Annex 4.9 Reliability and Availability Plan

Northern Powergrid: our business plan for 2023-28

Contents

Introduction

Our plan for the 2023-28 period includes proposals to invest £769m to improve the reliability performance of our network. In this document we explain how we have produced the plan we have in this area. The content is primarily intended for stakeholders who want to understand more about our approach, but do not wish to examine the engineering detail presented in our engineering justification papers (EJPs), which provide the detailed justification for the key elements of the plan.

We are pleased to be building on a positive performance trend. We are on track to outperform our reliability and availability commitments for 2015-23 having reduced the number of power cuts (customer interruptions (CI)) by 27 per cent and their length (customer minutes lost (CML)) by 37 per cent relative to our 2012-13 baseline. In doing so we are exceeding our business plan commitments to reduce the number of power cuts by 8 per cent and their length by 20 per cent. We have also reduced the number of customers experiencing extended power cuts lasting over 12 hours by a third, alongside a reduced the average length of planned outages by 20 per cent, to just over three hours.

Maintaining a high level of reliability is essential to our stakeholders and will become increasingly important as our country decarbonises and the uptake of low carbon technology increases. Most stakeholders were satisfied with their current level of service; however, the majority supported a further step change in performance to prepare for the future needs of customers.

Over 65 per cent in all stakeholder groups wanted to see at least a "major upgrade" to our network reliability and we have refined our ambition levels to reflect that feedback:

- Stakeholders support the need to invest in enhancing the technology to improve network capability.
- Stakeholders wanted to see ambitious plans for delivering performance improvements for customers who experience power cuts of more than 12 hours, in particular for those that are vulnerable.
- Stakeholders were supportive of the focus in our customer outcomes of the specific schemes that targeted areas of the network that have traditionally received a lower level of investment.

Our proposals build our current investment programmes and recognise changing network needs. They factor in innovation activities such as our Foresight project, and other network innovation allowance projects, to ensure that our 2023-28 plan sets the foundations for the future through the progressive use of technology, both existing and new.

In addition the following documents sit alongside our strategy and provide additional detail and justification:

- Investment in high voltage automation.
- Detailed engagement findings for reliability and availability.
- Key Measures and targets
- Engineering Justification Paper - high voltage remote control and automation.
- Engineering Justification Paper - low voltage technology.
- Engineering Justification Paper - worst served customers (WSCs).

Developing our plan

While we have met or exceeded our own reliability targets set by Ofgem in the 2015-23 period, we recognise there is an opportunity to build on our current performance and deliver a better service for our customers in 2023-28.

Led by our stakeholders, we have set the following customer outcomes described in our main business plan document:

- Reduce the number of power cuts that our customers experience by 12 per cent and deliver 25 per cent shorter power cuts. We focus in particular on reducing power cut duration in order to reduce the impact on customers, using technology-based solutions where possible.

- Reducing the number of customers who experience 12 hour power cuts by 50 per cent, and the number of six hour faults on our networks by 15 per cent.

- Reducing the number of customers that experience five or more interruptions annually, by 24 per cent ensuring over 99 per cent of our customers do not experience more than five interruptions in a year.

- Significantly improving the level of service for 2,835 of our worst served customers by reducing the number of interruptions they experience by at least 25 per cent through investing £4.3m in the 2023-28 period.

Supporting these outcomes are the following strategic objectives:

- Significantly increase our penetration of network remote control and automation capability on our network, doubling the rate of installation compared to the 2015-23 period, to achieve target service levels and in doing so, bridge the gap to the capabilities of other GB networks.

- Transition our Foresight network innovation allowance project delivered in the 2015-23 period into ‘business as usual’, facilitating the use of fault predictive technology and intervention ahead of failures, and embrace new fault location techniques from other innovation projects in the distribution network operator (DNO) community.

- Increase the quality and availability of information on our network, particularly at low voltage, to improve decision making both internally and externally.

- Implement targeted operational performance improvements to improve HV and LV restoration times to 45 minutes and 155 minutes respectively.

Building on the progress we have made

We have delivered significant performance improvements in reliability and availability during the 2015-23 period using automated power restoration technology. This technology has a proven track record - over half a million customers have been had the duration of a power cut reduced to less than three minutes by our automated power restoration system (APRS), with many more benefiting from further restoration within 15 minutes from our control centre using remote control. The roll out of that technology is still in progress. As it proceeds to cover more of the network, more of our customers will benefit from it.

Our investment programme of £35.1m in the current period has doubled the number of remote-control operation points on our high voltage network, significantly improving performance for a large number of customers through targeting areas of high customer density and lower than average network performance levels. The results of our benchmarking show that we have deployed less of this technology than other companies in our sector. Customers in other licence areas are paying for that investment through their bills and ours have not. We recognise that we can drive a further step change in performance through the deployment of this proven technology, although we will only pursue such an investment with the support of our customers. Our stakeholder engagement confirms a willingness to pay for this investment in return for the improvement performance. In addition to that, improvements in our supervisory control and data acquisition (SCADA) communication network and the introduction of pole mounted remote controlled switch disconnectors means we can deliver this across a larger portion of the network. Further details of the benchmarking in this area are set out in Appendix 1 of this annex, track record and benchmarking.

At low voltage, traditionally fuses are used at substations to protect circuits and any fuse operation requires an operative to attend on site to change the fuse. We have deployed 1,400 low voltage (LV) auto-reclosing devices that switch to a backup fuse within three minutes and are able to estimate the fault location with every operation. These devices are deployed extensively on intermittent faults once customers experience a first supply interruption. Our experience with using this technology, as well as the improvement in the technology readiness level of newer low voltage fault management devices, means that we are in a strong position for the wider implementation of these technologies across a larger portion of our network, targeting the worst performing low voltage circuits.

Our Foresight project has developed and deployed a range of low voltage pre-fault monitoring equipment that has been trialled to pro-actively identify and localise developing faults before a supply outage occurs. This technology enables the pro-active management of power cuts and creates new opportunities to innovate in improving the level of service that our customers receive allowing us to implement a ‘detect, localise, locate and repair’ strategy.

Full details of our Foresight project can be found here. The project also developed additional fault location devices that we will be looking to deploy during the 2023-28 period.

Technology deployment, across both high voltage (HV) and low voltage, will significantly increase the data collected about our network. In addition to pro-active fault management, it can be used in combination with operational information and smart metering data to improve our response to power cuts as we target faster restoration times at both HV and LV.

Further more innovative ways to leverage technology, such as the use of microgrids which is covered more fully in our whole system strategy, will also provide the opportunity to deliver resilience to areas of the network where performance is traditionally more difficult to improve.

Establishing targeted customer outcomes and objectives

Alongside the evolving operating environment, changes in stakeholder expectations, and new technologies, we have continued to measure ourselves against other networks, as well as against the reliability and availability performance in other industries and countries. Our findings have helped define the ambition levels that we have tested with stakeholders while Ofgem’s target setting methodology has helped define the minimum improvement required in the 2023-28 period.

In our approach to reliability and availability, we must balance the needs of future customers with the costs required today to meet those needs. In order to guide our level of ambition we have engaged extensively with stakeholders alongside benchmarking ourselves against our peers and the targets that Ofgem have set out.

In August 2020, we published our emerging thinking which set out a range of outcomes based on high level investment and operational response plans. The five scenarios set out for stakeholders ranged from maintaining our current performance for less expenditure, through to delivering a “new world” in terms of reliability and availability performance.

Service level A Your current package – but at a lower cost	**Service level B** Enhanced performance –for the same spend	**Service level C** Major upgrade	**Service level D** Breaking new ground	**Service level E** A new world
Maintain a highly reliable service – network available 99.98% of the time	**Improvements in number and length of power cuts while delivering targeted improvements for worst served and vulnerable customers**	**Further significant system-wide improvements in reliability levels**	**Major improvements in areas where our reliability performance varies the most through deployment of innovative technology**	**Levelling up of reliability performance across our network driven by widespread roll-out of innovative technology**
- Maintain existing technology on LV network - Use smart meter data (once available) to better inform how we prioritise reliability improvements - Adoption of operational best practices to respond to faults on our network	- Continued roll-out of Automated Power Restoration System (APRS) on our voltage network - Target investment in areas where customers are most regularly impacted by power cuts/network reliability - Increase our use of mobile generators to provide electricity to vulnerable customers during power cuts	- Accelerated roll-out of existing and new technology on the LV and HV network - Harness smart meter data for fault management and to develop asset replacement programmes - Broader programme to improve service for the most frequently impacted customers	- Extensive programme to address reliability issues for most frequently impacted customers - Commence roll-out of innovative fault prediction technology on our LV network - APRS across the majority of our HV substations - Smart meter data processing capabilities	- Significant improvements for frequently impacted customers – narrowing the range of performance experienced on our network - Widespread roll-out of fault prediction technology on the LV network - Advanced smart meter data processing capabilities

Table 1: Options published in Emerging Thinking Supporting Information[1]

In their responses to our emerging thinking, our stakeholders confirmed they were satisfied with the level of service they receive currently; however, the majority of stakeholders, over 65 per cent in all stakeholder groups, wanted to see at least a "major upgrade" to our network reliability (at least option C).

In addition to establishing our overall level of ambition, our engagement with stakeholders also focused on sub-components of our performance, set out within our detailed engagement findings. This allowed us to tailor our plan ambition levels a more granular level. The headline findings in our engagement which have influenced the ambition in each of the specific areas of the plan are as follows:

- Stakeholders support the need to invest in enhancing the technology on our network in order to deliver an improvement in the average level of service for customers; they want to invest now to be net zero ready in the future, however we must ensure efficient expenditure.

- Stakeholders felt that a major factor in the impact of a power cut was the length, and as such wanted to see a higher focus in reducing the length of power cuts over the number.

- Stakeholders wanted to see ambitious plans for delivering performance improvements for customers who experience power cuts of more than 12 hours, in particular for those that are vulnerable.

- Our stakeholders were supportive of the focus in our customer outcomes of specific schemes that targeted areas of the network that have traditionally received a lower level of investment.

[1] September 2020 Emerging Thinking ED2 Plan Emerging Thinking Overview.pdf

On our network, our customers experience a CI (the number of interruptions per 100 connected customers) performance of 49 power cuts, and CML (the number of customer minutes lost) of 37 minutes on average. The benchmarking that we have done (presented in more detail at Appendix 1) indicates that, when compared to our peers, there is scope for further improvement if we gear our network and operations up to match the capabilities to drive those higher level of performance.

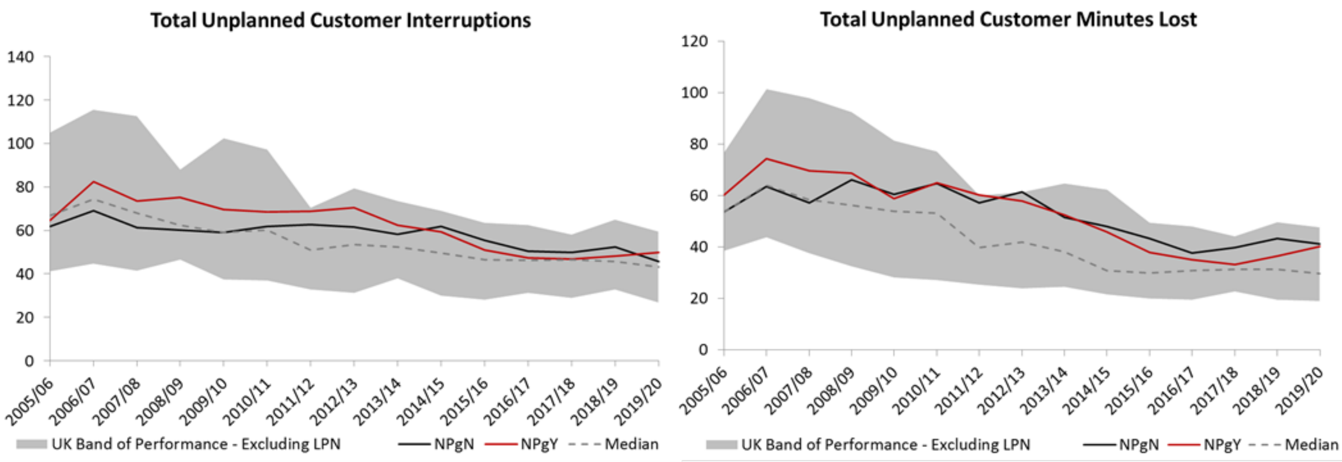

Figure 1: Benchmarking of Unplanned Customer Interruptions and Customer Minutes Lost

Our current performance puts us behind the median across our overall reliability measures. In order for our customers to receive the same level of service as other areas of the country we must be ambitious in our delivery of improvements in the 2023-28 period. As well as benchmarking overall performance, our analysis of remote switching technology has shown that, while our investment to date has been efficient and appropriately scaled, having exceeded Ofgem's targets in every year of the current period, there is a catch-up required in terms of network capability relative to other networks.

Ofgem's targets, set using the methodology laid out in the Sector Specific Methodology Decision,[2] provide a good calibration for our ambition. To meet 2023-28 interruptions incentive scheme (IIS) targets, by the end of the 2023-28 period we must reduce the number of unplanned customer interruptions on both of our networks by 12 per cent, relative to our current performance,[3] whilst to meet our unplanned customer minutes lost target we must achieve a 25 per cent reduction relative to our current performance.[4]

Overall our ambition levels are aligned to a 'major upgrade' against the calibrated scale we provided in our Emerging Thinking consultation, delivering a step change in performance for our customers. Our individual customer outcomes have been tuned to ensure we reflected the areas that stakeholders valued most, as well as those that required the most improvement. In a number of areas of our plan, such as proactive fault management, we will be 'breaking new ground'.

[2] https://www.ofgem.gov.uk/publications/riio-ed2-sector-specific-methodology-decision
[3] Current performance for CI is a 4 year average from 2017/18 to 2020/21
[4] Current performance for CML is a 4 year average from 2017/18 to 2020/21

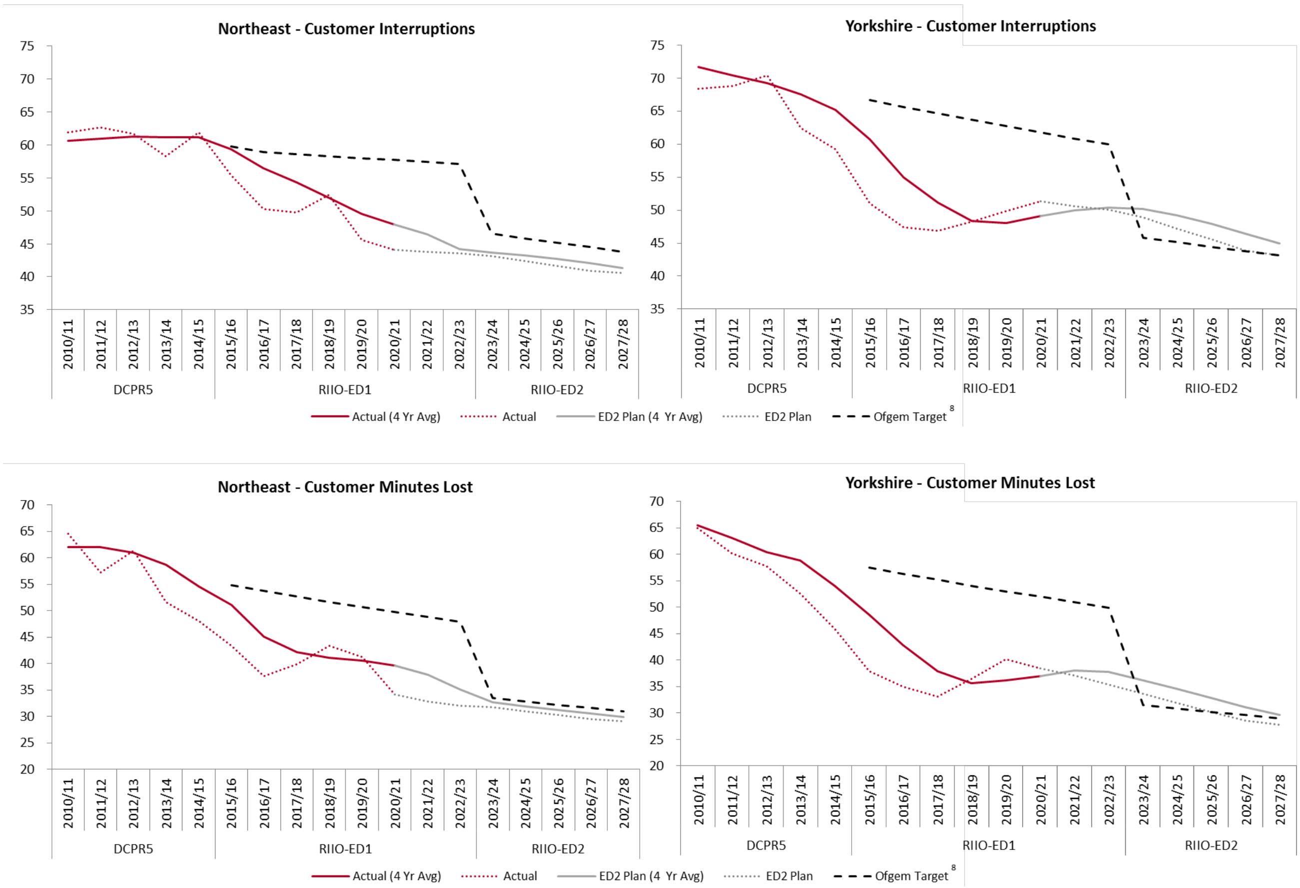

Figure 2: System-wide average performance – historic actuals and targets to 2028

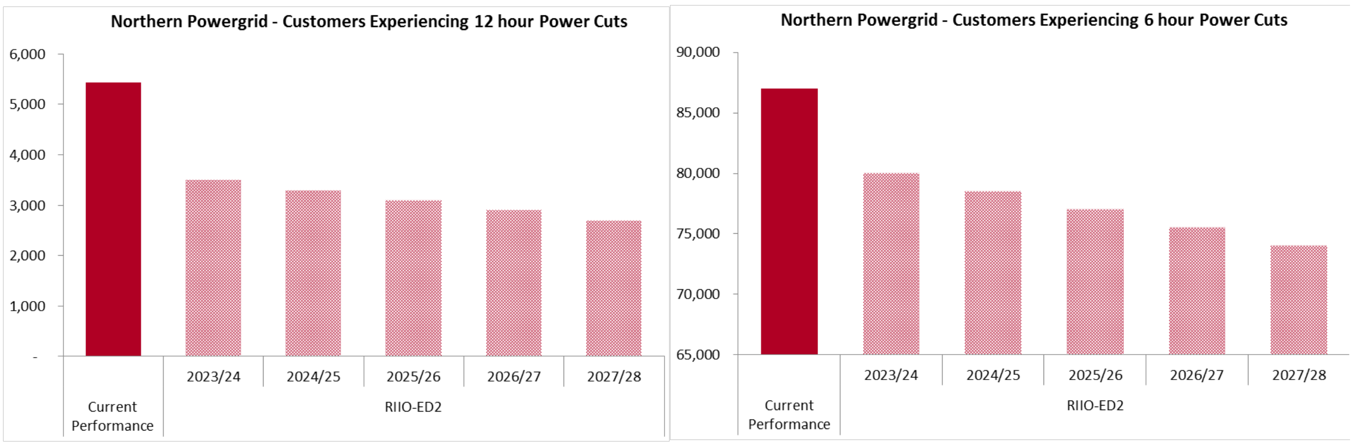

Figure 3: Long-duration power cut performance (>6 and >12 hours) - Customer outcome targets for 2023-28 period[5]

[5] Current performance is a 4 year average from 2017/18 to 2020/21

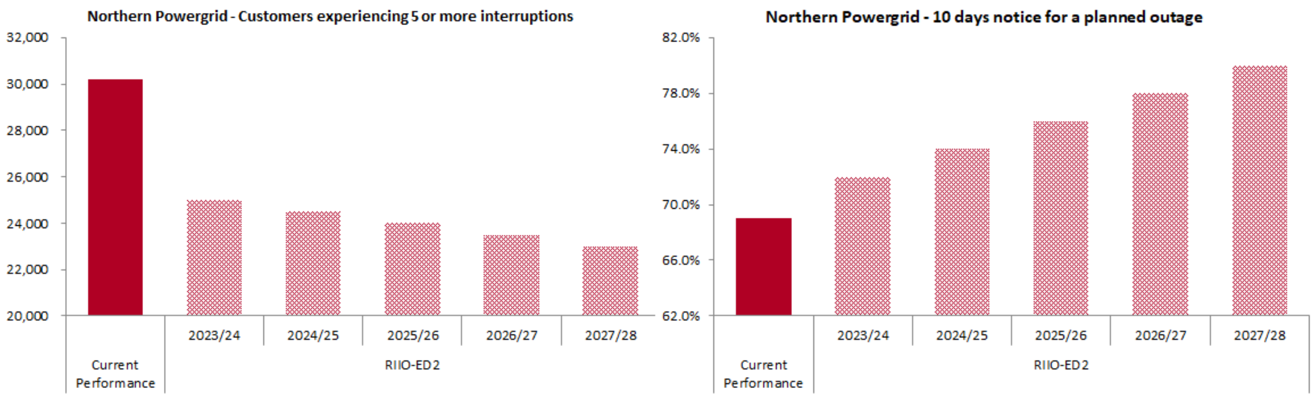

Figure 4: Customers who experience five or more interruptions and the proportion of planned power cuts where we give at least 10 days' notice - Customer outcome targets for 2023-28 period[6]

Cumulative Restoration Times	Current Performance[7]	Target Restoration Performance				
		2023/24	2024/25	2025/26	2026/27	2027/28
High Voltage Restoration Time						
Northeast High Voltage Restoration Time	51	49	48	47	46	45
Yorkshire High Voltage Restoration Time	52	49	48	47	46	45
Low Voltage Restoration Time						
Northeast Low Voltage Restoration Time	164	160	158	157	156	155
Yorkshire Low Voltage Restoration Time	181	165	162	159	157	155

Table 2: Restoration time targets for the 2023-28 period

Full details of our key measures and targets for the period 2023-28 can be found in our Key Measures annex.

[6] Current performance is a 4 year average from 2017/18 to 2020/21
[7] Current performance is the regulatory year ending March 2021

Developing the right blend of solutions

In developing our overall strategy for reliability and availability we analysed the wide range of factors that drive performance across the network, and the influence that they have on the required outcomes, in order to determine the most effective and cost-efficient way to secure the targeted improvement. Figure 5 below shows many of the factors that feed into system wide reliability and availability performance for delivering an improved level of service for our customers.

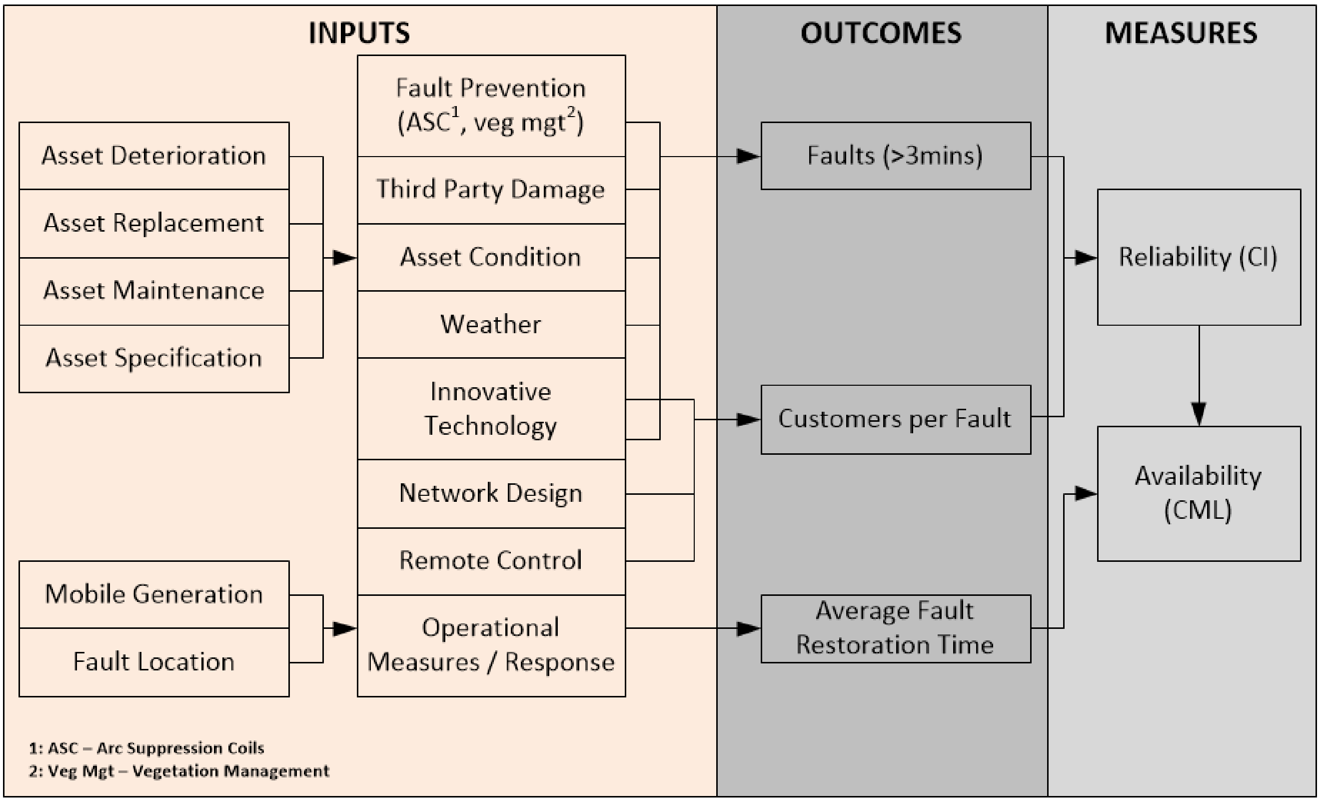

Figure 5: Drivers of system wide Reliability & Availability

The inputs contribute to three fundamental components, fault volumes, customers impacted per fault, and fault restoration times, which create the regulatory performance measures for the network. Looking at each of the outcomes in turn we can consider the main drivers for our decision-making process and what we already do in our existing approach to reliability and availability.

Fault rates

The most significant impact on fault rates is created by our asset renewal investments, which reduce the likelihood of faults occurring by taking system assets off the network that have suffered deterioration over time and through use.

In addition to these more general forms of asset reliability there are some investments that can be made to specifically avoid interruptions occurring on the existing assets that remain on the system:

- Arc Suppression Coils are a bespoke technical solution which helps further mitigate transient faults on the overhead network such that the device in essence off-sets the effects of the transient fault on the network, thereby delaying or preventing the operation of the associated circuit breaker.

- Triggered Spark Gaps are deployed on parts of our overhead network to mitigate some of the effects of lightning.

- Vegetation management is used to control the encroachment of trees on overhead lines which can influence fault rates across all voltage levels.

The nature of third-party damages vary, ranging from road traffic incidents impacting our assets, through to service strikes by construction works in the vicinity of our assets. Proactive activities which can reduce these incidents are limited. We design and construct our assets in ways to minimise damage, provide information on the location of our assets (commonly referred as 'safe-dig' packs) as a service for stakeholders, and engage with the agricultural community who work in the vicinity of our overhead line network.

Weather and environment can also have a significant impact across our network. Our asset construction standards consider these impacts, for example overhead line design standards vary according to expected wind and ice loadings. Further, storm resilience in response to high winds and flooding is a key part of our climate resilience strategy. Part of this response is set out in our vegetation management EJP, which is designed to mitigate the impacts on our overhead network of falling trees and wind borne debris, whilst flood risk is managed via the installation of defences that protect our major substation sites to "one in a thousand year" flood events.

Customers per fault

This parameter measures the average number of customers that are affected by a fault. It is driven by the way our customers are located relative to the sections of the network that feed their properties. This varies across the network, and particularly at the different voltage levels. For example, on our high voltage network the average customers per fault is 460 customers compared to just 20 for low voltage faults.[8]

We distribute high voltage electricity into and around local urban and rural areas using ring and interconnector circuits that will normally be operated with a split in the ring at the normally open point. This means that in a typical arrangement a single ring is operated as two radial feeders supplying either side of the open point (a point of isolation). These open points on those split rings are selected to optimise our ability to run the network safely and restore supplies in the event of a fault.

In order to reduce the customers connected to a circuit, we have a number of options:

- Infrastructure works to create more high voltage circuits and split existing feeders. Long term changes to the network can typically be made in this manner.

- Revised protection zones: On our high voltage network, pole mounted auto-reclosers are deployed throughout the overhead network. The settings of the control systems that trigger them are such that they help respond to transient faults, which come and go in a few seconds (for example, a lightning strike or some wind-borne debris). We can use these devices in a cascade to create several, (typically up to three) protection zones along a feeder. On underground circuits, the solution doesn't work as well for technical reasons - multiple protection zones would require a revision to the settings further into the network – this has the potential to create longer clearance times when faults do occur. This adds further risk to the assets exposed to the passage of fault current.

Fault restoration time

This outcome is largely driven by two factors: our operational response and the capability of the system to allow remote or automatic reconfiguration. Although we would prefer our customers to avoid an interruption altogether, when an interruption does occur, the objective is to restore as many customers as possible as quickly as possible by reconfiguring the network, before carrying out a permanent repair to the asset that has suffered the failure.

As a result, fitting actuators to the high voltage switches in our substations allows us to incorporate switching at key network locations is response to a network fault. This can be combined with switching software in our control system to automate network operation.

[8] Performance is a 4 year average from 2017/18 to 2020/21

Fundamentally, this serves only to shorten the average duration of the power outage. The way the measurement definitions work, they also have the potential to influence the reported customers per fault. That is because the definitions detailed in our measures of reliability allow a period of three minutes prior to a power cut being defined as a customer interruption. Accordingly, if the automatic or remote control facilities enable power to be restored in less than 3 minutes, the interruption falls out of the headline measurements and into the short interruptions category.

Operational protocols and performance also have a significant contribution to restoring customer supplies. This involves the dispatch of engineers to site to perform manual switching operations and to deploy mobile generation. Once all means of restoration have been exhausted then fault location and repair will commence.

Blending the solutions

To define the right mix of initiatives, we start with an assessment of the main areas of required improvements:

- Overall, our 132 kilovolt (kV) and extra high voltage (EHV) performance is amongst the best in the country; our high and low voltage networks are the areas to concentrate improvements on.

- Customers are more likely to experience a supply interruption from a high voltage fault than a low voltage fault.

- Broadly, the split is 75 per cent of our customer interruptions are due to high voltage faults compared to 25 per cent at low voltage.

- Faults at low voltage generally create a more significant impact for our customers than those on the high voltage network, because a much greater proportion of them require a repair in order to restore supplies and so they take, on average, 5 times longer to locate and repair than faults at higher voltage levels.

- Broadly, the split for customer minutes lost is 52 per cent at high voltage compared to 48 per cent at low voltage, even though the high voltage faults affect a higher number of customers per fault.

- At high voltage, fault rate performance is good but the customers per fault is higher than our peers and our restoration times are slightly better than the median performance.

- Therefore initiatives that address improvements to customers per fault using technology are a priority.

- At low voltage, the fault rate that we have to manage on our network is higher than our peers in the industry due to our extensive cable network incorporating CONSAC in the Northeast and Non CONSAC aluminium neutral waveform in Yorkshire; customers per fault is slightly above the median while our restoration performance is in the lower quartile.

- Therefore we need to look for options that efficiently improve the fault rate and focus on improving our restoration times because improving customers per fault at low voltage cannot be done without making very expensive network alterations.

High voltage

Improving the customers per fault metric at high voltage can be achieved in three generic ways:

- installing new circuits, which is generally a very effective but expensive way to drive improvement. We undertake this work where efficient as part of our overall network investment programme;

- increasing the number of protection zones which in turn increases fault clearance times. This is comparatively inexpensive but introduces a risk of further damage to equipment arising from such equipment conducting high amounts of energy whilst the fault is detected and extinguished (an important aspect of the design of our safety systems is to minimise protection operating times); or

- applying remote control and automation technology that shortens interruptions below the threshold.

The cost-effective way of improving this is by installing remotely controlled switches in combination with automated restoration switching routines. Across the industry automation has been successful in improving high voltage performance. Although the interruption has not been eliminated completely, the service level has been improved considerably, at a cost that is typically relatively low because it does not require any fundamental rebuilding of the network. We have an installed base of 17 per cent of our switches with automation capabilities, which to-date has successfully delivered against customer expectations and our regulatory targets; however benchmarking shows that this is one of the lowest concentrations amongst the DNOs and will not be sufficient to support achievement of our network performance targets in the 2023-28 period (see Appendix 1: Track record and benchmarking).

Increasing the number of automation points can be done in three ways:

- retrofitting actuators onto ground mounted switches;
- installing pole mounted auto-reclosers; and
- installing pole mounted remotely controlled switch disconnectors.

Our assessment suggests that we have nearly reached saturation with the scope to add auto-reclosers, so improvement in rural network performance requires us to install switch disconnectors. On urban networks there is significant scope to continue to retrofit actuators onto ground mounted switches.

There is more of a performance gap in Yorkshire than the Northeast and more opportunities to improve rural networks especially for areas of worst performing circuits. Therefore more automation on rural networks in Yorkshire using a mix of solutions is the priority. The optimum number of units to install is a function of the benefits per unit and the size of the relevant performance gaps. Any investment in this type of initiative will be complemented by improved performance in our existing automation units that stems from the upgrade of our secondary SCADA communications network, which will improve the speed and stability of performance.

The deployment of more fault restoration technology will be supplemented by incremental improvements from:

- continued diligence with vegetation management;
- asset replacement policies that target poorly performing or poor condition assets; and
- operational initiatives that drive improved high voltage restoration times.

Low voltage

Our low voltage performance is principally driven by the performance of our underground cable network. Some 95 per cent of fault volumes are associated with this asset class. The fault rates that we experience are largely determined by the decisions taken many years ago in terms of asset specification, where cable types were selected and installed that have since proven themselves to have a lower reliability performance than other designs. Weaknesses in the cable designs that lead to faults are then compounded by local economic and environmental factors, examples of which are:

- high levels of rainfall exposing weak points for water ingress;
- dry ground conditions leading to ground movement and mechanical stress;
- increased loading causing weakening of components arising from thermal cycling/stress; and
- disruption and damage caused through work done by other utilities

Digging up cables to replace them is a very expensive way to reduce these fault rates. For example we estimate that it would cost over £200m to replace approximately 2,250km of notoriously unreliable CONSAC cable in the Northeast, or close to £800m to replace similarly poor performing 7,500km of Non CONSAC aluminium neutral waveform cable in Yorkshire.

The most efficient approach to improving performance in relation to this type of asset is to respond promptly and decisively to the faults that arise and overlay larger sections of the cable when the fault performance of a circuit identifies it as a poor performer. This approach has allowed us to stabilise fault rates over the current period.

Going further and improving fault rates over the longer term in an efficient manner requires the use of pre-fault technology as developed in our Foresight innovation project. Our plan includes initiatives that increase our ability to monitor the low voltage networks to detect potential faults, using this information to target operational activity and longer term asset replacement.

The investment in monitoring can be leveraged by installing intelligent low voltage fault management or automation devices that are able to restore non-damage faults automatically. Our LV Network Automation engineering justification paper,[9] assesses the optimum economic level of targeted deployment of this pro-active fault management approach.

We expect this investment to improve performance in, particularly in areas of poorly performing cables, a gradual improvement in cable fault rates and the improved ability to target operational resource onto damage faults. Operational initiatives such as increased use of mobile generation, better fault location equipment, IT systems to aid in operational dispatch and decision-making will all combine with the network technology to improve overall restoration times.

This development in network technology is core to our creation of a more flexible low voltage network that provides increased operational visibility and operates in a similar manner to higher voltage networks using automation with alternative feeding arrangements via interconnection.

Conclusions

In summary, our evaluation of the options led us to three key initiative areas:

- increase the use of automation and technology across the network, specifically targeting the worst performing parts of our network;
- implement innovation through the use of pro-active pre-fault and fault management technology; and
- continue to drive improvements in “traditional” solutions such as operational response.

[9] EJP-10.2 LV Network Automation

Delivering the improvements

We will spend £153.8m per annum in total to deliver the targets set out in our plan in relation to the reliability and availability outcome. This is £13.5m per annum more than our expenditure in the 2015-23 period, representing a 9.60 per cent increase in annual spend and a £0.70 increase in the bill for an average domestic customer.

	2023-28 Total £m	2023-28 Annual Average £m	2015-23 Annual Average £m	Variance	
				£m	%
Non-load capex - HV automation	64.8	13.0	4.8	8.2	170.2%
Non-load capex - LV technology	21.9	4.4	2.9	1.5	51.0%
Non-load capex - worst served customers	4.3	0.9	0.0	0.9	-
Non-op capex	16.6	3.3	0.0	3.3	-
Network operating costs	435.5	87.1	90.0	(2.9)	(3.2)%
Closely associated indirect costs	141.1	28.2	26.4	1.9	7.0%
Business support costs	84.8	17.0	16.2	0.7	4.5%
Total Proposed Cost	769.0	153.8	140.3	13.5	9.6%

Table 3: Reliability and availability improvement plan costs

We will deliver our customer outcomes through:

- An optimised investment programme across our high voltage and low voltage network: our plan contains £65m of investment in HV automation and £39m (non-load capex - LV technology plus non-op capex in table 3) investment in a range of LV technologies across the 2023-28 period unlocking a step change in reliability performance. This step up in capability accounts for the increase in cost over and above those for 2015-23 and will prepare our network for the challenges of the future.

- Keeping on-going operational costs flat while delivering significant improvements in performance: We will build on our efficient network operating costs in the 2015-23 period by holding costs flat in the 2023-28 period while improving our level of service. We will continue to identify cost efficiencies to fund front-line performance improvements, such as driving down 12 hour power cuts and improving restoration times. A detailed breakdown of our operating costs is included in our costs in detail annex.

- Delivering targeted investment that improves services levels for our worst served customers (WSC): We plan to invest £4.3m during 2023-28 in improving services for our 2,835 WSCs by upgrading the assets supplying our rural communities and installing automation to help restore their supplies faster. This will significantly improve the level of service they receive by reducing the number of power cuts they experience by at least 25 per cent.

- Ensuring targeted replacement of our assets to manage risk: Our approach will ensure efficient expenditure on our underlying asset base, utilising technology to extend the life of assets while maintaining reliability and availability and delivering capacity benefit to be net-zero ready, which is covered in our asset resilience investment

- Delivering innovative solutions to reliability and enabling a future ready network: Through improving our network capability, we will continue to innovate in pro-active fault management, flexibility and microgrids to ensure that our network supports the needs of customers in the 2023-28 period and beyond.

High voltage automation

We plan to invest £65m in increasing the penetration of high voltage automation across our network, delivering a further 8,600 remote controlled switches in the 2023-28 period.

We have considered whether alternative options (such as operational improvements similar to those we have delivered in the past) and increasing our asset replacement programme can achieve these objectives. However, we have found that our proposed automation investment programme is the best overall value for money, and delivers long-term benefits for our customers. To achieve, for example, even a quarter of this performance improvement by HV cable overlays would cost almost three times the amount of this investment.

This investment will be at a blend of ground mounted and pole mounted switch locations. It will include the increased use of remote control across our overhead line network. This is possible now that we have made upgrades to our fault management software that will allow automated power restoration system use on the overhead line network. Some 30 per cent of the planned units will be deployed on our overhead line network, which will benefit our rural communities who generally experience more reliability and availability issues. These areas have typically received less investment due to the lower customer density. They are also the majority of our worst performing network areas.

A fundamental part of this activity will be enabled by installation of the latest enclosed switch disconnectors as a replacement for traditional air break switch disconnectors. These support both normally open point deployment and improved sectionalising of the overhead network. In addition to this change in approach, where Operational Restrictions are preventing full system coverage of APRS, we are implementing works to remedy these issues – our fault level strategy includes works to address these issues [INSERT footnote to EJP-11.2 Decarb - fault level].

Our high voltage automation investment is proposed as a bespoke price control deliverable[10], the justification of which is covered within our Investment in High Voltage Automation annex. This will provide the guarantee to our customers that their priorities will be met at the level of cost that is efficient and affordable, ensuring customers only pay for upgrades that we deliver in the period.

Category	Northeast (Units)	Yorkshire (Units)	Total (Units)
Ground Mounted Automation Point	803	5,217	6,020
Pole Mounted Automation Point	344	2,236	2,580
Total Automation Points delivered	**1,147**	**7,453**	**8,600**

Table 4: Breakdown of our High Voltage Automation Investment

Improving our network management

Our ability to actively manage the network is a key part of delivering an improved level of service at high voltage. As such we will develop our control facilities through expansion of our PowerON Fusion functionality and scalable upgrades to the network coverage of our APRS deployment.

[10] A Price Control Deliverable is a specific project or work programme deliverable that have an identified level of funding attached to them. If a specification is not delivered, the relevant proportion of associated allowances can be clawed back by Ofgem at the end of the price control.

This will include the replacement of our fleet of remotely indicating fault flow Indicators with 2,000 new units which enable an improved visibility of fault location for the control engineer. The details of this investment can be found in our Remote Indicating Fault Flow Indicators Engineering Justification Paper.

As part of our planning we have also undertaken an analysis of our high voltage network design, in some instances we have concluded that feeders running meshed may be preferable to the current arrangements of radial with automated open points. We will explore this further through some specific trials using key learnings from ENW's Low Carbon Networks Fund project C_2C to further understand the implications with protection and operational management. The incremental benefits and costs of network meshing verses deployment of APRS need to be understood before any wider rollout is planned, however our scaled APRS system will inform much of the detail required.

The investment for LIDAR and associated changes to vegetation management will positively impact performance across all voltage levels. At high voltage, anecdotal evidence suggests a higher level of the infested spans are within the defined boundaries with greater potential to impact fault performance.

Low voltage technology

At low voltage we need to deliver enhancements to our service given the relatively high fault rates that are associated with the legacy cable assets that make up the network in our region. This requires an innovative solution alongside more traditional ways of improving low voltage performance.

In doing so we will:

- Build upon the success of our Foresight innovation project and increase the benefits delivered by the use of low voltage fault management devices by improved targeting.
- Introduce low voltage pre-fault monitoring to ground mounted distribution substations to monitor our underground cable circuits.
- Expand our existing fleet of fault management and fault location devices to intervene pro-actively earlier in the fault lifecycle.
- Create synergies with our low voltage load monitoring plans to develop a suitable platform to concurrently monitor load and pre-fault activity. This will effectively further increase LV pre-fault monitoring coverage at distribution substations and our low voltage underground cable circuits by 2028.
- Utilise pre-fault data from low voltage network monitoring to deliver targeted replacement of our assets to maintain our current fault rates.

Our use of Foresight technology improves LV network reliability through fault anticipation and proactive intervention earlier in the fault lifecycle in order to reduce underground network fault rates. It also enables significant additional secondary benefits such as:

- improved health and condition information;
- improved targeting and effectiveness of asset replacement expenditure;
- long term reduction in fault costs;
- reduction in multiple interruptions for our worst serviced customers; and
- improved customer service by minimising local impact and disruption with remedial work progressed on a planned basis.

We will increase the monitoring of our network across 9,000 network locations covering 30 per cent of our network. This investment will focus on the worst performing areas of the network and enable the prioritisation of low voltage circuits with developing faults for proactive action, incrementally increasing the deployment of fault management devices to the prioritised circuits and mitigation of the impact of fault progression including planned cable section replacement.

This will be delivered through 7,000 low voltage guards, which will enable an increased level of data to be available to deliver pre-fault intervention. In addition, we will create synergies with our low voltage load monitoring plans (covered in detail in our DSO strategy), to develop a suitable platform to concurrently monitor load and pre-fault activity across 2,000 network locations. This will effectively further increase LV pre-fault monitoring coverage at ground mounted distribution substations and our low voltage underground cable circuits by 2028 to 9,000.

We will invest in 8,100 fault management and location devices for deployment on our low voltage assets. Traditionally these would be deployed to circuits where previous fuse operations have been identified, however they will utilise the fault monitoring data to inform deployment, allowing the devices to be proactively deployed before a power cut. This will help reduce the impact to customers when a non-damage fault occurs through the use of either a back-up fuse or power electronics within the device. They also gather fault location information enabling our operatives to locate and fix the fault quicker, whether that is through a planned intervention or in response to a fault. This targeted deployment will provide the most efficient use of fault management devices and allow our customers to receive significant benefit in the 2023-28 period, allowing us to protect customers for longer, enabling the time to plan the works required to avoid a permanent fault from occurring.

Worst served customer initiatives

In order to improve the level of service that our customers received on the worst parts of our network we will be delivering the following improvements:

- We will significantly improve the level of service for some 2,835 of our worst served customers by reducing the number of interruptions they experience by at least 50 per cent through investing £4.3m in the 2023-28 period.

- We will target our high voltage automation programme at the worst performing circuits on our network.

- We will use low voltage technology to enable the targeting of fault management devices on specific areas of the low voltage network.

Through our analysis of schemes capable of improving the level of service for our worst served customers, it has been established that significant improvements could be delivered by a technology led approach, delivering automation and, where necessary, reconfiguring the network to minimise the impact of faults.

In the Northeast, our programme of investment will focus on the installation of automated pole mounted switch disconnectors. With only limited reconfiguration of the network required, the existing network layout allows the appropriate plant to be retrofitted with automation and provide benefit. The introduction of automation allows isolation of the fault and therefore reducing the number of customers affected by faults.

We have identified seven schemes in the Northeast area that will develop an out-turn cost at £1,667 per customer. In Yorkshire we have identified eleven schemes to improve the quality of supply received by worst served customers. In addition to automating the network, some of these schemes require reconfiguration of the network. Whilst there is an added complexity of the schemes in Yorkshire as compared to those in the Northeast, a lower cost per customer of £1,351 is realised.

This is approximately 15 per cent of the cost of traditional solutions, ensuring we deliver efficient expenditure while still providing the majority of the benefit for our customers. As the phasing of the investment schemes is developed for the 2023-28 period, we will ensure we balance the delivery with our commitments to protect vulnerable customers.

Cumulative Number of Customers Addressed	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Worst Served Customers addressed in Northeast	83	45	71	331	7	537
Worst Served Customers addressed in Yorkshire	719	125	-	-	1454	2,298
Worst Served Customers addressed in total	**802**	**170**	**71**	**331**	**1,461**	**2,835**

Table 5: Profile of improvements delivered for worst served customers

Cost of Schemes (£m)	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Worst Served Customers schemes in the Northeast	0.2	0.2	0.2	0.2	0.2	1.0
Worst Served Customers schemes in Yorkshire	0.7	0.8	0.8	0.5	0.5	3.3
Worst Served Customers schemes in total	**0.9**	**0.9**	**1.0**	**0.7**	**0.7**	**4.3**

Table 6: Profile of expenditure to address worst served customers

Operational response

We are targeting a reduction of restoration times at high voltage and low voltage by 17 per cent and 14 per cent respectively. We are also aiming to achieve a significant improvement in our response to complex power cuts, by reducing the number of customers who experience a 12 hour power cut by 50 per cent and those that experience a 6 hour power cut by 15 per cent. This will be achieved through a mixture of traditional improvements and by utilising increased monitoring and fault location technology on our network to deliver an optimised response:

- Enhancing our operating model – we will continue to drive efficiencies in traditional response to unplanned power cuts. We will make enhancements to our operational model combined with optimised use of mobile generation including utilising innovative SilentPower vehicles to provide more low carbon restoration solutions. These electric response vehicles are equipped with an on-board energy storage system meaning they offer a cleaner, quieter alternative to diesel-powered generators to help power homes.

- Innovating in pro-active fault management – we will begin the transition to pro-active fault management, enhancing our operational skills and resources in order to repair assets before they impact customers.

- Improving our fault management and repairs processes - utilising the improved data available from a variety of sources to better inform operational decision making to deliver our restoration targets.

- Improving our logistics – better supporting our operational staff through accelerated equipment order processes to ensure they can access the right materials and equipment even faster.

An enhanced operational response model

We will continue to improve our "traditional" fault response alongside our other initiatives through improvements in technology as well as organisational alignment to ensure we drive continuous improvement in our response times. Improvements in our network capability across both high voltage and low voltage will enable operational improvements through lower numbers of customers being impacted by power cuts.

The topology of our networks, demographic of our customers and geography of our service territory means specific needs and continuous improvement profiles vary from region to region. We service a blend of rural and urban networks within Tyne & Wear and South Yorkshire, very sparse networks in Northumberland through to the predominantly urban networks of West Yorkshire. As such, how we develop and empower our teams can vary between areas meaning that we must consider a variety of dynamics when deploying new technology to drive our enhanced operational response.

As we tailor our 2015-23 works to enable our targeted response improvements through 2023-28, we will ensure we maximise the benefits of our commercial agreements with our contract partners to supplement the capabilities of our own workforce and enhance our operational response.

As part of our Data and Digitalisation plan, the improvement of our low voltage network management system will enable smarter working and provide a platform for us to optimise the deployment of resources. This will be accompanied by modernised hand-held technology allowing for the efficient allocation of jobs, along with the required closed-loop processes from the field, to serve our customers. This will be enabled through internal information gathered through hand-held devices linked back to our dispatch centre combined with global positioning system (GPS) data derived locations of field personnel, resource availability, and field personnel skills and authorisation codes, in combination with external data such as traffic and weather conditions.

A comprehensive review of our operating model (in-hours and out-of-hours) is being undertaken in preparation for the 2023-28 period. This is focused on ensuring that the resource levels of engineers, craft personnel and service providers is fit for purpose moving forwards in order to efficiently manage a blend of reactive and proactive interventions.

We will also be up-skilling our engineers and operatives to enable them to respond more effectively to unplanned power cuts through an extension to our existing workforce renewal programme. This will include delivering a self-dig capability in the remainder of the 2015-23 period which will allow us to maximise our workforce capability against the balance of contracted services.

We will be refining our out-of-hours duty manager concept prior to the commencement of the 2023-28 period to provide additional scrutiny and strategic oversight of operations ensuring a seamless transfer of responsibilities through shift changes; maximising the efficient response of field personnel and, in particular, targeting the restoration of customers experiencing long-duration power cuts.

Alongside increasing our response effectiveness, we will further increase the deployment of mobile generation to restore supplies following a power cut. This will target longer, more complex faults focusing on the restoration of our customers rather than the repair to the network. This will be balanced with the environmental impact of diesel generation which will mitigate through the use of low carbon fuels and battery generation – see our Environmental Action Plan.

We plan to increase in our fleet of SilentPower electric mobile generation vehicles to six. These vehicles have on-board energy storage systems which replace the traditional more noisy and polluting diesel generators and enable the restoration of customers where there is also the export of power (which is not possible with diesel generators). These self-contained, environmentally friendly vehicles represent the future of power restoration and are discussed in more detail within our vulnerability strategy.

Our key operational improvement initiatives for the 2023-28 period and enabling works in the current period are summarised at Appendix 2.

Facilitating a pro-active approach

In order to facilitate the move to pro-active fault management, we will be training our existing workforce to install, maintain, interrogate, and respond to the new low voltage fault predictive technology through a mixture of structured training and field support and mentoring. This will focus on enabling “digital skills” within our workforce and improve our ability to analyse monitoring data and use it to inform decision making.

Moving to pro-active fault management will be a culture change in the management of the low voltage network and ensuring our staff are supported and prepared is key to setting the foundations for our transition as we increase the rollout of this technology on our network.

This approach will embed a transition of working methodologies for a workload traditionally defined on a responsive basis to supporting and driving planned asset modernisation works to prevent faults ahead of time

Enhancing fault management processes

In addition to the transformation of our operational model, we also plan to align our management of the low voltage network by a deliberate shift to reduce faults. This will be coupled with providing an overall suite of modernisation activities geared at improving performance on the low voltage network through developing technology, including the use of fault predictive technology.

Network stewardship is realised in a variety of interventions or investments in the network, ranging from vegetation management through to a reduction in repairs of a temporary nature. Overall it allows us to work to avoid preventable events on the system and also reduce the restoration times. A key area that enhancements in our operating model can support is the reduction of the volume of work in progress at any given time. Our revised resource model will allow a higher volume of repairs to be completed within the regulatory post fault re-interruption window. The blend of resource will be complimented by enhancements to our civils/excavation activity in conjunction with our service providers and a shift to improved regional fault hubs. As an overall approach, this will allow us to reduce our repairs backlog, minimising further planned interruptions and reducing the risk of temporary repairs failing.

The other initiatives which are aimed at delivering operational response and network stewardship improvements will deliver improvements in terms of reduced number of incidents, and restoration time improvements across the whole network, including the extra high voltage, high voltage, and low voltage network. We will establish a network management systems ‘road map’ that supports a safe and faster journey to deliver restoration targets.

As we transition into the 2023-28 period, data availability will drive an improvement in our dispatch processes, harnessing the information from the increasing variety of sources including Foresight, smart meters, and LV monitoring to provide a more efficient operational response. This element of network stewardship and network awareness will be at the heart of a more informed workforce and supports our people in the shift from reactive works to proactive works. To further support this we will roll out the use of the hand held phase identification units, ensuring data we collect is further improved with phase details for the low voltage network.

Improving logistics

To further support our operational response, we are investing in the background logistics which support our people. The relocation of strategic wood pole stores supports the critical path of restoration for overhead line events. This will facilitate a cleaner coalition of safe logistics for pole delivery to point of fault in the 2023-28 period. To underpin this approach, a number of programming activities are underway within the current 2015-23 period.

We will empower our teams on the ground with an accelerated equipment order process to support the materials required for the conditions our teams are managing on-site. This will ensure the right materials are deployed at the earliest opportunity, reducing traditional paper-based interfaces which add to support efficiencies in the overall end to end restoration durations.

We will be investing further in the commissioning of more localised material 'lockups' across each of our six regions, aimed at providing 24/7 accessible materials for our field-based workforce to reduce response times. Again we are working to ensure these are available for use for the whole of the period 2023-28.

Key enablers for our plan

The ambitious targets that we are proposing to deliver for our customers rely on some targeted investment, as we have set out. The improvements we are looking to make will also be built on the enablers we have identified that are relevant to all areas in our plan.

Data and digitalisation

As detailed in our DSO strategy, our need for access to reliable network data to further enhance our capabilities and facilitate flexibility markets will grow exponentially. As part of this, the need to capture and store additional data in order to better utilise assets and operate a flexible network is key. The integration of network monitoring systems is important in harvesting data from a number of assets (such as pole mounted switches and auto-reclosers, low voltage monitors, fault detection and prediction devices, alongside disturbance recorders) to support data-driven decision-making in operational and planning timescales.

Our smart grid enabling investment during the current period provides us with a more robust and modern internet protocol (IP) based SCADA communications network. This will be used as the foundation of our 10 year network automation plan starting in 2023. In the 2023-28 period we will maximise the value of this investment by increasing automation and investing in upgrading our control systems to help restore power more quickly.

On the low voltage network, our proposed low voltage technology investment will allow us to increase the amount of operational information we collect about our network. This provides us with the opportunity to develop best practices regarding the use of low voltage monitoring data to enhance reactive and proactive fault response. This can be combined with information from smart meters to drive a more proactive approach to network management. To maximise the value of these new initiatives and allow rapid decision making, we will modernise our operational engineering hub to allow more efficient allocation of resources to faults.

We will also invest in additional data analytics to allow us to make better short-term decisions in our operational response. This will enable smarter working via the introduction of a new work management system that will effectively deploy resources using a series of data sources including business logic, GPS location of field personnel, resource availability, authorisation codes, alongside integrated traffic/weather status. The modernised hand-held technology enables efficient allocation of jobs, along with the required closed-loop processes from the field, to support our customers.

Finally, to support our overarching objective to provide our customers access to a modernised network, we will continue to enhance our provision of information on the reliability and availability of our network during the 2023-28 period.

- We will release more open source reliability and availability data on network performance using our data platforms.

- We will continue to keep our customers informed about faults through the latest digital channels, e.g. using our website, social media, and text messages to ensure customers are prepared.

More information can be found in our Digitalisation Strategy and Action Plan.

Innovation

Following our successful fault prediction technology innovation project Foresight, it is the conversion of this learning into business as usual, which is the key enabler to improving the reliability of our low voltage network during 2023-28. By the end of the 2023-28 period we will target fault predictive technology to cover 9,000 network locations – over 30 per cent of the network. This, combined with enhancements to our low voltage monitoring programme, will help us proactively intervene and prevent faults from occurring on our network.

By building on the granularity of fault analysis, we will enable more focussed investment on industry recognised poorly performing sub-sets of cable types and joints in our underground cable network. This is further supported by increasing our use of new technology in order to gather additional asset intelligence/information through the use of partial discharge surveys by portable installations. This approach will initiate a move from fault driven asset replacement model towards a more proactive approach based upon gathered asset condition information.

With Foresight driving our plans at low voltage, we also look to enable our disturbance recorders at our HV primary substations with an equivalent pre-fault technology as non-network innovation allowance (NIA) funded innovation activity.

Enabled by improvements in technology, customer flexibility will provide reliability and availability opportunities, which will develop in the 2023-28 period. We will also roll-out our battery based temporary generation SilentPower innovation as business as usual, targeted at vulnerable customers and long running interruptions to reduce our carbon footprint.

More information can be found in our Innovation Strategy.

People/skills

Our people strategy focuses more training capacity and capability to up-skill our existing colleagues in the evolving technical, industrial and digital skills required to manage an increasingly smart, digitised and connected energy system.

The main technology outputs from our reliability and availability strategy make a ‘digital skills’ enabled workforce a key part of our operational performance improvements. We will also up-skill our dispatch and field operations teams, recruiting the next generation of engineers and technicians to replace those who retire and leave the business, complimented with a workforce renewal and training programme that will equip us with a highly skilled and resilient workforce. As part of this, we will overlay improved capabilities in analysing and utilising pre-fault and fault data to support evolution of our networks.

These enhanced skillsets will help our people deal with increased levels of penetration of automated switches and the associated control interfaces, allowing us to maximise the potential of every network interaction.

As we expand our workforce to meet the needs of decarbonisation, power system engineers and data science analysts will become increasingly important in the future as we need to undertake risk based analysis to optimise network performance and balance intermittent energy resources. With the datasets our outputs will realise on the network, this expanded workforce will complement our upskilled colleagues.

More information can be found in our Workforce Resilience Strategy.

Appendix 1: Track record and benchmarking

Overall reliability and availability performance

On our network, our customers on average experience a CI performance of 49 power cuts per 100 customers, and CML performance of 37 minutes. But Ofgem's IIS target setting methodology would require a step change in our CI and CML performance relative to today.

Our performance has steadily improved since 2005, demonstrating significant improvement across the period against a backdrop of tightening Ofgem IIS targets. The performance of UK networks has improved, tightening the performance band particularly, with customer interruptions being closely grouped around networks that are similar in nature.

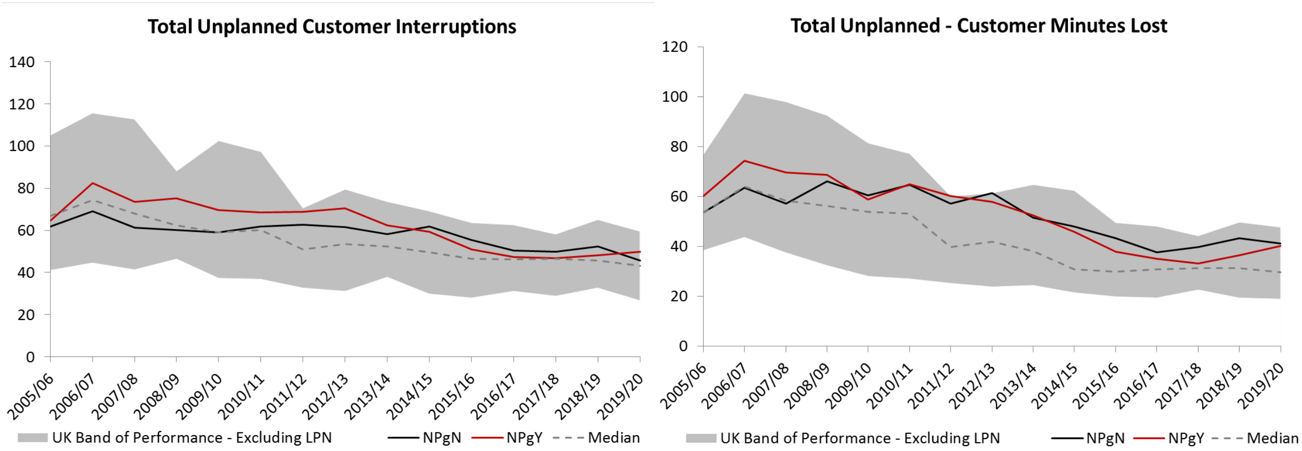

Figure 1: Benchmarking of Unplanned Customer Interruptions and Customer Minutes Lost

As benchmarking is a key aspect of Ofgem's reliability target setting for the interruptions incentive scheme; it is helpful to consider our performance against these targets. Both Yorkshire and the Northeast have performed well against the tightening 2015-23 targets. Through this period we have sought to optimise our networks' performance whist ensuring our investment decisions are rooted in economic rationality in line with stakeholders' expectations.

Maintaining outperformance is challenging as targets tighten due to built-in improvement factors. We have been one of the top three distribution network groups throughout the 2015-23 period on performance against IIS targets. We have earned over 80 per cent of the possible IIS reward available in every year, with both licences being strong contributors

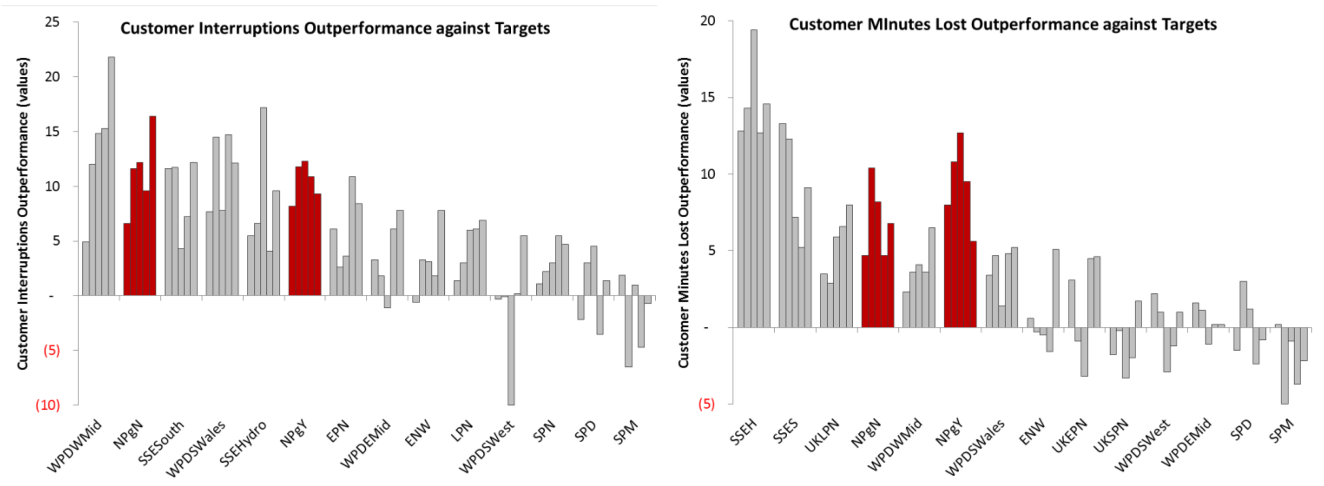

Figure 2: Benchmarking of outperformance against reliability and availability targets

The Council of European Energy Regulators' most recent benchmarking report (data update 2015/2016) shows the UK DNOs performing very well when compared to EU counterparts using the SAIFI (Total number of sustained interruptions in a year) / (Total number of consumers) measure. The System Average Interruption Duration Index (SAIDI) is the average duration of interruptions per consumers during the year. These are the equivalent measures of CI and CML. Despite consistent EU SAIFI improvement since 2012, the GB networks offer levels of SAIFI around a third of the EU cohort. Since 2014 the EU average SAIDI has improved rapidly but the UK networks continued to offer SAIDI metrics at half that of the EU average in 2016.

UK industry performance is also more stable, where despite some variability due to weather cycles a more consistent trend is evident compared to the EU average (although this in turn varies as new entrants join the EU cohort as can be seen from the climb in SAIDI between 2006 and 2009). The 2023-28 period's targets demand improvements on an already high level of reliability and availability performance in the UK, nevertheless we have a good track record on delivering improvements and are committed to meeting the challenge.

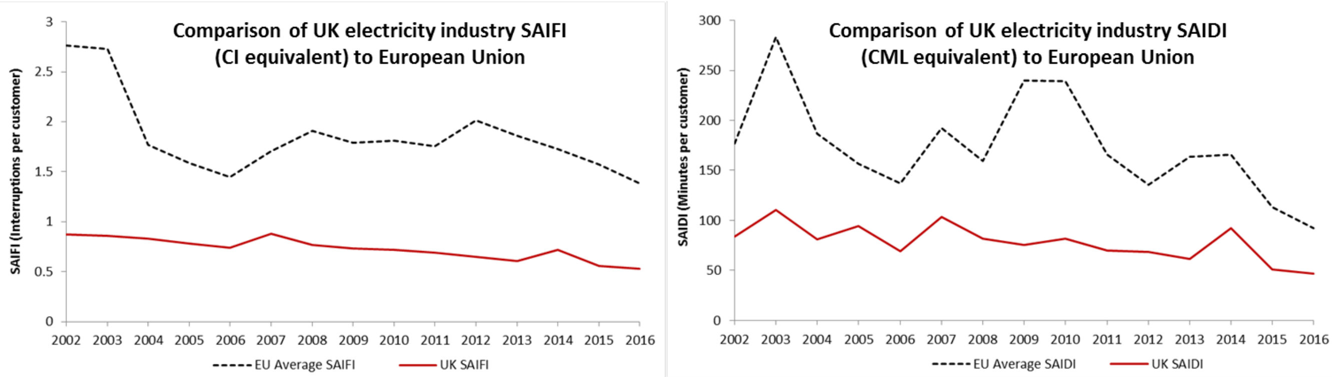

Figure 3: Benchmarking of UK DNOs against European Networks

132kV/EHV

Our extra high voltage network only accounted for five per cent of the total number of customers interrupted in the last four years and one per cent of the minutes of unavailability. This is common across most distribution networks in the UK, with our performance being in line with or ahead of the industry median. The relatively small number of extra high voltage power cuts means that the performance is variable on a year by year basis; however the trend across the industry is a significant improvement in EHV performance since 2005.

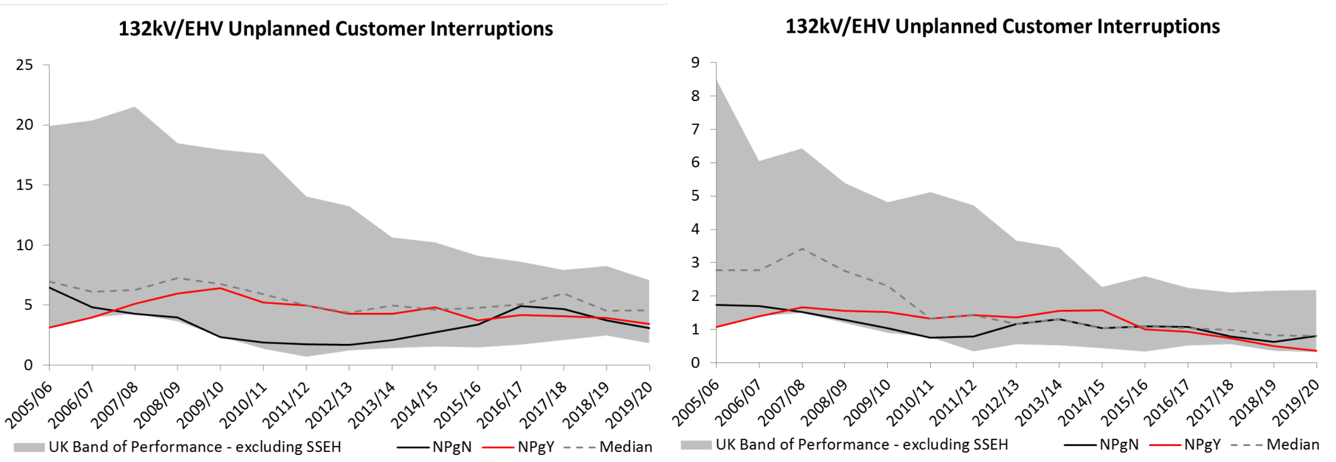

Figure 4: Benchmarking of extra high voltage unplanned customer interruptions and customer minutes lost- measured on a four year average [11]

High voltage

High voltage power cuts generally impact a large number of customers who experience a relatively short interruption as the network is reconfigured either through manual switching or remote control. As such the high voltage network has contributed to over 70 per cent of our customer interruptions in the last four years and 50 per cent of our customer minutes lost. Our performance has improved throughout the 2010-15 and 2015-23 periods although an absolute comparison of our network performance with other UK DNOs has the drawback that it does not take into account the differing network topologies in place.

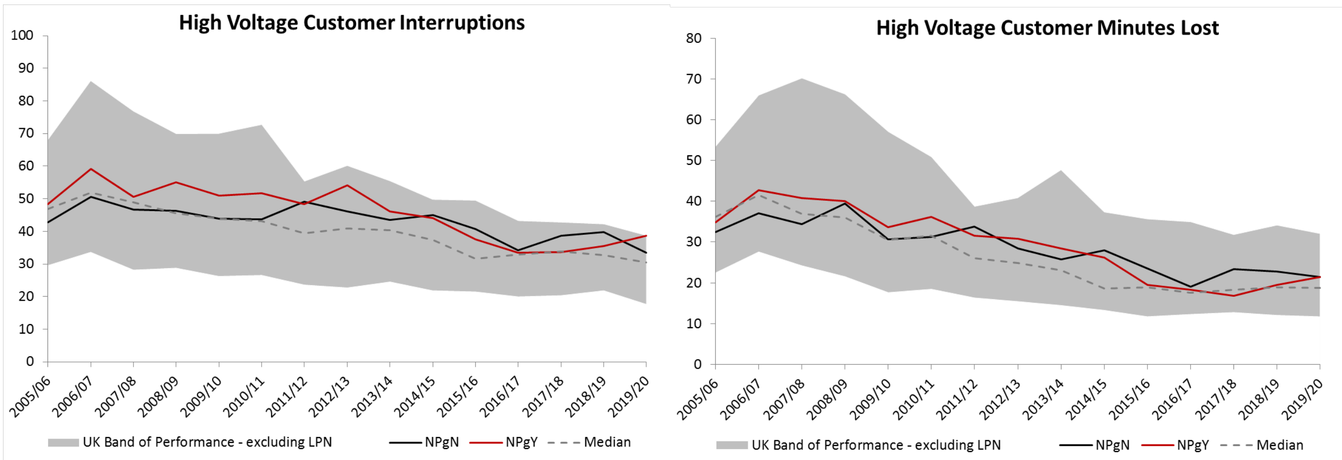

Figure 5: Benchmarking of unplanned high voltage customer interruptions and customer minutes lost [12]

In comparison to other networks, the number of faults on our high voltage network is very low, indicative of the strength of our asset management principles. However, the inherent network topology and comparatively low levels of automation contribute to the number of customers impacted by a single HV fault. This does however provide an opportunity to deliver significant improvements in the number of customers who experience power cuts, through the increase in automation we are planning to deploy across our network.

[11] We have excluded Scottish and Southern Energy Hydro (SSEH) due to the expansive nature of their EHV network topography offering a less comparable view of the wider distribution network.

[12] We have excluded London due to the significant difference in design and interconnectivity

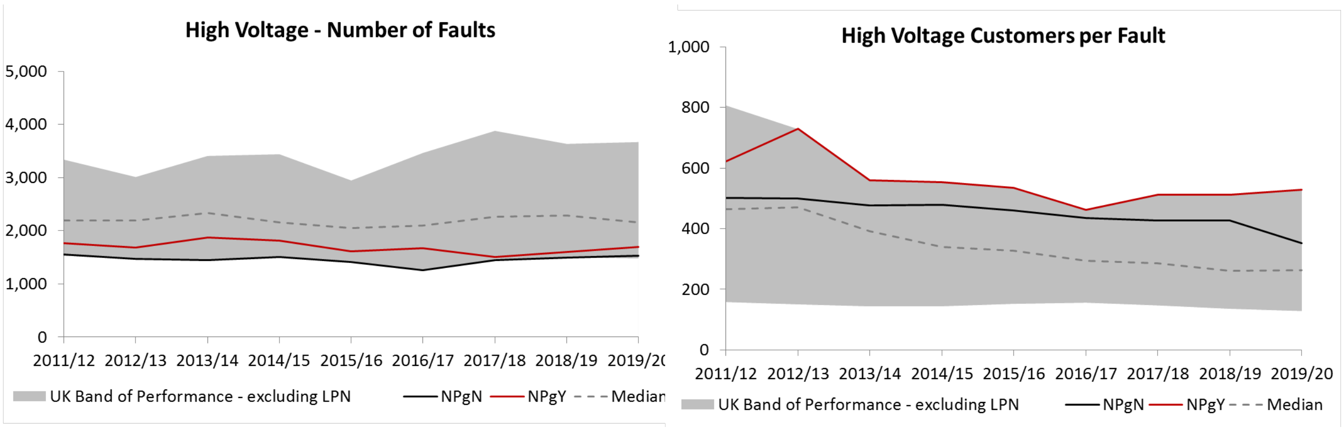

Figure 6: Benchmarking of unplanned high voltage faults and customers per fault[13]

This is further corroborated by benchmarking against the other DNOs, which shows that whilst we have successfully delivered against our regulatory targets and customer expectations to-date, we have a lower number of remote switching points on our networks when normalised for both the number of customers and length of the networks.

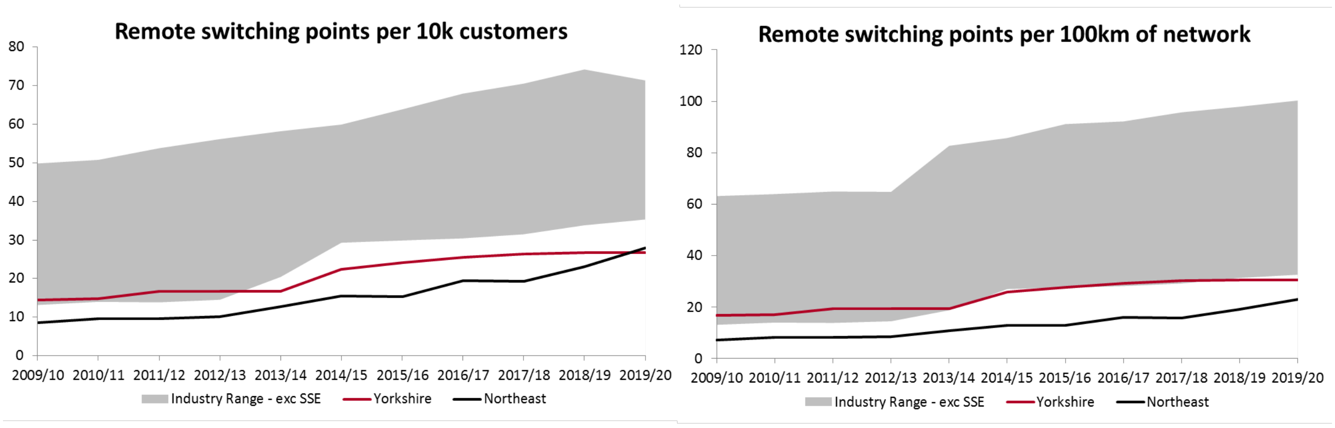

Figure 7: Benchmarking of remote switching points[14]

During the 2015-23 period the main focus has been on automating our ground mounted locations. We have made upgrades to our fault management software and are deploying new automatic switches that will allow APRS use on the overhead line network. This means there is scope for significant improvement through delivery of pole mounted automation in the 2023-28 period.

Analysis also indicates that 80 per cent of the interruptions and customer minutes lost in the 4 year period to 2019/20 at high voltage, were driven by the worst performing 20 per cent of high voltage circuits. This suggests that investing in targeted intervention across our network can provide significant benefits for customers.

Low voltage

The low voltage network, while making up over 80 per cent of total faults, only accounted for 20 per cent of customer interruptions in the last four years. The lack of interconnectivity, the challenges in fault location, and the fact that the vast majority of the low voltage network is underground, means that restoration times of LV faults can be significant. As such, LV faults account for 46 per cent of CML on our network.

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[13] We have excluded LPN area due to the significant difference in design and interconnectivity

[14] We have excluded Scottish and Southern Electricity Networks (SSEN) due to limited data availability

Though we have improved low voltage reliability and availability performance, this area is particularly challenging. This is due to relatively few technological options available at low voltage to improve performance and limited improvement options for changes to network interconnection for post fault switching. Traditionally the primary method of improving low voltage performance was through operational changes relating to fault response and repair, however cost and safety implications can be limiting factors in their improvement.

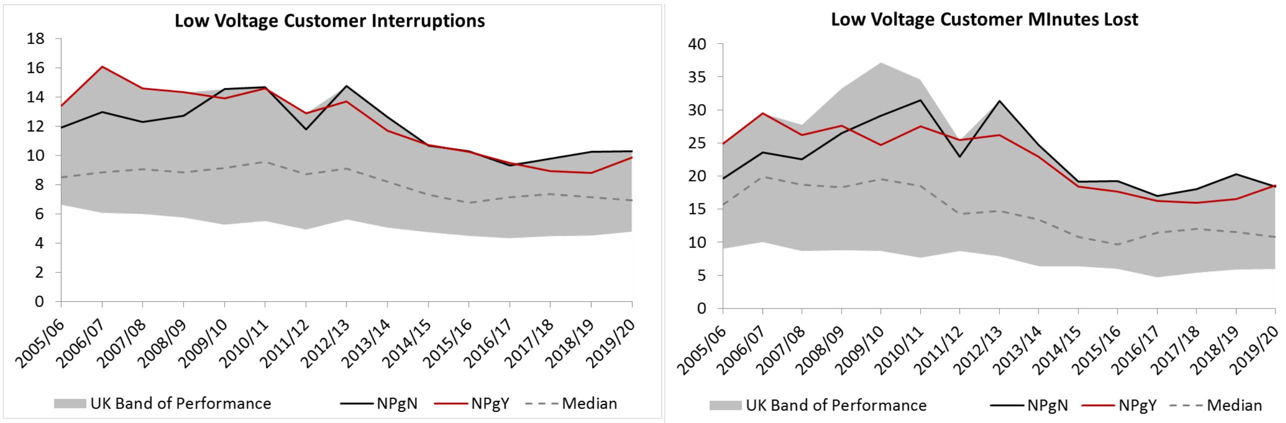

Figure 8: Benchmarking of unplanned low voltage customer interruptions and customer minutes lost

Low voltage network performance is mainly driven by the performance of our underground cable network; specifically fault volumes where 95 per cent of all faults are associated with this asset class. In particular a high rate of fault volumes is driven by two cable types; CONSAC cable in the Northeast, and waveform aluminium neutral cable in Yorkshire. Investing out these cable variants by asset replacement would have been inefficient, needing expenditure of over £1 billion. Justification for those fault volumes and our approach to dealing with it was well documented in our 2015-23 business plan.

An additional contributory factor to high fault rates is a regional affect experienced in the Bradford /Leeds conurbation of West Yorkshire, where a particular type of unarmoured lead sheath low voltage cable was installed up until the 1940s. The lack of armoured protection allows the lead cable sheath to be easily damaged and susceptible to water ingress.

However, managing low voltage power cuts is a challenge to all network operators and restoration times can be lengthy as most of the low voltage network is neither comprehensively monitored nor controlled automatically. Responses to faults are reactive as the condition of low voltage cable systems at any point in time is unknown and there is no capability of predicting the timing and location of faults before events occur.

Operational response

Operational response is one of the most challenging areas to drive significant performance improvements without increasing costs considerably and impacting safety. Traditionally it relies on increasing our ability to respond to a fault through increasing the number of operatives available or through utilisation, decreasing the working time while on site, utilising mobile generation, and increasing remote control across the high voltage network.

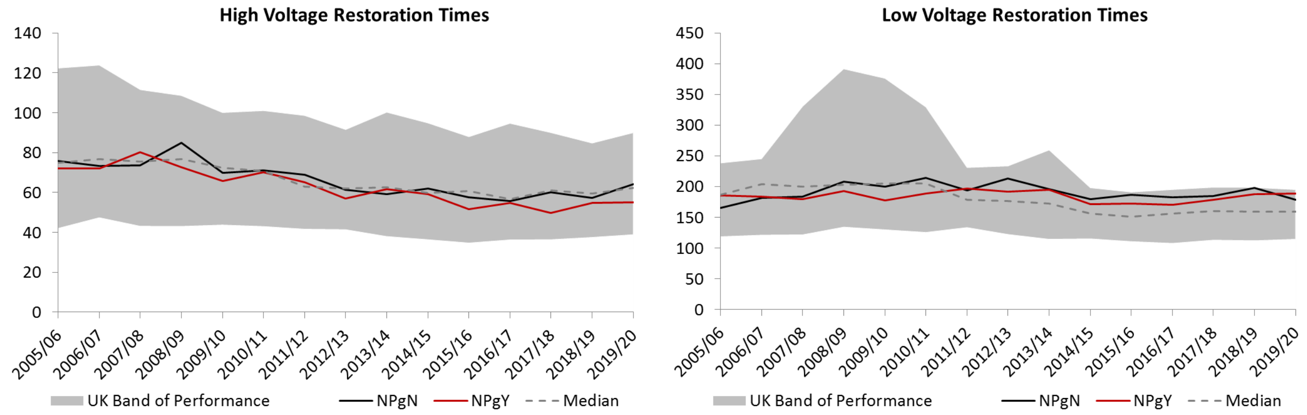

Figure 9: Benchmarking of unplanned restoration times at high voltage and low voltage

At high voltage, there have been improvements across the industry in restoration time in the 2010-15 period, largely driven by the increase in remotely operated switches. However, across the industry this has reached an equilibrium during the 2015-23 period, with a narrowing but stable band of performance. This is in the context of a headwind from the increase in automation, where power cuts that would previously have been restored by remote control are restored within three minutes and not included in the data.

At low voltage, sustaining consistent restoration time improvement has proved difficult over a long period, although some success can be seen, generally the performance band has tightened but top performers have not driven further improvements. The industry has become stratified into performance bands depending on network topology and geography. As we discussed in our low voltage strategy – it is a focus area for us due to the high fault rate of certain types of underground cables.

Costs

During the 2023-28 period we will keep our operational costs flat while delivering a significant improvement in service through lower restoration times and reducing the number of customers interrupted for more than 12 hours. This will be achieved through continuing to identify cost savings to fund investment in front-line performance improvements.

We are a leading operator on costs on a totex basis, which is the most robust way to evaluate efficiency. When disaggregated, our fault restoration costs are in line with the industry median; more information is included within our costs in detail annex.

Our fault costs are largely driven by our underground network; low voltage and high voltage underground faults, along with low voltage service faults, make up 75 per cent of our total network operating costs. This is due to the inherent challenges of repairing an underground cable; both establishing the location of the fault and the excavation of the cable, present significant time and cost challenges during restoration, while reinstatement of the site also increases the cost.

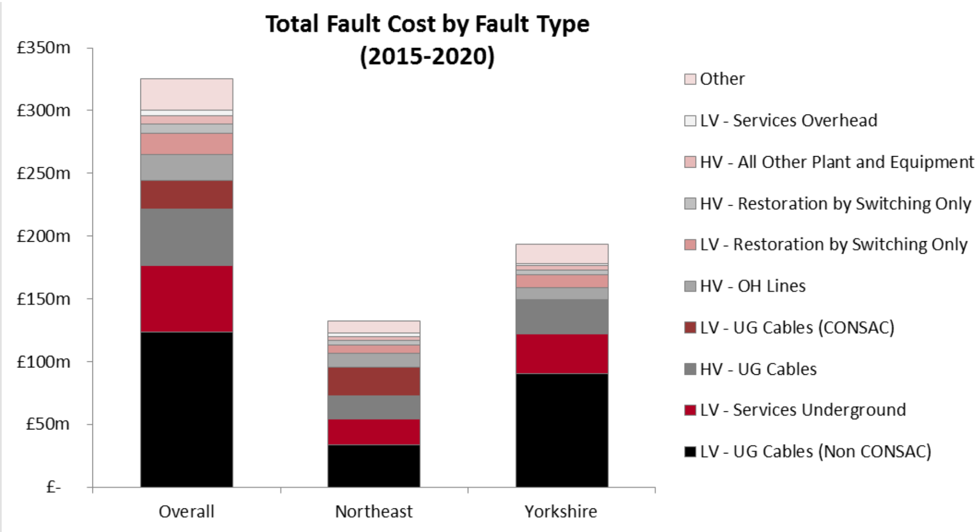

Figure 10: Breakdown of our total costs by type of fault

Appendix 2: Operational response initiatives

Key operational response initiatives	2015-23: Enabling works	2023-28: Implementation
Field Force Mobile – improvements in handheld technology for field staff	• Detail and scope requirements hand-held technology • Definition of the required closed-loop processes from the field to enhance material ordering processes • Defined routes to enable internal data gathered through hand-held devices. • Review of dispatch centre data flows and resource availability	• Deployment of our field force mobile initiative[15] as early in the period as possible offering automated locations of field personnel, resource availability, complete with skillsets and authorisation codes – all used in combination with traffic and weather datasets to provide an enhanced first response
Upskilling of work force	• Review, up-skill and revise where necessary our first-response profiles • Enhance Major Repair Team skillsets. • Add additional shift team support role to support self-dig capabilities • Localise external excavation resource for fault activity • Align resources with regional standby arrangements as required	• Complete training for required skillsets and in line with our Workforce Resilience outcome to invest in upskilling, we will ensure resource profiles are updated incorporating engineers, craft personnel and service staff enhancing our ability to track and deploy staff to faults more swiftly, not just by location, but also by enhanced skill sets and authorisations
Out of Hours Duty Manager	• Implement out-of-hours duty manager model across our dispatch areas to improve operational decision-making accountability • Update roles and responsibilities of the posts	• Optimisation of dispatch response and improved 24/7 coverage enabling seamless transition between shift rotas
Mobile Generation – SilentPower	• Agree vehicle types, gross vehicle weight ratings (GVWR) and fuel types (Hybrid/EV etc.) • Agree conversion specification with fleet support, including contract requirements • Procure solutions • Identify training requirements for users • Commence deployment of vehicles to agreed regions	• Deployment of enhanced fleet of SilentPower vehicles
Logistics	• Definition of geographical gaps for unmanned material storage facilities • Identify works required to future-proof legacy pole storage facilities • Identify and progress any planning permission requirements • Identify new locations as required for new installations of OHL pole storage	• Optimisation of our logistics capability to match the needs of the local network.

[15] Data and digitalisation justification annex

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