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DNV·GL

# Engineering Recommendation P2 Review Workstream 2.7: Alignment of Security of Supply Standard in Distribution Networks with Other Codes and Schemes

## Prepared for the Distribution Code Review Panel, P2 Work Group

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# 1. Introduction

Engineering Recommendation (ER) P2/6 places requirements on British electricity Distribution Networks Operators (DNOs) in respect of the minimum level of security of supply[1] they are required to provide for their customers. P2/6 is the planning standard that specifies minimum restoration times following asset failures. Minimum restoration times are a major determinant of the amount of redundancy that DNOs need to build into their networks because more redundancy increases the resilience of networks to asset failures. Increasing resilience also improves the ability of networks to maintain service during maintenance and network development activities.

ER P2/5, the predecessor to P2/6, has been in place for more than 4 decades and has only undergone relatively modest revision since P2/6 was implemented in 2006 following revisions to account for distributed generation.[2] In January 2014 the Distribution Code Review Panel[3] P2 Working Group (DCRP P2 WG), through the Electricity Network Association[4] (ENA), engaged a consortium consisting of DNV GL, Imperial Consulting (Imperial) and NERA Economic Consulting to carry out a fundamental review of ER P2/6. The project commenced in February 2015.

This report represents the output from "Workstream 2.7" of this project,[5] and focuses on the alignment of P2/6 (or any possible replacement thereof) with the broader regulatory framework to which DNOs are subject, and that may influence the degree of security of supply they choose to, or are obliged to, provide for consumers. This report proceeds as follows:

- Chapter 2 discusses the need for regulatory measures to constrain or influence the level of network reliability that DNOs choose to provide for their customers, and discusses the concept of "economically efficient" investment that such regulation should strive to achieve;

1 This report refers extensively to the concepts of security of supply and reliability, often interchangeably. In the absence of universally agreed definitions of these terms in the context of electricity networks, we define reliability as referring to the ability of the network to withstand failures in specific assets, and security of supply as referring to the experience of network users in respect of the likelihood and length of any interruptions to their access to the network.

2 "Revision of Engineering Recommendation P2", Open letter from the Chairman of the Distribution Code Review Panel to all electricity industry stakeholders, December 2012. As discussed further in the remainder of this report, the treatment of distributed generation in P2/6 is simplistic, which is being addressed by other workstreams of this review.

3 The Distribution Code Review Panel (DCRP) is the body responsible for overseeing the maintenance and development of the Distribution Code and its subordinate documents. Those subordinate documents include Engineering Recommendation P2/6. The ENA is the service provider to the DCRP for the physical maintenance of the Code and its subordinate documents.

4 Energy Networks Association is the industry body for UK energy transmission and distribution licence holders and is the voice and agent of the energy networks sector. ENA acts as a strategic focus and channel of communication for the industry and aims to promote the interests, growth, good standing and competitiveness of the industry. They also provide a forum for discussion among company members, and so facilitate communication and sharing of experience across the energy networks sector

5 See the Consortium's Project Initiation Paper for more details regarding the other project workstreams

- Chapter 3 provides background on ER P2/6, which, as noted above, is one element of the regulatory framework imposed on DNOs that aims to encourage the efficient provision of network reliability to customers;
- Chapter 4 describes other regulatory instruments that may affect the British DNOs' decisions regarding the levels of network reliability they provide for their customers;
- Chapter 5 describes briefly the range of measures applied in the regulation of electricity distributors in other jurisdictions to encourage them to provide efficient levels of network reliability;
- Chapter 6, drawing in part on the range of regulatory measures observed internationally as described in Chapter 5, sets out a range of options for the reform of P2/6;
- Chapter 7 discusses the advantages and disadvantages of each of the options for the reform of P2/6 set out in Chapter 6, focusing on interactions with other aspects of the regulatory framework; and
- Chapter 8 concludes by describing the conditions under which each of the options for reform is most likely to promote the efficient provision of network reliability, and notes what other forms of evidence would be required to make a full appraisal of the options. In particular, we describe how the evidence produced from the quantitative modelling being undertaken by Imperial through other aspects of this project will inform the overall assessment of the P2/6 reform options we identify.

While this report has been prepared by the NERA project team, it has benefited from input from the Imperial College and DNV GL project teams, as well as from comments received from the Working Group, and from a range of stakeholders through the stakeholder engagement process.

# 2. The Role for Regulation in Ensuring Efficient Network Planning

## 2.1. The Need for Regulatory Intervention in Network Planning

### 2.1.1. The economic characteristics of electricity distribution and the rationale for regulating reliability

The function of an electricity distribution network is to transport electricity to consumers, and in some cases (increasingly with growth in distributed generation and storage) from embedded producers to consumers in other locations. In essence, therefore, when a customer accesses the electricity grid, they purchase the right to use the capacity it provides in order to transport electricity. However, there will always be some risk that customers will not be able access the capacity they purchase in all conditions. For instance, extreme weather events or assets failures that occur for other reasons may disrupt the network's operations.

In markets for most goods and services, regulation of the degree of reliability of the transport network is not required. This is because competition amongst potential suppliers of transport services and for the goods and services to be transported will tend to result in consumers paying for as much reliability as they want. For instance, they can choose to contract with a transport company to ensure it keeps spare capacity to serve their needs, even in relatively extreme circumstances, or else they may choose to save money and accept a relatively high probability of service interruption.

But electricity distribution is different. DNOs[6] are natural monopolists, which economic theory shows do not have the same incentives to respond efficiently to consumers' demands as would a company operating in a competitive environment or to minimise the costs of developing and operating their networks. Electricity network businesses are also constrained in their ability to deliver different levels of reliability to individual customers due to the shared nature of their assets, particularly at higher voltage levels, which creates an economic "public goods" problem.

This public goods problem occurs because (absent smart meters[7]) DNOs have no way of knowing which particular (small) consumers are drawing power at a particular moments in time, they cannot ration the use of their networks by selected users when it becomes constrained, and have no commercial means of contracting with individual customers for different levels of security of supply. And economies of scale in the provision of network

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6 Note, this report considers the economic incentives on DNOs to provide efficient levels of reliability, and the appropriate form of regulation to achieve the efficient provision of reliability by DNOs. It does not explicitly consider the interface between DNOs and Independent Connection Providers. There may be a case for ensuring common regulations apply to both types of entities, but consideration of this is beyond the scope of this report.

7 Smart meters may address this problem because they make it possible for DNOs to identify which specific consumers are drawing power at any moment in time. Thus, they create the possibility that those individual consumers who place the lowest value on continuous electricity supply could have their demand curtailed when network capacity is scarce. As discussed further below, this could happen through a range of commercial channels, either through a voluntary response to a sharp rise in time of use distribution charges, or through the curtailment of users who have signed up to a contract allowing their load to be interrupted or constrained in certain conditions.

infrastructure means this problem cannot generally be overcome economically by providing separate assets for different consumers. Reliability of an electricity distribution system, like other public goods, [8] would therefore not be provided efficiently through competition.[9]

Moreover, in the presence of natural monopoly, regulation to prevent the exploitation of market power such as through revenue or price caps may encourage regulated companies to cut costs by reducing quality of service. Regulation of the level of reliability provided by distributors is therefore required to offset this incentive.

### 2.1.2. The role of P2/6 in regulating British DNOs

P2/6, alongside a number of other regulatory mechanisms discussed in the following two chapters, seeks to ensure that British DNOs design their networks efficiently, and in particular, invest efficiently to deliver security of supply to consumers. In considering reform of P2/6, it is therefore essential to consider its interactions with other aspects of regulation. Specifically, we need to consider whether this particular regulatory instrument is likely to encourage DNOs to invest efficiently in their networks and whether it can be improved, when considered alongside other prevailing regulatory instruments. We also need to consider the extent to which it duplicates other mechanisms, and so whether there is a need to retain P2/6 at all.

To provide background for this assessment, this chapter describes the key objective that the economic regulation of DNOs seeks to achieve, namely economic efficiency, and how this concept can be applied to the regulatory measures that influence the degree of reliability DNOs choose to provide when planning their networks. As further background, the next chapter describes a range of aspects of the regulatory framework within which DNOs operate that either place obligations on them in relation to the degree of security of supply they provide to consumers, or create financial incentives to undertake measures that enhance (or allow deterioration in) security of supply.

## 2.2. Objective: Enhancing Economic Efficiency

The concept of "economic efficiency" is a term that can, for the purposes of this discussion, broadly be interpreted as the property of protecting consumers' interests, which is established by law as the primary objective of the Gas and Electricity Markets Authority (GEMA). However, the concept of economic efficiency provides an analytical basis (rooted in academic literature on microeconomics) for assessing the merits of alternative forms of regulation, in a way that considering the rather vague objective of consumer protection does not. We therefore adopt the objective of economic efficiency as the basis for evaluating the options for reform of P2/6 in the remainder of this report.

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[8] Classic examples of public goods include street lighting and policing. Both services are enjoyed by all, whether or not they pay for them themselves.

[9] For the avoidance of doubt, smart meters will create the means to reduce the "free-rider" problem, but they will not change the fundamental economics of network businesses. Significant economies of scale will always be a constraint on the emergence of competition.

In the context of regulated network companies, a company is often described as "efficient" if the regulator considers that it is delivering the services required of it at the lowest cost that it can reasonably achieve. In the case of DNOs, for instance, Ofgem assesses companies' relative efficiency through a process of benchmarking to estimate their "efficient costs". However, this definition of efficiency, which Economists would generally describe as "productive efficiency,[10] where a firm uses the cheapest mix of inputs in order to produce a given amount of output, is just one aspect of what Economists term "economic efficiency".

Economic efficiency also encompasses the concept of "Pareto efficiency", sometimes referred to as "allocative efficiency",[11] which means that one could not reallocate resources to make one party better off without making another party worse off. In essence, this requires producers increase their output up to the point where the cost to consumers of producing more output becomes larger than consumers' willingness to pay for it. That is, firms operating in a market should produce as much output as possible, as long as consumers value that output at a price higher than the marginal cost of production.

Finally, there is a time component to efficiency. Basic microeconomic theory tends to focus on static efficiency, but this is a simplification. In practice, ensuring economic efficiency requires consideration of "dynamic efficiency", such that present consumers should not be made better off by harming future consumers, and vice versa.[12] In essence, this requires application of the concept of economic efficiency on a forward-looking basis.

## 2.3. Achieving Economic Efficiency in Practice

### 2.3.1. Applying the concept of economic efficiency to electricity distribution network planning

In this context, applying the concept of economic efficiency means that we should assess any planning standard against the extent to which it achieves the following objectives:

- First, DNOs have a choice as to the level of reliability they provide to network users, and the greater the reliability provided, the greater the costs that DNOs need to recover from consumers through regulated tariffs.[13] The concept of economic efficiency requires that DNOs should provide additional benefits to consumers in the form of enhanced reliability up to the point where network users' willingness to pay for additional reliability equals the marginal cost of providing it. If they provide less reliability than this, there is an efficiency gain to be had by incurring additional cost to enhance reliability, and vice

[10] Harold Fried et al (1993): *The Measurement of Productive Efficiency*, page 10.

[11] David Kreps (1990): *A Course in Microeconomic Theory*, page 153.

[12] Daron Acemoglu (2009): *Introduction to Modern Economic Growth*, page 338.

[13] Note, this statement is intended to make the general point that it is technically feasible to offer network users a range of different levels of reliability. In practice, regulations such as P2 (see subsequent chapters) may constrain the choice around the level of reliability DNOs are actually able to offer in practice.

versa.[14] Similar logic applies to other benefits such as loss reduction. (Economists refer to this dimension of economic efficiency as "*allocative efficiency*");

- Second, the concept of economic efficiency requires that reliability should be provided to network users using the cheapest means possible (Economists refer to this dimension of economic efficiency as "*productive efficiency*");[15] and
- Thirdly, DNOs should balance current and future costs and benefits when achieving objectives (1) and (2) above. Amongst other things, this means that DNOs should make efficient decisions on the timing and sizing of their assets, which are lumpy and long-lived. In some situations, especially when comparing operating measures with capital schemes, uncertainty around the future level of operating costs ought to be taken into account. (Economists refer to this dimension of economic efficiency as "*dynamic efficiency*").

In summary, any planning standard, when integrated into the overall package of regulatory incentives and obligations to which DNOs are subject, should enable, encourage and/or oblige DNOs to take *economically efficient investment decisions*, which make an efficient trade-off between the costs and benefits of reliability, and select the cheapest means of providing that reliability, whilst accounting for the specificities of their networks and the customers they serve.

### 2.3.2. Estimating the benefits of improved reliability

Achieving the economically efficient provision of reliability requires an assessment of the benefits of improved reliability to be compared against the costs of provision.

Larger network users, such as industrial consumers and larger embedded generators, may have some ability to pay for increased levels of reliability if they require it. However, the benefits of improved reliability cannot be observed directly, as the majority of small industrial/commercial and domestic consumers cannot directly reveal their reliability preferences by making market transactions. The benefits of reliability therefore have to be estimated.[16] For this reason research to estimate the value of improved reliability relies on proxy measures such as surveying and analysis of aggregate economic data, which can be imprecise, and sensitive to data, assumptions and methodological choices:[17]

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[14] Although this criterion for identifying the efficient provision of reliability (selected the level that equates marginal benefit and marginal cost) appears to focus on incremental changes in reliability, this criterion is in fact equivalent to requiring a baseline level of reliability that maximises efficiency.

[15] This criterion requires that DNOs consider both the private costs of any investments they undertake, as well as any externalities such as the social cost of overhead lines as compared to underground cables.

[16] In jurisdictions where smart meters are absent, consumers cannot express their preferences for different levels of reliability through the products and services they purchase from their electricity supplier. The level of reliability they obtain is "homogenous", whatever tariff or supplier they select.

[17] "Outage Cost Estimation Guidebook", Report no. TR-106082, EPRI, Sullivan, M. and Kean, D. 1995

- The nature of the economic costs of service interruption (and hence the value of reliability improvements) vary with customer type, which has implications for the choice of an estimation method:[18]
  - The cost of interruptions to residential customers depends on factors such as irritation or inconvenience caused by an outage, as well as the characteristics and personal situation of the consumer. The costs of interruptions to non-domestic customers is also variable, and depends on factors such as the nature of the industrial or commercial activity they undertake.
  - Because there is an absence of market data on these costs, they are usually estimated through "stated preference" surveys where consumers make choices from menus of service levels (such as changes in the probability of experiencing an outage) and trade this off against cost (such as changes in their bill).[19] The hypothetical nature of such questions enables measurement of reliability benefits under large number of conditions including outage timing, duration, and its frequency, but the results are sensitive to factors such as the survey design and the statistical techniques used to analyse survey data. These statistical techniques can also estimate the sensitivity of the value customers place on enhanced reliability, depending on their characteristics (eg., in the case of residential customers, income, socioeconomic group, age, etc).
  - The greater availability of actual cost data associated with outages for industrial and commercial customers allows for a more direct contingent valuation approach, which is often supplemented or substituted by estimates of losses based on analyses of macroeconomic indicators - gross value added (GVA) and value at risk (VAR) approaches.[20]
- Research results are typically expressed in a metric, referred to as VOLL or VCR[21], which assigns a monetary value to the quantity of energy unserved. The metric assumes that there is a linear relationship between energy unserved and customer losses, although more detailed representations, referred to as Customer Damage Functions (CDF), assume losses (per kW interrupted) as function of outage timing and duration, amongst other things. In theory, these alternative measures of the damage caused by interruptions may be more realistic than valuing avoided interruptions using VOLL/VCR because they account for a wider range of factors that influence the value customers place on avoiding interruptions, though they are much less widely used in practice.

Despite some practical limitations of the methods typically used to estimate the benefits of improved reliability, such as those noted above, such estimates represent the best available evidence about the value that customers place on reliability.[22] For instance, the empirical evidence on customer preferences for reliability in Great Britain is sizable and includes work

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[18] Sullivan, M. and Kean, D. 1995

[19] Sullivan, M. and Kean, D. 1995

[20] Sullivan, M. and Kean, D. 1995

[21] Value of Lost Load and Value of Customer Reliability

[22] Detailed discussion of estimation methods is included in Sulivan and Kean (1995)

by London Economics (2013) [23], Accent (2004 and 2008)[24], Reckon (2012)[25], and EU funded SESAME project.[26]

However, this evidence suggests a range of estimates regarding the value of improved reliability reflecting both variability of customer preferences and the limitations of the analytical approaches used to estimate them.[27] Nonetheless, it is clear from the evidence that the economic costs of interruptions (and thus the benefits of improved reliability) differ with customer type, outage timing and duration, and previous experience of outages:

- VOLL estimates for domestic customers from the sources noted above range from around £700/MWh to £59,000/MWh;
- The values for SME customers fell between £9700/MWh and £225000; and
- For larger commercial and industrial they ranged from £423/MWh to £12,336/MWh.[28]

Faced with this level of uncertainty regarding the value of improved reliability, power system planners and policy analysts often resolve to use a single VOLL estimate representing a simple or weighted average.[29] For instance, recent UK government and regulatory decisions have used a figure of £16,940/MWh based on a London Economics study.[30] However, the large ranges around published VOLL estimates illustrate the importance of sensitivity analysis in appraisals of policy measures and investment decisions that rely on such estimates,

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23 "The Value of Lost Load (VoLL) for Electricity in Great Britain", Final report for OFGEM and DECC, 2013

24 "Expectations of DNOs & Willingness to Pay for Improvements in Service", Final report for Ofgem, 2008
"Consumer Expectations of DNOs and WTP for Improvements in Service", Report for Ofgem, 2004

25 "Desktop review and analysis of information on Value of Lost Load for RIIO-ED1 and associated work", Reckon, 2012

26 www.blackout-simulator.com

27 There are many challenges inherent to the stated preference approach including cognitive biases, sample representativeness, transience of preferences, among others. For a discussion of surveying issues see:

"Willingness to pay and compensation demanded: experimental evidence of an unexpected disparity in measures of value", J. Knetsch, J. Sinden, The Quarterly Journal of Economics, Vol. 99, No. 3 (Aug., 1984), pp. 507-521

"Valuing security of supply: does experience matter?", A. Von Selasinsky, D. Schubert, T. Meyer, D. Most, Technische Universitat Dresden Working Paper, May 2014. Available at SSRN: http://ssrn.com/abstract=2442492

"The Effect of Power Outages and Cheap Talk on Willingness to Pay to Reduce Outages", IZA Discussion Papers 4307, Institute for the Study of Labor (IZA).

"The cost of power outages: a case study from Cyprus", T. Zachariadis, A. Poullikkas, Energy Policy, Volume 51, December 2012, Pages 630-641

28 It is interesting to note that large industrial and commercial consumers can have relatively low levels of VOLL. One explanation for this might be that VOLL for these types of customers is defined by the value of production foregone from the lack of electricity supply, or the price of electricity supply at which production becomes uneconomic anyway. If the production foregone during a power outage can be rescheduled to a time after supply is restored, this value foregone might be rather modest. Similarly, in industries with low margins, high electricity costs would deter large industrial customers from consuming electricity, as they would rather wait until the price falls.

29 Examples include:" Value of Customer Reliability Review", Australian EnergyMarket Operator, Sept 2014
"Electricity Market Reform - options for ensuring electricity security of supply and promoting investment in low-carbon generation", DECC, 2010

30 "The Value of Lost Load (VoLL) for Electricity in Great Britain", Final report for OFGEM and DECC, 2013

as discussed further in Chapter 7 below.[31] It is also possible that VOLL will change over time, due to factors such as increases in the penetration of electricity in the heating and transport sectors.

### 2.3.3. Market information on the value of improved reliability

In competitive markets customer preferences are revealed through market transactions. The amount of goods purchased reflects the equilibrium point between the benefits and costs as perceived by customers.

In the context of electricity network access the trade-off is between increased reliability and the price of its provision. While tailoring of physical assets to meet reliability preferences is not typically possible (discussed above), a similar outcome can be achieved through the use of interruptible network access contracts and/or time-of-use distribution network tariffs:

- Consumers or embedded generators/storage providers could contract with the DNO for the level of reliability they want, and consent to be disconnected in conditions when network capacity is scarce due to asset failures, for instance. In return they would pay lower network charges; or
- Consumers could be charged tariffs that rise substantially at times when network capacity is scarce to encourage them to curtail their consumption, or that fall substantially to encourage other parties like embedded generators or storage operators to send more power onto the distribution system.[32] The Forward Cost Pricing model used to set EHV distribution charges introduces some signals of the scarcity (or otherwise) of network capacity, but this approach involves an even more cost reflective approach, in which network charges vary over time to signal specific periods of scarcity due to factors such as outages of network assets or periods of high demand.

However, achieving such an efficient outcome through interruptible contracts and time of use network tariffs, while possible in theory, is difficult in practice. The rationing of network access is dependent on the availability of technological solutions to track and control network access through time. For individual customers (as a minimum) it requires the availability of smart meters and also smart appliances to overcome the well-known behavioural hurdles of customer engagement. In practice, rationing network access may also create other challenges for DNOs, such as those related to managing the data flow from smart meters.

Some forms of regulation that encourages DNOs to provide an efficient amount of reliability to network users is therefore likely to remain necessary for the foreseeable future.

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[31] For example current assessments of VOLL do not take into account future developments such as increase on electric vehicles and the consequent impact on mobility.

[32] Subject to successful coordination between suppliers and DNOs including areas such as: communication, and data sensitivity.

### 2.3.4. Considering alternative means of providing improved reliability

Network reliably has traditionally been determined to a large extent by the degree of redundancy of network assets that DNOs decide to provide. However, technological innovations now promise alternative means of providing reliability, and relieving capacity constraints at times of network stress. These new technological solutions include storage, more extensive use of load management, alternative sources of embedded generation and storage, and more flexible network actions. Increasing security through these measures is already technically feasible in some situations and sometimes applied in practice, and given the potential cost savings they may offer compared to conventional solutions, efficient network planning requires that DNOs consider these technologies in deciding which assets to provide.

The presence of these more innovative technologies does, however, complicate network planning. For instance, the DNO may not know the likelihood of a distributed generator, storage facility or Demand Side Response (DSR) provider being available when it is needed to support the network. The behaviour of DSR is largely determined by the price signals coming from the wholesale market, as a well as by the impact of production decisions during the "triad" on network charges for those customers able to manage their demand at key times.[33]

The use of non-network services to address network reliability through the planning process could take two forms: active management of their output by DNOs, or close passive monitoring:

- Under passive management approach, the DNOs would have no control over the operation of DG, storage or DSR, except possibly in exceptional/emergency conditions. They would plan their network around them, based on (1) an assumption on how likely it is that the existing supply of these technologies will be available when they are needed to support the network, and (2) scenarios on the future development of these technologies.
- The active approach would involve DNOs contracting specific firm services from DG, DSR or storage providers in exchange for compensation. This approach gives DNOs a better understanding (though possibly still an estimate) of what degree of reliability they can expect from the contracted providers.[34]

There are also operational measures that DNOs can make in some situations to improve security, often referred to as flexible network interventions. They include voltage control, network reconfiguration, and use of real-time ratings for transformers, overhead lines and underground cables. Their use may temporarily delay the need for other, more permanent solutions.

The discussion above establishes that there are a range of technological means of providing reliability besides the provision of redundancy, some of which are already in use, and some

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33 Examples include STOR plants, or DSR operating for the benefit of suppliers benefiting from wholesale price signals.

34 Such contracts may, of course, need to include sufficient penalty clauses to ensure that providers of "firm" services have an economic incentive to deliver on their contractual obligations.

of which may become increasingly widely used in the future as technology changes. Efficient network development relies on DNOs making use of these measures to provide reliability, where they are cost-effective.

### 2.3.5. Other considerations in the provision of network capacity

By specifying minimum restoration times, P2/6 to a large extent prescribes the minimum level of redundancy DNOs are obliged to provide, with the intention of ensuring particular levels of reliability. However, reliability of supply is not the only consideration of the planning process. Adding network assets may in some circumstances bring with it other costs and benefits that should be considered in network design to ensure efficient investment decisions take place.

In particular, if energy prices become more expensive as decarbonisation policies require the use of more expensive technologies to generate electricity, or fossil fuel prices rise, the financial cost of losses will grow. Given this trend, if may become efficient to incur higher capital costs to oversize distribution assets and reduce electrical losses, which might, as a side-benefit, provide higher reserve margins and thus (potentially) greater reliability. Oversizing individual lines and cables to minimise losses may also reduce the cost of providing additional redundancy. Depending upon the network and topology, providing additional network assets to achieve either lower losses or greater reliability may also increase load transfer capacity, increase the capacity of the network to accommodate embedded generators, and speed up connection times. Network planners also need to consider factors such as environmental and sustainability issues, and the aesthetic characteristics of their networks.

While not central to this study, a system of regulation aimed at promoting the economically efficient provision of network assets for reliability should also consider the other economic benefits of network assets.

### 2.3.6. We do not take the "status quo" level of reliability as the standard to be maintained

As discussed in the Consortium's Workstream 2.0 report, several stakeholders commented in our review process that the current level of network reliability is considered to be good, or that any reforms should not worsen reliability. Such apparent preferences for the status quo level of reliability are, however, inconsistent with our remit to conduct a "fundamental" review of P2/6.[35] While it is natural to take the existing standard as a starting point against which alternatives can be evaluated, we do not intend to take for granted that the current standard prescribes the "right", or economically efficient, level of reliability:

- It may be the case that P2/6 prescribes too much reliability compared to the level that is economically efficient, in the sense that the avoided cost of marginally reducing

[35] There is also a tendency, widely cited in the literature on willingness-to-pay research, for consumers to express a bias in favour of the status quo when asked what level of service they want to receive from utility companies. This "status quo bias" is another reason we place little weight on such statements expressing a preference for the current level of security of supply provided by P2/6.

reliability exceeds the saving network users would be willing to accept in return for more frequent interruptions. In this case, it would be efficient for whatever standard or other regulatory mechanisms to prescribe lower levels of reliability, which would ultimately reduce costs to the consumer.

- Conversely, it may be the case that P2/6 prescribes too little reliability compared to the level that is economically efficient, in the sense that the costs of marginally improving reliability are less than consumers' willingness to pay for the associated incremental benefits of less frequent interruptions. Hence, obliging DNOs to provide more reliability would be in consumers' interests.
- And because P2/6 imposes the same requirements on all DNOs in all circumstances and for all network areas, irrespective of real-life variations in the values consumers place on reliability and the costs (or savings) associated with increasing (or reducing) reliability, it may be the case that P2/6 prescribes too much reliability in some cases compared to the level that is economically efficient, and too little in others.

In the context of this review, and in line with our remit from the Working Group, we will consider all these possibilities regarding the performance of P2/6 and appraise the options for reform without any preconception about whether that the status quo should be maintained. Specifically, the modelling being undertaken by Imperial College will consider whether P2/6 prescribes too much or too little reliability.

### 2.3.7. Factoring in DNOs' planning and overhead costs

As discussed in more detail in subsequent chapters, some planning standards are extremely prescriptive, providing DNOs with a clear guide as to what to build and what not to build. Following such simple planning procedures is a relatively simple exercise for DNOs, which keeps the costs of undertaking network planning relatively low. In contrast, other planning standards may place more discretion in the hands of DNOs by imposing relatively few deterministic requirements, and thus increasing planning costs to some extent compared to the current standard. While these planning standards may provide DNOs with flexibility, it may also create costs as they do not have a "rule book" they can follow to simplify network planning. Investment decisions taken by DNOs using more deterministic planning standards may also be relatively easy for customers and third parties to understand, which may also confer some benefit where investment decisions need to be defended in legal proceedings.

Hence, the nature of the planning standard adopted affects the costs of planning the network, and ideally such differences in planning costs ought to be factored into the decision over how and whether to reform P2/6. In practice, however, we cannot reliably estimate the costs incurred by DNOs to apply alternative planning standards, but we will note this factor and consider it qualitatively in our assessment.

## 2.4. Conclusions

Electricity distribution networks are natural monopolies, regulated in Great Britain through revenue caps set by the regulator at periodic reviews. The incentives to minimise costs that such regulatory arrangements necessitates some form of regulation to ensure distributors do not seek to save money by minimising the quality of service offered to customers, such as in respect of reliability. Regulation of reliability is also needed to offset the "public good" nature of reliability in electricity distribution networks, as many consumers cannot contract for the level of reliability they are willing to pay for the DNO to provide.

P2/6, as well as a range of other mechanisms described in the next chapter, is one such piece of regulation that constrains the level of reliability that DNOs are obliged to deliver. As discussed in this chapter, the combination of regulatory mechanisms that seek to regulate the amount of reliability that DNOs are required or encouraged to deliver should seek to achieve an economically efficient provision of reliability, given a range of technological solutions.

Achieving the economically efficient provision of reliability is challenging in practice, however, most notably because it requires an estimate of the value that network users place on network reliability. Estimates of the value of reliability vary materially due to both underlying factors (timing and duration of outage, type of customer, etc) and with the techniques used to estimate it. Ideally, any regulatory instrument needs to allow for such uncertainties, as we discuss in previous chapter, and as analysed in detail in the Imperial modelling work.

# 3. Background on Engineering Recommendation P2/6

## 3.1. Overview of P2/6

As noted above, ER P2/6 is a planning standard that applies to British DNOs. DNOs are obliged to comply with P2/6 by the Distribution Code, and it also forms part of each DNO's licence.[36] We also understand that P2/6 can inform assessments against DNOs' adherence to their duties to "*ensure that their equipment is constructed, installed, protected… to prevent… interruption of supply, so far as is reasonably practicable*".[37] As discussed above, P2/6, the sixth version of the P2 standard, was implemented in 2006 following revisions to account for distributed generation (see below), and its predecessor (P2/5) had been in place for more than 4 decades.[38]

ER P2/6 is widely described as a *deterministic* standard in the sense that it makes prescriptive requirements about the minimum degree of security of supply DNOs are obliged to provide to consumers.[39] It defines the minimum degree of security of supply that DNOs must provide by specifying how quickly supply to consumers must be restored following outages of distribution assets. These requirements to plan for restoration of service following system faults influence significantly how much asset redundancy DNOs must provide. DNOs can provide higher levels of reliability than the minimum standards required by P2/6, for instance where a CBA demonstrates that it is efficient to do so.

## 3.2. Obligations Imposed Through P2/6

The original development of P2/6 set the deterministic obligations that appear in the current standard through an assessment of what degree of reliability it would be desirable to provide for consumers. In essence, we understand that these obligations were set to account for the probabilistic nature of system failure, capital costs reflective of conditions in the 1970s, and the benefits of enhanced reliability from adding additional network assets, as measured by the assumed value of changes in an Expected Energy Not Supplied (EENS) index, which captures information on outage frequency, duration and lost load. From this comparison, the deterministic obligations placed on DNOs to provide security of supply were calibrated.[40]

The minimum reconnection times following an outage of a particular distribution asset that P2/6 specifies depend on the level of "group demand", which reflects the peak load served by

36 "Electricity Distribution Network Planning – Engineering Recommendation P2/6", Open letter from Ofgem to distributors and customer groups, August 2007

37 The Electricity Safety, Quality and Continuity Regulations 2002, Section 3.

38 "Revision of Engineering Recommendation P2", Open letter from the Chairman of the Distribution Code Review Panel to all electricity industry stakeholders, December 2012

39 "Final Report: Review of Distribution Network Design and Performance Criteria", KEMA with Imperial College London, July 2007

40 Based on information from various sources, in particular: KEMA and Imperial College London, Final Report: Review of Distribution Network Design and Performance Criteria (G06-1646 Rev 003), 19 July 2007.

a particular asset net of latent demand.[41] The standard specifies reconnection times for six sizes of demand group, and for two types of outage events.[42]

The greater the load served by a particular asset (ie. the higher its group demand), the shorter the minimum reinstatement time, and thus the higher the degree of redundancy, required by P2/6. For instance, minimum reinstatement times in P2/6 are shortest for the largest demand groups (in excess of 60MW at peak) and require N-2 redundancy.[43] However, no network redundancy (N-0) is required for demand groups of less than 1MW at peak.[44]

The standard also deals with maintenance outages for large demand groups through restoration times specified for second circuit outage, a fault following a planned outage.

P2/6 is primarily concerned with security of supply to demand users and does not contain any provisions regarding minimum restoration times or other constraints on continuity of service to distributed generators.[45] It does, however, recognise the contribution of embedded generation in determining the capability of the network; the security contribution of generation is added to the security contribution from network assets.[46]

An implication of the requirements imposed by P2/6 is that more redundancy will be required for more pivotal assets serving a higher number of consumers. By implication, P2/6 tends to require greater levels of redundancy (ie. faster restoration times) for assets at higher voltage levels, and for more pivotal assets, such as those serving large urban centres. However, the only *formal* distinction is by demand group, with no differentiation by factors such as region, customer types, rural vs.major cities, and so on.

Finally, it is important to note that, while P2/6 applies a range of obligations on DNOs, companies can apply for derogations from these requirements. There may be a range of reasons why Ofgem would grant a derogation, such as when it would be uneconomic to comply due to especially high costs or low consumer benefits.

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41 "Latent demand represents demand masked by distributed generation that would cause the value of measured demand to increase if the DG was not producing any output." From source: "Distributed generation addressing security of supply and network reinforcement requirements", UK Power Networks, Report A8, 2014

42 ER P2/6

43 N-1/N-2 network planning standards require the network to continue to function without interrupting any customers following the loss of 1 or 2, respectively, significant network components such as primary feeders.

44 ER P2/6. Note, DNOs can provide more redundancy in situations where it is economically justified, such as where an individual customer is willing to pay for it.

45 This is important because even for a dual circuit system an outage of the circuit where DG is connected might render it ineffective.

46 The methodology for assessing the contribution of distributed generation to security of supply is contained in supporting documents to ER P2/6 - the Engineering Technical Reports 130 and 131 (ETRs 130/131): (1) "Application Guide for Assessing the Capacity of Networks Containing Distributed Generation", ETR 130, Energy Networks Association, July 2006; and (2) "Analysis Package for Assessing Generation Security Capability - Users' Guide", ETR 131, Energy Networks Association, July 2006.

## 3.3. The Limitations of P2/6

As discussed extensively in other documents prepared by the Consortium for the P2 Work Group,[47] P2/6 has a number of limitations that may create a case for its reform. Some of these limitations are listed below, and relate (amongst other things) to changes in power sector technologies not envisaged at the time P2 was developed, changes in the economic trade-off between the costs of providing network assets as compared to the value of avoided interruptions, or aspects of network planning and operation not accounted for by the existing deterministic planning standards in P2/6: [48]

- The use of EENS implies that the cost of interruptions to large customers is weighted more heavily than for small customers. It may be desirable to review whether this is consistent with the relative economic consequences of interruptions to different types of users;
- The standard includes no provision for demand groups below 1MW, leaving it up to the DNO to determine the level of reliability to be provided;
- The standard lacks explicit consideration of generation capacity or "prosumer";
- The standard is not specific about how and by what means reliability is to be achieved. This prevents consistency in reliability experienced by final customers, particularly those connected at lower voltages;
- P2/6 does not address operational considerations, so does not account for factors such as how failure rates vary with asset life;
- While the standard sets specific restoration times following outages it does not put any requirements on the frequency of acceptable outages for individual customers;
- The standard deals neither with common mode failures[49] nor High Impact Low Probability (HILP) events;
- P2/6 only considers the load served at peak by particular assets, not the persistence of high demand throughout the year (ie. consumers' load duration curves). This might result in inefficiently large redundancy requirements in areas where network assets serve a relatively high amount of load at peak, but very little at other times of the year. It may not be efficient to provide redundancy for relatively short-lived peaks in demand;
- P2/6 does not explicitly allow or disallow responsive demand to be included within the security of supply assessment for any given Group Demand;[50]

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[47] "Engineering Recommendation P2 Review (Phase1 1), Project Initiation Paper", ENA, Report No.: 16011094/110, 2015.

[48] "Final Report: Review of Distribution Network Design and Performance Criteria", KEMA with Imperial College London, July 2007. "Electricity Distribution Network Planning – Engineering Recommendation P2/6", Open letter from Ofgem to distributors and customer groups, August 2007.

[49] Common mode network failures can arise where there is a risk of multiple faults occurring following a single event, eg. a fire.

[50] "Accommodating Demand Side Response in Engineering Recommendation P2/6 – Change Proposal", Capacity to Customers (C2C) Project, Electricity northwest, 2013.

- P2/6 does not differentiate between urban and rural networks, or more generally it assumes all customers value electricity equally;
- P2/6 does not consider the trade-off between the levels of redundancy required (eg. N-1/N-2) and the economies of scale achievable in procurement of network components. For instance, a DNO can increase redundancy by installing a larger number of relatively small (and thus higher cost) assets rather than a smaller number of relatively large (and thus lower cost) transformers to provide the same network capacity; and
- P2/6 does not consider the security of DG's connection when assessing its security contribution, nor does it consider the connecting DG's security requirements.

Considering these (and other) limitations of P2/6, the remainder of this report explores the options for improvements in distribution planning standards, with a focus on its interactions with other regulatory mechanisms that affect DNOs' decisions about the degree of security of supply they provide for consumers.

# 4. Interactions with Regulatory Mechanisms to Promote Security of Supply

To provide background for our identification and assessment of P2/6 reform options, this chapter reviews other regulatory mechanisms, incentives and obligations that may impact on DNOs' decisions over how much reliability to provide and the technological means by which they do so.

## 4.1. The Interruptions Incentive Scheme

The Interruptions Incentive Scheme (IIS) is a financial mechanism that rewards (penalises) DNOs for reducing (increasing) interruptions compared to targets set by Ofgem at periodic reviews of their price controls. The IIS therefore provides a financial incentive for DNOs to improve reliability.

Ofgem sets each DNO's IIS targets, and monitors their performance, using aggregate indices of Customer Interruptions (CI) and Customer Minutes Lost (CML)[51] on each distribution network, with a distinction between planned and unplanned outages. Ofgem calibrates the scheme to provide penalties and rewards to companies at "incentive rates". Penalties and rewards are calculated as the product of the incentive rate and the difference between the actual and the targeted CIs/CMLs.

Ofgem decided to align the IIS incentive rates with that of the RIIO-T1 Energy Not Supplied incentive[52] (equal to £16,000/MWh). The incentive rate of the RIIO-T1 was designed by Ofgem to reflect "the value customers place on electricity when they are without supply",[53] measured by VOLL.[54] The specific CI and CML incentive rates are calculated based on the VOLL assumption of the RIIO-T1 Energy Not Supplied incentive. Rates vary between £0.12 and £0.55 million per CI, and between £0.28 and £1.34 million per CML, both in 2012-13 prices.[55]. Different incentive rates are set for different DNOs, but there is no variation in incentive rates for different customer types or for different times of the day or year.[56] The rates determined in the RIIO-ED1 price control do not significantly differ from the rates in the IIS of the previous DPCR5 price control.

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51 CI is the number of customers whose supplies have been interrupted per 100 customers per year. CML is the average number of customer minutes lost per customer per year. (For both measures, only interruptions longer than three minutes are considered). Source: Ofgem, "*RIIO-ED1 Glossary of Terms*", p.4.

52 Ofgem, "*Strategy decision for the RIIO-ED1 electricity distribution price control – Reliability and safety: Supplementary annex to RIIO-ED1 overview paper",* 04 March 2013, p.9.

53 Ofgem, "*Strategy for the next transmission price control - RIIO-T1 Outputs and incentives: Supplementary Annex*", 31 March 2011, pp. 42-43.

54 Ofgem's estimate of VOLL was based on a thorough review of a number of sources, including: the views of industry stakeholders, macroeconomic studies and (to a greater extent) consumer survey estimates of VOLL from Great Britain and from other jurisdictions.

55 These ranges are valid for the 10 slow track DNO's in Ofgem RIIO-ED1.

56 Ofgem, "*RIIO-ED1: Final determinations for the slow-track electricity distribution companies, detailed figures by company: Supplementary annex to RIIO-ED1 overview paper*", 28 November 2014, pp. 14-15.

Overall revenue exposure to the IIS is 250 Return on Regulatory Equity (RORE) basis points per annum.[57] This exposure is symmetrical, i.e., electricity distribution companies could be penalised or could receive a reward up to this amount. The incentive rate on planned interruptions is half the incentive rate on unplanned interruptions, when sufficient notice for these planned interruptions is given. This difference in the incentive rate is aimed to reflect the difference in the inconvenience caused to consumers by planned and unplanned interruptions. Annual targets for planned interruptions are set at the "annual average level of planned interruptions and minutes lost over the previous three year period"[58], and are therefore updated annually.[59] DNOs can propose alternative targets for both planned and unplanned interruptions in their well-justified business plans.[60]

Unplanned CI and CML targets are predetermined for the whole of the price control period using data up to 2012-13. Targets are determined as follows:

- Interruptions data is considered at different voltage levels (HV, LV, EHV and 132kV) separately. Benchmarks for CI and CML are determined separately for DNOs at each of these voltage levels. The aggregate of these benchmarks gives the overall CI and CML benchmark for each DNO.
- The DNO-specific average of CI and CML is calculated (also using disaggregated interruptions data), using the previous 4-10 years of actual performance.
- To set the starting target for CI (for each DNO), the average CI value of the previous 4 years is used. The targets for later years are determined using annual improvement factors. If the starting target (i.e., the actual performance) of the DNO is below the benchmark, an annual improvement factor of 0.5% is applied to determine CI targets for later years. If the DNO's performance is worse than the benchmark (ie., if the starting target is above the benchmark), then an improvement factor of 1.5% is applied.
- The CML starting target is calculated as the weighted average of the recent performance of the DNO and of the CML benchmark, which is calculated as the CML/CI benchmark multiplied by the greater of the CI benchmark and target. Improvement factors are set separately for different voltage levels, and equal 1% for LV, EHV and 132kV, and 3% for HV.[61]

In principle, the IIS can influence network design decisions at all voltage levels, as fewer interruptions achieved, such as through the provision of more (or larger) assets, provide DNOs with additional incentive payments. However, we understand that the IIS is most likely to influence DNOs' behaviour at lower voltage levels (HV and below), where P2/6

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57 This exposure is converted to a fixed £ value, as set out in the license.

58 Ofgem, "*Strategy decision for the RIIO-ED1 electricity distribution price control, Outputs, incentives and innovation: Supplementary annex to RIIO-ED1 overview paper*", 26a/13, 04 March 2013, p. 33.

59 There is a two-year lag applied in the calculation; e.g., the 2015-16 target is set based on the average annual performance between the 2011-12 and 2013-14 period.

60 Ofgem, "*Strategy decision for the RIIO-ED1 electricity distribution price control, Outputs, incentives and innovation: Supplementary annex to RIIO-ED1 overview paper*", 26a/13, 04 March 2013, pp. 32-33.

61 Ofgem, "Strategy consultation for the RIIO-ED1 electricity distribution price control - Reliability and Safety: Supplementary annex to RIIO-ED1 overview paper", 122/22, 28 September 2012, pp. 22-28.

requires less redundancy, and absent the IIS, DNOs might be tempted to provide relatively low levels of security.

The IIS also differs from P2/6 in that is provides a continued incentive to network maintenance and improvement, not just a minimum standard at the point of design. For instance, the IIS provides an incentive for DNOs to improve reliability through operational measures, such as enhanced maintenance, as well as through the provision of additional capacity. It also provides an incentive for DNOs to avoid interruptions, whereas P2/6 only places obligations on DNOs to achieve certain restoration times once an outage occurs.

However, it makes a number of simplifying assumptions. The IIS provides only limited incentives to DNOs in respect of avoiding HILP events, as Ofgem removes the effect of major events from the computation of DNOs CI and CML indices for the purpose of computing penalties and rewards.[62] It also treats all consumers alike, with a common value placed on all avoided interruptions and minutes lost, irrespective of the time of interruption or the type of consumer interrupted. One implication of this approach is that it will tend to encourage DNOs to provide better reliability to consumers for whom it is relatively cheap to provide additional security of supply (such as those in urban areas) and less to customers in areas in which it is more costly to enhance security of supply. This may or may not be efficient, depending on whether customers for whom it is relatively expensive to provide reliability (such as those in rural areas) place the same value on reliability as those in urban areas.

## 4.2. Guaranteed Standards of Performance

The Guaranteed Standards of Performance (GSOP) are guaranteed service levels that electricity distribution companies are required to meet. If a distribution company fails to meet these requirements, it must make a set payment to the customer affected. These payments are designed to compensate the customer for the inconvenience of supply interruption, but are not designed to compensate the customer for financial losses incurred as a result of the supply interruption. The payments provide an additional incentive for distribution companies to maintain or improve security of supply.

In 2014, as part of the RIIO-ED1 Price Control, Ofgem decided to amend the Guaranteed Standards of Performance (set out in Statutory Instruments No. 698, 2010), as follows:

"Statutory regulations set out guaranteed standards of performance on reliability, under which a customer is entitled to claim a fixed payment from the DNO if their supply has been interrupted for a certain period. We are reducing this period to 12 hours (from 18 hours currently)[63] and are removing exemptions so that all customers receive payments for being off supply irrespective of their location.[64] We are doubling the payments DNOs make to

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62 Ofgem, "*Strategy decision for the RIIO-ED1 electricity distribution price control, Outputs, incentives and innovation: Supplementary annex to RIIO-ED1 overview paper*", 26a/13, 04 March 2013, pp. 34-35.

63 For interruptions classified as normal weather events.

64 In the period of the DPCR5 price regulation, there were exemptions in place for customers in the Highlands and the Islands of Scotland.

customers following a prolonged period without supply caused by severe weather. These will be £70 after the initial period of interruption[65] followed by an additional payment of £70 for each successive period of 12 hours without supply. The cap per customer has been increased and is now £700. We will consult shortly on a new statutory instrument to introduce these arrangements".[66]

The exact payment to be made by the DNO to the customer depends on a number of factors, as follows:

- It depends on the exact event (i.e., the failure to meet certain conditions). Failure to restore supply within a certain time period is the most common of these events, however, there are other events that trigger payment, such as the failure to provide notice of a planned interruption, the failure to make or keep an appointment with the customer etc;
- The payment also depends on the weather conditions at the time. For instance, the payment is lower if weather conditions were severe at the time of the service interruptions;
- The payment (for supply interruption events) depends on the duration of the power-cut. Payments increase with the length of the supply interruption in a stepwise manner, and a maximum cap is applied to payments per customer; and
- Payment depends on the type of customer: Non-domestic customers are entitled to higher payments than domestic customers (in the case of some events). However, payments to non-domestic customers are usually only double the payments to domestic customers, and thus do not reflect the size of financial losses incurred (as a result of supply interruptions, for example).[67] The guaranteed standards are not intended to cover the consequential losses to customers as a result of a power-cut.[68]

The Guaranteed Standards provide very specific incentives for distribution companies. For example, the Standards provide incentives for distribution companies to resume supply within 12 hours of the interruption (under normal weather conditions), however, they do not provide incentives to resolve the issue as soon as possible within the 12 hour initial period.

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65 The time period depends on the scale of the severe weather event (defined according to the number of related faults at high voltage and above).

66 Ofgem, "*RIIO-ED1: Final determinations for the slow-track electricity distribution companies –Overview*", 28 Novermber 2014, paragraph 3.37.

67 Ofgem, "*Strategy decision for the RIIO-ED1 electricity distribution price control – Reliability and safety: Supplementary annex to RIIO-ED1 overview paper*", 26f/13, 04 March 2013, pp. 47-51.

68 In general, customers are required to apply to their DNO to receive Guaranteed Standards of Performance Payments. However, payments to customers in the Priority Service Register are made automatically.

## 4.3. RIIO Price Controls

### 4.3.1. Producing business plans justified with reference to consumer outputs

Under RIIO, as under the previous procedures for setting price controls for GB energy networks, at the start of a price control process DNOs are required to prepare a business plan. DNOs' business plans and their operational decisions must ensure they adhere to the various obligations to ensure security of supply that are imposed on them through their respective licences, and these obligations include P2/6.

However, a cornerstone of the new RIIO framework is the increased focus of the regulatory regime on innovation and encouraging DNOs to plan and operate their networks with a greater focus on the needs and preferences of their customers. Ofgem therefore expects DNOs' business plans to be justified with reference to the outputs that these plans deliver for consumers. In principle, as long as DNOs meet the licence obligations, DNOs can vary the level of security of supply provided to consumers if they can demonstrate to Ofgem that the levels of expenditure proposed are commensurate with the levels of outputs that will be provided to consumers in return, and that the selected levels of output are in consumers' interests.

The RIIO process allows for a range of outputs that consumers might value, including reliability of supply. In practice, DNOs might justify making investments to improve security of supply, or changes in network investment policy that would allow reliability to deteriorate, through the application of Cost Benefit Analyses (CBAs), which would then be subject to regulatory scrutiny.

### 4.3.2. Ofgem's cost assessment process

Once DNOs have submitted their business plans, Ofgem then follows a process of assessing whether they are well-justified. DNOs may then be "fast-tracked", in which case their business plans are accepted in the whole, or they may be subject to a more detailed review to determine appropriate levels of allowed revenue, and the outputs they are obliged to deliver in return.

This process, according to the RIIO handbook, involves deploying a "toolkit" of cost assessment and benchmarking techniques, from which Ofgem ultimately derives its estimate of efficient costs for each DNO, and ultimately allowed revenue. In practice, at the RIIO-ED1 price control review, Ofgem used two types of cost assessment technique, each of which received a 50% weight in deriving Ofgem's cost forecast:

- A "disaggregated" or "activity level" analysis, which appraised companies' cost forecasts on a line-by-line basis using a range of techniques including benchmarking to median performance in terms or unit cost or volumes, regression-based benchmarking, and detailed engineering assessment; and
- Totex benchmarking analysis, in which companies' total expenditure was regressed on a time trend variable, and an index measuring their respective scale. This analysis assumed, in essence, that companies' efficient expenditure only varied due differences in their size and the scale of their networks.

Despite the apparent focus of the RIIO regime on customer outputs, this framework (in itself) provides relatively little incentive to incur additional costs to improve reliability. Companies that plan to incur additional costs to improve reliability in their business plans will, in fact, tend to perform relatively badly in the benchmarking which tends to mistake variation in service levels for differences in companies' relative efficiency (especially in the totex modelling).

The IIS may offset this undesirable problem of the cost assessment process, by providing funding for improvements in reliability. However, as noted above in Section 4.1, the IIS does not provide funding for schemes that reduce HILP events, and, moreover, the incentive on DNOs to invest to improve reliability may be muted by the process of resetting the IIS targets at periodic reviews. Specifically, there is a risk that spending money today to improve reliability will result in IIS targets getting more stringent at the next review, because there is no predefined mechanism for setting such targets.

### 4.3.3. Output obligations

DNOs' RIIO settlements also include obligations to deliver outputs, which are specified in the form of requirements to achieve certain improvements in DNOs' Health and Criticality Indices and their Load Indices. In essence, these obligations require companies to invest to achieve pre-specified reductions in substation loading, and improvements in asset condition.

If DNOs fail to meet targets, Ofgem has indicated that it might claw back funding from DNOs at the next review, or similarly might provide additional funding if DNOs deliver additional outputs. The prospect of increases or reductions in revenues creates a marginal incentive for DNOs to improve asset condition and reduce loading of substations, both of which will tend to improve security of supply.

However, as discussed in Section 3, these obligations might focus DNOs on delivering reliability measures by adopting these conventional solutions that involve adding or replacing assets, and not through more innovative non-network solutions. For instance, it might be more efficient to interrupt consumers (in return for a contracted payment) when an asset failure occurs, rather than investing to improve asset condition to reduce the likelihood of the asset failure. Shifting the focus of the output incentives towards the outputs actually experienced by consumers might offset this problem, as we discuss below in Section 7.3 below with reference to changes in the IIS mechanism.

## 4.4. Regulatory Treatment of Distribution Losses

DNOs can influence the scale of distribution losses, a major driver of costs to consumers, through choices regarding the size and type of equipment they install on their networks. For instance, adding network capacity can in some conditions reduce losses,[69] as do other measures such as fitting low-loss transformers. However, unlike the way DNOs' investments

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[69] We understand that increasing the size of distribution cables, for instance, reduces losses. However, it is not always the case that increasing the size of network assets reduces losses. For instance, we understand from working group members that on the HV network, increasing the size of a transformer increases the fixed losses (iron losses), which can outweigh the savings by reduction in variable losses (copper losses).

to improve reliability are remunerated (at least in part) through the IIS, Ofgem does not use a financial incentive mechanism to reward loss reduction. In fact, Ofgem abolished the losses incentive mechanism because losses are challenging to measure and attribute to DNOs,[70] so the former losses incentive scheme created the risk that DNOs would experience windfall gains and losses unrelated to any costs incurred or effort expended to reduce losses. The imprecision of loss measurement would also undermine any financial incentive to reduce losses.

While DNOs have no direct financial incentive to reduce losses, save for the Losses Discretionary Reward that provides some limited funding to DNOs for actively seeking to reduce distribution losses, they do have a licence obligation to consider loss reduction in planning their networks.[71] In principle, therefore, DNOs could use the value of loss reduction in justifying investment schemes at periodic reviews. But in practice the benchmarking process does not obviously reward expenditures for loss reduction, such as in low-loss transformers. For instance, unless Ofgem were specifically to identify the costs of proposed expenditures to reduce losses and remove them from DNOs' benchmarked costs, DNOs risk finding that Ofgem's benchmarking models, which control mainly for differences in scale amongst companies, penalise discretionary expenditure to reduce losses. Furthermore, DNOs currently have incentives to invest in a large number of (highly utilised) small assets to provide the level of redundancy required by P2/6 whilst minimising the costs associated with high levels of redundancy, which probably results in increased losses as compared to scenario where there is a lot of spare capacity.[72]

Hence, while not directly related to the question of how much DNOs invest to deliver reliability to consumers, decisions on network design affect losses, and investments to reduce losses might provide additional security of supply. The two topics are therefore linked, and given the lack of any clear incentive or obligation on DNOs to fit low loss equipment, in considering reform of P2/6, there may be merit in considering the inclusion of loss reduction into any future planning standard.

## 4.5. The NETS SQSS

The National Electricity Transmission System (NETS) Security and Quality of Supply Standards (SQSS) is a set of standards to which the Transmission Owners (TOs) are obliged by their licences to comply, and that set out design and operational requirements for the NETS, including provisions for the security of generation connections. The parts of the

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70 This challenge may be largely resolved by the deployment of smart meters at all consumers' premises.

71 Condition 49.2 in "Standard conditions of the Electricity Distribution Licence " from 1 April 2015 states: "The licensee must design, build, and operate its Distribution System in a manner that can reasonably be expected to ensure that Distribution Losses are as low as reasonably practicable." https://epr.ofgem.gov.uk//Content/Documents/Electricity%20Distribution%20Consolidated%20Standard%20Licence%20Conditions%20-%20Current%20Version.pdf.

72 Under the current regime the incentives are set to deliver a required level of redundancy at a lowest cost. This means it is sometimes more efficient to build a network using a large number of small building blocks because the requirements imposed by N-1 or N-2 contingency levels call for smaller reserve capacity requirements than if the network was built with large components. There is a direct trade-off, however, between the amount of spare capacity and losses.
What about the RIIO incentives based on load-indices? They're incentivising low loadings.

NETS SQSS that relate to demand security reflect closely the assumptions in ER P2/5, the immediate predecessor to P2/6, which was otherwise equivalent but did not include provisions for recognizing the security contributions from embedded generation.[73] As a result, the SQSS shares most of the same advantages and disadvantages as P2/6, which we discussed in Chapter 3. In particular, some of the trends that drive the need to review P2/6 may also create a rationale for reforming the NETS SQSS, notably the possible future growth in embedded generation, demand response and storage, which means the challenge of transmission planning will be expanded from solely satisfying all local demand requirements to accommodating outputs from distribution systems at some times/locations.

In addition to the requirements in the NETS SQSS in respect of the resilience of the transmission network, the NETS SQSS also sets out requirements regarding the amount of capacity that the TOs should be obliged to provide to (1) ensure peak security, and (2) make an optimal trade-off between the costs of providing network assets and constraint costs. These obligations take the form of deterministic requirements on the amount of transmission boundary capacity to provide, combined with a general obligation that the TOs should provide more capacity when it is economically justified on the basis of a CBA.[74] However, these requirements in respect of the provision of boundary capacity sit alongside requirements in respect of how much redundancy the TOs are required to provide.

P2/6 and the NETS SQSS both apply to network companies at Grid Supply Points (GSPs), which is where the transmission and the distribution networks connect. The shared heritage of the two standards has helped to facilitate an alignment between the two standards, although some minor differences have remained. The fact that the boundary between transmission and distribution networks is fundamentally arbitrary provides an argument for this alignment to continue.

However, detailed discussion of the appropriate planning standard for transmission lies outside of this review, and given that future reform of the NETS SQSS could follow from any proposals we make in respect of reform of P2/6, we see no reason why the current drafting of the NETS SQSS should constrain our consideration of reform options.

## 4.6. EU Network Codes

The goal of the EU network codes is to facilitate the harmonisation, integration and efficiency of the European electricity market. The European Network of Transmission System Operators for Electricity (ENTSO-E) was mandated by the European Commission to draft the electricity network codes. Most of the network codes have been submitted to the European Commission and are currently under review. After the network codes receive the European Commission's approval, they are likely to be voted into EU law and implemented across all Member States.[75] Article 8(7) of Regulation (EC) 714/2009 states that "*the Network Codes shall be developed for cross-border network issues and market integration*

73 Open letter to electricity industry stakeholders from the chairman of the Distribution Code Review Panel http://www.dcode.org.uk/assets/images/P2%20Security%20of%20Supplies%20Open%20Letter.pdf

74 NETS SQSS, version 2.3, para 4.4-4.10.

75 http://networkcodes.entsoe.eu/

*issues and shall be without prejudice to the Member States' right to establish national network codes which do not affect cross-border trade*".[76] All network codes have been drafted in accordance with this requirement.

It is important to note that we have not sought to assess the compliance of prevailing energy sector regulatory arrangements with these codes, and that we have assumed that the reform of P2/6 is not the primary vehicle through which compliance will be achieved. Nonetheless, we have reviewed all draft EU Network Codes at a high level to identify any *constraints* they may impose on potential reforms to the P2/6, including the identified improvements and alternatives to the planning standard (see Section 6). We present our findings in Table 4.1 below, in which we summarise the core intentions of each code, and any potential provisions of these codes that may constrain our consideration of options for the reform of distribution network planning standards in Great Britain.

Following this review, we have not been able to identify any obvious high level constraints on the options we have identified for the reform of P2/6. However, we envisage it would be necessary for Ofgem to seek its own legal advice regarding the compliance of any reform option it eventually decides to adopt with the final EU Network Codes once they are adopted into law.

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76 E.g., see Entsoe, "*Network Code on Load-Frequency Control and Reserves*", 28 June 2013, p.4.

**Table 4.1**
**EU Network Codes - Intentions and Provisions**

| Code Type | Code | Intentions of the code & Description | Potential Relevance for the Reform of P2/6 |
|---|---|---|---|
| **C** | **NC RfG : Requirements for Generators** | Facilitate the shift in European power generation towards RES by setting out technical requirements on new generators connecting to the T & D system<br><br>Ensure non-discriminatory treatment of generators across Europe<br><br>Increase network security by determining when new generators are required to stay online in the event of frequency or voltage disturbances | By setting out technical requirements on the dynamic behaviour of power plants with respect to operation in disturbed conditions (such as voltage and frequency deviations), the NC RfG may decrease volatility in power generation and thus increase security of supply. DNOs (and TSOs) will likely become better informed about the way generators behave under disturbed operating conditions. |
| **C** | **DCC: Demand Connection Code** | Align Europe's connection rules<br><br>Set technical requirements on large new demand users and distribution network connections to the transmission system, to increase network security<br><br>Facilitate the use of DSR technologies<br><br>Sets requirements for electricity users who want to feed back power into the system | By facilitating the use of DSR technologies, the DCC may make DSR solutions of increasing reliability more widely available. Additionally, if the DCC increases network security, it may decrease the costs of reliability provision for DNOs. The DCC also makes statements on reactive power exchange and short circuit level management. |

| | | | |
|---|---|---|---|
| C | **NC HVDC: HVDC Connections and DC Connected Power Park Modules** | Establish clear European rules for managing HVDC lines and connections to them, to ensure that HVDC lines contribute to system security and the promote the integration of RES | No obvious impact on P2/6 reform options, based on our high-level review. |
| O | **NC OS: Operational Security** | Establish common rules for operating electricity transmission networks, to maintain the security of the interconnected European transmission system<br><br>Legally binding rules for cooperation between DSOs and TSOs, to minimise investments, reduce costs and losses, and facilitate RES | By imposing legally binding rules for cooperation between TSOs and DNOs, the NC OS aims to minimise investment and other costs and reduce electrical losses. To the extent that these objectives are met, providing reliability may become cheaper for DNOs. |
| O | **NC OPS: Operational Planning and Scheduling** | Ensure the smooth operation of the transmission systems, by setting common requirements and methodologies for adequacy and operational security analysis<br><br>Ensure coordination between TSOs, and between TSOs and DNOs | If DNOs become better informed about different operational security constraints and other potential threats to network security (as a result of the coordination and cooperation requirements on TSOs and DSOs specified in the NC OPS), DNOs costs for providing reliability might decrease. |
| O | **NC LFCR: Load Frequency Control and Reserves** | Formalise existing voluntary agreements on load frequency control processes and on the level of reserves required from TSOs<br><br>Sets out the requirements on reserve providing DSOs | No obvious impact. |

| | | | |
|---|---|---|---|
| **O** | **NC ER: Emergency and Restoration** | Sets procedures and remedial actions to be applied in Emergency, Blackout and Restoration States, to prevent the propagation or deterioration of an incident in the system.<br><br>Requires the preparation of System Defence and System Restoration plans by each TSO. | No obvious impact on P2/6 reform options, based on our high-level review. |
| **M** | **NC CACM: Capacity Allocation and Congestion Management** | Help achieve a fully integrated European electricity market, by setting out the rules on capacity calculation and allocation (intra-day and day-ahead), congestion management, and by defining bidding zones | No obvious impact on P2/6 reform options, based on our high-level review. |
| **M** | **NC FCA: Forward Capacity Allocation** | Promote the development of liquid and competitive forward markets in Europe, by setting coordinated rules for capacity calculation and allocation (in timescales before day-ahead) | No obvious impact on P2/6 reform options, based on our high-level review. |
| **M** | **NC EB: Electricity Balancing** | Facilitate the integration of national balancing markets, by establishing a standardised set of requirements on how TSOs procure and exchange balancing services | No obvious impact on P2/6 reform options, based on our high-level review. |

*Source: NERA review of EU Network Codes, and summaries of EU Network Codes from entsoe.eu website, the website of the European Network of Transmission System Operators for Electricity. Code type 'C' stands for Connection Code, 'O' for Operational Code, and 'M' for Market Code. The regulation on capacity allocation and congestion management is labelled a binding guideline, and not a network code, for legal reasons.*

## 4.7. Interactions with the Wholesale Market

Accounting for the contribution to network security from the installation in distribution systems of non-network technologies needs to account for the availability of such installations due to technical characteristics and failure rates (as with conventional network technologies), but also the availability of "fuel" in the case of intermittent generation (eg. wind and PV), and the availability of stored energy for storage providers. The production (or consumption) decisions of other DSR, generation and storage technologies also depend on the conditions prevailing in the wholesale market (defined to include the wholesale energy, capacity and ancillary service markets). Hence, such technologies may, in some situations, behave in a way that reflects conditions in the national wholesale market, and not in a way that is supportive of the distribution system (and vice versa).

Hence, embedded generators that may be in the position to provide support services to DNOs during contingency events provide less reliability to the distribution system because they don't receive any commercial signal regarding the value of their output to the DNO at that moment in time. That is, distribution charges, unlike wholesale energy prices, do not contain any instantaneous signal regarding the scarcity of capacity. While this problem could be mitigated through contracting for firm services or real-time locational pricing of distribution access, there will still remain a need for the DNO to assess the likelihood that providers of non-network solutions will behave in a way that supports the distribution system.

# 5. Lessons from International Practice

## 5.1. Alternative Approaches to Regulating Reliability

Regulators around the world adopt a range of different mechanisms to encourage or mandate electricity distributors to provide economically efficient levels of reliability, and thus offset any incentive they may have to reduce their costs by reducing security of supply. This chapter reviews a range of international experience to support our assessment of P2/6.[77]

Broadly, there are two approaches to regulating reliability, with some jurisdictions using a combination of both. In some jurisdictions, the regulator sets *reliability incentive mechanisms* that encourage distributors to achieve (or beat) targets using financial incentives and/or penalties, whilst leaving companies free to decide what measures to take to improve reliability. Reliability incentive mechanisms usually encourage distributors to improve performance in respect of the average duration and frequency of interruptions per customer over a predefined geographic area, with incentive/penalty rates linked to the concept of VOLL (see Section 2.3.2 above).

The IIS and the GSOPs are examples of this approach, although the regulatory framework in Britain is unusual in that it also includes a design standard. In other jurisdictions where reliability incentive mechanisms are applied, for example in Italy, the Netherlands and multiple US states such as Pennsylvania and New York, reliability performance targets are not supplemented by deterministic planning standards.[78]

In other jurisdictions, regulators set prescriptive *reliability design standards* to mandate particular levels of reliability, or constrain the process through which distributors must select the nature and amount of investments they take to improve or maintain reliability.

Where regulators impose design standards aimed at a certain level of reliability, this typically entails a prescribed method of determining a level of reserve capacity over a group of assets, usually categorised by the amount of demand they serve. The standards vary from the most rigid and simple where redundancy levels are set at contingency levels (ie. N-1 or N-2) to standards where more flexibility is allowed through the use of probabilistic methods which may recognise the security contributions from distributed generation and flexible demand.

In addition to these measures, many jurisdictions apply additional mechanisms aimed at providing reputational incentives for improved reliability by obliging distributors to publish their performance in improving reliability, and using targeted programmes aimed at improving service to "worst-served" customers. Lastly, regulators in some jurisdictions, such as California, apply direct scrutiny of spending programmes related to reliability,

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77 This chapter provides a qualitative overview of the schemes that are in place internationally. We do not seek to compare the economic efficiency achieved through different regulatory mechanisms. In practice, such a comparison would be inhibited by inconsistency in the measurement of reliability, and the inability to observe which particular regulatory institutions are driving the level of reliability provided by network operators.

78 http://www.pacode.com/secure/data/052/chapter57/subchapNtoc.html, "2014 Electric Reliability Performance Report", New York Department of Public Service, June 2015, and "Approaches to setting electric distribution reliability standards and outcomes", The Brattle Group, 2012.

supplemented with some utilities not provided with incentive mechanisms that automatically reward/penalise distributors for achieving reliability above/below a target.[79]

An overview of approaches for selected jurisdictions, published in a recent review of security of supply regulation by the Brattle Group on which this chapter draws extensively, is shown in Table 5.1.

**Table 5.1**
**Comparison of Regulatory Approaches in a Range of Jurisdictions**

| Jurisdiction | Reliability standards | Incentive scheme (% of revenue at risk) | Guaranteed standards scheme | Planning standard | Detailed asset management plan | Separate treatment for "worst circuits" | Different standards for urban/rural |
|---|---|---|---|---|---|---|---|
| ACT | SAIDI, SAIFI | no, expected in 2014 | no | no | no | no | no |
| NSW | SAIDI, SAIFI | no, expected in 2014 | yes | deterministic | yes | yes - standards for individual feeders | yes |
| Queensland | SAIDI, SAIFI | yes (+/-2%) | yes | deterministic, internal only | yes | no - reporting only | yes |
| SA | SAIDI, SAIFI, maximum outage duration | yes (+/- 3%) | yes | deterministic, internal only | yes | no | yes |
| Tasmania | SAIDI, SAIFI | no, expected in 2012 (+/-5%) | yes | no | yes | no | yes |
| Victoria | SAIDI, SAIFI., MAIFI | yes (+/- 5% to 7%) | yes | probabilistic | yes | no - reporting only | yes |
| NT | no standards of any kind | no, expected in 2014 | from 2012 | no | no | no | -- |
| WA | SAIDI, SAIFI, maximum outage duration | no | yes | no | yes | no | yes |
| New Zealand | SAIDI, SAIFI for investor-owned distributors | no | no | deterministic, internal only | yes | worst performing regions are highlighted | no |
| UK | SAIDI, SAIFI | yes (4%) | yes | yes, but in practice is exceeded | no | program to encourage investment | no |
| Netherlands | CAIDI,SAIFI | yes (5%) | yes | no | yes | no | no |
| Italy | SAIDI, SAIFI | yes (6.2%) | yes | no | no | yes; recently introduced | yes |
| California | SAIDI, SAIFI | yes | no | no | yes | yes | yes |
| New York | SAIDI, SAIFI | yes (+0/-1.4%) | no | no | yes | yes | yes |

*Source: Brattle Group[80] Note, while we have performed the secondary research regarding the approaches taken to regulating reliability operated in other jurisdictions, as summarised in this table and elsewhere in this chapter, detailed primary research is outside of our scope.*

## 5.2. Reliability Incentive Schemes

There are two key elements to incentive mechanisms aimed at encouraging distributors to provide an efficient level of reliability: (1) the measure of reliability used to set targets and

[79] Reliability Investment Incentive Mechanism (RIIM) from : "Regulation of the Power Sector", I. Perez-Arriaga, 2013

[80] Source: "Approaches to setting electric distribution reliability standards and outcomes", The Brattle Group, 2012.

measure performance against the target, and (2) the means of calibrating rewards or penalties, and thus encouraging distributors to provide an efficient level of reliability.

### 5.2.1. Reliability measures and targets

The most commonly applied metrics in reliability incentive schemes capture the average frequency and duration of power interruptions for every customer (or per 100 customers) per reporting period. These are the metrics applied in the IIS: Customer Interruptions (CI) and Customer Minutes Lost (CML). They have close counterparts in the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI), which are more prevalent internationally, following the codification by the IEEE.[81]

In Pennsylvania and California, the regulator sets a further target expressed by the Customer Average Interruption Duration Index (CAIDI), which measures average power restoration time (by minutes) for every customer who lost power during reporting period. Other indices include SAIDI, SAIFI and MAIFI, the Momentary Average Interruption Frequency Index.[82] MAIFI, also used in Australia, is very similar to CI/SAIFI, but it tracks momentary interruptions which are usually excluded in the other two.[83]

The criteria for including particular interruptions in the aggregate reliability indices are another important dimension of regulatory regimes that apply reliability incentive mechanisms. For instance, in some jurisdictions, extremely short interruptions are excluded, and in others the interruptions caused by extreme "force majeure" events are excluded.[84] Duration thresholds and the criteria for excluding force majeure events in the calculation of performance metrics vary across jurisdictions.[85] The thresholds for inclusion are important because performance incentives and penalties will be ineffective in encouraging distributors to reduce the length and frequency of those interruptions that are systematically excluded from performance indices.

The level of disaggregation at which performance indices are set for different categories of consumers also varies across jurisdictions. Sometimes performance indices are disaggregated in an attempt to set different targets and penalty/incentives for different types of consumer, reflecting differences in the value they place on reliability. For instance, in Italy and Tasmania the targets are set by location: rural/urban, etc. In New York the reliability standards are set by network configuration: radial network areas (typically suburban areas)

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81 IEEE 1366-1998 standard

82 "Electric service reliability in Pensylvania", Pennsylvania Public Utility Commission, August 2014 and "2014 PG&E Annual Electric Reliability Report", Pacific Gas and Electric Company, February 27, 2015. Other metrics in California include the number of Customers Experiencing Multiple Interruptions ("CEMI") or the "SAIDET", which represents the total minutes attributable to customers experiencing a total, annual interruption time that exceeded 150 minutes.

83 "Distribution determination 2011–2015 for United Energy Distribution", AER, 2010.

84 This occurs in the IIS mechanism used in Great Britain, for instance.

85 IEEE 1366-2003 standard includes a statistically based definition for classification of major event days, the 2.5 Beta Method.

are differentiated from interconnected or network ones (urban and financial districts, with higher load density).[86]

To the extent that reliability targets are designed to provide distributors with incentives to achieve an efficient level of reliability, the mechanisms used to set targets and update them over time are important drivers of the incentives placed on the distributor to ensure efficiency. Long-term commitments from regulators to leave targets unchanged, or at least to reset targets in a predefined and predictable way, send the most credible signal to distributors regarding the economic value of reliability improvements. The threat that performance targets can be reset by the regulator in an unpredictable way may undermine the incentive properties of the scheme. However, the use of fixed targets in the short-term combined with an incentive rate will still provide some incentive to deliver reliability through short-run/operational measures, even if longer-term signals are blunted by the absence of defined mechanisms for updating targets.

### 5.2.2. Approaches to encouraging or enforcing compliance

Reliability incentive mechanisms encourage distributors to provide an efficient level of reliability via a system of rewards for performance above a defined target, and penalties for performance below it. Such reward and penalty regimes apply in Italy, the UK and the Netherlands, among others.[87] The practice of only applying penalties for performance below target, with no reward for exceeding targets, is in place in fewer jurisdictions such as New York State.[88] In all cases the annual revenue at risk from those incentives is often capped, and the rewards and penalties tend to be symmetric where both are present.[89]

Also, it is common as a complementary measure for regulators to monitor and publish companies' reliability performance as a way of applying reputational pressure on distributors to improve reliability, possibly with information on how reliability varies across different geographic areas or class of customer, and variation in outages according to their cause.[90] Reporting requirements on major outage events are often much more detailed.[91]

In some jurisdictions, the threat of penalties is deemed sufficient to enforce minimum network reliability standards. The Pennsylvania Code, for example, under its electric service reliability enforcement section, only includes provisions for the Public Utilities Commission's right to investigate, issue corrective orders, and levy unspecified penalties which may include licence revocation. This approach is not limited to the US. In New

86 "Approaches to setting electric distribution reliability standards and outcomes", The Brattle Group, 2012. Note, we know from our own project work in North America that, except for Manhattan, many areas of New York have extensive amounts of isolated networks and radial distribution.

87 "Approaches to setting electric distribution reliability standards and outcomes", The Brattle Group, 2012

88 "2013 Electric reliability performance review", State of New York Department of Public Service, June 2014

89 "Approaches to setting electric distribution reliability standards and outcomes", The Brattle Group, 2012

90 Pennsylvania is an example. Electric Reliability Standards (52 Pa. Code §§ 57.195)

91 Pennsylvania is an example. Electric Reliability Standards (52 Pa. Code §§ 57.195)

Zealand about half of DNOs are only subject to information disclosure regulation, without the use of financial incentive mechanisms.[92]

Where financial incentive mechanisms are used to encourage reliability, caps and floors on distributors' exposure to incentives and penalties, which apply in some jurisdictions, including Great Britain, can undermine incentives on distributors to improve reliability. If there is a chance a cap or floor will bind, then the marginal value distributors place on reliability improvements diminishes, providing an incentive to provide lower levels of reliability than would be economically efficient.

## 5.3. Reliability Design Standards

In some jurisdictions, as in Great Britain, regulatory authorities set planning standards that impose binding constraints on the levels of reliability that distributors must provide, either by means of explicit requirements on the amount of capacity and/or redundancy distributors must build into their networks, or by imposing requirements on the planning process.

For instance, P2/6 imposes deterministic requirements on DNOs' asset planning that effectively prescribes contingency level for different classes of assets whilst making provisions to recognise security contributions from some types of embedded generators.

Some states in Australia adopt a similar approach, notably New South Wales and to a lesser degree Queensland and South Australia.[93] The unusual aspect of the Australian market is a legal requirement embedded in national regulation – which thus applies to all states, even those that also set deterministic standards – to perform cost-benefit studies for a certain class[94] of capital investment projects with the aim of improving efficiency.

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92 "Electricity distributors' performance from 2008 to 2011", February 2013

93 In Queensland and SA the distributors have significant discretion in application of standards in cases where investments can be deferred through operational measures. "Electricity Network Regulatory Frameworks", Productivity Commission Inquiry Report Volume 2, April 2013

94 The AER's "Regulatory investment test for distribution Application Guidelines" states that circumstances where a RIT-D proponent does not need to apply the RIT-D include where the:

- RIT-D project is required to address an urgent and unforseen network issue that would otherwise put at risk the reliability of the distribution network or a significant part of that network
- estimated cost to the Network Service Providers (NSPs) affected by the RIT-D project of the most expensive potential credible option to address the identified need is less than $5 million (as varied in accordance with a cost threshold determination)
- cost of addressing identified need is to be fully recovered through charges other than charges in respect of standard control services or prescribed transmission services
- identified need can only be addressed by expenditure on a connection asset which provides services other than standard control services or prescribed transmission services
- RIT-D project is related to the refurbishment or replacement of existing assets and is not intended to augment a network or
- refurbishment or replacement expenditure also results in an augmentation to the network, and the estimated capital cost of the most expensive credible option to address the identified need in respect of the augmentation component is under $5 million (as varied in accordance with a cost threshold determination).

## 5.4. Combining Design Standards and Performance Targets

The Australian national regulatory framework includes provisions affecting reliability planning, which exist alongside the regional rules described above. In 2014 a Regulatory Investment Test for Distribution planning (RIT-D) was introduced, which requires that distributors perform CBAs for capital expenditures on network extensions that meet certain criteria.

The aim of RIT-D is to ensure that once a need for investment is identified (which is driven by locally set reliability standards) the distribution businesses deliver it by the most economical means. The test is applied to projects above a certain financial threshold ($5m million), which are not aimed at addressing urgent system contingencies, such as for renewal of aging assets. The legal principles underlying the RIT-D recognise that projects with negative net economic benefits would still pass the regulatory test if they are addressing reliability needs.

The RIT-D includes a requirement to consider a range of credible network and non-network options in the planning process. The regulatory guidelines for the CBA studies give a lot of interpretational freedom to the parties tasked with carrying out the test, which are the distribution businesses themselves. The directions from the regulator include only general considerations of issues such as the range of market costs and benefits to be included. The specific assumptions, even the key ones such as VOLL or study time-horizon, only need to pass a non-specific reasonableness test.

The RIT-D in its current form has only been in force since 2014, therefore there is no available evidence about its benefits in the Australian market. However, the presence of other deterministic planning standards that potentially prescribe more or different investments compared to a RIT-D mean that the potential benefits of improving efficiency through the use of CBAs is somewhat diminished. For instance, the Australian Energy Regulator (AER) recognised in 2013 that a restructuring of regulation to remove the specific design standards could contribute to more efficient outcome.[95]

## 5.5. Conclusions

This survey of the regulatory mechanisms aimed at achieving an efficient level of reliability illustrates that a range of different types of regulatory instruments are used in different jurisdictions. Deterministic planning standards, like P2/6, are applied in some jurisdictions, but in others they are not applied, or have been replaced by other types of obligation, requiring distributors to plan in accordance with CBAs, and/or placing greater reliance on the financial incentive mechanisms to encourage distributors to plan efficiently. We discuss the relative strengths and weaknesses of these alternatives, in particular with reference to the British case, in subsequent chapters.[96]

[95] "Issues Paper - Regulatory investment test for distribution", AER, January 2013

[96] Addressing the suitability of these alternative mechanisms for the British context is particularly important, given that there may be a range of regulatory and institutional differences as compared to the jurisdictions discussed above that may affect the optimal regulatory arrangements to ensure the efficient provision of reliability.

# 6. Options for the Reform of P2/6

Based on the range of regulatory mechanisms that are in place both within Great Britain and internationally to encourage efficient investment in distribution systems, we have identified a range of "high level" options for the reform of P2/6.[97] Of course, the high-level nature of these options mean that some of them, if adopted, would require further work to design and codify:

1. *Retaining P2/6 without revision* might be desirable if there is no clear evidence that (i) alternative deterministic standards would materially improve efficiency, and (ii) there is also evidence to show that, taking as given evidence on other aspects of the regulatory regime, a deterministic planning standard remains necessary to ensure DNOs invest efficiently;
2. *Retaining a deterministic planning standard that seeks to define the efficient reliability requirements DNOs should provide, but with improvements compared to P2/6* such as to account for the role of non-network solutions such as embedded generation, storage, demand side response, etc:

   This approach would oblige DNOs to provide a given level of reliability, calibrated to ensure an efficient trade-off between investment costs and the costs of interruptions, at least on average. It may also be desirable to develop some systematic process for the periodic review of the deterministic planning requirements to ensure they remain consistent with the costs of providing reliability, the range of technological solutions available, current assumptions on VOLL, and so on;
3. *Implementing a non-deterministic planning standard* would involve abandoning the approach of specifying required levels of investment or service levels, placing more discretion in the hands of DNOs, obliging them to plan their network efficiently, such as by conducting CBAs.

   The expectation that DNOs should undertake CBAs to determine the efficient levels of reliability is nothing new. As discussed in Section 4.3 above, under the RIIO framework, Ofgem expects DNOs to justify their investment decisions with this type of evidence across a number of areas, albeit with some discretion on how and the extent to which they meet this expectation in their price control business plans. Moreover, ACE Report No. 51, published in 1979, makes clear that the deterministic recommendations in P2/5, which are similar to those in P2/6, may not be appropriate in all cases, and "*Where it is considered that the costs of providing the normal levels of reliability of supply implied by Engineering Recommendation P2/5 are too high, or where it is thought that a higher level may be justified, or in appropriate cases to assess the contribution to be made by generation, an examination using cost-benefit studies may be called for*".[98]

   In essence, therefore, this option involves departing from the approach of specifying the levels of reliability DNOs are obliged to provide under P2/6, and instead codifying a

[97] Any change to P2 might need to be reflected in some combination of changes to DNOs' licences and changes to the Engineering Recommendation itself.

[98] ACE Report No. 51 1979, Report on the Application of Engineering Recommendation P2/5 Security of Supply, Energy Networks Association, Section 3.3.

requirement to determine optimal levels of reliability using some form of CBA approach. In practice, such a non-deterministic standard could be implemented in many different ways, and in particular, with very different levels of prescription regarding DNOs' obligations to use specific methods and assumptions for network planning. For instance:

*A.* At one extreme, a new planning standard could simply state that DNOs have an obligation to plan their networks in a way that they can demonstrate is economically efficient, without defining how they should plan their networks, or defining the term "economically efficient" explicitly. DNOs would then be responsible for interpreting this obligation as they see fit, thus affording them extensive discretion and flexibility, and justifying their approach to the regulator;

*B.* At the other extreme, network planning procedures could oblige DNOs to plan their networks by conducting CBAs, and specifying how these CBAs should be conducted, the investment options they should consider, the specific types of costs and benefits that DNOs should consider, the assumptions they should make, such as in respect of the benefits of avoided interruptions or lower losses, and so on. In fact, the standard could go so far as specifying that DNOs should use a specific model, which could be developed through some later industry process;

*C.* Of course, in between these extreme positions, there may be intermediate approaches that oblige DNOs to plan their networks efficiently (following option 3A), but making some high-level requirements on how they should conduct CBAs (taking some aspects of option 3B);

4. *Implementing a non-deterministic planning standard, while retaining some deterministic de minimis elements*. This option would work by imposing some deterministic minimum reliability requirements for some aspects of network design, such as those for which prescribing economically efficient levels and types of investment through a "rule" does not entail material risk of error, while leaving other elements of network design at the discretion of the DNO and placing an obligation on them to plan efficiently. Hence, as at present, this approach would determine *de minimus* levels of reliability, but would incorporate into the planning standard an obligation on DNOs to determine whether additional levels of reliability are required using CBAs, and following option 3, might also offer guidance on how such CBAs should be conducted. If some deterministic elements were retained within the planning standard, it would also be important to consider whether the scope of the obligations it imposes should be expanded or curtailed compared to the current standard.

5. *Abolition of the planning standard*, may be desirable if other regulatory mechanisms are already in place to encourage DNOs to plan their networks efficiently to provide security of supply, such that there is no need for specific requirements to be placed on DNOs in respect of the reliability they are obliged to provide, or to verify compliance. This option would offer DNOs more flexibility than options 1 to 4, but achievement of efficient outcomes for consumers would place much greater reliance on other aspects of DNOs' regulatory incentive package, such as the IIS. Indeed, if such an approach were adopted, it may be desirable to strengthen other aspects of the regulatory settlement to send stronger or clearer signals to DNOs regarding the economic value of reliability. This approach might be particularly desirable if, as discussed in Section 2.3.3, consumers were exposed to time-of-use distribution pricing that allowed them effectively to select their

desired level of network reliability by curtailing their demands at times when network capacity is scarce.

# 7. Appraising Options for Reform of P2/6

## 7.1. Introduction to considering reform options to P2/6

In this section of the report, we aim to assess the advantages and disadvantages of all the options set out in the preceding chapter, as compared to the option of retaining P2/6 in its current form. The main criterion for this assessment is whether, when combined with the other existing regulatory instruments affecting DNOs' incentives to provide reliability to network users, they are likely to improve the economic efficiency (as defined in Chapter 2) of network planning.

It is important to note, however, that this assessment of alternative reform options is contingent on the findings of modelling that is being conducted as part of this review process by Imperial College. Hence, in some cases noted below, our recommendations and conclusions are conditional on the findings from the modelling, and seek to provide an economic framework for the interpretation of modelling results for use in the Options Paper that the Consortium will produce as part of Workstream 2.9.

## 7.2. Improvements to the deterministic planning standard

One of the options identified in Chapter 6 is to introduce a new deterministic standard, similar to the P2/6, but updated to reflect a current assessment of the value of reliability as compared to the costs of investment, as well as factors such as accounting for those non-network solutions that provide reliability. These new requirements in respect of the levels of reliability DNOs are obliged to deliver could be set using *de minimis* obligations, as is the intention of the current P2/6, or option 4 described in Chapter 6. Alternatively they could be set to target the efficient levels of reliability, following option 2 described in Chapter 6.

While an updated deterministic standard, achieved by making adjustments to P2/6 would not bring about fundamental change in the way DNOs are regulated and the way they plan their networks, it may still serve to improve the economic efficiency of the investment decisions taken by DNOs when compared with the current standard.

### 7.2.1. The benefits of deterministic planning standards

Before we discuss the conditions under which the introduction of a new deterministic planning standard (options 2 and 4) would be beneficial to DNOs and their customers, it is useful to review the general costs and benefits of deterministic planning standards (compared to more flexible arrangements). These advantages include the relative simplicity and transparency of planning decisions that can be taken from the use of a deterministic standard, which may keep down the costs of planning the network, and the ease with which compliance with the rules can be tested by the regulator and the DNOs' own management, as discussed below.

The simplicity of deterministic planning standards reduces the complexity, and thus the costs, of network planning faced by DNOs. For instance, deterministic standards such as P2/6 specify the levels of reliability DNOs are required to deliver, in effect determining the level of asset redundancy DNOs must provide and avoiding the need for DNOs to decide themselves what level of redundancy it would be economically efficient for them to provide.[99] In essence, DNOs know what levels of redundancy are necessary to comply with investment planning rules, and do not need to evaluate whether it is economically efficient to provide particular levels of reliability.

Conversely, under a non-deterministic approach in which DNOs are required to conduct CBAs or there is no formal planning standard at all, DNOs would have discretion in deciding the optimal level of reliability (based on customer demand for reliability and the costs of providing reliability), and in deciding on the least-cost way of delivering this level of reliability. This increased flexibility and independence (while it may enhance economic efficiency – see 7.3.1) will also increase the responsibilities and planning costs of DNOs. For instance, DNOs may need to hire more network planning experts to conduct CBAs and identify the optimal levels of supply reliability. Thus, deterministic planning standards keep DNO's network planning costs low.

However, in assessing the increase in costs that would result from placing more discretion to plan networks in the hands of DNOs, and requiring them to undertake CBAs, it is important to recognise that DNOs already perform CBAs, at least for some categories of investment, to support their submissions to Ofgem at price control reviews. Ofgem has also discussed the need for DNOs and other regulated network companies to make use of CBAs on an ongoing basis to inform their investment decisions. Extending the use of CBAs by placing more discretion to select optimal levels of reliability in the hands on DNOs might therefore not add materially to the range of capabilities DNOs need to retain in their businesses. Moreover, as noted in Chapter 6, guidance from 1979 on the application of P2/5 (ACE Report No. 51) always envisaged that CBAs had a role to play in identifying efficient levels of reliability where the application of ER P2 was not appropriate.

Deterministic standards also make it relatively simple for DNOs to demonstrate compliance with the rules: a DNO's network either meets the pre-set criteria, or it does not. This ease of demonstrating compliance may simplify legal or regulatory challenges to DNOs' planning decisions, such as wayleaves hearings or cases where customers attempt to seek legal recourse against DNOs for losses incurred due to interruptions to their supply. In fact, a number of stakeholders have commented that the Working Group ought to consider this factor in assessing the case for changing the deterministic nature of P2/6:

- We agree that having a deterministic standard may, in some cases, reduce the administrative costs associated with demonstrating the need for investments, as the need for certain levels of reliability is specified explicitly in regulation. However, no deterministic standard can ever be comprehensive, and there may be different ways in which DNOs can comply with requirements to achieve a certain level of reliability. Hence, even a deterministic planning standard cannot remove entirely the need for DNOs to justify investment decisions in such proceedings using more evidence than simple references to regulatory requirements to provide particular levels of reliability, such as P2/6.

[99] While the P2/6 does recognise the contribution of embedded generation to security of supply, it does not recognise the role of other forms of non-network solutions in increasing reliability. Thus, in the majority of cases, P2/6 requirements effectively dictate the level of redundancy DNOs must provide. For a further discussion, please see Chapter 3.

- Moreover, other infrastructure industries are not regulated through deterministic planning standards, and companies in these industries may still have to defend their investment decisions in legal proceedings. Hence, while a non-deterministic standard may increase the complexity and the cost of defending investment decisions, this increase in costs cannot (in itself) justify retaining a deterministic standard. As discussed below, deterministic standards may prescribe economically inefficient reliability requirements and investments, and the benefits of removing any such inefficiency need to be compared to any potential increase in the costs of legal challenges to DNO planning decisions.
- Nonetheless, in respect of wayleave hearings, if P2/6 were replaced with a less deterministic approach to regulating reliability, as discussed further below, there may be a need to put in place some new criteria of guidance to be followed when the Secretary of State is being asked to impact on private land rights to assess whether a strong public interest case has been met by the DNO. Such criteria could make reference, for instance, to the DNO putting forward robust techno-economic evidence that the proposed power lines are cost-beneficial (ie. they are in the interests of consumers), and that the DNO has considered alternatives, such as non-network solutions.
- And in respect of the role that P2/6 plays in resolving legal challenge when customers seek to recover the damages suffered as a result of outages, there may be other legal protections that would limit DNOs' exposure to such claims in the absence of P2/6. For instance, we understand that DNOs' connection agreements contain provisions that limit companies' liabilities in respect of outages, which are backed-up in the Electricity Act. However, if such protections do not afford DNOs equivalent protection to demonstrating compliance with P2/6, it is possible that DNOs may need to take out additional insurances to cover the additional risks they face. It may be that market evidence could be obtained on the likely cost of such insurance to inform the case for reform of P2/6, though performing this research is beyond the scope of this report.
  - If a deterministic standard were removed, and this caused DNOs to incur higher insurance costs, we assume Ofgem would need to consider at the price control whether DNOs should be allowed some additional revenues to cover such increases in insurance costs. DNOs could also self-insure, which means this cost would show-up in other areas, such as the direct costs of compensation payments, or an increase in the required rate of return to compensate for companies bearing more risk.

Deterministic planning standards may also keep costs for Ofgem low, as checking compliance with deterministic standards is relatively straightforward. By contrast, if DNOs were obliged to plan the level of reliability provided by their networks using CBAs, with more discretion and flexibility given to DNOs, checking compliance would be more complex, and potentially costly, for the regulator. Removing the planning standard entirely, in contrast, would remove the need for explicit regulatory oversight of compliance[100] with regulatory requirements in respect of reliability, and thus probably reduce the direct costs of regulation.

Some stakeholders have also suggested to us through the engagement process that deterministic planning standards mitigate the regulatory risks DNOs face, as they provide a

[100] The nature of regulation would change such that there would be no need to confirm whether a DNO is compliant or not, just to compute rewards or penalties under mechanisms such as the IIS in respect of DNOs' actual performance.

defined standard against which some investments will be considered necessary (or "efficient", in the vernacular of the Ofgem cost assessment process) and thus funded through the price control mechanism. However, we do not consider that removing or reducing the use of deterministic planning standards would have such an effect, as the Ofgem cost assessment process, which sets DNOs' allowed revenues, has seen a substantial departure from scheme-by-scheme appraisal. For instance, Ofgem's totex benchmarking, which at RIIO-ED1 received a 50% weighting in the cost assessment, uses a high-level regression equation to predict expenditure as a function of network size. Scheme-by-scheme appraisal was used to some extent as part of the remaining 50% of the cost assessment, but Ofgem and its technical experts only examined a sub-set of DNOs' proposed capital schemes.[101]

### 7.2.2. The costs of deterministic standards

Deterministic planning standards prescribe the level of supply reliability DNOs are expected to provide, and may prescribe or limit the way in which such reliability should be delivered. However, in practice it may be difficult for any regulator to accurately determine the optimal levels of reliability to require that should be written into a deterministic design standard, and/or the least cost means of delivering or improving security of supply. In practice therefore, deterministic planning standards may come at the cost of reduced economic efficiency.

In specifying the required level of reliability, a deterministic planning standard should be reflective of the benefits to consumers of security of supply, and the costs of providing it. In other words, reliability requirements should be set at a level that targets the allocatively efficient level of reliability (see Section 2.2). However, a deterministic planning standard, such as the P2/6, that prescribes uniform reliability levels across all parts of the network is likely to be inherently inefficient for two reasons:

- First, the value customers place on reliability varies from consumer to consumer. While it is challenging to vary reliability at the level of the individual customer, due to the shared nature of network assets and technological limitations, it would be desirable, and may be possible in practice, to account for some systematic variations in the value consumers place on reliability across locations, customer types, etc.
- Second, the cost of providing a certain level of supply reliability varies depending on factors such as the density of population, topography, and so on.

Thus, a planning standard that prescribes the same level of supply reliability across all consumers and locations is likely to prescribe inefficient levels of investment to provide reliability in many cases. Since DNOs themselves may be best informed about the costs and benefits of improving reliability in their own supply areas, giving more flexibility to DNOs in determining optimal reliability levels, and reducing the use of deterministic planning standards, may increase economic efficiency.

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[101] In addition, Ofgem may limit this potential risk increase. For instance, under the alternative option of a non-deterministic planning standard with a CBA obligation, Ofgem could introduce a compliance verification procedure, e.g., it could approve the CBA methodologies of DNOs ex ante. Alternatively, Ofgem itself might prescribe the exact methodology DNOs should use to conduct CBAs, or even some of the assumptions DNOs should make as part of their CBAs. A higher degree of prescription would further limit regulatory risk. We discuss this option in Section 7.4.

Further, a deterministic planning standard may not only prescribe the required level of supply reliability, but may also prescribe the means through which such reliability should be provided. This may limit productive efficiency, as DNOs may be prevented from delivering supply reliability through the least cost option. For example P2/6 does not recognise the role of some non-network solutions in improving security of supply.[102] While it does recognise the contribution of embedded generation to reliability in a simplistic way, it does not account for electrical storage or demand side response. These solutions may come at a lower cost than investments in network redundancy (or in embedded generation).[103] Thus, the same level of reliability could potentially be provided at a lower cost, especially where they provide a wider range of services, if more flexibility was given to DNOs in network planning.

Another cost of setting deterministic planning standards is that the level and type of investment they prescribe may not remain economically efficient if the costs or value of reliability change over time, for reasons such as changes in the costs of providing network assets, the available technological solutions for providing reliability, and the value placed on reliability by customers.[104] In principle, this requires periodic review and reform of planning standards to assess whether they remain appropriate, which imposes cost on the industry and on the regulator.

### 7.2.3. Potential improvements to P2/6

Based on the advantages and disadvantages identified above, it may be possible to retain a deterministic standard but introduce some improvements to the current ER P2/6. This way, the key benefits of the P2/6 (such as its simplicity and transparency) may be preserved, while the economic efficiency of the requirements it imposes may be improved. As noted in Section 7.2.2, some potential improvements to P2/6 to better promote economic efficiency are:

- Updating of the prescribed level of reliability, based on an updated assessment of the value of reliability and the cost of provision. As discussed below, Imperial's quantitative modelling will identify whether any efficiency gains could arise from raising or lowering reliability requirements, and what the extent of such benefits may be.[105] However, if this approach were adopted, it might then be necessary periodically to update the new standard in the same way, perhaps at pre-defined intervals such as at price control reviews.
- Varying reliability requirements based on (1) the cost of providing (and increasing) reliability in different conditions or (2) differences in the VOLL for different customer

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102 For a more detailed and specific list of the limitations of engineering recommendation P2/6, please see Section 3.3.

103 A comparison of cost would need to account for any differences in reliability of non-network solutions as compared to conventional network solutions.

104 When faced with a particular investment decision, all a DNO can ever do is take a view on these key drivers of the uncertain and changeable value of reliability and cost of provision, with an appropriate degree of sensitivity analysis. However, in calibrating a deterministic standard, DNOs will not be able to consider changes in the value of reliability and cost of provision; they will have no choice but to follow the rules. The problem noted in this paragraph therefore relates to ensuring the efficiency of successive investment decisions made over a period time, not the challenge of ensuring that particular investment decisions continue to appear economically efficient when assessed with hindsight.

105 Any change to P2 to prescribe higher/lower levels of reliability might need to be reflected in changes in DNOs' licences.

types. In general, more granular approaches to setting reliability requirements in deterministic planning standards allow the planning standard to better recognise such fundamental variations in the efficient levels of reliability. However, more granularity comes at the cost of complexity, and requires that the regulatory body setting the planning standard to have sufficient information to robustly set different reliability requirements for different conditions.[106]

- Incorporating non-network solutions (besides distributed generation) in the planning standard. For instance, an improved deterministic planning standard, while prescribing redundancy requirements, could set out more ways in which non-network solutions can substitute for traditional network assets. A well-designed planning standard that accounts for non-network solutions, would allow DNOs to provide the prescribed level of reliability at the lowest cost, by substituting between network investments, embedded generation, demand side response, and electrical storage, and thus improve productive efficiency, where the specificities of their networks allow each technology to be deployed. However, it may be challenging to codify how DNOs should treat non-network solutions within a deterministic framework. While it may be easy to recognise the firm non-network services the DNOs contract for with third party providers, the contribution of DSR or electrical storage to security of supply may vary enormously depending on the circumstances.[107] In these circumstances, any standard that pre-determines the contribution of non-network solutions to providing network reliability may be wrong in a large number of circumstances, and thus promote the inefficient take-up of these alternative technologies.

The above improvements to P2/6 are not necessarily mutually exclusive, and a combination of such improvements might well improve efficiency. However, as noted earlier, an improved deterministic standard would not change the fundamental limitation that deterministic standards impose on DNOs' particular levels of required reliability, which will not be efficient in all circumstances. Imperial's modelling will allow us to measure the benefits of any improvement to the deterministic standard, as discussed briefly below.

### 7.2.4. Using the Imperial modelling to assess the case for retaining a deterministic planning standard

Imperial's quantitative modelling, as discussed in a separate report, optimises the use of network investment and non-network solutions to provide an economically efficient provision of reliability for network users. In essence, therefore, Imperial's model can identify the efficient levels and types of network investment, use of non-network solutions, reliability, redundancy, and so on. Imperial can also run this model in a way that constrains it to build the network following the investment requirements imposed by P2/6. P2/6, as a relatively simple deterministic standard, will not achieve precisely the efficient levels of investment (etc), for the reasons described above.

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[106] In fact, DNOs themselves may be best placed to estimate the benefits and costs of providing additional reliability. Thus, rather than improve P2/6, removing a formal planning standard or imposing an obligation on DNOs to perform CBAs to determine efficient reliability levels may be the optimal approach. We discuss these options below.

[107] Note, the Imperial modelling will investigate the variability of the contribution of non-network solutions to providing network reliability.

The cost differential between the “right answer” and the one in which the model is constrained to follow P2/6 defines the efficiency loss associated with having the current deterministic standard. In essence, this gap quantifies the “error” in the deterministic requirements imposed by P2/6, and the higher this cost gap, the higher the potential benefit from reforming the planning standard. If the potential improvement is small, however, it may lead to a conclusion that the case for reform of P2/6 is limited, and therefore there is a reason to recommend retaining P2/6 (Option 1 – see Chapter 6).

However, if the gap is substantial, there may be merit in considering improvements to the deterministic standard (Option 2 or Option 4). In addition to estimating the potential benefit from improvement, the Imperial model also allows the Consortium to consider the reduction in this cost gap achievable by improving the deterministic standard. Hence, if we find that a material proportion of this gap can be closed through such improvements, it may be sufficient to recommend revisions to the deterministic standard that improve efficiency, and thus retain the other benefits of a deterministic planning standard summarised in Section 0 above.

However, if the modelled cost gap is substantial, and cannot be closed through improvements in the deterministic standard, it may support a conclusion that the “right answer” in terms of the provision of reliability cannot easily be codified in a deterministic way. Hence, we may need to consider other options that place more discretion on DNOs to plan their networks efficiently (see options 3 to 5 in Chapter 6).

The modelling may also lead to the same conclusion if the size of the cost gap, after considering potential improvements to the deterministic standard, is variable and depends on parameters that are highly dependent on the circumstances facing the DNO. In this case, codifying deterministic requirements may prescribe inefficiently high or low levels of investment in many cases, and thus lead us to consider options involving more discretion for DNOs. In principle, the problem of a deterministic standard that prescribes too much reliability in some cases and too little in others can be mitigated by setting only de minimis requirements (Option 4 rather than Option 2, discussed below in Section 7.5), but such requirements need to be combined with obligations on, or incentives for, DNOs to undertake CBAs to consider whether it is appropriate to provide higher levels of reliability in individual circumstances.

A similar conclusion would follow from a finding that the efficient provision of reliability and/or the security contribution of non-network solutions depends on factors that are uncertain now, but will become less uncertain in the future. In this case, it probably does not make sense to codify new deterministic requirements that may become inappropriate as new information emerges, such as in respect of the costs of new non-network technologies. In this case, it would be more natural to recommend either adopting options for reform of the planning standard that place more discretion in the hands of DNOs, or recommending a future, possibly periodic, review of the planning standard as the underlying uncertainty is resolved.

A finding that the efficient provision of reliability and/or the security contribution of non-network solutions depends on factors that are unknown now *and will remain unknown for the foreseeable future* would have different implications for the reform of P2/6. If the “right answer” depends on such factors, there would be little value in placing a high degree of discretion in the hands of DNOs, unless they are better placed to assess the impact of this factor than the regulator or independent parties such as the Consortium or the Working Group. In this case, retaining a deterministic approach might be more appropriate, subject to periodic revision in the future.

Overall, the option of introducing some improvements to P2/6 while retaining a deterministic planning standard might improve efficiency. However, a deterministic rule can only function effectively if the regulator is able to codify the optimal solution ("the right answer") within a reasonable margin of error. Imperial's modelling will inform us about whether this is the case in practice. If, based on Imperial's modelling, we find that the regulator cannot codify the optimal solution within a reasonable margin of error, for instance, because the cost gap remains large under all the possible improvements considered or is highly sensitive to the circumstances facing the DNO, it would support the case for an alternative option that places more discretion for network planning in the hands of DNOs.

## 7.3. Removing the Planning Standard Entirely

Possibly the most radical option for reforming ER P2/6 would be the complete removal of the planning standard (option 5 in Chapter 6). Under such an approach, the importance of financial incentives would increase substantially, as these incentives and DNO's assumptions of investment costs would ultimately determine the level of reliability delivered. As we discuss below, for this option to be effective in promoting efficiency, the existing financial incentives provided to DNOs to improve reliability would need to be better aligned with the value consumers place on reliability (see Section 7.3.4 below) to ensure that DNOs build and operate networks in an economically efficient manner.

### 7.3.1. The benefits of removing a formal planning standard

As discussed in Section 7.2.2, deterministic planning standards may constrain economic efficiency because they do not account for the variability of the costs associated with providing additional security in different areas, and the variability of the value consumers place on uninterrupted network access. The existing standard also omits any treatment of non-network solutions, save for distributed generation. Removing the planning standard would address these issues and enhance economic efficiency by recognising the informational, commercial and technical advantage that DNOs have over the regulator (or any external body, including the P2 Working Group) in defining the efficient levels of network reliability.[108]

To a large extent, the benefits of this approach rest on how closely the financial incentives on DNOs to maintain or improve reliability reflect the economic value of reliability to consumers.[109] Under this approach, DNOs' decisions on the level of reliability to provide

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[108] For instance, it is clear that DNOs are better placed than other bodies to identify the most efficient means of providing reliability on their own networks, and to appraise alternative technological solutions for providing reliability.

[109] For this reason, it would not be possible to use the Imperial model to meaningfully evaluate the efficiency gap between "the right answer" and the decisions in respect of the amount and type of reliability measure that would emerge from DNOs following financial incentive mechanisms. This is because any differences between these two outcomes would arise only from either (1) assumed differences in the way reliability is valued by the Imperial model vs the regulatory mechanisms, which would be arbitrary, and (2) an assumption that DNOs follow regulatory incentives imperfectly, where assumptions on the nature of imperfect responses to regulatory incentives would also be arbitrary.

will depend on (1) the revenues offered for improving reliability under the prevailing financial incentive schemes, as compared to (2) DNOs' own estimates of the costs of providing reliability. DNOs would then select the level of reliability to provide, including the least cost way of providing this identified level of reliability, to maximise the profits they earn under financial incentive schemes, ie. the difference between (1) and (2). If the financial incentive scheme reflects the true economic value of reliability to consumers, this profit-maximising outcome is also economically efficient.[110] In Section 7.3.4, we discuss how the design of the IIS could be changed better to align the marginal financial incentives DNOs face with the marginal value of reliability to consumers.

Overall, the complete removal of the planning standard, if DNOs respond effectively to a financial incentive scheme that better reflects the marginal value that consumers place on reliability,[111] would give rise to a range of benefits to consumers:

- Allocative efficiency would increase, as the level of reliability provided by DNOs would get closer to the economically efficient level. While the regulator may have the same information on the value of reliability to customers as DNOs, DNOs have an informational advantage in estimating the costs of providing reliability. Instead of imposing deterministic requirements on DNOs in respect of restoration times, as under P2/6, the DNO itself would determine the level of reliability to provide, based on its own cost assumptions and the financial incentive rate, which is set by the regulator to reflect the marginal value of increased reliability to consumers.
- The removal of the planning standard could enhance productive efficiency, as DNOs would be motivated by the financial incentive and by their revenue control to find the least cost means of providing reliability. DNOs would be free to invest in network or non-network solutions as they see fit, to deliver a level of performance at the lowest possible cost, and would not be constrained by deterministic requirements in respect of how to treat non-network solutions for the purpose of network planning.[112]
- Compliance cannot be tested, as there is no defined planning standard against which to test compliance. Instead, consumers' interests would be protected through the financial incentive scheme (and possibly through reputational mechanisms), and the regulator's compliance testing costs would fall to zero.

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110 Financial incentive schemes, such as the IIS, operate by setting performance targets and financial incentive rates (as discussed in Section 4.1). According to economic theory, only the financial incentive rates actually impact DNO behaviour, and thus the level of reliability provided by DNOs. By proxy (i.e., through performance indices), the incentive rates determine the marginal value to DNOs from improving reliability. DNOs will maximise profits by setting reliability at the level where the marginal value and the marginal cost of increasing reliability are equal. By contrast, the performance targets do not affect behaviour, but determine the allocation of resources between the government (ultimately consumers) and DNOs. As long as performance targets are not set too high (such that DNOs would prefer to leave the market, rather than to operate), incentive rates alone affect DNOs' network planning.

111 As discussed in Chapter 2, the value customers place on improved reliability could be defined by assumptions on VOLL, or some in a more sophisticated way such as using customer damage functions.

112 We note that it is irrelevant for productive efficiency considerations whether the financial incentive rate set by the regulator actually reflects the value consumers place on reliability improvements. Note also that this might not be achieved to the same degree with a deterministic planning standard, as discussed above, if it pre-defines factors such as the security contribution of non-network solutions in a way that is inaccurate in some cases.

- An additional benefit of the complete removal of the planning standard is that it may promote innovation.[114] P2/6 may limit innovation in the provision of supply reliability, because it does not recognise the role of some non-network technologies in providing network reliability. This means DNOs tend to have stronger incentives to provide reliability using those means recognised in P2/6, as opposed to using new and innovative ways of maintaining or increasing reliability. Non-network solutions, such as embedded generation, electrical storage or demand side response may provide reliability to consumers at a lower cost than network redundancy. By allowing DNOs to select the cheapest ways of providing reliability, DNOs will be encouraged to innovate to find the lowest cost solution of providing the efficient levels of supply security. Any resulting innovations may decrease the costs of providing reliability in the future.

### 7.3.2. The costs of removing a formal planning standard

The costs of removing a formal planning standard are, in essence, the converse of the benefits of a deterministic planning standard, as set out in Section 0. We do not discuss these factors in this section for the sake of brevity, but they include the possibility that network planning becomes more complicated and costly for DNOs as they are provided with more discretion, and that the costs of defending legal challenges might rise as demonstrating the need for certain investments becomes more subjective. Such costs need to be offset against the potential efficiency gains from removing deterministic planning standards that may be identified by the Imperial modelling (see Section 7.2.4 above) as the gap between the costs of planning the network in accordance with the "right answer" and in accordance with the most efficient of the potential deterministic standards identified for consideration.

Further, some parties have expressed concern through the stakeholder engagement process that, without a common national deterministic planning standard, such as P2/6, differences will necessarily emerge in the procedures adopted by DNOs in deciding what level of reliability to provide, and in the level of reliability consumers in different parts of Great Britain experience. We consider that this should not be a material cause for concern for the following reasons:

- First, a range of evidence suggests that customers in different areas experience vastly different levels of supply reliability, even with P2/6 already in place. For instance, based on data from 2002/03-2011/12, the recent average reliability performance of DNOs, as measured by CIs and CMLs has varied widely. For CI and CML, there are threefold and twofold differences between the best- and worst-performing DNOs, respectively.[115] New unplanned CI and CML targets – set by Ofgem at RIIO-ED1 – also vary widely by

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114 DNOs may have some marginal incentive to innovate through the IIS mechanism that would reward innovative (or any other) measure that enhanced reliability, as well as through some innovation funding mechanisms established by the RIIO framework. Nonetheless, allowing DNOs more flexibility in network planning would likely enhance DNOs' ability and incentive to innovate.

115 Ofgem, "*Strategy consultation for the RIIO-ED1 electricity distribution price control - Reliability and Safety: Supplementary annex to RIIO-ED1 overview paper*", 122/22, 28 September 2012, p. 24. Only figures on EHV lines are compiled using data spanning 2002/03 to 2011/12. Figures for all other voltage levels are compiled using data spanning 2008/09 to 2011/12. These figures refer to unplanned interruptions.

DNO.[116] We understand that Imperial's modelling will also present further evidence about the extent to which security of supply differs across different regions of Great Britain. If these results corroborate the finding that there are substantial differentials in reliability levels even under the current deterministic planning standards, then the above concern would seem not to be serious.

- Second, since the cost of delivering security of supply varies across circuit types, differences in the level of reliability provided to consumers in different parts of the country, or even to different customers in the same region, may be economically efficient. Hence, even if current levels of reliability were equal throughout the country, a shift in regulation to one that recognises these differences in costs would enhance economic efficiency.
- Third, some stakeholders have suggested that the existence of a common planning standard across the country benefits larger industrial and commercial consumers that operate across multiple regions. Similarly, distributed generators have expressed a desire for more consistency in the network planning policies surrounding their connections to the grid. Whilst common planning procedures may simplify such generators' connection processes or consumers' utilities procurement activities, this potential benefit of uniformity would need to be offset against any cost savings associated with more efficient network planning, and the benefits of innovation that come from more diverse planning procedures. Moreover, even if network planning procedures are common across the country, as noted above, effective reliability levels differ materially even with a common deterministic standard in place.
- Fourth, under all of the identified reform options, Ofgem could impose some restrictions on DNOs to harmonise assumptions or approaches (see option 3 in Chapter 6),[117] which may mitigate these stakeholder concerns.

### 7.3.3. The impact of current financial incentive schemes to encourage improved reliability

Encouraging the efficient provision of reliability through financial mechanisms requires that the marginal incentives DNOs face are closely aligned with the marginal value of providing reliability. We understand anecdotally from the stakeholder engagement process conducted through this study that the IIS and the Guaranteed Standards of Performance (see Chapter 4) already influence network development and operation and encourage DNOs to undertake some measures to improve reliability. And, in fact, we understand that CIs and CMLs have trended downwards since the implementation of the IIS scheme.

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[116] Ofgem, "*RIIO-ED1: Final determinations for the slow-track electricity distribution companies, detailed figures by company: Supplementary annex to RIIO-ED1 overview paper*", 28 November 2014, pp. 14-15. Note, as discussed below, such variation in CI/CML performance may well be efficient and should not be seen as a shortcoming of P2/6 or any other existing regulatory instrument.

[117] For instance, under the non-deterministic planning standard option, Ofgem could decide to oblige the DNOs to adopt a common procedure in conducting cost-benefit analyses. Ofgem could in theory even determine some of the assumptions DNOs must make in their CBA procedures, such as setting a common VOLL value (for all consumers, or for specified consumer groups). We discuss this further below.

However, the DNOs consider that these instruments have only a limited influence over their investment decisions. From the stakeholder engagement process, we understand that the IIS has primarily motivated investments in relatively low-cost automation and other operating measures aimed at reducing the impact of outages. We also understand that it does influence the level of reliability provided at the low voltage (LV) level, but not at the high and extra high (HV/EHV) voltage levels. Therefore, while in their current form the impact of financial incentives for reliability on DNOs' investment decisions may be limited, there is no reason in principle why financial incentive schemes could not be used as the primary mechanism for encouraging DNOs to provide the efficient level of reliability in the future.

### 7.3.4. Possible improvements to the efficiency of financial incentive schemes

First, if P2/6 requires a higher level of investment than DNOs can economically justify when valuing reductions in interruptions at IIS incentive rates, then it is obvious that the IIS will not affect decisions over what level of reliability to provide while P2/6 remains in its current form. If the IIS incentive rates were higher, possibly reflecting policymakers' estimate of the value of reliability, then it would encourage a greater provision of reliability.

Second, there are a number of design features of the IIS that limit the incentive it confers on DNOs to invest to manage interruptions and provide reliability efficiently, and these features could, in time, be altered if more reliance were placed on the IIS as a means of ensuring the efficient provision of reliability. These possible changes include the following:

- Removing the cap and floors on rewards and penalties. If a DNO expects to hit a cap/floor, or believes there is some reasonable probability that it will do so, then the marginal incentive to further improve performance to reduce penalties or earn greater rewards is muted;
- Including exceptional events in the CI/CML performance indices. Currently, because relatively high-impact events are excluded from the CI/CML performance indices, the IIS mechanism provides no incentive to reduce the likelihood or impact of such incidents, such as by providing additional redundancy or deploying other non-network solutions;
- Making the representation of consumer benefits from reduced interruptions more granular (eg. variable by customer type, location, etc.). This change in approach would send more efficient signals to DNOs regarding the economic value of reliability improvements, and possibly account for the fact that different types of customers place a higher value on reliability than others. There may also be a case for accounting for interruptions to generation customers in DNOs' CI/CML indices;
- Implementing a predictable mechanism for updating targets over time so that DNOs know what share of the benefits from investing in reliability schemes they will capture. Currently the methods used to set targets for reliability are not fixed, and depend on the methods Ofgem decides to use at periodic reviews. Absent a predictable mechanism for resetting targets, DNOs' incentive to reduce the likelihood and impact of interruptions will be muted, especially towards the end of each regulatory control period, given the possibility that the benefit of any reduction will be "taken away" by Ofgem in the form of a more stringent target for the next control period;

- Ensuring the share of benefits DNOs retain from improved reliability (and vice versa) is the same as the share of costs they bear under the IQI from spending marginally more money. This would ensure that DNOs make an efficient trade-off between the costs and economic benefit of projects to reduce interruptions, such as in deciding whether to provide additional reliability.

Some of these possible changes to the IIS scheme would, if implemented, increase the risks that DNOs bear, especially the inclusion of high impact events in the calculation of CI/CML indices and the removal of caps and floors. This might have implications for DNOs' Weighted Average Cost of Capital (WACC). The possibility of greater shocks to cash flows might increase default risk, increasing DNOs' cost of debt and/or reducing debt capacity, both of which would tend to increase the WACC. The possibility of large IIS penalties driven by major interruptions without an equal and offsetting scope for upside rewards would also expose DNOs to additional asymmetric risk, which may increase DNOs' cost of equity, and thus the WACC. Alternatively, DNOs may be able to purchase insurance to protect them from financial exposure to penalties under the incentive scheme resulting from high impact events. While this might offset any increase in the WACC, it would create a new cost DNOs would need to recover from consumers.[118]

However, it is important to recognise that, while these additional risks impose costs on DNOs that they would ultimately need to recover from consumers, consumers are bearing these risks already which itself imposes a cost on them. Imposing larger penalties on DNOs or offering them larger rewards in respect of interruptions would, in effect, amount to a reallocation of risk from those who cannot control it (customers) to those who can (DNOs), which for the reasons discussed above, may improve efficiency.

### 7.3.5. Possible changes to other regulatory instruments

There may be some other improvements Ofgem could make to the regulatory framework for DNOs that would be particularly beneficial if DNOs were provided with more discretion to plan their networks efficiently. For instance, the RIIO model seeks to remove capex biases through the application of benchmarking to all cost categories, combined with the IQI and totex incentive mechanism. However, there might still be a degree of a capex bias in the LI/HI output obligations (see Section 4.3.3 above). Specifically, obliging DNOs to reduce loading and improve the health of assets might reduce the incentive to find ways of delivering the same benefits to consumers but with fewer assets, or to maximise the utilisation of assets.

## 7.4. Implementing a Non-Deterministic Planning Standard

### 7.4.1. The rationale for an obligation to undertake CBAs

An alternative to P2/6, and to deterministic planning standards in general, is to implement a non-deterministic planning standard that places an obligation on DNOs to perform CBAs to

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[118] Note, estimating the impact of the mooted changes to the IIS on DNOs' financing costs is beyond the scope of this study, and would, in any event, depend on the precise nature of such reforms adopted by Ofgem (eg. at the RIIO-ED2 price control review).

identify efficient levels of reliability and the most efficient means of delivering this reliability through a combination of network and non-network solutions (see option 3 in Chapter 6).

As with the complete removal of the planning standard, discussed in the previous section, this option places more discretion in the hands of DNOs to plan efficiently than would a deterministic standard. And in fact this option is similar to the option of complete removal, as DNOs would still need to undertake their own CBAs to compare the costs of reliability with the value they would earn from financial incentive schemes, and to identify the cheapest means of delivering reliability.

What this option adds, therefore, is simply a regulatory requirement to undertake CBAs. This would have the effect of making the DNOs' decision-making processes subject to regulatory (and possibly public) scrutiny, and potentially improving the transparency of this process to other interested parties. Therefore, in theory, the addition of the CBA obligation should not change the investment and reliability outcomes compared to the option of removing the planning standard and improving the efficiency of financial incentive mechanisms. Instead, it increases accountability of DNOs to justify planning decisions to the regulator and the public. An obligation to plan in accordance with CBAs might also compensate for any shortcomings in the financial incentive mechanisms, eg. if it is not possible to make the reforms listed in Section 7.3.4 above.

### 7.4.2. Degree of prescription in a non-deterministic planning standard

A non-deterministic planning standard can in practice be designed in many different ways. In particular, Ofgem can impose a number of constraints on DNOs CBAs, or at the other extreme could give DNOs a completely free hand in deciding the approach they follow and the assumptions they make. In essence, by varying the degree of prescription in a non-deterministic planning standard, Ofgem can either increase the discretion of DNOs in planning their networks, or it can impose common restrictions on all DNOs, in effect creating a common methodology:

- At one extreme, a new non-deterministic planning standard could simply state that DNOs have an obligation to plan their network in an economically efficient way, without making explicit requirements on how they should interpret this requirement. DNOs would then be responsible for interpreting this obligation as they see fit, and for justifying their approach to the regulator, if required.[119]
- At the other extreme, the new network planning standard could oblige DNOs to use a specific CBA model (developed through an industry process, for instance) to determine the economically efficient level of supply reliability, and the economically efficient way of delivering the identified optimal level of reliability. This common framework (the CBA model) would identify precisely the types of costs and benefits DNOs should consider and the assumptions they should make. Adopting a common methodology might also minimise the costs by the regulator for monitoring and compliance verification.

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[119] Such an approach would not impose any further requirements on DNOs, compared to the option of having no planning standard in place, and relying on the financial incentive scheme. This option is thus only interesting as a theoretical extreme, and not as a credible alternative to consider.

However, there are a range of potential intermediate options for a non-deterministic planning standard. For instance, the regulator could impose some high-level requirements on DNOs on how exactly the CBAs should be conducted, such as the types of costs and benefits to consider, and the way to account for non-network solutions. The regulator could also specify what economic value DNOs should place on particular economic benefits associated with providing network assets, which could simplify the planning process, especially where such parameters are particularly uncertain or difficult to estimate. For instance, the might wish to specify particular levels of VOLL per customer class that DNOs should use in planning, or a value to place on reduced losses (see Section 7.6 below).

In general, more prescriptive requirements to perform CBAs tend to simplify, and thus reduce the costs of, network planning. However, less prescriptive requirements might allow DNOs more scope to innovate and potentially identify more economically efficient solutions than a more prescriptive "rule book" for undertaking a CBA would allow.

If a non-deterministic planning standard is implemented, and some industry process is initiated to identify CBA methods that should be used to identify the economically efficient levels of reliability, we are aware that there is a large body of literature that could be drawn on to inform it. For instance, ACE Report No. 51 provides some guidance on the application of CBAs to identify efficient levels of reliability,[120] as does a large body of more recent literature. However a survey of this evidence is beyond the scope of this report.

### 7.4.3. Regulatory oversight and compliance testing

Under the option of completely removing the planning standard, no compliance testing can be in place as there is nothing to test compliance against. The financial incentive mechanism and reputational incentives ensure that consumers' interests are protected. In theory, these incentives would ensure the same outcome under the CBA-obligation (non-deterministic planning standard) option. However, if such financial incentive mechanisms were supplemented with an obligation to perform CBAs when planning the network, the regulator would need to have a mechanism for testing compliance with this obligation, and holding DNOs to account in instances where they fail to comply.

As discussed earlier, testing compliance with the deterministic P2/6 standard is straightforward, as the reliability requirements determine the required level of network redundancy, in the majority of cases. Compliance testing is inherently more difficult when a formal planning standard remains in place, but the rules allow more discretion for DNOs in planning their networks.

There are a range of different ways in which the regulator could check compliance with a non-deterministic requirement to undertake CBAs in network planning. For instance:

- The regulator could conduct regular spot checks to assess whether DNOs' CBAs meet the criteria set out in the planning standard.

[120] ACE Report No. 51 1979, Report on the Application of Engineering Recommendation P2/5 Security of Supply, Energy Networks Association.

- DNOs could also be obliged to publish their CBAs, allowing industry stakeholders and interested parties to scrutinise these analyses, which would allow Ofgem to monitor compliance by investigating complaints from stakeholders that DNOs are not planning efficiently. This approach would also support dissemination of innovative planning approaches across the industry.
- Ofgem could also provide ex ante approval of DNO's planning methodologies, if DNOs are left with some discretion in their approaches to conducting CBAs, or approve the CBA modelling tool itself if a common methodology were adopted across all networks. Such an ex ante approval of CBA methodologies could follow a process similar to the approach Ofgem uses to approve tariff methodology statements from regulated transmission and distribution networks.
- Another option for oversight is the ex post scrutiny of individual investment decisions (and associated CBAs) by the regulator. However, such an approach would be very costly for both the regulator and the DNOs, impose significant regulatory risk on the DNOs, and distort DNOs incentives in respect of the choice between capital and operating measures to improve reliability.

### 7.4.4. CBA-obligations within a deterministic framework

It is also possible to place obligations on DNOs to conduct CBAs within a deterministic framework. Under option 2, where deterministic requirements define the efficient provision of reliability, CBAs would not be used to determine the optimal levels of reliability to provide, but would be aimed exclusively at identifying non-network solutions to providing the desired level of reliability and thus reducing costs to the DNO. In essence, once the need for an investment to meet the reliability requirements specified in the deterministic standard is identified, a CBA would be used to determine the least cost way of delivering it. Under option 4, with de minimis deterministic requirements, CBAs would also be used to identify how much additional reliability it is efficient to provide, as discussed further below.

As discussed in Section 5.4, there are parallels between this approach and that used in some Australian states, where the Regulatory Investment Test for Distribution requires distributors to publish planned network investment projects above the cost threshold of $5 million. Third parties can then bid to provide the same level of reliability through alternative, cheaper investments. DNOs are required to conduct CBAs for capital expenditures on network extensions that meet certain criteria, and required to consider a range of credible network and non-network options in the planning process. The RIT-D is specifically intended to increase the use of non-network technologies when appropriate, and to enhance productive efficiency in providing security of supply.[121]

Combining a CBA-obligation with a deterministic standard (option 2) is likely to marginally enhance productive efficiency in delivering reliability more efficiently, as compared to option 2 (a deterministic standard prescribing the level of reliability it is efficient to provide on

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[121] Some parties have suggested to us that tendering for non-network solutions might not be efficient if the pool of bidders (or potential bidders) is small. This may be the case, but nonetheless, if such competitive tendering arrangements are not put in place it will likely be difficult for DNOs, Ofgem or others to objectively assess the number of potential bidders.

average). However, as long as it is combined with a deterministic standard that prescribes the level of reliability to provide it does little to improve allocative efficiency. Options 3-5 may be superior in this regard, as they all allow more flexibility to define the appropriate level of reliability through a CBA process.

### 7.4.5. Conclusions on non-deterministic planning standards

Obligations to plan networks in accordance with CBAs can increase the accountability of DNOs, and, if planning models and/or documents are published, the transparency of DNOs' investment decisions. They may also provide justification for investment decisions taken by DNOs in forums such as legal proceedings, depending on the evidentiary standard applied in such proceedings. They also provide a back-stop that obliges efficient planning, should financial incentive mechanisms be limited in their ability to encourage DNOs to plan efficiently. However, enforcing the obligation to undertake CBAs themselves are costly, and the regulator would need to have compliance testing and enforcement procedures in place to ensure that DNOs meet the obligations placed on them.

## 7.5. Combining Deterministic and Non-Deterministic Elements into a Single Planning Standard

As discussed above, option 4 in Chapter 6 combines some deterministic elements into a non-deterministic planning standard based on an obligation to perform CBAs.

In principle, if DNOs were obliged or incentivised to undertake CBAs to identify efficient levels of reliability and the least-cost means of delivering it, then they should achieve economically efficient decisions without placing additional deterministic requirements on them. However, setting deterministic requirements regarding the level of reliability could be codified as a deterministic standard for some types of investment if the level of economically efficient reliability rarely falls below a specific threshold. Setting this minimum level of investment as a deterministic planning requirement would save the DNO the costs of conducting CBAs to confirm that this level of reliability is required, on the basis that it almost always will be. We understand that the modelling being conducted by Imperial will seek to identify cases in which the lowest level of economically efficient investment to provide reliability is robust to changes in circumstances and assumptions, so can be codified.

An implication of such a *de minimis* deterministic requirement is that, should (in very specific circumstances) a CBA identify that a lower level of reliability were economically efficient, the planning standard would prevent the DNO from targeting this lower level (unless they obtain a derogation). In general, such an approach would introduce economic inefficiency to network planning, but this problem could be overcome by applying to the regulator for derogations from the deterministic requirements imposed by the planning standard.

## 7.6. Interactions with Distribution Losses

There is a link between network assets and losses, as discussed in Section 2.3.5 of this report. More network capacity delivers more reliability, but it also reduces electrical losses as a side-benefit.[122] Therefore, it is efficient to plan distribution networks considering the benefits of both increased reliability and loss reduction. Similarly, where assets are oversized to account for the value of loss reduction, this may open up new and cheaper options for providing reliability by creating new links between oversized assets as a substitute for duplicating assets to provide reliability through redundancy.

The value of loss reduction could be factored into each of the reform options, depending on interactions with the form of regulation established by Ofgem to encourage efficient levels of investment and effort by DNOs to reduce losses. The deterministic approach could, for example, prescribe a capacity headroom in sizing of network assets to achieve reduced loading. Alternatively, the regulation could take the form of a specific requirement to procure low-loss assets in the nature of energy efficiency design standards in buildings or white goods.[123] The inherent weakness of these approaches, however, is the inability to accommodate the changing cost base of network assets, wholesale electricity price and uncertainty in demand growth.

With the options for reform of P2/6 that place greater reliance on DNOs' discretion to plan networks, the regulator could define a value to be placed on loss reduction by the DNOs in network planning. Re-introducing a financial incentive mechanism to reduce losses would be necessary for the reform case which dispenses with the planning standard, but this may bring other undesirable consequences due to the technical difficulties in measuring losses and the potential for windfall gains and losses by DNOs. Smart metering technology may resolve this difficulty, however, by facilitating loss measurement.

## 7.7. Ensuring Consistency with the Regulatory Settlement

On the condition that this review process concludes that reform of P2/6 is necessary, the implementation of more radical reform options may well be impractical before the end of the RIIO-ED1 settlement in 2023 given that these options would change the demands being placed on DNOs as compared to those agreed in setting the price control. The advantage of such a delay, however, is that it would allow DNOs time to prepare to adopt the preferred option, such as the development of suitable models and training of staff to adopt to new, potentially more demanding, working practices.

The more modest reforms retain the nature of the current deterministic model, and thus do not alter materially the requirements placed on DNOs before the end of the current control period.

[122] This only applies if assets added to improve reliability are operated in parallel to existing assets, not if assets are added and kept solely for back-up in outage conditions.

[123] In designing such regulatory instruments, which is beyond the scope of this report, it would be important to account for any technical challenges associated with integrating low loss assets into existing distribution systems, which we understand is particularly important for interconnected networks.

An improved deterministic model could also be implemented as an interim measure with a view to implementing a more radical approach after the end of the ED1 control period.

# 8. Summary and Conclusions

## 8.1. Different Mechanisms for Regulating Reliability

The system of revenue caps imposed on the privately owned electricity network companies in Great Britain provides strong incentives to reduce costs, including (potentially) savings made at the expense of lower quality of service. Some regulatory mechanisms are therefore required to encourage or mandate DNOs to provide an efficient level of quality of service, including the provision of assets or other operational measures to provide an economically efficient level of reliability.

ER P2/6 is one such regulatory instrument that requires DNOs to achieve certain restoration times following the failure of a distribution asset. Complying with these minimum restoration times often requires DNOs to put in place particular amounts of redundancy, with increasing security requirements for assets serving more load. In practice, a range of other regulatory instruments are used that also affect DNOs' decisions over what level of reliability to provide, most notably the IIS. Other jurisdictions use different types and combinations of regulatory instruments to achieve the efficient provision of reliability. Notably, not all jurisdictions use deterministic planning standards, of which P2/6 is an example.

Our review of alternative approaches to regulating reliability, as well as other discussions with the P2 Review Group, leads to a range of options for the reform of P2/6:

1. Retaining P2/6 without revision;
2. Retaining a deterministic planning standard that seeks to define the efficient reliability requirements DNOs should provide, but with improvements compared to P2/6 such as to better account for the role of non-network solutions such as embedded generation, storage, demand side response, etc;
3. Implementing a non-deterministic planning standard, which would involve abandoning the approach of specifying required levels of investment or service levels and placing more discretion in the hands of DNOs to plan their network efficiently, such as by conducting cost-benefit analyses;
4. Implementing a non-deterministic planning standard that obliges efficient investment (following option 3), while retaining some deterministic elements that define a "bare minimum" level of reliability; or
5. Abolition of the planning standard, and relying instead on other regulatory mechanisms to encourage DNOs to plan their networks efficiently.

## 8.2. Appraising the Economic Efficiency of these Alternatives

### 8.2.1. Quantifiable effects

A deterministic planning standard, by its nature, instructs DNOs to provide certain levels of reliability. If the levels of reliability P2/6 prescribes are economically efficient, then the current deterministic planning standard may itself be considered economically efficient. However, if a large "gap" exists between the economically efficient level of reliability and that prescribed by P2/6, then there may be case for reform (ie. adopting one of the reform options 2-5 listed above). The quantitative modelling being conducted by Imperial will estimate the size of this "gap".

In assessing whether option 2, the updating of the current deterministic standard, can address any such efficiency gap, two considerations are particularly relevant:

- First, it will be important to evaluate whether alternative distribution planning standards can close the gap between the economically efficient level of investment and that prescribed by P2/6. For instance, if the Imperial modelling finds that P2/6 prescribes systematically too much or too little reliability, then there will be a case for changing the requirements it imposes on DNOs accordingly. This may lead to a recommendation to adopt option 2 above.
- However, even if it is possible to specify a new deterministic standard that closes the gap between the economically efficient level of investment and that prescribed by P2/6 in many cases, it is also important to consider the *variability* of the gap. The Imperial modelling may show that the economically efficient level (or type) of investment to provide reliability depends on external factors that can be observed by the network planner (eg. network configuration, topography of the region). If these factors cannot easily be accounted for when codifying a deterministic planning standard, then a new deterministic standard that seeks to prescribe the level of reliability it is efficient to provide on average (option 2) will in many cases prescribe too much or too little provision of reliability. This finding would lead to a recommendation to consider adopting one of options 3-5 above.

Options 3-5 all place more discretion in the hands of DNOs to decide the economically efficient level of investment, such as by conducting CBAs to identify the optimal level and type of investments to provide reliability. In this sense, the difference between these options is hard to quantify as they can all, in principle at least, oblige or incentivise DNOs to plan their networks efficiently, without defining specifically what levels of reliability they are required to provide.[124] In principle, a quantitative comparison of these options would all lead to the same answer, ie. that the DNO reaches the economically efficient solution. The consideration of these options, at least within the scope of this report, can only be qualitative, as discussed below.

However, the one exception is option 4, which does require DNOs to plan efficiently such as by using CBAs, but prescribes minimum levels of reliability that the DNO is allowed to provide. Obliging DNOs to provide minimum levels of investment may have some benefit because it simplifies network planning (as discussed below). But on the other hand, if even the minimum requirements are set too high in some cases, some loss in efficiency may result. The Imperial modelling can be used to quantify any such loss in efficiency with the *de minimis* deterministic planning requirements imposed by option 4.

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124 Option 5 (removal of the planning standard entirely) will, of course, only incentivise DNOs to provide the economically efficient provision of reliability if the financial incentive mechanisms are calibrated to encourage DNOs to value improvements in reliability at the value consumers themselves place on such improvements. For this reason, as discussed above, some improvements to the IIS mechanism might be desirable if option 5 were selected.

### 8.2.2. Qualitative effects

A benefit of deterministic planning standards, that would be lost if one of options 3-5 were adopted,[125] would be a loss of simplicity in the planning process. While there may be an efficiency loss associated with a deterministic planning standard that prescribes potentially inefficient levels/types of investment to provide reliability, it does simplify the task undertaken by network planners, as they do not need to decide on the efficient level of reliability. Placing more discretion in the hands of DNOs may add cost and complexity to their planning activities, which would need to be offset against any potential efficiency improvement identified by the quantitative modelling.

DNOs' network planning decisions may also become less simple to understand for those outside the DNO who take an interest in them (eg. embedded generators, large customers, government, Ofgem). This factor is a cost that ought to be taken into account in the overall evaluation of the reform options. However, there may be ways to offset its effect, such as by developing a process whereby DNOs publish their investment plans and policies. There may also be value in having a process whereby Ofgem approves the planning methodologies published by DNOs, eg. because it may help DNOs to defend investment decisions against legal challenges as they can cite a regulatory document setting out the investment planning process they follow.

Options 3-5 might also create less uniformity in the planning procedures adopted, and the levels of reliability provided, by different DNOs. This is a natural result of abandoning a common deterministic planning standard, but we are sceptical as to whether it is a problem:

- Variation in the degree of reliability provided is probably economically efficient as the costs of providing reliability vary across the country, as may the value network users place on reliability. This is a benefit that can be accounted for through the Imperial quantitative modelling (see above);
- It may be the case that, at the higher demand groups, P2/6 provides some consistency on the risk of consumers being affected by a major incident. Nonetheless, with the deterministic planning requirements in respect of reliability imposed by P2/6, the actual levels of reliability consumers experience vary enormously, so to suggest P2/6 achieves uniformity across network users is incorrect; and
- Having different DNOs applying different investment planning policies brings potential benefits in the form of innovation in planning; but
- Some network users that engage with multiple DNOs might face higher costs as a result of having to understand multiple investment planning policies. This factor is a cost that ought to be taken into account in the overall evaluation of the reform options. However, as in the case of the costs DNOs face due to more complicated network planning (see above), these effects could be mitigated through making DNOs' planning procedures and the standards they apply as transparent as possible, and possibly engaging with network users on planning procedures and the standards through public consultation.

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[125] Albeit to a lesser extent under option 4, which still sets some minimum deterministic requirements.

### 8.2.3. The need for additional regulation to support more flexible planning standards

Option 5 is a relatively extreme case in which Ofgem essentially ceases to explicitly regulate the level of reliability provided by DNOs, or the means by which they provide it. Instead, this option relies on other regulatory mechanisms, the IIS in particular, to encourage DNOs to provide efficient levels of reliability using the cheapest means possible. As discussed in this report, while theoretically compelling, for this solution to encourage DNOs to provide efficient levels of reliability, some reform of the IIS would be required to provide greater exposure to the costs of interruptions, in particular high impact events that are currently excluded from DNOs' CI/CML indices. Such a change in the IIS might affect the financing costs (ie. the Weighted Average Cost of Capital) and financeability (ie. ensuring DNOs can cover interest costs and obtain an investment grade credit rating with a sufficient degree of certainty), though further work would be needed to assess these effects. Any such increase in financing costs might increase costs to consumers, but they would also be passing some of the risk around interruptions through to the DNO, so consumers would achieve some offsetting benefit in exchange.

Option 3 is similar to option 5, in that it also places increased reliance on DNOs to plan efficiently, but it reinforces the incentives conveyed through the IIS and other mechanisms to *oblige* DNOs to plan efficiently and select the economically efficient level and type of investments to provide reliability in accordance with a CBA. As discussed in chapters 6 and 7, there are different ways in which this obligation could be specified, with varying degrees of prescription. Such an obligation could also be combined with reporting requirements placed on DNOs to publish their CBA modelling, which may support sharing of innovation, to procure non-network solutions competitively (eg. following the Australian "RIT-D" approach, as discussed in Chapter 5), and/or for DNOs to obtain Ofgem's approval for their planning methodologies.

Given (1) the benefits from disseminating information that follows from obliging DNOs to publish their planning methodologies and/or models, and (2) the challenges involved in redesigning the IIS to facilitate complete removal of any planning standard, option 3 may therefore be preferable to option 5.

In terms of the choice between options 3 and 4, ie. whether to combine a CBA obligation with some de minimis deterministic elements (see above), option 4 only adds value if there are certain aspects of network planning for which the *minimum* efficient levels and/or types of investment to provide reliability can be codified in a way that will apply to all network configurations, etc. If so, setting some deterministic requirements may simplify the planning process, and thus reduce DNOs' planning costs.

For example, suppose the Imperial modelling demonstrates that it is almost never economically efficient to provide less resilience than N-1 on HV overhead lines. In this case, it would be relatively straightforward to codify a requirement that DNOs provide at least this level of security. Option 4 should not be used to define the level of investment that the modelling shows is efficient *on average* (as would be the case under option 2). Specifying this level would not achieve efficiency as there would be many cases where this obligation would require too much investment in reliability.

## 8.3. Other Considerations

### 8.3.1. Other benefits of network assets

In setting the new planning standard, it may be desirable to consider the other benefits of network assets in defining the economically efficient level of investment, in particular the benefits of loss reduction. Under option 2 (and possibly option 4, to some extent), this means factoring in any other benefits into the definition of what level of reliability is required by a deterministic standard. Under option 3 (and also under option 4), this involves allowing/obliging DNOs to consider other factors in determining the efficient level of investment when undertaking CBAs. Under option 5, this involves providing DNOs with new financial incentives for other benefits (to the extent they do not already exist) to encourage them to plan efficiently.

### 8.3.2. Ensuring consistency with the regulatory settlement

If this review process concludes that reform of ER P2/6 is necessary, the implementation of any reform option that places more onerous obligations on DNOs, and/or exposes them to more financial risk may well be impractical before the end of the RIIO-ED1 settlement in 2023. However, the advantage of such a delay in implementation is that it would allow DNOs time to prepare to adopt the preferred option, such as the development of suitable models and training of staff to adapt to new, potentially more demanding, working practices.

More modest reforms that retain the nature of the current deterministic model (options 2 or 4), and/or do not alter materially the requirements placed on DNOs, may be implementable before the end of the current control period. In fact, even if this review process concludes that one of options 3 or 5 should be implemented, an improved deterministic model (options 2 or 4) could be implemented as an interim measure with a view to implementing a more enduring solution after the end of the ED1 control period in 2023.

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