ANTICIPATE, REACT, RECOVER

Technical annex: Principles for setting levels of service

NATIONAL INFRASTRUCTURE COMMISSION

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Introduction

The Commission's **Resilience study** recommends that government set clear, proportionate and realistic standards every five years for the resilience of energy, water, digital, road and rail services.

In setting these resilience standards,[1] government will need to determine the right balance between the costs of resilience, impacts of disruption and consumer expectations to determine the 'level of service' to aim for across infrastructure sectors.

The Commission has found from its research and engagement with relevant stakeholders, that:

- **a.** levels of service[2] are characterised and understood differently both across and within economic infrastructure sectors[3]
- **b.** there are a range of approaches used to balance costs and expectations to determine what level of service operators and regulators should aim for[4]
- **c.** there is not an established approach to understanding levels of service for low probability, high impact events
- **d.** it is difficult to 'quantify' the benefit of resilience when making the case for specific investments.

With these issues in mind, this technical annex sets out five key principles to follow when setting levels of service across economic infrastructure.

These principles provide a starting point for better and more consistent decision-making on levels of service across economic infrastructure. Crucially, these principles encourage decision makers to appropriately balance costs, consumer expectations and impacts when determining acceptable and unacceptable levels of service in each infrastructure sector. This includes high impact, low probability events.

Whilst the primary use for these principles is to help understand acceptable levels of service, these principles can also be adapted and applied when making the economic case for investments that have large impacts on resilience.

Cost benefit analysis and extreme events

Principle 1: Minimise costs and risks for potentially catastrophic events as far as practicable.

For frequent or less uncertain events, cost benefit analysis approaches can be a useful tool for setting levels of service. We know that consumers tend to base their views on infrastructure services on their past experiences.[5] For events that happen more frequently, many consumers have experienced these events, and because of this, stated and revealed preference surveys capture their views fairly well. There is also sufficient data and understanding of everyday events to accurately capture the impacts of disruption.

For example, levels of service in the energy and water sectors, such as metrics for the supply/demand balance of water,[6] or customer minutes lost from electricity disruption, compare costs to willingness to pay or tolerate events.[7] The use of cost benefit analysis for these levels of service allows costs, impacts and expectations to be compared against each other, as these are likely to be a reasonable estimation of the actual costs, impacts and public expectations.

However, these approaches are less suitable for understanding acceptable levels of service in more extreme or rare circumstances. This is because:

- If an event is rare, or unlike an event that has happened in recent history, it is difficult for consumers to conceptualise the event and to form views on the right level of service. Any consumer views captured through stated and revealed preference techniques for these events are less accurate.
- Secondly, if the event is rare, there is no data or little understanding of the scale of impacts of the event. Any assessment of the potential impact is therefore highly uncertain. Therefore, widely used techniques, such as comparing expected damages to expected costs, cannot be used with much confidence.

The Commission therefore argues that for truly extreme events, government, regulators and operators should take an 'as low as reasonably practicable' approach instead of traditional cost benefit analysis approaches. This means that the cost and risks of catastrophic events are reduced as far as is reasonably practicable. This approach should only apply to events that are truly extreme and/or catastrophic, where the case can be made that the impacts would be so severe, that any damages will be likely to outweigh the costs of resilience.

This approach has been widely used and endorsed by the Health and Safety Executive to be used when assessing health and safety risks. [8] A similar approach has been used to set out business cases for large flood risk protection schemes such as the Thames Barrier.[9] In this case, policy makers moved away from making decisions based on the probabilistic cost benefit approaches, and instead used reasonable preventive measures.

Understanding consumer views

Principle 2: Use a range of methods to understand consumer views on disruption.

Many levels of service are set by balancing consumer views with costs. For example, the methodology used to set the loss of load expectation standard in the energy sector relies on balancing consumers' willingness to accept disruption with the marginal cost of increasing resilience.[10] This is also the case in the water sector, where consumer views are used to set performance commitments for companies.[11] When consumer views are considered, these are often captured using stated preference approaches, in order to produce 'willingness to pay' or 'willingness to accept' values that can be easily compared to costs.

One issue is that consumer views and tolerance of infrastructure failures are time inconsistent, meaning that they change depending on whether the consumer has experienced disruptions recently. For example, a stated preference survey conducted a short time after a consumer has witnessed a disruption to the infrastructure service is more likely to elicit higher values for the service. Had the consumer never witnessed disruption at all, the value they place on the infrastructure service is likely to be lower. Stated preference approaches might therefore not adequately capture how much the consumers truly value infrastructure services. This issue with stated preference approaches has been identified through the Commission's social research and through academic studies.[12,13]

Considering this, when attempting to understand consumer views, stated preference approaches should be triangulated with other methods. This will improve the validity of the evidence base used to understand consumer views when setting levels of service. Other methods include: the use of operational data to understand trends and types of complaints from consumers; data from behavioural research; and revealed preference approaches. All of these, when used alongside stated preference approaches, provide a wider evidence base that should be used to properly understand consumer views.

Presenting expected values

Principle 3: Consider the widest possible range of impacts of potential disruptions or failures.

The Commission's research found that often expected values were used when setting levels of service during specific events or preventing specific hazards. Expected values represent the sum of a range of outcomes multiplied by the probability that they will occur. For resilience, many hazard-specific levels of service use expected values to compare costs to benefits. For example, the setting of drought risk standards requires an understanding of both event probability and potential impacts to generate expected damages resulting from a drought.

Whilst expected values are a useful decision-making tool, especially for well understood hazards, they are often presented as one single weighted average. However, a single number does not show the decision-maker the distribution of values beneath that number. For example, two events with very different risk profiles can result in the same expected value.[14]

To aid better decision-making, it is critical that the distribution of risks and values are shown. This is because some risks might be more tolerable than others, and the extremes might be less tolerable than the averages reflect. Expected values can also hide uncertainty and presenting impacts under a range of scenarios can aid better decision making where there is significant uncertainty, such as climate impacts.[15]

Discounting the benefits and costs of extreme events

Principle 4: The right discount rate should be used for assessing costs and benefits of resilience, which might be lower for extreme cases where lives or irreversible socio-economic changes are at risk.

Discount rates are used to understand the costs and benefits of resilience across different time periods. For example, they are used to appraise the costs and benefits of investments for flood risk interventions.[16]

The standard discount rate used in project appraisal is the Green Book social time preference rate.[17] This has three components: 'pure social time preference' is the preference for value now rather than later; 'catastrophic risk' captures unpredictable risks; and the 'wealth effect' reflects that society expects to be richer in future because of economic growth.

Pure social time preference should be excluded in the discount rate when using appraisal to determine the right level of service for extreme events with the potential for irreversible socioeconomic changes. This aligns with the Green Book supplementary guidance, which advises that, for cost benefit calculations that involve large, irreversible wealth transfers (in the context of resilience, this would include the impact of extreme events on future generations), pure social time preference should not be applied.[18]

Since widespread or catastrophic infrastructure failures fall into this category, any discount rate applied when looking at these events should exclude pure time preference. Examples might include extreme cases of electricity loss that have consequences for the economy, or a major flood or hurricane that leads to loss of life.

The Commission has produced a simple worked example to illustrate the impact of using a discount rate for low probability, high impact events that does not include pure time preference. The example is based on a set of stylised parameter assumptions found in table 1.

Table 1: Parameter assumptions for worked example.

Parameter	Value
Appraisal period	100 years
Likelihood of extreme event	1% annual probability
Cost of event	£5 billion
Green Book discount rate (with pure time preference)	3.5% (0 – 30 years) 3.0% (31 – 75 years) 2.50% (76 – 125 years)
Green Book discount rate (without pure time preference)	3.0% (0 – 30 years) 2.57% (31 – 75 years) 2.14% (76 – 125 years)

Table 2 – Impact of applying discount rate for extreme events, without pure time preference

Annual Probability event	Discount rate	Net present value of expected damages (£bn)
1% annual probability	With pure time preference	162
1% annual probability	Without pure time preference	184

Table 2 provides an indicative understanding of the impact on expected damages, when the discount rate used does not include pure time preference. The expected damages for each year are calculated as:

Cost of event x Annual probability of event = Expected damages

The expected damages have then been converted into net present value terms, using the green book discount rate; with and without time preference as shown in table 2 and summed for the duration of the appraisal period.

This simple worked example shows that when pure time preference does not form a part of the discount rate, the expected damages (or benefits) resulting from resilience appraisals are higher, as shown in table 2. For this example and for resilience more widely, higher expected damages will mean that the optimal investment level required to achieve any given levels of service will change. This is because the investment is made up front while the expected damages (or benefits) accrue later, therefore a lower discount rate will raise the net present value of the expected damages, requiring a higher upfront investment to protect against them.

Social and cross-sectoral impacts

Principle 5: Consider wider social impacts and any impacts on other dependent sectors qualitatively or quantitatively.

Our research has found that for many levels of service across sectors, whilst there may be impacts on other sectors, they are often not considered as part of assessments to set levels of service. An example is the 'value of lost load' standard in the energy sector: currently this only attempts to capture the impact of lost industrial production, but does not explicitly capture the wider impacts to other infrastructure sectors, such as electrified rail.

These impacts should be considered because infrastructure sectors are becoming increasingly interdependent,[19] while general industry services are more reliant on the energy and digital sectors. An awareness of these impacts is important for an understanding of the full range of costs stemming from infrastructure disruptions and therefore the benefits that increased resilience investments will bring.

In an example of this approach, the Royal Academy of Engineering have emphasised that a holistic view of impacts on wider industry and other infrastructure sectors need to be considered when deciding on the right level of resilience for major electricity disruptions.[20] Considering this, the Commission argues that when setting levels of service, impacts on other sectors and wider industry should be considered either quantitively or qualitatively.

Endnotes

1 Levels of service are one way to express these standards. As explained in the final Resilience report, standards also apply across all the different aspects of resilience.
2 Standards or thresholds that are used to express the quality and/or availability of an infrastructure service that an infrastructure provider should aim for
3 Arup (2019), **UK Levels of Infrastructure Service Review**
4 Steer Group (2020), **Investigating the methods used to set committed levels of service**
5 D. Pearce and E. Özdemiroglu et al. (2002), **Economic Valuation with Stated Preference Techniques**
6 Performance targets for water companies, where supply must exceed demand plus targets set for headroom. Costs calculated include financial and/or environmental factors of providing supply-demand solutions, and benefits are understood by consumers' willingness to pay.
7 Average number of minutes that a customer has their supply interrupted.
8 Health and Safety Executive, **HSE principles for Cost Benefit Analysis (CBA) in support of ALARP decisions**
9 H. Bondi (1967), London Flood Barrier
10 Department of Energy & Climate Change (July 2013), **Reliability Standard Methodology**
11 Frontier Economics (March 2017), **Performance Commitments and Outcome Delivery Incentives at PR19**
12 BritainThinks (January 2020), **Social Research: Regulation & Resilience**
13 D. Pearce and E. Özdemiroglu et al (2002), **Economic Valuation with Stated Preference Techniques**
14 A good **worked example** of this has been produced by the Institute and Faculty of Actuaries
15 Institute and Faculty of Actuaries (2020), **Infrastructure resilience policy briefing**
16 Environment Agency (2014), **Flood and coastal erosion risk management: Long-term investment scenarios**
17 HM Treasury (2018), **The Green Book: Central Government Guidance on Appraisal and Evaluation**
18 HM Treasury (2008), Intergenerational wealth transfers and social discounting: **Supplementary Green book guidance**
19 HM Treasury (March 2020), Valuing infrastructure spend: Supplementary guidance to the Green Book
20 Royal Academy Of Engineering (November 2014), **Counting the cost: the economic and social costs of electricity shortfalls in the UK**

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