the national or local grid (eg from malware or social engineering). Smart meters have been designed in such a way to minimize such risks. They are 'detached' and one-tier away from the direct operation of the distribution network so better placed than some European systems for this to lead to an increase in cyber attacks. The proposed European Network and Information Security Directive addresses the key role that electronic communication and computer networks now play in all infrastructure sectors and is expected to introduce new resilience and reporting obligations for cyber incidents in the energy sector in the near future. [15]

According to a cyber security lead from a major energy retailer: '*We see cyber security as our obligation to our customers and we include this philosophy in all we do. We have recently rendered our support to PETRAS, a £9.8m EPSRC research into cyber security of the Internet of Things. The latest cyber security philosophy is to increase the focus on detection and the ability to respond to incidents quickly – identifying the scenarios that could cause problems….With the move to an increasing demand of customer self service online, our system perimeter is extended to our customer homes and we will continue to protect the interests of our customers.'* [16] Emerging utility models and aggregators will need to think about these issues – but with new systems they may be able to make them secure by design. Some incumbents with old legacy systems may have hidden vulnerabilities. Questions remain as to whether new entrants will have the same obligations in this area as incumbents.

[15] *Cross-sector resilience report – phase 1 -,* UKRN, April 2015

[16] Interview with Cyber Security team member. Energy retailer, 17 May 2016

**Table 2: Some examples of recent cyber incidents in global utilities**

| Date & location of attack | Details |
|---|---|
| January 2016<br>Israel Electricity Authority | Regulator's office.<br>System affected by malware. |
| December 2015<br>Ukraine | Attackers used stolen user credentials to remotely access and manipulate the industrial and control systems and shut down power. Seven 110kV and 23 35kV substations were disconnected for three hours. |
| October 2015<br>UK | Phishing attacks on BG led to the E Mail addresses and account passwords of around 2,200 customers to be posted online, in the same week as Talk Talk and M&S suffered similar incidents. |
| 2014<br>USA & Spain, France, Italy, German, Turkey & Poland | Software of a number of industrial control system equipment providers was infected. Attackers could have caused damage to energy supplies. |
| November 2011<br>Illinois, USA | Hackers destroyed a pump belonging to a regional water utility by obtaining access using stolen log in names and passwords |

*Source: Sustainability First*

### 4.4.2 Resilience against other malicious attacks / terrorism

Energy and water companies need to plan extensively for the threat of malicious attacks. These can take very many potential forms – ranging from the very local to the nationally catastrophic. Such threats are not new. For example, in 1996 there was a foiled IRA attempt on six major substations – using information obtained from the public library.

This issue is well recognised. In water, for example, the Security and Emergency Measures (Water and Sewerage Undertakers) Direction 1998 require licensed water providers to provide plans to ensure provision of the water supply during an emergency or security event. One of four key areas in the Government's counter-terrorism strategy is to increase the resilience of the UK's Critical National Infrastructure. The CPNI provides advice on these matters. The regional approach to Critical Infrastructure Resilience (CIR) proposed in the Scottish CIR Strategy from 2011 has attracted international attention and is the first of its kind in the UK.

In the main, utilities do tap into top expert advice and incident planning exercises clearly do take place. However, some have been critical of some current British approaches to disaster alert technology, arguing that the technology to intelligently shut down systems without the public coming to harm is available and should be used.[17]

[17] *UK water networks 'vulnerable to terrorist attack,'* Utility Week, July 2015

### 4.4.3 Local response and recovery

At a local level, many companies play active roles in the Local Resilience Forums that co-ordinate activity of key responders during emergencies. The extent to which these Forums are able to be proactive, including on high impact low probability events, and able to engage in joint planning, or able to share the lessons from their experiences more widely, is unknown. Some participants in the workshop thought more clarity was needed on the future role of the Forums and suggested that these should be able to identify and equip designated 'community' focal points (such as schools) to have back-up power and resources in an emergency.

## 4.5 Wastewater and drainage

The resilience of the wastewater and drainage sector has come a long way in the last few decades. However, given the complexity of the system, securing its resilience is challenging. Water UK's current 21st century drainage project is looking at strategic options for resilience, including the redesign and simplification of the current framework, such as putting all assets under one ownership umbrella – whether this be local authority, water company or another body. This should help ensure that the good practice that is currently taking place is spread more widely.

The approach taken to drainage resilience depends on whether the problem is caused by ground water (in which case solutions may be limited to tankering out sewers) or surface water. The latter can be managed by taking a holistic approach to **catchment management**. Small sustainable drainage schemes, that often fail to attract the same level of attention as big capital projects, can be very effective here. Payments for ecosystems services (PES), market based incentive schemes to encourage third parties to play an active role, have been successfully used by some companies to encourage activity in this area.

## 4.6 Conclusion on existing approaches

The energy and water sectors are currently in somewhat different places in regards to resilience. From our very high-level analysis it would appear that the water sector can learn from the energy sector's experience with markets and the involvement of third parties. The energy sector in turn can learn from the water sector's experience with working collaboratively with a wide variety of actors to reduce the impact of geographic resilience challenges such as flooding.

When identifying the approaches to resilience, both sectors need to be aware of how they are direct users of each other's resource. The Environment Agency's work on future demand for water from electricity generation is a good example of the existing research that is already available in this area.[18]

[18] For example, see *Water use and electricity generation,* Environment Agency, December 2013

**Case study – Welsh Water and Rainscape**

RainScape is Welsh Water's approach to sustainably managing the surface water entering the sewer network. RainScape catches rainwater in areas such as Llanelli, Burry Port and Gowerton and slows down the speed at which it goes into the sewers, reducing sewer flooding and pollution and creating greener, cleaner communities to live in. The project has learnt from work from around the world - from Malmö, Sweden to Portland, USA – and uses a mix of traditional methods, along with green infrastructure including, basins, planters, swales, porous paving, grass channels and underground storage.

**Case study – South West Water and Upstream Thinking**

The Upstream Thinking partnership brings together South West Water, the Devon Wildlife Trust, the Cornwall Wildlife Trust, the West Country Rivers Trust and the Exmoor National Park Authority to change land management practices to protect rivers. Whether it's alleviating soil compaction, restoring wetlands or encouraging water-storing sphagnum mosses, Upstream Thinking approaches can significantly increase water storage and reduce run-off. In the Working Wetlands project in central Devon, for example, researchers showed that 11 times more water leaves intensively managed grasslands than Culm grasslands during storms.

*Source: Welsh Water and South West Water Website*

## 5. What are 21st century long-run resilience issues for citizens & consumers?

Section 4 summarised how the water and energy sectors address long-run resilience today. Clearly much work is already in hand in this area and the sectors are largely 'looking after themselves'. Government, regulators and companies, however, each recognise that this picture is starting to evolve due to **climate and technological change.**

In our discussions for this paper, the following **new and / or emerging key factors** were identified as being driven by climate and technological change and thought to be the most likely to impact resilience in water and energy for citizens and consumers in the longer-term:

- **Electricity dependency and as an IT / communications enabler;**
- **Complex interdependencies;**
- **Emergence of new actors;**
- **'Black swan' events and new and growing types of extreme risk; and**
- **Citizen / customer expectations and perceptions.**

Each sector clearly needs to be on the right track with its own approach to resilience, but, in addition, also needs to take account of these 'new' and wider issues. Taking

these topics in combination suggests that it is helpful to look beyond a narrow sector-specific approach when starting to think about possible 21st century approaches to resilience (which we do in Section 6).

## 5.1 Drivers for change: climate and technological change

**Climate change** is already having a significant impact on water resource issues, through droughts and changing rainfall patterns etc. This impact is likely to grow. In energy, it is leading to the move to low carbon technologies that present challenges to existing networks. Increasing temperatures are also challenging the efficacy of cooling water for power generation (e.g can cause algal blooms that require more water treatment – and which increases the amount of energy needed). Unlike demographic change, which can be relatively easy to plan for, climate change is particularly problematic as it is still unclear which future scenario will dominate, where shocks to the system will occur and their likely duration. For water in particular, climate change is adding a whole new dimension to the existing supply-demand balance. There is therefore a strong case for improving resilience in this sector.

**Technological change** is also leading to a need to rethink current approaches to resilience. Our economic and social dependence on electronics, computing, and communication networks (including wireless networks) is as never-before and continues to increase. Businesses, government, individual citizens and consumers now depend on digital systems in every aspect of their daily life and work. Although much of this is 'visible' to users (such as ATMs), much is invisible and takes place at some distance from the end-consumer. The Machine-to-Machine (M2M) market, where millions of devices constantly communicate with each other, is growing rapidly.

## 5.2 Electricity dependency & as an IT / communications 'enabler'

Electricity is the underlying enabler for much electronic and communications connectivity. When things go wrong, electricity can also 'disable' other services. Our existing reliance on electricity is demonstrated in the case studies from Lancaster and New York that demonstrate what can happen when the power goes down. The dependency of modern life on electricity is set to increase. As smart services evolve, and we move closer to a world where the **Internet of Things** becomes a reality, electricity dependence will rise. Government policies to encourage the electrification of transport (Electric Vehicles - EVs) and electric pumps and heat networks will add to the dependency in this area.

**Case study – The Lancaster flood, 2015**

In December 2015, Storm Desmond led the River Lune to flood the substation in Lancaster. Around one hundred thousand homes were without power for more than 24 hours. A study of the incident by Professor Roger Kemp has highlighted our increasing dependency on electricity. Without electric **power**, not only did electric heating and public and private lighting not work but also gas central heating systems. **Water** couldn't be pumped in high-rise buildings and door locks and lifts didn't function. Payments systems and ATMs went down and petrol pumps didn't work.

Of greater impact to the response and recovery effort, however, was the effect on **communications**. Mobile and wireless free phones lost coverage within an hour and Wifi routers didn't work – making access to the Internet in the effected area impossible. There was no operational digital radio making the only source of news for many in the area that coming from a local radio station with a generator. Students went to the hospital to charge their mobile phones as it was the only place with 'publicly' available back-up generation.

The University had to close a week early. Even though it had CHP and a wind turbine, as the system wasn't designed for islanding and there was no Active Network Management, when the 11kv feeders were lost it closed down. The hospital, which did have a generator, became a community focal point.

Analysis of the incident indicates the importance of the time of day, week and year, along with the weather situation, on the impact it had. There was an increase in community cohesion, unlike in other major overseas power-cuts which have reportedly led to violence and looting. As the impact on other areas of the country was not as severe, Lancaster was able to borrow 75 diesel generators, from as far away as Northern Ireland and the West Country, to bring back power. This may not always be the case.

Professor Kemp's report concludes '*We need a regular national review of our dependency and how we function without electricity*.' The review asks who should provide resilience: electricity companies, internet service providers or consumers?

Source: *This summary is taken from Living without electricity – one city's experience of coping with loss of power,* Professor Roger Kemp, Royal Academy of Engineering, IET and Lancaster University, May 2016

**Case study – New York, A testimony from Hurricane Sandy, October 2012**

First, the TV screen went blank. I had been watching a live report from waterfront Breezy Point, engulfed in flames from a gas line that burst when the storm started. The lights went next. My four neighbours, flashlights in hand, gathered in the hallway outside our eighth-floor apartments, , sharing a wireless radio, which needed to be wound up constantly. The streets a few blocks away were under water. The subway was shut, the phone building damaged.
In the morning I awoke to a drenched landscape and the eerie New York quiet that comes from no traffic. Fortunately, being October, we had no need for heat or air-con. I lit the stove with matches (the pilot light is electric). I ate a roll that I had laid in with other food that didn't need heating or cooling. (Thank you, Mayor Bloomberg, I thought; I'm glad I heeded your dire warnings.) Eventually, reluctantly, I trekked down eight steep flights of stairs. (No elevator, of course.) My small flashlight provided little help.

Outside my building, a passer-by said that a food shop was open a block away and I headed there. The school across the street had set up charging stations. A few buses were running, but were packed with people escaping to Uptown Manhattan hotels and friends in neighbourhoods with electricity (who knew?). Traffic lights were out. The store, however, was busy and lit by lanterns. The line to the cashiers, who calculated by hand because the registers were down, wound around the store. I'd been to the ATM before the storm, having learnt from 9/11 when no one could get cash. Everyone had the same limited information, mostly gathered from the observations of those who had walked around our neighbourhood.

The mood was light until the handyman in my building warned that anyone living above the sixth floor would soon have no water. It comes from large old wooden tanks on the roof and those tanks are pressured by electricity. I had already prepared bottles and kept them in the fridge, a lesson learned from the last big blackout. I needed to fill the tub so I could flush the toilet (but the water drained away). Our street's electricity was the last in the downtown area to return – at the end of the third day. My phone was still out more than a week later.

The storm killed more than 50 people. The area's losses were in the billions of dollars. Thousands of homes were damaged or destroyed. Some have yet to be repaired. The city's infrastructure is still under construction. In the year following the storm, the city sent out flood zone maps and emergency planning instructions. My building claimed it had installed emergency lights, but during the next blackout (caused by street construction), they were nowhere to be seen. Our board of directors periodically discusses the need for a small generator.

*Source: Elaine I., Greenwich Village, New York June 2016*

## 5.3 Complex interdependencies

The complexity and interdependencies **within the energy and water 'systems'** are increasing. This is clearly most evident in **electricity.** Here the value chains, that were disaggregated to increase efficiency and reduce costs, have already created various 'boundaries' between different actors and the need to manage the interfaces to ensure resilience for the end consumer.

The development of local renewable electricity distributed generation, and the introduction of two-way flows onto the system whereby users can both buy from and sell energy onto the network, increases system complexity further. Although this can increase resilience at the local level, it also poses challenges around intermittent supplies and the need to balance the system at both the regional and national levels.

In electricity, to deal with the low carbon challenge, a 'suite' of innovative technologies are emerging rather than one single transformative change. According to the Chair of the Energy Systems Catapult, this is leading to '*A busy and difficult path*' where multi-vectors need to be integrated in order to secure security of supply.[19] Some consider that this increased complexity means that markets alone won't deliver the necessary changes. The House of Lords Science and technology Committee has concluded '*It is imperative that the electricity system is viewed as a whole. It is important that an end to end approach is taken, so that complex interactions are not missed between the many component parts of the system*.'[20]

In **water,** the opening up of the retail market will create new interdependencies. Although this may lead to a positive increase in focus on demand side solutions, it will also lead to new joints in the system. The challenges of droughts and floods are also leading to a slowly increasing focus on upstream issues. Abstraction licensing and catchment management arrangements involve managing the interfaces between a large number of often diverse interest groups. The interface between water companies and farmers is clearly important here, both in terms of the use of water at peak (for irrigation) and the management of catchments to reduce flooding downstream. The Water Resource Networks that exist in the South East and East clearly already do a lot of good work to bring these different actors together. The South East water companies are starting to look at whether there is potential for them to develop a single Water Resources Management Plan for the region, rather than developing them separately and then co-ordinating them afterwards. At the workshop there was some discussion as to whether more could also be done to build links between the Water Resources South East and Water Resources East networks.

Just as there are interdependencies between the different actors within sectors, there are also **interdependencies between the sectors**. The water sector relies on

[19] *Global energy policy challenges and innovation*, Nick Winser, Chair, Energy Systems Catapult, Speech at the Energy Futures Lab, 22 March 2016

[20] *The resilience of the electricity system,* The House of Lords Science and Technology Committee, March 2015

the energy sector not just to power communications systems but also for the energy for pumping (both water and sewage) and for certain treatment processes. The energy sector in turn relies on water abstraction for thermal and nuclear cooling. If sludge is used as a future source of power, this interdependency could evolve further. Although the energy sector is the largest water user, it is a 'non-consumptive' user and the pressures it puts on the water system are localised. New links between the sectors are also developing. For example, Thames Water is using one of its reservoirs as the site for floating PV arrays, so reducing their need to import power.

In both the energy and water sectors, new technologies and approaches designed to increase resilience may further increase their respective inter-dependencies. For example, desalination is energy intensive and fracking or Carbon Capture and Storage (CCS) are water intensive (although according to DEFRA estimates of water usage in the latter two processes vary significantly).[21]

There are also increasing links between the **energy and transport** sectors with EVs providing a future opportunity to develop 'mobile electricity storage' devices and buses in Aberdeen running on hydrogen that has been created using spare wind power.

There is now an acceptance that a more national view is required of the '*system of systems*' and various academic networks are now working in this area (such as The Infrastructure Transition Research Consortium and the EPSRC-funded Adaptation and Resilience to a Changing Climate [ARCC] programme). However, beyond these university studies, the lack of a clearer forward look across sectors / vectors can make planning difficult. This issue, and who should be responsible for what, is explored further in Section 6.2.

## 5.4 Emergence of new actors

**IT and digital communications** are leading to innovative, but sometimes disruptive, approaches in every walk of life. This is starting to make itself felt via the emergence of new activities and new players in the energy sector, and in potential changes in the water sector. Big data, and the exponential growth in computing power, are in many ways making the task of anticipating trends, and identifying the opportunities to address resilience issues, easier. For example, new automated weather forecasting systems in the water sector enable companies to pump water in advance of hot spells.

Government and regulators have been keen to encourage **markets and new entrants** in both sectors as a way of increasing innovation and competitive pressure. On the one hand, new players and 'Non Traditional Business Models,' through innovative practices and increasing diversity, could bolster resilience. On the other hand, they might also decrease resilience. For example, by posing challenges to

[21] Between 20-17 % Discussion with DEFRA, 13th May 2016

existing players and the maintenance, integrity - and resulting resilience - of existing networks and processes. Given the rapid and dynamic pace of change that is driven by digital ICT, it can be hard for traditional industries and for established actors – be these government, regulators or incumbents – to 'keep up'. Markets can also potentially impact on the resilience of the environment (as there is no 'market for resilience' here – except possibly in fairly narrow recreational terms). These issues are explored in more detail in Section 6.3.

## 5.5 'Black swan' events and new and growing types of extreme risk

'Black swan' events, such as **significant terrorist events, solar storms** or **Artificial Intelligence** algorithms causing problems by 'having a mind of their own,'[22] are by their nature exceptionally difficult to predict. Their impact is often determined by the confluence of several unrelated causes. They are therefore largely outside the scope of this paper.

**High Impact Low Probability (HILP) risks** may be slightly easier to anticipate but it may be hard to know where or when they will happen. Some types of extreme risk are not new, but may become more commonplace in the future or, due to electricity dependency, have a greater impact. This may make them highly disruptive or even catastrophic.

Significant **cyber attacks** would be one example in the energy and water sectors. Another is the impact that **extreme weather (such as intense rainfall)** can have on services. Unlike water resource availability that can be modelled, the latter is more difficult to anticipate. With climate change it is likely to be a growing threat if the '**bunching**' of different events leads to a cumulative impact greater than the sum of its parts.

The Boscastle flash flood, following 8 hours of rain in August 2004, is one example. This washed 75 cars, 5 caravans, 6 buildings and several boats into the sea and destroyed approximately 100 homes and businesses. Helicopters had to rescue 150 people clinging to trees, cars and rooftops. The 2007 Gloucestershire floods is another. This took out the Mythe water treatment works in Tewkesbury and led to loss of water supply for 350,000 people for up to 17 days.

Given their unpredictability, mitigation, rather than prevention, may be a more appropriate response to black swan or 'HILP' events. **How you decide if something is a 'HILP' event is another question**. As extreme weather, for example, becomes more prevalent, and we get better at managing it, there could be an increasing public expectation that it should be planned for. However, at a location-specific level this could be cost-prohibitive at scale. There are challenges in getting communities and service providers to:

- come together to plan when there is no emergency;

[22] For example, *Superintelligence: Paths, Dangers, Strategies,* Nick Bostrom, 2015

- continue to 'pull together' in an emergency if some feel that the service providers in an affected area have not been sufficiently prepared; and
- decide in the future which options to adopt to address these issues, given that the costs of different options are likely to fall on different groups (eg whether you decide to let a substation flood, to build flood defences to protect it or to build it on stilts will have varying distributional impacts).

Who should address these issues is explored in Section 7.

## 5.6 Citizen / customer expectations and perceptions

Citizen and consumer expectations of energy and water services may be changing as a result of several factors. Individual views are clearly often shaped by external influences, be these new media, social institutions, advertising or learning from personal or observed experience. These are called 'endogenous preferences.'

**Those that have experienced disruptions**, whether this be flooding, water restrictions or power loss, may have different views about resilience than those that have not. Several of the water companies interviewed for this paper said that those with greater experience of water-use restrictions (eg hose-pipe bans) did not want to see frequent bans in the future, whereas those with no experience were more willing in principle to accept restrictions. The examples from power cuts in New York and Lancaster would seem to indicate that people may have different attitudes to the resilience of energy supplies depending on what is cut. The case studies would seem to indicate that having dependable lighting and communications could be more of a priority than power for cooking, for example.

**New technologies**, could also change public expectations of resilience. In energy, for example, the full impact of smart metering and smart homes has yet to be felt. Whether a new generation of people with smart security, smart lighting and heating systems etc start interacting with essential household services in a different way remains to be seen. However, it is clear that digital communications and social media are leading to an expectation, particularly among younger people, of near-constant connectivity and a demand for instant response when there are problems.

**Urbanisation** may also impact on public expectations. In rural areas, farmers for example may have their own generators or water supplies; community infrastructure may also be more resilient. In towns and cities, people have less experience of adapting to natural environmental risks. They do not necessarily know their neighbours or indeed their localities that well – and power failures or interruptions to water supply may be a more unsettling experience.

Another issue is that in a **competitive energy or water market**, consumers may perceive the services provided as the same as those in any other market. If this is indeed the case, they may expect to be able to access and use the services in question as and when to suit them. This could impact on public tolerance for any lapses in the reliability of service. When supplies go down, they may expect the market to be able to solve the problem and be frustrated if this does not happen.

Lastly, **public scepticism with established institutions and processes**, particularly at a pan-national and national level, is adding a new dimension to resilience challenges – particularly when these involve critical national infrastructure issues. Many citizens feel disconnected from MPs and Parliament.[23] This can make it difficult for people to feel empowered to engage with the political process to achieve change. Concern over the lack of progress on significant national resilience issues such as flooding can erode public confidence in the ability of the establishment to deal with difficult security of supply challenges. For example, in his evidence to the recent Environmental Audit Select Committee report on flooding, Dieter Helm noted that the government's response to flood events was like '*sticking plasters*.' The report concluded that 'there is a '*lack of effective long-term strategic planning about how to manage flood risk*.' The Committee also highlighted the lack of transparency in terms of publishing reviews and allocating flood defence spending in this area.[24] These factors may make people fatalistic about their ability to influence major change or the ability of those elected to represent them to lead on this. In the process, people may become resigned to the status quo – even if they are not particularly satisfied with it. Whether the growing agenda for local and devolved decision making is able to counter this trend remains to be seen.

# 6. Key areas in which '20th century' approaches to resilience for citizens & consumers might need to change

This Section explores how '20th century' approaches to resilience may need to change for the 21st. In discussion, three key areas emerged where either adapting existing approaches or considering new approaches might help to support long-run resilience. These were:

- **The local, regional and national landscape;**
- **An increase in cross-sector approaches; and**
- **Market approaches and other interventions.**

For each, we discuss the potential opportunities and risks for citizens and consumers that may arise.

## 6.1 The local, regional and national landscape

For all the reasons described, the energy sector, and in some ways to a lesser extent the water sector, are going through a period of significant long-run change. It is perhaps helpful to take a slightly long-term view here. Although there was probably never a 'golden age' of resilience, fifty years ago, both water and energy were largely publicly owned, integrated monopolies, responsible for all end-services to customers – organised to some extent at a regional level (other than energy production) and in

[23] For example, *Open up! Report of the Speaker's Commission on Digital Democracy*, January 2015

[24] *Flooding; co-operation across government,* Environmental Audit Select Committee, June 2016

some respects perhaps more readily able to plan for long-run resilience and clearer on their responsibilities.

In the intervening years there have been structural and market changes that mean that the operational roles and responsibilities of the companies in both sectors have changed somewhat. These drivers mean that the companies continue to evolve. As discussed in Section 5, there seems potentially to be a growing 'regional' dimension to many of the business activities for **both** the water and energy sectors. This is for different reasons and also perhaps at a different pace. As the geographical landscape for resilience changes, questions arise as to whether the general focus of resilience should also become more 'distributed.' This in turn raises the challenge of how to co-ordinate such approaches (without necessarily leading to consolidation) and who should pay for them.

### 6.1.1 Opportunities for resilience from the local, regional & national landscape

The emergence of new local and regional approaches in the energy and water sectors provides opportunities for increased **diversity**. In many ways, diversification can be a real aid to resilience. **Local and regional approaches** to resilience can be **tailored** to meet resource and community needs and in turn can be shaped by **community knowledge** of the local area – as well as local values. This intelligence may in some ways help improve the anticipation of future trends that may impact on the area. If the community feels that it has a stake in the services, and that some of the benefits of the system can be retained at their level, they may be more likely to play an active role in the **demand side** and to take part in the protection / maintenance of services and in **response and recovery** when things go wrong. Local approaches can also tap into current trends for the **devolution of citizen and consumer power** and overcome the sense of scepticism and disengagement with governance processes noted earlier. In the process, these approaches could also potentially unlock new sources of funding. Regional approaches, in terms of **water** trading between neighbouring companies or potentially from further afield, can clearly bring some benefits in terms of risk and resource sharing.

Although local and distributed approaches may bring many positive benefits in terms of resilience, this doesn't mean that there is no longer a **role for 'big-kit'** or large scale solutions, such as gas, nuclear or large reservoirs. Under some scenarios, these large-scale solutions may offer significant resilience. It is therefore important to understand any impacts that new local approaches may have.

### 6.1.2 Costs and risks to resilience from the local, regional & national landscape

Many local and regional services, in **electricity** at least**, still need to a connection to an existing grid**; either to export power or as backup when the sun isn't shining or the wind isn't blowing. The issue of how you put a cost on back-up was discussed at the workshop. Charging methodologies, the range of likely lengths of time back-up may be needed for, etc are all relevant here. A view was expressed that insurers are not yet fully integrated into such discussions.

Local approaches can increase the number of commercial hand-offs and **interfaces in the system** and can make the value and supply chain long. It can also increase the profile of existing vulnerabilities such as the risk of cyber attack as the number of points of entry onto the system increase. Storage may change the need for continued connections to the grid but at today's cost it is not yet viable – even in the off-mains-gas communities who have the highest energy bills.

The connection of intermittent renewables to distribution networks makes it more **expensive to ensure system balancing**. Current active discussions on the nature of the interface needed between the system operator (SO) and distribution system operators (DSO) in electricity are testament to this. The picture is potentially made more complicated by the fact that in the UK, changes in the electricity system are leading to the development of some clear regional differences. A 'north-south divide' is starting to emerge due to prevalence of PV in the South and resulting summer-time constraints at midday where there is low demand. In water, participants at the workshop thought that having different local and regional approaches may confuse consumers, particularly if they lead to different usage restrictions in neighbouring areas.

Perhaps the biggest risk of community approaches to resilience, however, is the impact that these can have on the **usage of existing assets**. If more people go 'off grid', this reduces the number of people among whom the fixed costs of retaining the grid can be shared. As the existing assets become increasingly redundant, the **opportunities for risk pooling and cost-smearing go down**. The cost to remaining grid users goes up. As well as these distributional impacts, there is clearly the potential for assets to become stranded if they are not sufficiently maintained. If this happens, they clearly will no longer be able to provide back-up power for local and community schemes. Some predict this could lead to a 'death spiral' for existing networks.

Given this potential risk, unsurprisingly there are currently intense debates about the costs that local schemes should meet with respect to existing electricity networks and who should pay for the transmission or distribution cables that may become more lightly loaded. In discussion, some concern was expressed that some new local actors contemplating private wire grids below supply license requirements to escape DUOS and / or TNUOS charges.

**Case study – Nevada and solar power**

In the US, there is a long standing debate on the issue of solar power and private wires. For example, in December 2015, the Nevada Public Utilities Commission (PUC) decided to change the way the grid is compensated for its services. Practically, this changed the way that solar customers were compensated for electricity exported to the grid. Users' reimbursements for feeding electricity into the grid were cut by three-quarters. Instead of netting the meter electricity (i.e. compensating customers the full retail rate for exported solar), the utility will now only compensate this electricity at the wholesale rate. Fixed charges will gradually increase (up to three times the current rate). In the UK, the issue is well understood by the regulator. Ofgem has recently signalled that they are looking into how both transmission and distribution charges should be structured in the long run, so that networks can continue to recover sunk or fixed costs, back-up costs and other resilience associated costs.

Source: For full detail: http://pucweb1.state.nv.us/PDF/AXImages/PRESS_RELEASES/300.pdf

## 6.2 An increase in cross sector approaches

It is clearly important that each sector gets its own approach to resilience 'right.' However, in addition, both sectors now also need to take account of cross-sector issues. The inter-dependencies between different services within a sector and between sectors outlined in Section 5 are now recognised as an important resilience issue for the 21st century. For example, in 2009 the report *Infrastructure interdependency analysis: Requirements, and capabilities and strategy*, was produced for the Centre for the Protection of the National Infrastructure. In 2012, *Interdependency Planning and Management Framework* was published by Infrastructure UK and in 2013 *Infrastructure Interdependencies Timelines* was published by Engineering the Future.

The Cabinet Office's Infrastructure Security and Resilience Industry Forum has been set up to foster stronger cooperation between Government, regulators and infrastructure owners and operators and is now an important vehicle for stakeholders to share resilience information and experience. Also of relevance is The Environment Agency's Infrastructure Operators Adaptation Forum, which is attended by sector regulators as well as companies to facilitate cross-sector sharing of information and experiences of overcoming the challenges from long-term climate change. [25] The extent to which either of the above Forums is able to co-ordinate proactive planning work, engage the public in deliberations, or address the wider societal elements of resilience outlined at the beginning of this paper is not known.

The **National Infrastructure Commission** (NIC) is a key positive development in this area and will have a remit that extends across sectors. It is not yet clear whether the NIC will be able to move from collating different plans to examining the benefits

[25] *Cross-sector resilience report – phase 1,* UKRN, April 2015

of moving to a more integrated infrastructure planning and delivery approach – either regional, or more national / country level.

### 6.2.1 Opportunities from cross-sector approaches

Cross-sector approaches can facilitate **information-sharing** to better anticipate trends as they impact on citizens and consumers. They can also facilitate a better **understanding of the protection levels the different sectors are working to**. This is important as it can reveal critical interdependencies and the critical paths that may exist in decisions regarding different options. They can also highlight whether some assets are 'over protected' as they would not be resilient due to problems elsewhere / outside the boundaries of that specific asset operator. Sharing information about the types of vulnerabilities / failures that may occur can help ensure that the right approach to resilience is taken in different circumstances. These include:

- **Single point failures** - where assets in a locality may be inter-dependent when faced by things like floods. In such cases, identifying the weakest link is important. For example, this could be roads being inaccessible so emergency generators can't get to where they are needed; and

- **Cascade failures -** where it might make sense to decouple assets (to 'island' a CHP system for example) and increase diversity.

Taking a cross-sector approach enables the possible **synergies** that may exist in different resilience **solutions** to be explored. For example, a focus on particular local areas where there are 'hot-spots' of issues (eg electricity constraints or flood vulnerabilities) allows decision makers to identify links in the area and plan strategically. An example of where this approach is being taken is the work on 'smart infrastructure' implementation for Ebbsfleet, where a cross-sectoral, holistic view of utilities provision in a large (15,000 dwelling + 1M sqft commercial) brownfield development is being taken.[26] Other examples of synergies in approach include the potential for sharing infrastructure 'corridors' to reduce land use and engineering costs[27] or the recycling of old assets by another sector eg broadband cables in old Victorian sewers[28] or grey water in old gas pipes. These types of approach could lead to trade-offs between the technical and social aspects of resilience. In the latter case, for example, re-using old gas pipes might not be technically optimal from a water point of view but it could be potentially socially beneficial if it meant grey water systems could be installed at lower cost.

Taking a holistic view of resilience crucially enables a more **comprehensive assessment of the value for money, and affordability**, of future changes. Indeed, some have noted that '*individual innovations [to secure resilience and low carbon] taken together are changing the risk profile of all consumers, particularly the most*

[26] *Infrastructure resilience*, Richard Ploszek, HMT, July 2015

[27] *Infrastructure resilience in an inter-dependent world*, summary of collaborative workshop, ciria , July 2015

[28] *Workshop 2: Use of data and critical inter-dependencies*, ciria, July 2015

*vulnerable, dramatically and in ways that have not been fully analysed*.'[29] A cross-sector approach should lead to questions such as: how do decision makers ensure that all costs at the boundaries are factored into a decision; whether the overall distributional impacts of different resilience approaches on citizens and consumers are fully understood; and whether there is agreement as to how the risks and rewards of new approaches should be shared between different companies and companies and consumers.

A more co-ordinated cross-sector approach to resilience can potentially facilitate a more **citizen and customer focused decision-making process**. It can encourage the examination of resilience 'in the round' and should thus factor in how the public can contribute; both on the demand side and if necessary, during response and recovery. This issue is explored further in Section 7.

### 6.2.2 Risks of cross-sector approaches

Identifying the inter-dependencies between resilience initiatives in different sectors is undoubtedly complex. There is a risk that it gets so complicated that decision-makers get bogged down in the whole process. This complexity could lead to **inertia,** or to reverting to a more **technical focus** to resilience rather than one that takes account of the broader societal dependencies outlined at the beginning of this paper. There is also a risk that in seeking to identify synergies, the debate becomes so high-level that it leads to **sector specific insights getting 'lost'** and the solutions put-forward being flawed. These are clearly real risks. The benefits of this wider cross sector approach to resilience planning therefore need to be clearly quite significant if these are to be overcome.

Taking a cross-sector approach should help reveal the size of the resilience challenge. This could potentially lead to **resistance from citizens and consumers** should the total costs of long-term resilience become more apparent. This could make the issues more political and have the unintended consequence of working against more timely, considered and impartial decision-making (eg a knee-jerk response).

## 6.3 Market approaches and other interventions

The role of market approaches and other interventions to secure resilience came up in many of the discussions for this paper. The energy and water sectors are clearly in different places here. Markets can help deliver efficiency, reduce costs to consumers and free up resources for investment elsewhere. The question of their impact on long-run resilience remains, however, to some extent unanswered. The New-Pin workshop in February 2017 will explore whether markets alone are able to deliver long-run resilience or whether other interventions may also be needed.

[29] *Living without electricity – one city's experience of coping with loss of power,* Professor Roger Kemp, Royal Academy of Engineering, IET and Lancaster University, May 2016

### 6.3.1 Opportunities of market approaches to secure resilience

Market approaches can help provide **cost-efficient, faster and more flexible approaches** to resilience, in response to changing demands and pressures, than regulation. This is important given the significant uncertainty that surrounds many decisions relating to resilience. Market approaches can help reveal information about system capacity and aid price discovery across regulated, sector and geographic boundaries, which in turn can help stimulate **innovation and a wider diversity in approach** that should aid cost-efficient planning to meet long-term trends and short term shocks. Diversity also reduces the risk of single point failure and offers choice when shocks strike.

When deciding whether to facilitate and encourage markets, regulators need to make a judgement call as to whether commercial confidentiality considerations will act as a barrier to the wider sharing of information among companies that could otherwise be instrumental in managing resilience. They also need to take into account that some commercial interventions, whilst providing benefits to resilience in a given set of existing parameters, could act as a distraction from more significant and wider systems based resilience challenges. A clear view on the size of the potential problem and the size of the potential prize, and being aware of the strengths and the limits of market approaches, is important.

### 6.3.2 Risks of market approaches to resilience

Markets tend to optimise adequacy rather than resilience, particularly at a national systems level. For some long-run resilience issues **market failures may be largely invisible**, until it is too late. In other cases, however, the risk of market failure may be seen as a risk worth taking (eg for some High Impact Low Probability risks like cyber attacks). Markets can also strip out the redundant capacity that may be needed to absorb / buffer against shocks. It may also sometimes be more effective and cheaper to address some resilience challenges through standards in other areas such as **planning, building and product specifications – rather than through the market.** This can help ensure that systems and services are 'secure by design.' Markets on their own may not be able to ensure the **interoperability** between different commercial and technical approaches that may be in the public interest.

There are also questions as to how far markets can sufficiently address the **capital adequacy** needs associated with resilience (major energy, water, flood defence). Scenario planning and modelling can help inform such decisions.

### 6.3.3 Markets, innovation and regulation

Ensuring that market approaches that encourage new entrants (such as DG developers or water traders) do not undermine the resilience / back-up role of existing networks, is a difficult issue. At the workshop there was some debate as to whether regulators should incentivise new approaches / innovations to create markets or to encourage integrated approaches. Questions were asked as to whether it was sufficient for regulators to focus on removing barriers or whether

more active involvement was needed to support collaborative approaches to resilience (e.g. perhaps across several companies).

Ensuring **fair and transparent cost allocations and access pricing rules** are clearly important here. These need to be set at the right level to enable an informed decision as to whether system balancing is best done locally or regionally. A discussion is also needed about public expectations on how much 'back-up' can be provided from being connected to a national (or regional) network. It would be ill conceived to assume that this can be provided 'free of charge'.

In order to maximise resilience in a market-led context, it will become increasingly **important to reconcile potential conflicts**. For example, a resilient service for a PV 'pro-sumer' may mean being able to supply electricity onto the network at the summer peak as their contribution to resilience. This may conflict with the period when DNOs carries out summer maintenance work to ensure that their networks are resilient for the winter. An example from water could be who should bear the costs of treating water resources that have different chemical compositions to enable trading to occur. In such cases, it will be important that the needs of these different actors are balanced in as transparent and fair a way as possible whilst firmly keeping an eye on the resilience of the overall system. Ensuring that costs, risks and benefits are shared fairly, and that there is a level playing field amongst different market participants, would seem important for future *system* resilience.

Thought also needs to be given as to how incumbent companies are able to take part in market solutions to ensure that outcomes aid rather than erode resilience. **Regulated companies may need to be appropriately incentivised** to take part in 'cross-boundary' trading, for example. However, if this has a knock-on negative impact on the resilience of other parts of their business this needs to be understood and factored into the decision. Given that in water, for example, some such trades may be relatively rare (potentially restricted to severe / extreme drought scenarios), ensuring the right incentives are in place- and effective - can be difficult. Business continuity / disaster recovery tests may be needed to play out what could happen in future scenarios and to assess how services could respond if the anticipated trades / collaboration doesn't happen. Regulators also need to be prepared for what to do if providers fail in a competitive market to ensure that services to consumers remain secure.

**Case study – Disruptive innovation in the communications sector**

The experience in telecoms may be instructive here – particularly for energy. Over The Top players (such as Skype, Netflix and WhatsApp) have been able to provide their services over the internet direct to end users, bypassing traditional distribution systems and avoid the involvement of the multiple systems operators in the control or distribution of content. The resulting exponential innovation in services, and downward pressure on costs, has been welcomed by consumers. The extent to which such models can be transferred to the energy sector and what this would mean for long-run resilience of energy systems remains to be seen. However, it is worth noting that in Australia, Telstar has now deployed a home solar *plus storage* solution, as part of an entire home connectivity package. The extent to which disruptors receive a proper signal (eg a price signal or license condition) about the full impacts of their actions on an overall system is a crucial area for debate.

Based on *Will telcos become the 'over the top' players in smart energy*? Paul Budde, Global Smart Grid Federation, March 2016

## 7. From a citizens and consumer perspective, how do you judge if you are on the 'right track' to achieving long-run resilience?

This paper has explored how the pace of change in regard to resilience, particularly in the electricity sector, is fairly fast. This means that all actors with an interest in security of supply need to regularly ask if they have the right enablers for resilience in place and be in a position to assess the effectiveness of these tools against a changing backdrop. This Section examines the different 'enablers' for securing resilience and asks what, if anything, might be missing from the current toolbox.

Following discussion for this paper, it became clear that there was a need to move from a focus largely on the technical enablers for resilience, to a consideration of the wider enablers for resilience. On the basis of our conversations, we identified the following factors from a citizen and customer perspective, as enablers that may help secure resilience. These are:

- **Stakeholder engagement;**
- **Sharing information;**
- **Standards and decision-making tools;**
- **Metrics; and**
- **Leadership.**

For each of the enablers explored, there is a question as to who best leads on what: government, devolved authorities, regulators or companies.

## 7.1 Stakeholder engagement

**Why it is important:** Our discussions have led us to conclude that stakeholder engagement is an important enabler for understanding and identifying actions for resilience. However, customers and other stakeholders are not always aware what their company, or others in the sector, are doing in regard to resilience. Citizens, consumers and other stakeholders need to be actively engaged in decisions to identify what their views on risk and resilience are, to help set priorities for change, and to use their combined intelligence to help identify and anticipate vulnerabilities in the system. **Underpinning this is the need for a conversation amongst stakeholders and customers about what level of risk is acceptable / appropriate in the sectors and a debate about what to do when shocks occur.** Engaging the public in this way can secure their buy in to be able to deal with response and recovery in the event of an emergency and to ensure that ultimately they are willing to pay the cost of resilience initiatives. Engaging citizens and consumers on the 'bigger picture' is important if a common language is to be developed to discuss cross sector issues.

**Effective engagement on resilience:** This issue will be fully explored in the October New-Pin workshop. Timely stakeholder engagement in the selection of new technical and commercial approaches (such as the move to heat networks in energy) is vital to understand customer behaviour, shape services and ultimately *at the end* of an active engagement process to try and ensure that customers accept the changes being proposed – both in terms of service outcomes and associated costs. In a way, this is a type of 'Citizen / Consumer Readiness Level (CRL)' assessment. This could build upon a traditional Technical Readiness Level assessment. For example, a CRL approach could assess issues such as the inter-operability and practicality of installing different household measures to improve resilience. It could explore what may need to change for **users** to be willing to accept the installation of storage devices (eg for water and energy) in their homes.

Attention is also needed as to how information can best be presented in a way that enables citizens and consumers to understand and compare approaches so that they engage with companies and service providers in resilience discussions. Information, particularly concerning risk, needs to be presented in an accessible manner. Many people frequently misunderstand standards (eg the phrase a '1 in 100 year event' doesn't mean much to many people whereas a 1% chance by 2116 may possibly be clearer). Making the range of possible impacts clear is important to get a considered response. For example, people may have one view if there is a theoretical problem with just their own supply ('I could go and stay with friends and family') and another if the whole town's supplies are cut off. They may also find it easier to take a view on tangible services (such as water resources) than intangible services (such as wastewater or electricity balancing). In discussion, some thought that it could be difficult to get consumers focused on long-term resilience issues in water due to the relatively low levels of bills, unless they had experienced specific problems. Others reported that with deliberative research techniques this problem could be overcome.

**Who should lead?** For stakeholder engagement to support effective resilience planning, it is important to be very clear as to what the 'community of interest' might be that needs to be engaged and who is best placed to lead on this. At the workshop, the point was made that society's interests are not just an aggregation of individual interests and needs. Also, much focus of engagement activity is on **the 'average' user.** This can clearly mask a range of different views and distributional impacts. It is important that those leading on stakeholder engagement recognise these issues and take them into account.

Energy and water **companies** are currently incentivised under their respective price control arrangements to engage their customers in decisions about outcomes that clearly often have a resilience dimension. It is crucial for service providers to develop these relationships if they are to be responsive to what their users want. Engagement carried out to feed into price controls or other regulated initiatives (eg WRMPs) also needs to 'knit together' with that carried out as part of any relevant infrastructure planning / development activity.

How stakeholder engagement is to be incentivised on **cross-sector resilience issues**, and who should lead, is less clear. Given the systemic nature of many resilience issues it is important that engagement processes recognise that companies may not always be in control of some of the key levers to get the outcomes that citizens and consumes may want. It would therefore seem to be appropriate on some issues for engagement about citizen and customer expectations on resilience to take place on a cross-sector basis, be that at a local, regional or national level. For example, at the workshop questions were raised as to whether energy consumers should pay for catchment management projects to help reduce flood risk. How this type of option is factored into current engagement activity is not clear. It does not feel appropriate to leave **education on cross-sector issues** *entirely* to service providers (although companies clearly do have a role here as they can make local issues 'real' and 'come alive'). It should also be recognised that incumbents may in theory also have vested interests in securing a particular outcome from engagement initiatives. For energy resilience, different arrangements may be needed as it could also be that retailers, who do not have a geographic footprint, may be less well-placed to play a significant role.

Taking a cross sector approach to engagement can be beneficial if it leads to consultations etc being more 'joined up' and avoid consultation fatigue (particularly when resources of public interest groups are stretched). Citizens and consumers may then develop a better understanding of the different resilience risks and opportunities they may face– including the potential costs of mitigation. If decision makers engage the public in a discussion of what their assumptions and principles for decision-making etc should be, it may help build confidence in an inherently complex set of issues and decisions. Citizen and stakeholder engagement in cross-sector resilience plans should also provide a good forum for the issue of electricity dependency to be explored. Given this, it would seem appropriate to ask the public whether the thresholds for the resilience of our electricity system are still appropriate in their view for 21st century life.

There is a *potential* gap in terms of who engages with **local community level** stakeholders. As Section 6.1 explored, the interests of these groups may not always coincide with the interests of incumbent providers. As partnerships and collaboration on resilience can potentially be fruitful, regulators will no doubt want to think carefully about whether any specific mechanisms are needed to ensure the engagement of the members and customers of wider groups in resilience thinking (eg of third-parties and Non Traditional Business Models).

At the workshop it was thought that local actors and also potentially insurers can help stakeholders and other customer groups to conceptualise risk. It was also suggested that consumer, citizen and NGO groups could play a role in terms of leading on engagement in some resilience related issues.

## 7.2 Information sharing

**Why is it important?** Having a robust evidence base of resilience challenges, customer requirements and the costs and benefits of different options would seem important. Information is key if all actors are to be able to anticipate problems, select the right approach to secure reliability in the circumstances and then respond to emergencies effectively. New technologies, such as network sensors and monitors, along with digital communications, are leading to the exponential growth in the volume and types of information available. For information and **data** to be useful, it needs to be **open** and capable of being interrogated at an appropriate **level of granularity**. It also needs to be inter-operable, so that it can meet the needs of multiple end users and be correlated against data from other sources (such as that from the Met Office) and other service providers, in a locality, for example.

**Who should lead?** In many cases, it will be in a **company**'s own best interests to share information about resilience with its stakeholders and partners as a way of ensuring security of its own services. Sharing information on lessons learned, when things go wrong, can help all service providers become more resilient. The wider sectors (eg IET, UKWIR and CIWEM) already produce much valuable research and information in this area; linking this further with the activity of other stakeholder groups could potentially increase the impact.

**Regulators** do have some role to play in encouraging companies to share information that can help address sector wide and systemic resilience challenges. Innovation programmes, such as Ofgem's Low Carbon Network Fund and Network Innovation Competitions, where funding criteria include the need to disseminate project findings, and can also help ensure that information on successful approaches to resilience (but also crucially failed approaches) is shared more widely. This can help ensure that dead ends are identified, trials aren't repeated without good reason and mistakes and barriers are overcome. Reputational regulation can also facilitate greater information disclosure.

There are some aspects of resilience that are so broad it can be difficult for an individual company or regulator to gather the right information. One particularly difficult area is data on the **cost of disruptions** - eg electricity shortfalls. The House

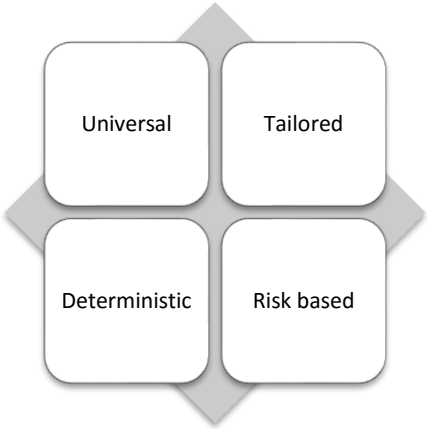
of Lords Select Committee on Science and Technology noted, '*In order to make effective decisions on resilience, reliable information about the true costs of electricity shortfalls is needed. We are surprised to find a paucity of information in this area. We recommend that the Government funds further research into the costs of shortfalls and publishes its findings*.'[30] A report by London Economics for DECC and Ofgem in 2013 found large variations between different estimates of the Value of Loss of Load, leading some to conclude that *'…no concrete conclusions can be made on the costs of electricity supply interruptions.'*[31] Others have commented that poor resilience can have non-marginal impacts (such as the impact of drought on the horticultural trade or tourism) that existing research methodologies for valuing infrastructure (such as willingness to pay research) may not capture.[32] The issue of how to capture citizen and consumer views in this area will be examined more closely in the October New-Pin workshop.

Third parties, including NGOs, can play an important role in building up a resilience evidence base. For example, Green Alliance has two projects seeking to do this with respect to flooding. One is working with the Highways Agency to examine the balance of expenditure on natural infrastructure compared to 'hard' infrastructure for flood events. The other, with the National Trust, is examining the contracting and legal frameworks to make a market work for flood management.

## 7.3 Standards and decision-making tools

Standards can potentially act as an enabler to help secure resilience. In our discussions, four different types of standards were identified. These can be distinguished in terms of: how they are applied (universal or tailored); and the basis on which they are set (deterministic or risk based).

**Diagram 3: Different 'types' of possible future standards in the energy and water sectors**




*Source: Sustainability First*

[30] *The resilience of the electricity system,* op cit

[31] *Living without electricity*, op cit

[32] *Economic evaluation of systems of infrastructure provision: concepts, approaches and methods*, iBuild / Leeds Report, October 2014

### 7.3.1 How standards are applied

In **water**, resilience 'standards,' in so far as these exist, currently vary by company and are thus tailored to local and catchment circumstances. In **energy,** on the other hand, current resilience standards are universal. Universal standards have the benefit of enabling equality of treatment and greater cohesion (no 'post-code lotteries'). They can protect high cost to serve customers. Given increasing electricity dependency, there could be a strong argument for maintaining universal standards for this service. Indeed, Dieter Helm has noted '*In the coming digital economy, security and stability of [electricity] supply will become more and more important. Consumers and industry will all be relying on a very secure and continuous broadband and they will want ample electricity to power these systems that will dominate the economy*,' and has raised the question '*Isn't it reasonable [for consumers] to regard electricity as a USO [**Universal Service Obligation**] service*?'[33]

As universal standards can be inflexible, however, they can make it more difficult to optimise overall system cost-efficiency and make it harder to incentivise demand management. They can also make services unresponsive to the requirements of new users. The contribution of universal standards to enabling resilience may therefore be limited.

As more innovative local approaches develop, customers may start to be able to choose between a '**menu' of different resilience standards**. In particular, some larger customers with back-up generators in electricity or flexibility on when they abstract water, may have more flexibility to choose lower standards from their service provider to save money - or indeed to opt for higher standards to ensure a firm supply. The scope for commercial signals to pro-sumers is being actively tested in energy.

**Case study: ENW C2C post fault demand response**

ENW's Capacity to Customers (C2C) tariff enables customers to choose between a firm connection – and associated standards and commitments / promises on reliability – or to opt for an interruptible connection, and a higher level of risk – but only to be triggered when there are faults on the system. New technologies are enabling the company to segment the customer base to different levels of coverage so that company actions can be more directly targeted to alleviate a problem on a particular part of the network. C2C is a type of post-fault flexibility service. Flexibility will become increasingly important if the roll out of EVs and heat pumps leads to the need for a more responsive system.

A move to more **bespoke / tailored standards**, as may increasingly happen in a pluralistic system made up of local and national elements, may incentivise demand management and help offer greater system flexibility. Tailored standards can be good for achieving optimal solutions for individuals or specific communities.

[33] *EFN, The CMA Energy Market Investigation, Companies 5 – 0 CMA*, Dieter Helm, March 2016

However, these do not help to balance the interests of different actors or manage the interface between local and national systems. They can also hasten the **unwinding of cross subsidies**.

There is potential scope for more creative solutions here. At the workshop and in comments on the draft paper, several people noted that **resilience doesn't need to be 'binary.**' Approaches that identify a '**mitigated state**,' although not ideal, may be better than seeing a complete loss of supply. This could include trickle flows or low voltage supplies in emergency situations (and with appropriate safeguards for customers in vulnerable circumstances).

**Who should lead on how standards are applied?** Given the distributional impacts that changes in this area can have, the government and regulators should play a key role in working with consumers and other stakeholders to **design frameworks for standards**, particularly for those that relate to household and domestic consumers. Health and safety regulators will also need to take the lead on how resilience standards are applied when they have an impact in their areas.

### 7.3.2 Basis on which standards are set

If the energy and water sectors become ever-more inter-dependent, an approach based on **deterministic 'optimal' standards** for securing resilience may no longer be as relevant as in the past - where standards, in energy at least, were in many ways applied in a 'set and forget' fashion. Deterministic standards can be difficult to set at the right level (risk of gold plating or under-capacity); are often based on historic experience; and tend to be inflexible.

Deterministic standards do, however, have benefits. They can:

- Provide clarity for long term investment decisions and build momentum in approach;
- Encourage 'secure by design' solutions;
- Help ensure inter-operability;
- Help encourage optimal solutions for set parameters. In this way, they are suitable for when there are clear boundaries & objectives (eg in terms of drinking water or environmental quality); and
- Enable easier comparisons between services.

Approaches to decision-making that take into account the anticipated risks faced by citizens and consumers, and the associated resilience outcomes, may be more suited to future uncertainty. The benefits of a move to more **probabilistic or risk based standards** include:

- They can reflect resource constraints and uncertainties and enable options to be assessed against a wide range of future conditions;
- Easier to take systemic risks into account and focus on holistic impacts;
- May help assess High Impact Low Probability 'black swan' risks and to decide whether prevention or recovery is the right approach;

- Flexible and agile; and
- Good when there are complex interactions, numerous actors and potentially multiple objectives and benefits.

The potential down sides of risk-based standards should be fewer. They can be more difficult to ensure inter-operability and by being less clear-cut, may not necessarily command public confidence – especially once there is a crisis.

**Who should lead on deciding the basis on which standards are applied?** Who should lead is likely to depend on the standards in question. If the standards have a health, safety or environmental dimension, there may be a stronger case for government and regulators to lead. This could also be true for standards that raise questions around inter-operability. At the workshop views were quite noticeably divided on the role of elected representatives in deciding the basis on which standards should be applied. Some expressed concern that elected leaders may press for standards to be set at too high a level as they may want to avoid taking any risks. Others thought it was important that government representatives were involved in this area as they should ultimately have society's interests in mind and that this type of activity shouldn't be 'farmed out.' There was agreement, however, that government should have a role in setting standards that have some degree of inter-dependency.

### 7.3.3 Decision making tools

A more **risk based approach to decision making** can help decision makers explore some of the difficult judgements that they may need to face, such as identifying what could be an acceptable level of failure of certain assets and who should bear the costs of this. It could enable a more nuanced approach that takes into account the requirements of: the site (eg the need for higher standards for a hospital); the location (eg should there be higher standards for a Central Business District in a major city); the position of the infrastructure compared to homes etc (eg if an electricity substation is at the same level as surrounding houses, it might make sense for it to flood as the houses that it feeds would be empty anyway); and events (eg are higher standards needed for key national events (eg a major international conference or sports event).

There is growing interest in the use of different and stochastic decision-making tools in this area, including Robust Decision Making, sensitivity testing, Monte Carlo risk analysis and real options analysis. Researchers from Leeds have noted that the latter '*often has a more discursive aspect as the qualitative judgements of experts are elicited, though these may then be converted into probability distributions that lend themselves more readily to mathematical models…. This is appropriate as a way of dealing with uncertainty, particularly in relation to new technologies …. Smart grids are one specific example in which the approaches have been usefully applied. However, there have also been many institutional and regulatory challenges to*

*implementation. In particular, the pricing mechanism has tended to incentivise incremental gains over system innovation.* '[34]

Others have identified game theory as being applicable in this area as it can inform a decision-making approach by generating a set of near-optimal, feasible and 'stable' results, allowing the analysis of the various trade-offs involved, and of potential fall-back positions, noting that '*The outputs from such an approach can be more practical in real-world situations when compared to the 'optimal', but often impracticable options, given by conventional multi-objective optimisation methods*.'[35]

Whichever decision-making approaches are adopted, it is important that as far as possible the public are somehow effectively involved in agreeing the assumptions that drive any decision making algorithms to give wider confidence in the resulting analysis. Given the complexities, simple 'common sense' tests of any conclusions are also highly useful.

## 7.4 Metrics

**Why are these important?** Resilience is such a key issue for citizens and consumers that measuring long-run reliability would seem to be important to allow the public and providers to judge performance, make comparisons between areas and companies and to track progress over time. Customers may not be aware of differences in resilience between companies. Clearly articulated expectations and perhaps 'resilience goals / targets', as opposed to inflexible deterministic standards for resilience, may help drive change and build consensus on the level of ambition for change. Metrics reported against such goals can also help build understanding of the reasons for any differences. However, it is important to remember that metrics are just one of the tools that companies have to help secure resilience. Company culture and ethos, and the desire to be 'masters of their own destiny,' can also have an impact.

**Who leads?** In carrying out the research for this paper, there was not a strong sense that **company boards** have a clear view of how resilience in the broad 21st century sense that we have outlined in this paper is measured or judged within their organisations. Most of those interviewed thought that this was largely done on a scheme-by-scheme basis. It may be helpful to use a wider group of metrics to track company performance on resilience over time. In the workshop, it was thought that long-term investors would want assurance on the likely resilience of their investments over time.

Currently, in the electricity sector, the main resilience metrics for citizens and consumers are **Customer Minutes Lost** and **Customer Interruptions**. In water, there

[34] iBuild / Leeds Report, op cit

[35] https://www.sussex.ac.uk/webteam/gateway/file.php?name=ukew-policy-note.pdf&site=25

are currently no equivalent *national* metrics, although in the last price review every company set clear targets for supply interruptions, and the water and sewerage companies set targets for the number of properties to be impacted by sewer flooding (as a proxy for wastewater resilience). Some companies publish their own internal measures but these are not necessarily comparable with those of other providers. For example, Anglian Water's business plan for PR14 contains some useful metrics by which they and their customers can assess their resilience (eg number of people supplied by a single water treatment works, number of pressure managed controlled networks, number of free water audits etc). Both sectors also use customer satisfaction and value for money measures to track performance. Although these pick up some aspects of resilience, particularly in terms of short-term performance, on their own they may only give limited insight into some long-term resilience issues (particularly in terms of systems). In the water sector, the work that Water UK is currently undertaking on the sector strategic dash board could be a good start-point for the creation of a wider group of resilience measures.

At a workshop for The International Centre for Infrastructure Futures and iBuild, it was noted that measurements of outcomes '*…rely on the interactions of assets and services from multiple infrastructure sectors.* ***It is therefore no longer sufficient to monitor performance solely on an infrastructure by infrastructure basis***.' [36] In this environment, identifying the scope of the metrics used and the **interdependencies** between indicators is important. In water, for example, it may be necessary to sometimes look at water and wastewater measures together to get the full resilience picture. Thinking through how electricity and gas dependency is reflected in resilience measures is another challenge. The scope for the development of **cross-sector metrics** will also need to be explored by actors such as the National Infrastructure Commission.

**Effective metrics:** To be useful, resilience metrics need to be outcome based and related to why the service is needed by citizens and consumers. In this way they should be connected to public expectations and the societal needs fulfilled by the service in question. To enable meaningful comparisons, a common methodology for determining outcomes may be needed. Metrics need to be set at the relevant geographic scale – a national average might be meaningless if it masks lack of resilience in some areas. More granular metrics may be useful. For example in energy, weighting electricity interruptions according to concentration (average distance between interruptions, the number of consumers interrupted per event and the number of minutes lost per event). Ideally, measures need to be linked to future plans and visions for infrastructure, to avoid being backward looking or historic. Indicators also need to be controllable.

From a public interest perspective, softer measures of how companies and others (such as local authorities and other service providers) deal with events would also seem important.

[36] *A critique of current infrastructure performance indicators*: *Towards best practice*, International Centre for Infrastructure Futures and iBuild, May 2015

The complexity of measuring resilience is likely to lead to a nuanced collection of metrics which can inform judgement rather than a single number. Some of the most revealing metrics may be qualitative, including views about customer service, rather than quantitative. Although metrics may be one helpful aid to resilience discussions, both inside and outside companies, getting these 'right' is unlikely to be an easy or a one-off process. An iterative approach is likely to be needed to respond to changed circumstances and to avoid unintended consequences.

## 7.5 Leadership

**Why is this important?** Research has shown that the public think three qualities are important in a good leader: being a good communicator; being decisive; and having integrity.[37] Resilience covers a great breadth of issues and wide range of actors. Strong leadership – in terms of being decisive and communicating this plan to others – is therefore vital to ensure co-ordination and maintain momentum. There are also significant risks in getting resilience 'wrong.' Integrity is needed to decide who should bear which risks – be these by group (consumers / citizens or companies, today or tomorrow, for example) or geography.

**Who leads on overall vision and policy**: The **Government** clearly must play the leading role in setting the overall strategic direction and high level vision for resilient energy and water systems (and to a lesser extent perhaps services) and for drawing up the policy frameworks to deliver these. The most contentious policy issue behind most questions of system resilience is likely to be around who should pay for what (both today and tomorrow) and whether policies are affordable. At a national level, the House of Lords Science and Technology Committee has commented that '*The decision of how to balance resilience and affordability must ultimately be taken by the Government*.'[38] Others have noted '*The UK needs to decide where it wants its infrastructure systems to sit on the resilience - efficiency spectrum.*'[39] At the workshop there was a strong feeling from some that questions of risk shouldn't be outsourced and that those in accountable positions should draw the boundaries between risk and reward sharing. Others felt strongly that consumers should determine how much is affordable and what they are willing to pay. The cost of resilience, and some of the questions as to how to balance different interests, will be explored in the New-Pin stakeholder engagement workshop in October.

Another difficult policy area is flooding where the recent Environmental Audit Select Committee report concluded that '*government appears to be reactive rather than proactive.*'[40] The mix of public and private funding in flood management means that policy decisions can have quite significant cost and distributional impacts. The fact that this area cuts across Departmental boundaries (DEFRA, DCLG, DoT, BIS and of course HMT) also adds to the challenge of leadership on this issue.

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[37] *What is leadership?* Britain Thinks, January 2016

[38] *The resilience of the electricity system,* op cit

[39] *Living without electricity*, op cit

[40] *Flooding; co-operation across government,* Environmental Audit Select Committee, June 2016

**Who leads on cross-sector issues**: Development of a more detailed strategic vision, and the integration and co-ordination of different sector, regional and locally based resilience initiatives, should in principle be able to be taken forward by the **National Infrastructure Commission**. The Commission should be able to take a coherent cross-sector approach to resilience, understand trends and questions of adequacy and liaise with both central and local government, helping to 'knit together' both strategic and local approaches in the process. It should also have a role in defining how broadly or narrowly debates in the area should be framed. However, to gain public confidence in its decisions and to gain legitimacy, clear accountability arrangements with government will be needed that take into account the social and political context of the Commission's work. Mechanisms will also be needed for the Commission to be able to work with other actors to flag up with Government when it considers that incremental changes aren't enough and larger scale interventions are needed.

**Regional and local government** also has a key leadership role in terms of building on local intelligence, engagement and ownership and encouraging the development of a wider diversity of cross-sector approaches. There are some potentially strong regional actors **(Northern Power House, city mayors)** but without the Regional Development Agencies, a gap remains. Local resilience plans may find it difficult to join up with those at the national level in the absence of initiatives such as the Northern Power House (assuming the latter is able to become an effective regional group).

**Regulators** clearly have a role in providing and / or stimulating leadership on the development of frameworks for the delivery of resilient services in their sectors. They can also build on existing approaches, including networks such as the **UKRN** (UK Regulators' Network), to share information and identify where a more consistent approach to resilience may be productive and to explore cross sector impacts. Regulators also have an oversight role, tracking the extent to which resilience has been embedded in services and systems.

**Who leads at a sector level: Companies** will need to demonstrate leadership by taking action to meet customer expectations on resilience and by being willing to develop approaches that may go beyond the confines of their regulated asset base. Regulators and government will need to make clear any boundaries that this type of approach may need to respect and also what governance arrangements will need to be in place to manage these risks and deal with the consequences of any unplanned failures. Within firms, leaders will play a vital role in terms of developing future resilience thinking and **motivating staff** to deliver. This will be vital if the sectors are to move from a risk-averse culture on resilience to one that is more agile and actively manages risk. Focusing on the staff / User Readiness Levels (URLs) of new approaches to resilience may help drive change. Company managements will need to be comfortable in dealing not only with the direct impact of technical change but also indirect impacts such as the risks of new partnership working. **Investors** also

have a role here, particularly if they are going to exercise long-term stewardship over their investments[41].

**Effective leadership on resilience**: Existing institutional processes can be reactive, slow and clunky and find it difficult to keep up with the rapid response demanded by resilience issues arising from digital developments or increase in extreme weather events. Institutional inertia, and the difficulty of working across organisational boundaries - departmental, regulatory, company - can make it difficult for decision-making in this area to be nimble and flexible. It can be easier, for example, for leaders to champion big flagship infrastructure projects, particularly where these have an impact on jobs and growth, than to support potentially effective (and cheaper) resilience measures that may be local, piece-meal, require work across departments, organisations and funding streams. These issues need to be addressed if leadership is to be effectively exercised on this topic.

**Case study – ABC - Active Beautiful and Clean Singapore**

In the 1960s Singapore had water rationing. Thanks to the Government's Public Utilities Board 'Four National Taps' programme this is no longer the case. This programme covers: local catchment water (the number of reservoirs has gone up from 3 in the 1960s to 17 today, many fed by harvested urban storm water); imported water; NEWater (reclaimed water using membrane technologies, mainly for industrial uses – currently used for 30% of total demand and with a target of 55% by 2060); and desalinated water (to meet 25% of demand by 2060).

The programme is part of the Active Beautiful and Clean strategic initiative that was launched in 2006 to improve the quality of water and life by harnessing the full potential of water bodies and creating a vision of a City of Gardens and Water. Drains, canals and reservoirs are integrated with the surrounding environment in a holistic way, making community spaces for all to enjoy. The Utilities Board has developed the ABC Water Design Guidelines to provide reference to developers and industry professionals on how to implement environmentally sustainable green features. This is part of the Board's effort to get partners to jointly work on a common vision of sustainable water management.

Source: Singapore Government's National Water Agency – Public Utilities Board 2015 annual report

## 8. Managing the responsibilities & relationships between different actors

Discussions for this paper have highlighted the importance of ensuring that appropriate frameworks are in place to ensure that decisions on long-run resilience

[41] This issue was to some extent explored in New-Pin's February 2016 paper on *Trust and confidence* (see the Sustainability First website)

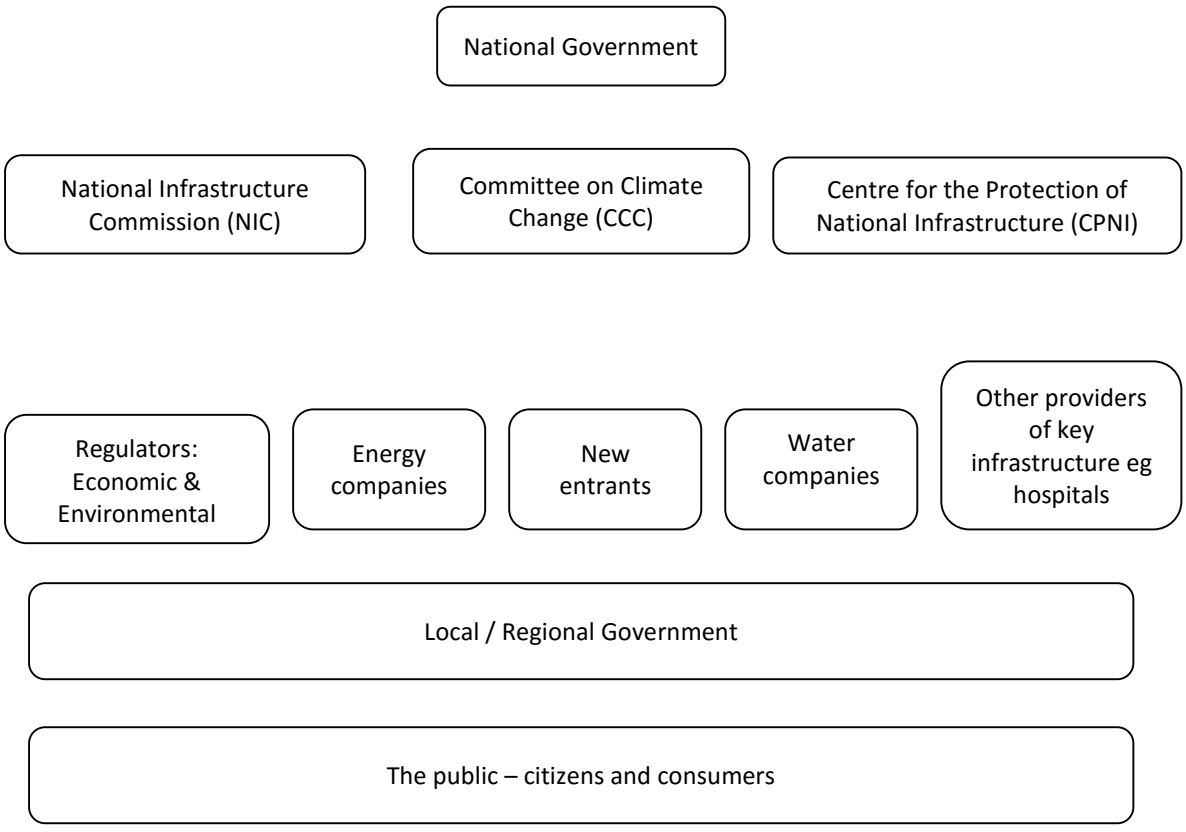
are made at the 'right' level to enable a joined-up view to be taken and to avoid 'knee-jerk' or short-term political interventions in response to an emergency.

At the workshop participants thought it was important to assess whether the institutional framework today is the right one for the future, as some (but clearly not all) of this was established before certain current resilience threats existed. This Section examines whether the responsibilities for identifying the boundaries for ensuring resilience, the relationships around the different actors involved and the trade-offs between them, are currently understood and in the appropriate places.

Diagram 4 provides a high-level overview of the key different actors involved in securing resilience. It indicates that there is potentially a significant piece of work to do in managing the responsibilities and relationships between actors and 'knitting together' what happens at the national and local levels. We would very much hope that getting clarity in these areas would be a priority for the National Infrastructure Commission.

The role of the insurance industry in terms of resilience was also discussed at the workshop. Although compensation can help people 'bounce back' from a shock, schemes like Flood Re can also potentially delay the need to sort out underlying resilience issues (the pollution haven effect).

**Diagram 4: Key actors with a role in securing long-run resilience – where should the 'lines' / links be drawn?**




*Source: Sustainability First*

The 'straw-man' in Table 3 is intended to stimulate discussion on how the responsibilities for leadership and delivery for resilience could be managed between different actors. The Table is a 'starter for ten' in terms of assigning responsibilities for resilience in terms of: stakeholder engagement, services and systems.

**Table 3: 'Straw-man' to stimulate debate on how responsibilities for resilience boundaries and trade-offs can best be managed**

**Central government (including the NIC, CCC and CPNI)**

| Leadership | Delivery |
|---|---|
| Currently<br>• Climate change frameworks<br>• Energy and water policy, including frameworks for supply / capacity<br>• Planning, building & product standards<br>• Emergency planning co-ordination<br>• NIC Strategic vision for infrastructure<br>In future?<br>• Strategic vision for resilient systems & services (learning lessons between sectors, actors [eg developers and farmers] & types of events)<br>• Greater understanding of how regional approaches fit together for systems and services<br>• Clarity on who should lead on what at the local, regional & national levels<br>• Improved co-ordination between Departments on resilience issues; particularly between the Cabinet Office, DEFRA, DECC, DCLG and HMT – not just following crisis. Understanding of how competition plans interact with resilience strategies<br>• An holistic view on how risks and rewards of resilience initiatives should be shared between different actors and whether overall approach is affordable for consumers and citizens of current and future generations<br>• Joined up cross sector strategy on the demand side (covering efficiency and behaviour change)<br>• Align national and local policy frameworks to identify ways of delivering wider societal benefits & to enable local infrastructure models to emerge<br>• Future-proofing planning, building & product standards (eg not using ground floor for living if susceptible to flooding)<br>• Reviewing farming supports to tackle upstream catchment management issues | Currently<br>• Delivered through central and local government, regulators and companies<br>• Funding for response & recovery for significant emergencies<br>In future?<br>• Educate the public on national cross sector resilience issues<br>• Mechanisms to enable public dialogue / engagement on long-term cross sector resilience issues and what is an acceptable & affordable pace of change<br>• A framework for assessing distributional impacts of different resilience options<br>• Increased visibility in government plans as to who plans for what in terms of resilience<br>• NIC to develop cross sector resilience metricsWork with insurance industry on future flooding risk post Flood Re<br>• Managed withdrawal / resettlement programme for communities at risk of coastal erosion / flooding<br>• Steps to enable open data to be used to increase resilience<br>• Use National Parks to showcase upstream catchment management programmes |

**Regions**

| Leadership | Delivery |
|---|---|
| Currently<br>• Regional growth initiatives (eg Northern Powerhouse & elected mayors)?<br>• Some water companies co-ordinate WRMP plans across regions (eg Water Resources East Anglia covers 3 companies & is also working with farmers)<br>In future?<br>• Environmental Commissioners at water catchment levels (will Natural Environment Plan support this?)<br>• Greater understanding of how local & cross sector approaches fit together<br>• Regionally based cross sector stakeholder engagement on resilience<br>• Regional based spatial planning<br>• Regional resilience strategies for systems & services – developed between companies in a region working together<br>• In water – companies develop WRMPs together in an integrated way with neighbouring companies and other abstractors (WRSE starting to do this)<br>• In water – increased catchment based decision making | Currently<br>• There are some strong actors (eg Northern Power House, city mayors) but without the Regional Development Agencies a gap remains<br>In future?<br>• Regionally based resilience measures<br>• Plans to cope with large scale resilience emergency |

**Local government**

| Leadership | Delivery |
|---|---|
| Currently<br>• Spatial planning<br>• Local Resilience Forums (reactive – co-ordination)<br>In future?<br>• Ability to develop new ways of planning & managing local infrastructure, particularly in areas which go beyond traditionally regulated space<br>• Engage stakeholders on local cross sector resilience issues<br>• Engage stakeholders on (and publish) resilience plans for cities most at risk eg London & Leeds<br>• Local Resilience Forums (preventative – co-ordination)<br>• Possible fiscal decentralisation to enable local infrastructure projects | Currently<br>• Elected mayors have some flexibility to develop and raise finance for local infrastructure<br>• Response & recovery in face of emergencies<br>In future?<br>• Local government direct provision of services designed to enhance resilience (eg in heat networks & energy efficiency)<br>• Develop inventory of local resilience measures to share good practice & enable co-ordination in a crisis? |

**Regulators**

| Leadership | Delivery |
|---|---|
| Currently<br>• Price reviews incentivise resilience on individual company level<br>• Environmental regulators review company long term plans<br>• Energy – innovation incentivised<br>In future?<br>• Resolving tensions between different stakeholders at local / regional / national levels<br>• Assess whether companies are embedding and mainstreaming approaches to resilience<br>• Support culture change in companies to better manage risks<br>• Explain how resilience duties are taken into account in *all* of own decisions | Currently<br>• UKRN publishes comparative resilience research (largely focused on response / emergencies)<br>In future?<br>• Engage stakeholders on cross sector resilience issues<br>• Consultation on common cross-cutting resilience issues that may impact on price reviews etc?<br>• Share good practice examples of proactive approaches to resilience – within and between sectors |

**Companies & trade associations**

| Leadership | Delivery |
|---|---|
| Currently<br>• Strategic plans drawn up (largely on company by company basis)<br>• Involved in long-term scenario planning work<br>• Educating citizens and consumers about services provided & engaging them on resilience priorities and responses<br>• Working in partnership with stakeholders to help them understand resilience challenges<br>• Co-ordinating local response to floods<br>• Energy- sharing of lessons learnt from innovation work<br>In future?<br>• Strategic plans drawn up following consultation and in co-ordination with other companies & partners<br>• Stimulating debate about future resilience standards and response<br>• Engaging stakeholders in development of proactive resilience strategies<br>• Co-ordinating local resilience prevention initiatives<br>• Working in partnership with other local actors to help build more resilient social and community infrastructure<br>• Sharing innovation learning within and between sectors and with wider actors<br>• Stress testing resilience of supply chains and sharing findings<br>• Promote sector narrative on need for strategic response to resilience challenges?<br>• Form sector based resilience forums – forums in each sector periodically liaise<br>• Work with the insurance industry to get more strategic and holistic approach to flooding | Currently<br>• Meeting existing resilience standards and agreed outcomes for service delivery<br>• Emergency response priority service for customers in vulnerable circumstances when supplies are down<br>• Energy – Active innovation strategies and projects / sharing of learning<br>• Water – tenders for innovative approaches<br>• Water – working with wider range of stakeholders including farmers to develop flood resilience<br>In future?<br>• Embedding & mainstreaming good resilience practice<br>• Proactive innovative approaches without regulatory / government prompting<br>• Form new body to promote water resource trading options?<br>• Water – sharing innovation learning?<br>• Networks for sharing resilience best practice – between sectors |

**Community, citizen, consumer & environment groups**

| Leadership | Delivery |
|---|---|
| Currently<br>• Active in stakeholder engagement (often at a service level)<br>In future?<br>• Work with local authorities and companies to build intelligence about community vulnerability and resilience<br>• Active in stakeholder engagement at a systems level | Currently<br>• Working in partnership with companies on specific initiatives<br>• Developing community energy schemes etc |

**Individual citizens and consumers**

| Leadership | Delivery |
|---|---|
| Currently<br>• Volunteering in times of crisis and in specific projects<br>In future?<br>• Active engagement in discussions about resilience<br>• Crowd sourcing ideas on how to respond to resilience challenges | Currently<br>• Demand reduction – energy / water efficiency<br>In future?<br>• Demand reduction & demand side response for energy & water as a service package |

**Academia**

| Leadership | Delivery |
|---|---|
| Currently<br>• Collaborative research (eg ITRC and ARCC Networks)<br>In future?<br>• Research into how to get the right approach between behaviour change and building standards for things like heat pumps | Currently<br>• Cambridge grey-water scheme |

*Source: Sustainability First*

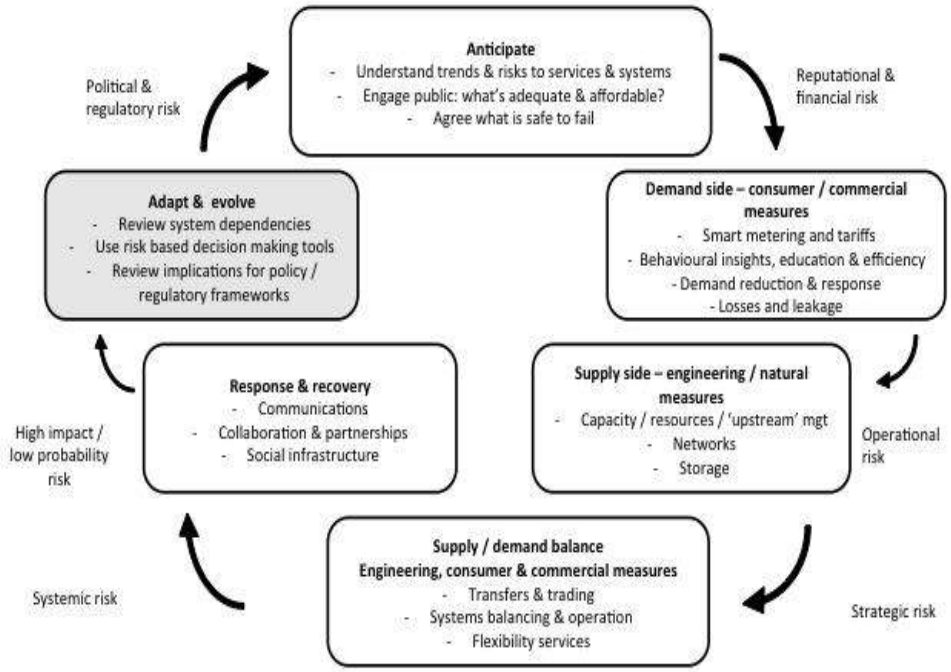
# 9 Conclusions – How to take forward a 'public interest' focus on resilience?

This paper has explored the current state of long-run resilience from a 'public interest' perspective for citizens and consumers in the energy and water sectors – and how this may need to evolve and adapt for an uncertain future. The question of the costs of resilience has not been examined in this paper. These were to some extent considered in our 'Long-term affordability' workshop in 2015 and will be examined further in the New-Pin workshop on stakeholder engagement in October 2016.

There are clearly no single 'right' approaches to achieving long-run resilience. An adaptive, agile and 'learning' approach capable of looking across the full range of risks is needed. This 'circular' approach, that addresses different types of risk, is summarised in Diagram 5. It is worth noting that we have placed the demand side before the supply side. This is in recognition of the need to ensure that services and systems put the public interest at their heart and that approaches which seek to maximise flexibility and value for money are given due attention. To ensure resilience, the key stage in the diagram is arguably the shaded box, when on the basis of experience, services and systems – and associated regulatory and policy frameworks – adapt and change. As each circle completes, and each time a new significant decision impacting on resilience needs to be made, it is important to ask

whether the 'boundaries' of that particular decision are clear and understood by all parties. Only then will it be possible to fully understand the full costs of the different options, who will bear the risks, who should lead and the relationships that will be needed to drive change.

**Diagram 5 – Summary of suggested approach to securing long-run resilience for citizens and consumers**




*Source: Sustainability First*

## 9.1 Principles for securing long-run resilience

This paper has demonstrated that long-run resilience is a complex and difficult area. There will undoubtedly be different views as to how this is best ensured and conflicts managed. Identifying the principles that might under-pin resilience would therefore seem an important step to guide the manner in which to take forward the public interest discussion on this topic. Principles can act as a reference point during change and help build consensus around what might be the most appropriate approach. This is vital for a cross-sector view of long-run resilience.

The principles below, which build on those outlined by Ofwat in December 2015[42] and Bristol City Council in their Resilient Bristol 2066 Strategy,[43] are intended as a starter for ten to stimulate debate:

[42] *Towards resilience – how we will embed resilience in our work,* Ofwat, December 2015. The principles identified in this discussion paper are framed in a slightly different way to those in Ofwat's paper (eg on affordability) and also include the principle of a 'cross-sector view.'

[43] *Resilient Bristol 2066 Strategy,* Green Capital Partnership Board, April 2016

1. **Risk based** – Resilience approaches should take into account the full range of risks including current and future operational, strategic, systems, High Impact Low Probability (HILP), political / policy, reputational and financial risks.

2. **Agile** – Resilience approaches need to be able to adapt to changing risks and circumstances. It is important that technical and commercial solutions are wherever possible adopted on a no regrets and optionality basis. Approaches that deliver multiple benefits should be given serious consideration. Governance processes also need to be sufficiently dynamic so that they don't cause inertia and get in way of change.

3. **Engaged stakeholders** – Resilience approaches need to have the services used by citizens and consumers at their heart. They should be built on an understanding of the needs and priorities of citizens and consumers (which may not always be the same) and ensure that the public are able to play an active role in sharing local knowledge, demand management and response / recovery. Stakeholder engagement is also key to ensure that the public have confidence in decisions and are willing to continue to give firms the social license to operate in the sectors. For this to happen, it will be important that the public are informed and educated (including at a cross-sector and national level) about the risks faced so that they understand that systems aren't infallible but are also able to input / share their views as to what is 'non-negotiable.'

4. **Understanding of affordability** – The cost and affordability of resilience is a key issue. It is important that resilience solutions take account of whole life cycle costs; not just the costs of initial investment but also on-going maintenance costs, factoring in any likely response costs to disruptions. To keep costs manageable, resilience approaches clearly need to be efficient. If there is a conflict between resilience and efficiency, a strategic approach should be taken. The distributional impacts of different approaches should be modelled and debated *before* major decisions are taken. When significant decisions are needed, questions of fairness both within and between generations should be considered.

5. **Cross-sector view** – Given the increasing inter-dependency between sectors, and the rising dependency on electricity, a coherent view of resilience is needed. This needs to ensure an approach which is joined up technically, commercially and from the citizen and consumer view-point.

6. **Partnerships and collaboration** – Resilience approaches should build connections and links between different actors to promote diversity, develop capacity for response and recovery and to spread good practice.

7. **Transparency** – The assumptions used in resilience plans and decisions should be transparent and shared amongst key stakeholders. This can help build confidence in decisions and the legitimacy of the decision making process. Plans also needed to be adequately explained so that stakeholders understand what is happening.

# Annex A: Current responsibilities for securing resilience amongst key actors and institutions

## Electricity

- **Statute:** The Electricity Act 1989 and subsequent legislation. Places separate duties upon the Secretary of State, the regulator, and the licensed companies (the transmission system operator and the distribution networks) for ensuring security and quality of supply. Electricity suppliers are not required to meet a customers' demand for supply in every circumstance, but rather, to ensure that sufficient supplies are available to their customers within reason.

- **Licences:** Spells out individual responsibilities of different actors. Licence breaches can entail fines of up to 10% of turn-over. In extremis, a Licence can be rescinded. Licenses also set out the structure of incentive arrangements, including where relevant with respect to resilience, supply security and balancing.

- **Statutory codes:** set the frameworks, multi-party agreements and common contractual conditions for safe technical operation, industry charges and market operation (e.g. Balancing & Settlement Code, Connection codes, Grid codes (T&D). Governance of codes, including ability to change codes, is industry-led, but Ofgem has new review powers (Energy Bill 2016).

- **Technical regulations and standards:** industry-owned technical requirements for safe and secure operation of a synchronous system (SQSS, P2/6, Load Indices etc).

- **Co-ordination bodies:** The Energy Emergencies Executive Committee (E3C). Representatives from DECC, Ofgem and the industry together develop and implement downstream emergency arrangements for electricity and gas and carries our exercises on the National Emergency Plans (NEPs) for the sectors.

- **Regulatory incentives:** eg Networks via RIIO: DNO Quality of Supply – Customer Interruptions (CIs); Customer Minutes Lost (CMLs). Network companies provide annual reports which cover these issues and can lead to allowances being adjusted.

- **Commercial frameworks:** Delivery of long-run resilience is also dependent upon timely delivery for the long-run via electricity sector commercial frameworks. In practice this requires a mix of:

    - **Market signals** (wholesale prices, carbon price) to bring forward and adequately remunerate new plant – and subsidies where market fails
    - **Subsidies to address market failure** - for low carbon, flexible capacity.

- **Regulatory incentives –** to remunerate appropriate network build; to incentivise balancing of supply and demand (Transmission now; distribution in the future at the transmission / distribution interface) ; innovation.
- **Other stimuli** - for innovation (eg demand-side, storage, flexibility), for efficiency.

## Gas

- **Statute:** The Gas Act 1986 is the main piece of legislation setting out responsibilities for the on-shore gas market.

- **Licences:** Spells out individual responsibilities of different actors. National Grid is the sole licensee of the gas National Transmission System (NTS) infrastructure in the UK. The three inter-connectors to the NTS are also licensed and regulated by Ofgem to ensure secure supplies are maintained.

- Unconventional hydrocarbon exploration and production is subject to the onshore licensing regime, although additional regulatory requirements and planning permissions apply. A detailed Statement of Environmental Awareness must be submitted with the licence applications. The Oil and Gas Authority was established to deal with the upstream gas sector in April 2015. The Environment Agency is the environmental regulator for onshore shale gas etc.

- **Statutory codes:** The current Gas Transmission Charging Review is proposing changing the relevant codes and the introduction of new types of capacity charges and products. Need new codes etc for development of bio-gas and use in distribution networks?

- **Regulatory incentives:** eg the Gas Distribution Networks are incentivised in areas such as reliability, new connections etc.

- **Co-ordination bodies:** See E3C in the electricity Section.

## Water

Note: due to different ownership and regulatory arrangements in the three nations, most of this Section refers primarily to England and Wales.

- **Statute:** The Security and Emergency Measures Direction 1998 provides for minimum service levels (10 to 20 litres of drinking water per person per day) that offer some protection to public health. The Direction requires companies to provide plans to ensure provision of the water supply.

- The Water Act 2014 imposes a primary duty on Ofwat to: secure long-term resilience of the systems on which essential water and sewerage services rely; promote action to respond effectively to pressures on the environment (climate

change), population growth and changes in behaviour; ensure long-term planning and investment; and promote measures to manage water sustainably and reduce demand so as to reduce pressure on water resources.

- **Licences:** eg The Environment Agency's Catchment Abstraction Management Strategies help identify the amount of water available for future abstraction licensing.

- Ofwat can intervene on specific issues when required, such as issuing guidance on critical infrastructure in the context of climate change in PR09.[44]

- **Regulatory incentives:** eg Outcome Delivery Incentives (ODIs) in PR14.

- **Technical frameworks:** eg The Environment Agency's Regional Action Plans, River Basin Management Plans and the National Environment Programme. The Agency also produces the Water Resource Planning Guidelines that require companies to produce Water Resource Management Plans (covering 25 years plus) every 5 years. These cover a range of issues including demand forecasts for households and emissions of Green House Gasses. These do not currently explicitly link into the Drought Plans that water companies are required to produce every three years but this is subject to a current review.[45]

- **Co-ordination bodies:** Note - Ofwat does not have a formal emergency incident response role in the water sector.

- **Commercial frameworks:** Delivery

## Wastewater and drainage

- **Statute :** The resilience duty imposed on Ofwat in the Water Act 2014 also covers sewerage. Sewerage companies have to meet numerous environmental standards that can have an impact on resilience, largely driven by European Directives.

- **Licences:** eg in October 2011, the responsibility for private sewers and lateral drains was transferred to sewerage company license holders.

- **Technical frameworks:** Water and sewerage companies do not currently have to prepare sewerage and wastewater plans, in the same way that they have to produce water resource plans. This was one of the recommendations of the Ofwat Task and Finish Group on Resilience. Water UK's Twenty first century drainage project, that is examining how to ensure sewerage systems are fit for

[44] *Cross sector resilience report, Phase 1,* UKRN, April 2015

[45] *Draft Water Resource Planning Guidelines, A summary of consultation responses*, Environment Agency, March 2016

the future and developing tools to enable long-term planning, is a good step in this direction. [46]

- **Regulatory incentives:** eg Sewerage companies will introduce monitoring for the vast majority of their combined sewer overflows by 2020.

[46] *Creating a great place for living- enabling resilience in the water sector,* DEFRA, March 2016