Storm Arwen

RIIO-ED2 Re-opener Submission

31 January 2024

Electricity Distribution

nationalgrid

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2 Executive summary

This document presents National Grid Electricity Distribution's (NGED) proposals for the Storm Arwen re-opener under RIIO-ED2 Special Licence Condition 3.2 part J and is made in accordance with the Re-opener Guidance and Application Requirements Document (version 3 published 3rd February 2023). It is supplemented by a separate Excel spreadsheet that captures the costs of each initiative for each licence area and for each year of RIIO-ED2.

Storm Arwen occurred on Thursday 25th and Friday 26th November 2021 and resulted in widespread network damage across a number of regions, leaving around one million homes without power. The extent of damage and disruption experienced due to challenges with network resilience led to several investigations being completed by both Government and Ofgem. A number of recommendations were identified to address the findings of the investigation; these included both short-term improvements and longer-term strategic developments.

The Storm Arwen re-opener provides an opportunity for Distribution Network Owners (DNOs) to apply for additional allowances to enable implementation of key report recommendations.

NGED's Storm Arwen re-opener proposals predominantly focus on fault prevention through targeted resilience activities and enhancements to fault response to restore supplies efficiently to minimise customer impact.

NGED has considered a number of initiatives, ranging from extensive replacement to targeted works and performed optioneering activities to identify the best value solutions. The initiatives recommended for implementation are intended to deliver immediate impact during the current price control. All activities are either in addition to, or enhancements to existing activities and therefore have not been funded as part of the existing RIIO-ED2 allowances. The activities proposed by NGED include;

- Physical improvements such as selective undergrounding of overhead lines, targeted conversion of open wire LV circuits to covered conductor and interconnection of spurs, both across DNO boundaries and within licence areas.
- Extension of resilience tree clearance to HV circuits.
- Introduction of technological advancements for early fault detection.
- The introduction of storm forecasting and modelling capabilities to enable more effective identification and implementation of preventative work programmes.
- Enhanced data capture and analysis to create a risk-based visualisation of the NGED network to ensure maximum value is obtained from additional resilience work activities targeting the most critical sections of network.
- Reduction in the number of customers within protection zones and the application of automation to overhead spur lines to reduce the number of customers impacted by faults.
- Introduction of enhanced technology to better pinpoint faults, reducing patrol times.
- Provision of additional mobile generation and pre-emptive arrangements for early deployment of resources to support areas likely to be impacted by storms.

The package of initiatives proposed has been designed to strike a balance between preventative action and improved response in the event of a storm event. This approach will reduce the number of faults experienced on the network during storm events, coupled with reduced response time to re-establish supply improving customer experience.

Detailed cost estimates have been derived for each initiative. The tables below summarise the costs associated with implementing each proposed initiative and the proposed adjustments to our ED2 baseline allowances. All costs in this submission are stated in 2020/21 prices (unless otherwise stated).

Re-opener additional funding requirements (£m 2020/21 prices)						
NGED	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
(2a) Undergrounding HV overhead lines in wooded areas	-	-	2.13	2.13	2.13	**6.38**
(5a) Replacing LV open wire overhead lines impacted by trees	-	-	2.79	2.79	2.79	**8.36**
(6) Resilience tree cutting on HV circuits	-	-	2.02	2.02	2.02	**6.06**
(8) Application of Pre-Fix detection for fault location	-	-	0.95	1.71	2.76	**5.43**
(9) Torque tooling for LV fuses	0.10	-	-	-	-	**0.10**
(10) Reducing customers in a protection zone to 1000	-	-	4.28	4.28	4.28	**12.84**
(11) Automation of spur protection	-	-	0.62	0.62	0.60	**1.84**
(12/13) LineSight detectors to identify nested and low conductor faults	-	-	1.21	1.21	1.21	**3.64**
(14) Increased volumes of mobile generation	-	-	5.03	0.05	0.05	**5.12**
(14a) Using suitcase generators	-	-	0.17	-	-	**0.17**
(17) Pre-emptive movement of resources	0.06	0.06	0.06	0.06	0.06	**0.32**
(18) Enhancements to telephony servers	-	0.41	-	-	-	**0.41**
(20) Inter-DNO interconnection	-	-	0.47	0.47	-	**0.94**
(20a) Inter-NGED DNO interconnection	-	-	0.36	0.36	-	**0.73**
(20b) Intra-NGED DNO spur interconnection	-	-	1.04	1.04	-	**2.08**
(21) Network geospatial mapping	-	1.49	0.25	-	-	**1.74**
Closely associated indirects	-	-	1.71	1.80	1.71	**5.22**
Total	**0.16**	**1.97**	**23.10**	**18.54**	**17.60**	**61.38**

The following table provides a breakdown of the overall costs by NGED licence area.

	RIIO-ED2 Storm Arwen expenditure (£m)
WMID	16.52
EMID	14.40
SWALES	10.06
SWEST	20.39
NGED	**61.38**

While some costs have already been incurred, the majority of the expenditure for these improvements is planned for years 3-5 of RIIO-ED2.

In addition to the initiatives proposed in this submission, NGED is currently developing further technological enhancements to deliver strategic long-term improvements to network resilience. We did not consider these to fall directly within the scope of the re-opener and, as such, have not included funding requests to further progress development. We do however believe it is appropriate to outline these initiatives as some of the proposals within the re-opener submission provide the building blocks towards the long-term strategic work.

3 Mapping to submission requirements

This submission is made in accordance with the requirements specified in Part J of Special Licence Condition (Sp.C) 3.2 of the Electricity Distribution Licence and the Re-opener Guidance and Application Requirements Document (version 3 published 3rd February 2023).

The guidance document requires that re-opener submissions contain a table that cross references the content of the submission against the requirements specified in the licence and section 3 of the guidance. The reference table for this re-opener submission is provided below.

Location of re-opener requirements in this document

Reference	Requirement	Location in document
Sp.C 3.2.69(a)	Changes to business operation	Preferred Options section (9).
Sp.C 3.2.69(b)	Allowance modifications sought	Within each initiative in the Preferred Options section (9), summarised in the Cost Information section (10).
Sp.C 3.2.69(c)	Basis for modifications and profiling	Within each initiative in the Preferred Options sections (9).
Sp.C 3.2.69(d)	Supporting evidence	Within the background sub-section of the Preferred Options sections (9). Technical details for specific initiatives provided in Appendix B Technical Details (12).
3.8	Needs case	Needs Case section (5)
3.10	Alignment to business strategy	Alignment to current strategy covered by Needs Case section (5) Longer term strategy (6)
3.11	Need for specific investment	Details for each initiative in the Preferred Options section (9). The Preferred Options section (9) also includes links to specific Storm Arwen report recommendations/comments.
3.12	Rationale for level of expenditure	Details for each initiative in the Preferred Options section (9).
3.13	Optioneering	Summary of optioneering outcome in the Options Considered Section (7). Detailed review of each option in Appendix A (11) including description of the current practice as a counter-factual.
3.14	Preferred option(s)	Details of background, rationale for levels of expenditure, delivery profile and expenditure requirements for each preferred option provided in the Preferred Options section (9)
3.15	Project delivery	Profile of volume delivery included for each initiative in the Preferred Options section (9)
3.16-3.17	Stakeholder engagement	Summary of generic and specific stakeholder engagement provided in Appendix C Stakeholder Engagement (13)
3.19-3.20	Cost information	Summary provided in Expenditure Requirement Summary Section (8). Details for each initiative in the Preferred Options section (9). Licence area summaries provided in the Cost Information section (10). Licence term adjustment values in the Cost Information section (10). A separate Excel file summarising the costs is provided alongside this document.
3.22	CBA and engineering justification	Reasons for the initiatives in the background to each proposed initiative in Preferred Options section (9), which also links the proposals to specific Storm Arwen recommendations.

4 Introduction

Storm Arwen

Storm Arwen occurred over two days on Thursday 25th and Friday 26th November 2021. Strong northerly winds led to widespread network damage across several regions in the UK, with most damage occurring in the North.

Around one million homes experienced a power cut, with some customers being off supply for several days.

While NGED was not affected to the same extent as other network companies, broader learnings from the impacts and response to Storm Arwen are applicable to how NGED operates its network and responds to storms.

Storm Arwen BEIS report

The Secretary of State for Business, Energy and Industrial Strategy (BEIS) commissioned a report into the response to Storm Arwen in December 2021. The review was carried out in collaboration with industry and Ofgem with the aim of identifying lessons to be learned and actions to take forward.

The final report was published in June 2022 and identified forty-five actions across seven different themes including Network Resilience, Restoration and Response, Secondary Impacts, Communication, Customer Welfare, Compensation, and Supporting Local Resilience Forums.

Storm Arwen Ofgem report

Ofgem carried out a separate and complimentary report that investigated what the network companies did before, during and after the event, and investigated compliance of the relevant licence conditions of the Distribution Network Operators involved.

The final report was also published in June 2022 and identified twenty specific actions.

Relevant recommendations and actions

This re-opener submission focusses mainly on enhancing Network Resilience and improving Restoration and Response. While various aspects of the BEIS and Ofgem reports are supported by our proposed actions, the works we have outlined predominantly address the following recommendations and actions:

Relevant BEIS Actions

No.	Actions
Planning E2	Review and update as required the current distribution and transmission network infrastructure and standards (including ERT132, OHL designs and vegetation management) to ensure they are fit for purpose, especially for spur lines in rural areas.
Restoration & Response R1	E3C to review and update industry best practice to ensure DNOs can quickly identify faults and safely assess the extent of network damage earlier in a severe weather event. This review should include the role of smart meter data and technology for this task.
Restoration & Response R2	E3C to identify options to enhance the use of mobile generators in reducing the length of power disruption, covering the population of mobile generators held by the DNOs and resourcing options to transport, install, refuel and remove.
Restoration & Response R7	Each DNO to review their severe weather escalation plans, trigger points and resulting preparatory actions, to ensure all relevant factors that can influence scale of impacts are considered, e.g., wind direction.

Relevant Ofgem recommendations	
No.	**Recommendation**
Network Resilience 1	E3C should review current network infrastructure standards and guidance, including those for vegetation management and overhead line designs, to identify economic and efficient improvements that could increase network resilience to severe weather events.
Network Resilience 3	E3C should assess the feasibility and benefits of developing a standard-based approach to organisational resilience to improve the speed of customer restoration during severe weather events.
Handling of Incidents 6	E3C should review and update industry best practice for identifying faults and assessing the extent of network damage, to reduce customer restoration times.
Handling of Incidents 8	E3C should identify options to enhance the use of mobile generators in reducing the length of power disruptions.
Handling of Incidents 10	DNOs should stress test their telephony systems and websites to ensure adequate capacity during severe weather events.

5 Needs Case

Incident prevention

Ideally, faults should be prevented. Preventing faults from occurring means that customers are not affected by power cuts during a storm. It also means that there are fewer incidents to manage and repair by the DNO and consequentially fewer customers affected.

Physical changes to the network can provide a resilience improvement during storm events. NGED is proposing a number of physical measures for targeted implementation across the network to improve fault prevention. Due to the cost and extent of the work, it is not feasible to undertake these works on a significant scale and, as such, works will be targeted to deliver improvements to the most vulnerable areas and critical circuits. The proposed physical measures include:

- Undergrounding/diversion of vulnerable overhead lines in wooded areas.
- Installing covered conductors to LV open wire circuits.
- Applying resilience tree clearance to HV circuits.

To ensure work is directed appropriately, in-house storm forecasting and impact modelling tools will be developed. The tools will enable identification of asset risk profile (in relation to storm exposure and frequency) in addition to more general indicators, such as condition and criticality.

Through innovation projects, such as NGED's Pre-Fix project, NGED has identified network monitoring and data analysis techniques that can detect and locate faults ahead of failure. Application of these technologies will enable removal of defects from the network, thus preventing failure during storms. A further advantage is that the same technology also provides the opportunity to deliver improved fault detection and location during storm events.

Incident impact reduction

When network faults do occur, their impact on customers should be minimised.

Reductions in the number of customers affected by HV faults can be achieved by subdividing the network into smaller protection zones so that fewer customers go off supply, and by increasing the amount of network automation in place to quickly re-route and restore power.

The use of remote control allows electricity supplies to be quickly rerouted without the need to send a person to site. These switching operations can be initiated by staff in our control centre or automatically by computer algorithms. The algorithms use information from fault passage sensors to indicate which section of the network contains the fault and then communicate with remotely controlled devices to restore supplies to the maximum number of customers possible in less than three minutes.

The use of automatic reclosing circuit breakers enables power to be restored where the cause of the fault is a transient event, such as a windborne branch causing a short circuit. In these circumstances the circuit breaker can re-energise the line automatically.

NGED is proposing to install more remotely controlled devices and network automation to reduce the number of customers affected when a fault occurs. There are also proposals to install automatic reclosing circuit breakers to replace fuses on spurs to remove the need to send operatives to replace fuses that have blown due to transient events.

Incident response

When faults do occur on the electricity network, a fast response enables power supplies to be restored quickly. Restoring supplies quickly minimises the impact of faults on customers.

Fast restoration can be achieved by using technology to reconfigure the network, providing alternative power supply via alternative routes to customers not directly impacted by the faulted part of the network.

Technology can also be used to provide an indication of the location of faults so that field teams can be directed to where the damage is, without the need for patrolling the circuit and associated delays.

While technology can speed up the initial restoration and location, repairs may not be able to be carried out due to enduring weather conditions or resources being tied up on other activities. Therefore, mobile generation can provide temporary power supplies for customers.

Repairs and manual switching rely upon field teams and therefore having sufficient resources available enables these activities to be carried out without undue delays.

This re-opener submission proposes several activities that will have a positive impact, including:

- Installing monitoring equipment that can identify the location of faults.
- Using additional mobile generation.
- Interconnecting networks to provide alternative sources.
- Mobilising response resources ahead of time to ensure immediate and effective response for a storm event.

Customer service

It is important that customers can contact DNOs during storms to report issues and find out when supplies will be restored. This requires telephony systems to have adequate capacity to deal with high volumes of calls.

This re-opener submission proposes to bring forward telephony server replacement to ensure that telephony services remain resilient during periods of high call volumes.

6 Long Term Strategic Developments

Overhead Line Design

A review of overhead line design standards was conducted by the Energy Network Association following Storm Arwen to assess the suitability of the standards for storm resilience. The review confirmed that the current standard is fit for purpose and that overhead lines will be resilient to storm events (within the design standard thresholds of a 1 in 50 year extreme event) provided vegetation risk is appropriately managed.

As with many other distribution networks, the overhead line population within the NGED license areas have a large percentage of overhead lines that were constructed pre-1988 i.e. to a lesser standard than the current 1 in 50 year extreme event design requirement. When factoring in line location, altitude, ice accretion risk and the high wind loading, the legacy components of the current network are at greater risk of experiencing failure during extreme events.

In order to meet the current resilience criteria, pre-1988 overhead lines require upgrades and modifications to provide adequate support during dynamic, structural load events. Modifications required include reduction in span lengths, enhanced foundations (to withstand higher applied loads) and wider phase spacing.

Although a large percentage of overhead line failures during storm events can be attributed to fallen trees or windblown debris from damaged trees, where trees are not the contributing factor, failure of “legacy” structures designed pre-1988 are the main contributing factor. Analysis post Storm Arwen confirmed that a substantial proportion of the HV line failures were pole failures designed as light duty BS1320 or variations such as ENA TS 43-10, which were built up until 1988.

Currently, approximately half of NGED’s network was installed prior to 1988, and is therefore more susceptible to storm damage. Full replacement of overhead lines by rebuilding to current standards is costly and would take time to implement.

Whilst the initiatives in this Storm Arwen submission are focused on applying targeted solutions for quick wins over the short to medium term, discussions need to be held to look at a longer-term solutions for how overhead line resilience can be improved and what mechanisms could be introduced to financially support long term upgrade works.

Network Mapping and Risk Identification

In recent years, NGED has employed helicopter-mounted LiDAR technology for data capture on the High Voltage (HV) and 132kV overhead networks since 2020. We are broadening the scope of LiDAR to also encompass the EHV network (33kV and 66kV). The use of LiDAR allows us to evolve our vegetation management contracts to be more targeted, enabling NGED to direct tree cutting to parts of the network in most need of cutting.

There is a desire to extend our LiDAR data capture capability to the LV network and utilise other methods of data capture to ensure 100% capture of the HV and EHV network. This will enable a complete three-dimensional geospatial representation of all of our overhead line network. This would be achieved through vehicle mounted LiDAR devices.

Extending the geospatial mapping to the complete network will establish a unified geospatial system applicable to all voltages. The extension of the data capture represents a focused digitalisation strategy to enhance the safety, reliability, and resilience of the entire overhead network, irrespective of voltage level.

Further to capturing all voltage levels and developing these into a geospatial map, NGED will also be further enhancing the visualisation and reporting system to introduce dynamic modelling of historical and forecasted storms to proactively identify network assets at potential risk of damage during stormy weather.

This work is being progressed at present and will look to combine storm modelling with the LiDAR geospatial digital twin, along with supporting asset data including, overhead line assets, operational protection zones, customer numbers and Priority Services Register customers. The output will be a risk-based model that considers the likelihood of vegetation affecting the network and the consequential impact on numbers of customers.

This integrated, digitalised approach will play a crucial role to identify network risks, enabling prioritisation of activities that would improve network storm resilience activities including;

- Informing decisions related to directing HV resilience cutting by identifying the HV feeders most at risk of vegetation related damage.
- Identify the HV overhead network located within wooded areas that should be targeted for undergrounding to prevent damage from trees.
- Identify low voltage open wire overhead lines that are affected by trees, to target which lines get converted to covered aerial bundled conductor.

We are not requesting any additional funding in this re-opener to progress either the extension of our LiDAR and visualisation model to the LV network, nor the development of forecasting and modelling tools to support targeted, risk-based work plans. We do however believe that it is important to flag the continued investment that NGED is making to move to a data-driven, risk-based approach to resilience activities. The proposals presented in this submission, for which we are seeking additional funding through the Storm Arwen re-opener, rely on the development and implementation of the activities identified above to have maximum impact and improve network integrity under extreme events. The importance of these supporting activities should not be underestimated when considering how enhanced storm resilience can be provided across networks.

LTE – Improving telecoms resilience and accelerating decarbonisation across the whole energy system

Securing energy security and resilience

Within the telecoms commercial sector there is a drive for higher bandwidth services, such as fibre and 5G. With these new services comes a program of change including the Public Switched Telecoms Network (PSTN) switch off and 2G/3G sunsetting, all of which have very limited power resiliency. Furthermore, decarbonisation of the energy system through increased electrification will require increased and enhanced telecoms to deliver an even more efficient, resilient and responsive energy system. For DNOs to maintain the reliability of supply and to unlock latent capacity through more dynamic operation, more reliable, resilient and comprehensive telecommunications coverage will be essential to support command and control functions.

As customers seek to connect more low carbon technologies, the role of enhanced communications, in supporting the improved utilisation of existing networks, will become more important. The increasing dependency of the UK economy upon electricity will require enhanced operational resilience to external threats such as increasingly adverse weather or the actions of hostile third-party actors.

Increased responsiveness will deliver tangible benefits to the energy sector. Making this approach 'Business-as-Usual' will require fit-for-purpose operational communications to ensure a robust and real-time network response to market events.

In light of the above, key policymakers within both the Government, Opposition and Whitehall have been engaged on the need to allocate radio-spectrum access to the energy network operators. This Long Term Evolution (LTE) communications network would help minimise the number and duration of power outages by enabling operators to more extensively monitor and control network infrastructure in real-time, identifying issues early so that proactive and prompt action to prevent disruption to customers' energy supplies can be taken.

A whole systems approach to accelerating decarbonisation

Enhanced operational communications are essential to managing the energy system's transition from a passive, carbon intense system, to an active, decentralised, interconnected and decarbonised system. Distribution Network Operators (DNOs) are becoming more operationally flexible, agile and responsive to maximise the capacity of existing infrastructure to facilitate rapid connection of low carbon technologies at scale, while minimising the costs to household and business consumers. This is particularly important as the UK moves towards a whole system, spatial approach to energy network planning and management with the establishment of the Future System Operator (FSO).

The electricity and gas networks are increasingly collaborating to generate and distribute green energy. Radio spectrum access will help integrate and coordinate these diverse systems enabling network assets to respond in real-time to a much more dynamic supply-demand context. With enhanced operational control serving both the transmission and distribution levels of the energy system, a more resilient, secure and low carbon whole energy system will be enabled, maximising the speed and scale at which greater volumes of low carbon technologies and embedded renewable generation can be connected. Enhanced operational control through radio spectrum is essential to National Grid's DSO capability build, enabling greater automation, connectivity, and digitisation of network infrastructure. By unlocking additional grid capacity, enhanced operational control will enable more communities to connect low carbon technologies.

As with the other developments raised in this chapter, there is no request for additional funding as part of this re-opener to support NGED ongoing activities within the LTE space. We do however feel it is prudent to raise the importance of the work that is ongoing in this arena and how it will enhance our communication resilience during storm events as well as our communication response post storm events.

7 Options considered

NGED has considered a range of options to improve performance during storms. Appendix A provides details for each of the option considered as part of the optioneering, alongside a description of current practices that are used as a counterfactual.

The options are a combination of preventative options, post-fault options and customer support options. The initiatives and selection status is summarised in the tables below. Options that have been proposed for the Storm Arwen reopener are described in more detail in section 9.

No	Category	Description	Programme Years	RIIO-ED2 Cost (£m)	Status
1	Preventative	Undergrounding all LV & HV overhead lines	50	644.92	Rejected
2	Preventative	Undergrounding overhead lines in wooded areas	20	9.88	Rejected
2a	Preventative	Undergrounding HV overhead lines in wooded areas	20	6.38	Proposed
3	Preventative	Undergrounding HV overhead lines with restricted cutting	10	7.39	Rejected
4	Preventative	Replacing all HV overhead lines with covered conductor	40	114.80	Rejected
5	Preventative	Replacing all LV open wire overhead lines with ABC	20	49.50	Rejected
5a	Preventative	Replacing LV open wire overhead lines impacted by trees	20	8.36	Proposed
6	Preventative	Resilience tree cutting on HV circuits	20	6.06	Proposed
7	Preventative	Fund solar panel and battery storage in domestic properties	20	12,043.29	Rejected
8	Preventative	Application of Pre-Fix detection for fault location	8	5.43	Proposed
9	Preventative	Torque tooling for LV Fuses	2023/24	0.10	Proposed
10	Post-fault	Reducing customers in a protection zones to 1000	3	12.84	Proposed
11	Post-fault	Automation of spur protection	3	1.84	Proposed
12	Post-fault	Nested fault detection using LineSight *	3	3.64	Proposed
13	Post-fault	Low conductor detection using LineSight *	see 12	see 12	Proposed
14	Post-fault	Increased volumes of mobile generation	2025/26	5.12	Proposed
14a	Post-fault	Using suitcase generators	2025/26	0.17	Proposed
15	Post-fault	Additional in-house resources	n/a	Not costed	Rejected
16	Post-fault	Contracted additional resources	n/a	Not costed	Rejected
17	Post-fault	Pre-emptive movement of resources	ED2	0.32	Proposed
18	Support	Enhancements to telephony servers	ED2	0.41	Proposed
19	Support	National Energy Outage Platform (NEOP)	ED2	0.16	Deferred
20	Post-fault	Inter-DNO interconnection	ED2	0.94	Proposed
20a	Post-fault	Inter-NGED DNO interconnection	ED2	0.73	Proposed
20b	Post-fault	Intra-NGED DNO spur interconnection	ED2	2.08	Proposed
21	Support	Network geospatial mapping	ED2	1.74	Proposed
22	Preventative	Visualisation and modelling of vegetation and network impact	ED2	2.64	ED2 baseline
23	Support	Private LTE network	ED2	Not costed	Deferred

* The same solution addresses both initiatives and therefore only one lot of the costs are required

8 Expenditure Requirement Summary

The following table summarises the preferred options and associated expenditure requirements. Full details of the requirements of each option, including forecast costs, are presented in Chapter 9.

Re-opener additional funding requirements (£m 2020/21 prices)

NGED	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
(2a) Undergrounding HV overhead lines in wooded areas	-	-	2.13	2.13	2.13	**6.38**
(5a) Replacing LV open wire overhead lines impacted by trees	-	-	2.79	2.79	2.79	**8.36**
(6) Resilience tree cutting on HV circuits	-	-	2.02	2.02	2.02	**6.06**
(8) Application of Pre-Fix detection for fault location	-	-	0.95	1.71	2.76	**5.43**
(9) Torque tooling for LV fuses	0.10	-	-	-	-	**0.10**
(10) Reducing customers in a protection zone to 1000	-	-	4.28	4.28	4.28	**12.84**
(11) Automation of spur protection	-	-	0.62	0.62	0.60	**1.84**
(12/13) LineSight detectors to identify nested and low conductor faults	-	-	1.21	1.21	1.21	**3.64**
(14) Increased volumes of mobile generation	-	-	5.03	0.05	0.05	**5.12**
(14a) Using suitcase generators	-	-	0.17	-	-	**0.17**
(17) Pre-emptive movement of resources	0.06	0.06	0.06	0.06	0.06	**0.32**
(18) Enhancements to telephony servers	-	0.41	-	-	-	**0.41**
(20) Inter-DNO interconnection	-	-	0.47	0.47	-	**0.94**
(20a) Inter-NGED DNO interconnection	-	-	0.36	0.36	-	**0.73**
(20b) Intra-NGED DNO spur interconnection	-	-	1.04	1.04	-	**2.08**
(21) Network geospatial mapping	-	1.49	0.25	-	-	**1.74**
Closely associated indirects	-	-	1.71	1.80	1.71	**5.22**
Total	**0.16**	**1.97**	**23.10**	**18.54**	**17.60**	**61.38**

The following table shows the total costs per licence area.

	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	0.05	0.59	6.24	5.04	4.61	**16.52**
EMID	0.04	0.59	5.75	4.15	3.87	**14.40**
SWALES	0.04	0.30	3.75	3.16	2.81	**10.06**
SWEST	0.03	0.49	7.36	6.19	6.32	**20.39**
NGED	**0.16**	**1.97**	**23.10**	**18.54**	**17.60**	**61.38**

9 Preferred options

Introduction

This section provides a description of each initiative that is proposed to be taken forward.

These activities are additional to the activities planned for RIIO-ED2 and are therefore reliant upon the additional funding provided through the re-opener process.

For each initiative the following information is included:

- An overview description of what will be carried out and the impact it will have.
- The rationale for the levels of expenditure.
- The delivery profile.
- The proposed levels of expenditure.
- A link to Storm Arwen report statements/recommendations.

The profile of expenditure is provided for the four NGED licence areas, which is then summarised for all initiatives per licence area in the Cost Information section (section 10).

Most expenditure is proposed to start during the third year of RIIO-ED2, following the conclusion of the re-opener process, once there is certainty that funding will be available.

The proposed initiatives for which costs are included in the Storm Arwen re-opener are summarised in the table below. These also include closely associated indirects related to where there are programmes of work that require more extensive planning and coordination.

Option no.	Initiative description
2a	Undergrounding HV overhead lines in wooded areas
5a	Replacing LV open wire overhead lines impacted by trees
6	Resilience tree cutting on HV circuits
8	Application of Pre-Fix detection for fault location
9	Torque tooling for LV Fuses
10	Reducing customers in a protection zones to 1000
11	Automation of spur protection
12/13	LineSIGHT detectors to identify nested and low conductor faults
14	Increased volumes of mobile generation
14a	Using suitcase generators
17	Pre-emptive movement of resources
18	Enhancements to telephony servers
20	Inter-DNO interconnection
20a	Inter-NGED DNO interconnection
20b	Intra-NGED DNO spur interconnection
21	Network geospatial mapping
-	Closely associated indirects

(2a) Undergrounding HV overhead lines in wooded areas

Background

Damage to overhead lines during storms can result in snapped poles, conductors being brought down and windborne debris causing flashovers. Placing the conductors underground can avoid such damage and make the networks very resilient to storms.

The vast extent of overhead conductors currently used on the network means that wholesale undergrounding would be prohibitively expensive, take many years to deliver and therefore resilience would take a long time to establish. Taking a more focused approach is therefore needed.

Approximately 340km of HV overhead lines pass through designated wooded areas (such as National Forest Estate Woodlands). Undergrounding or diverting overhead lines from wooded areas removes the risk of tree damage on that section of overhead line, improving resilience.

Rationale for levels of expenditure

The volumes of activity are determined by the length of existing line passing through the wooded areas. It is proposed to complete works over a 20 year programme, commencing in year 3 of RIIO-ED2.

It is noted that undergrounding of HV overhead lines relies on adjustments or extensions to existing wayleaves. There is a possibility that route changes will need to be made to accommodate the undergrounding. This may lead to longer lengths of cable being required compared to the overhead lines. At this stage it is unknown how many constraints will be encountered and therefore no additional cable length has been included. It is envisaged that experience in RIIO-ED2 will provide evidence of the scale of diversions and extra length for any future works.

Any route diversions required would require a subsequent design check in relation to HV supplies to substations within the wooded areas. The scale of additional cable length is currently unknown and therefore no additional cable length has been included.

Cost proposals assume a like-for-like length with no additional costs included for consequential works such as substation or switchgear modifications i.e. move to ground mounted instead of pole mounted. Any re-opener metrics should be based upon the length of cable installed, not the length of overhead line removed.

In order to be consistent with existing RIIO-ED2 cost benchmarking, the unit costs are taken from Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement of HV underground cables [redacted].

Delivery

It is proposed that the programme is spread over 20 years, with three years of activity in RIIO-ED2. This leads to the following volumes:

Volumes (km)

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
EMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	-	-	[redacted]	[redacted]	[redacted]	[redacted]
NGED	**-**	**-**	[redacted]	[redacted]	[redacted]	[redacted]

The majority of this work is cable installation, which can be delivered by existing dig and lay contractors. Additional resources will be required to dismantle the existing overhead lines and to carry out the jointing of the new cables to the existing network, which will either be sourced from internal staff or contractors.

Expenditure

The overall costs of the proposed activity are as per the table below:

Undergrounding HV overhead lines in wooded areas (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	0.51	0.51	0.51	**1.54**
EMID	-	-	0.40	0.40	0.40	**1.20**
SWALES	-	-	0.52	0.52	0.52	**1.55**
SWEST	-	-	0.70	0.70	0.70	**2.09**
NGED	**-**	**-**	**2.13**	**2.13**	**2.13**	**6.38**

Link to Storm Arwen reports/recommendations

Page 7 of the BEIS Storm Arwen report states:

> *The storm damage was predominantly caused directly by strong winds or falling trees in both storms [Storm Arwen and Storm Eunice].*
>
> *The evidence suggests the priorities for enhancing physical resilience should remain on the following: EHV and HV lines, protection from sustained high wind speeds, and tree cutting policy.*

Page 8 of the BEIS Storm Arwen report goes on to state:

> *Overhead lines cannot be fully protected from windborne debris except by burying cables underground. This is routinely done in urban areas, and almost two thirds of the distribution network is already underground, but undergrounding would not be a cost-effective means of providing resilience on long spur routes that serve smaller numbers of customers.*

The BEIS report recognises that undergrounding fully protects network from windborne debris but is not cost effective for long spurs that service low numbers of customers. It also recognises that damage during a storm is caused by strong winds and falling trees.

Recommendation 1 of the Ofgem Storm Arwen report states:

> *E3C should review current network infrastructure standards and guidance, including those for vegetation management and overhead line designs, to identify economic and efficient improvements that could increase network resilience to severe weather events.*

This proposal seeks to enhance resilience to tree damage in severe weather for overhead lines that pass through wooded areas. In recognition that undergrounding is a higher cost activity, the undergrounding is targeted at areas where there would be a greatest risk of trees causing damage to overhead lines.

(5a) Replacing LV open wire overhead lines impacted by trees

Background

The traditional construction of LV overhead lines uses bare conductors in a vertical formation, with sufficient clearance between phases provided by having the conductors follow a similar sag determined by the tension in the conductors.

Windborne debris, such as twigs can easily bridge the phases causing flashovers. Falling branches can cause the upper conductors to be 'stretched', increasing the sag and causing live phases to clash. Such damage is more likely where the LV lines pass in close proximity to trees along roads and in customers' gardens.

LV overhead open wire lines can be made more resilient to windborne debris by converting them to Aerial Bundled Conductors (ABC); which are covered conductors twisted together to form a single multi-phase arrangement.

The use of ABC prevents flashovers from smaller windborne debris, but will not prevent the damage that would be caused by a tree falling on a line. It will provide resilience for the majority of situations encountered during storms. It is therefore proposed to convert LV open wires to ABC conductor on the parts of the LV overhead line network that are subject to trees and where the is a risk that the trees could cause damage.

To facilitate the conversion of LV open wire conductors, NGED will be further developing and expanding the existing geospatial visualisation and reporting system to include the low voltage overhead network. This will enable us to identify highest risk conductors and allow a targeted replacement programme. NGED is not requesting any additional funding through this reopener to support this development of LV geospatial mapping, but it's delivery will facilitate much more targeted work on the LV network.

Rationale for levels of expenditure

The volumes of open wire conductor are derived from NGED mapping data that records the types of conductor. The following table shows the volumes for all four NGED licence areas as at the end of RIIO-ED1. The amount of open wire is highest in the South West and the proportion of network that is open wire ranges from 52% in East Midlands to 75% in West Midlands:

Licence Area	Open wire (km)	PVC (km)	ABC (km)	Total (km)	% Open wire
WMID	4,173	50	1,308	5,531	75%
EMID	2,135	1	1,982	4,118	52%
SWALES	1,690	1	1,355	3,046	55%
SWEST	4,453	22	2,571	7,045	63%

Data reported in table CV29 in the annual Cost and Volumes RRP return provides information on the proportion of LV lines subject to trees, which, as at 31 March 2023, gives the following proportions.

Licence Area	% subject to trees
WMID	[redacted]
EMID	[redacted]
SWALES	[redacted]
SWEST	[redacted]

Assuming that these proportions apply equally to all types of conductor, the application of these proportions to the network volumes gives the length of open wire conductor that is subject to trees.

There are parts of the network, where there is greater risk that the trees near the lines will cause faults. It is assumed that this applies to [redacted] of line subject to trees and that a performance benefit can be gained by converting the open wire conductor to ABC. Using WMID as an example the length of line that would be converted is [redacted] based upon the product of

- Total LV network length (5,531km)
- x % open wire (75%)
- x % subject to trees ([redacted])
- x % where a performance improvement can be gained ([redacted]).

This leads to the following volumes for the whole programme

Licence Area	Total programme (km)
WMID	[redacted]
EMID	[redacted]
SWALES	[redacted]
SWEST	[redacted]
NGED	[redacted]

It is impractical to convert this length of open wire conductor in a short period of time and therefore it is proposed that the work is a 20-year programme starting from the third year of RIIO-ED2.

In addition to changing the conductor, there may also be a requirement to relocate or change some poles, which may be of inadequate strength or have an issue such as leaning. It is assumed that 10% of poles associated with the open wire being changed will need to be replaced. The volumes impacted are derived by applying similar proportions to the population of LV poles as at 31 March 2023, which gives the following volume of LV poles to be changed.

Licence Area	Total programme (poles)
WMID	[redacted]
EMID	[redacted]
SWALES	[redacted]
SWEST	[redacted]
NGED	[redacted]

In order to be consistent with efficient costs determined as part of RIIO-ED2 cost benchmarking, the unit costs for the replacement LV conductor [redacted] and LV poles [redacted] are based upon Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement.

Delivery

It is proposed that the programme is spread over 20 years, with three years of activity in RIIO-ED2. This leads to the following volumes of conductor:

Volumes of LV conductor (km)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
EMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	-	-	[redacted]	[redacted]	[redacted]	[redacted]
NGED	**-**	**-**	[redacted]	[redacted]	[redacted]	[redacted]

It also leads to the following volumes of LV poles.

Volumes of LV Poles (poles)						
Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
EMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	-	-	[redacted]	[redacted]	[redacted]	[redacted]
NGED	**-**	**-**	[redacted]	[redacted]	[redacted]	[redacted]

The majority of this work is overhead line work and the resources will be provided either from NGED direct resources or be supplemented where necessary by contractor resources.

Expenditure

The overall costs of the proposed activity, combining the costs of the conductors and poles are as per the table below:

Replacing LV open wire (£m)						
Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	0.94	0.94	0.94	**2.81**
EMID	-	-	0.48	0.48	0.48	**1.45**
SWALES	-	-	0.33	0.33	0.33	**0.99**
SWEST	-	-	1.04	1.04	1.04	**3.11**
NGED	**-**	**-**	**2.79**	**2.79**	**2.79**	**8.36**

Link to Storm Arwen reports/recommendations

The conclusions on page 11 of the BEIS Storm Arwen report state:

> *The current design standards/guidance, including vegetation management guidance and overhead line designs, and industry practices across distribution and transmission networks, such as tree cutting procedures, should be reviewed to reflect the damage inflicted on the network by Storms Arwen and Eunice and determine how best to improve future network resilience to similar scale events.*

Page 7 of the BEIS Storm Arwen report states:

> *The storm damage was predominantly caused directly by strong winds or falling trees in both storms [Storm Arwen and Storm Eunice].*

Recommendation 1 of the Ofgem Storm Arwen report states:

> *E3C should review current network infrastructure standards and guidance, including those for vegetation management and overhead line designs, to identify economic and efficient improvements that could increase network resilience to severe weather events.*

While there were fewer customers impacted by faults on the LV network, such faults tend to be dealt with toward the end of restoration activities, because resources are focused on the HV network aiming to restore higher numbers of customers. This means that customers with LV faults can be off supply for prolonged periods of time.

This proposal seeks to prevent faults from arising on the LV network, by changing the type of conductor to a covered design. This makes the LV network more resilient to tree contact and in order to get the best storm resilience benefit the programme is targeted at open LV wires that are impacted by trees.

(6) Resilience tree cutting on HV circuits

Background

There are two types of tree cutting that take place, cutting to achieve safety clearances in accordance with ENA technical specification 43-8, and cutting to achieve resilience in accordance with ENA Engineering Technical Recommendation (ETR) 132.

The government mandated resilience tree clearance through the changes implemented in the Electricity Safety Quality and Continuity Regulations made in 2006, following severe wind storms that affected supplies for several days in autumn 2002. The regulatory risk assessment document that accompanied the legislation suggested that the work should be targeted at strategic circuits.

NGED has been focusing resilience tree clearance activities on EHV networks and consequently, price control submissions and allowances have been solely focused on clearance at EHV. We therefore propose to expand the scope of resilience clearance to cover a proportion of the HV overhead line network and request additional funding for this because it is not included in current RIIO-ED2 allowances for NGED.

The prime reason for carrying out the resilience clearance is to reduce the number of faults (and hence customers affected) during storms. Expanding this to focus on the HV network will protect hundreds of customers on each circuit from being affected by tree related faults.

The proposed approach for the work is to target main lines in the first protection zone from primary substations. This is because faults in the first protection zone cause the source circuit breaker to trip, interrupting supplies to all the customers on the circuit, whereas faults in subsequent protection zones impact fewer downstream customers. While automation will restore supplies outside the faulted zone from alternative sources, focusing on the first protection zone will lead to fewer customers being impacted by short interruptions.

Rationale for levels of expenditure

A sample of circuits has been traced to provide an indication of the proportion of overhead line network that falls within the first protection zone of HV circuits, with the remainder being main line downstream of the first protection zone or conductor on protected spurs. The following volumes are therefore based upon the percentage in the first zone applied to the overall overhead network reported in annual regulatory report as at 31 March 2023.

Licence Area	Total HV OH network length (km)	Length in first protection zone (km)
WMID	14,453	[redacted]
EMID	11,742	[redacted]
SWALES	12,002	[redacted]
SWEST	16,234	[redacted]
NGED	54,431	[redacted]

In order to be consistent with existing RIIO-ED2 cost benchmarking, the unit costs are the same as the benchmark values used for HV resilience cutting, which are based upon Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for tree clearance. The specific cost used for the calculation is [redacted].

Delivery

The tree clearance will be delivered by tree clearance contractors and will be implemented either as an extension to existing contracts or separately negotiated new contracts, depending upon contractor availability and the timing of contract renewals in each licence area.

It is proposed to spread the HV resilience programme over 20-years, addressing approximately 1% of the HV network per annum. This leads to the following annual volumes in RIIO-ED2.

Volumes of resilience cutting on HV networks (km)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
EMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	-	-	[redacted]	[redacted]	[redacted]	[redacted]
NGED	**-**	**-**	[redacted]	[redacted]	[redacted]	[redacted]

Expenditure

The overall cost derived from the proposed volumes and benchmark unit costs lead to the values shown in the table below.

Cost of resilience cutting on HV networks (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	0.46	0.46	0.46	**1.37**
EMID	-	-	0.51	0.51	0.51	**1.52**
SWALES	-	-	0.45	0.45	0.45	**1.35**
SWEST	-	-	0.61	0.61	0.61	**1.82**
NGED	**-**	**-**	**2.02**	**2.02**	**2.02**	**6.06**

Link to Storm Arwen reports/recommendations

The conclusions on page 11 of the BEIS Storm Arwen report state:

> *The current design standards/guidance, including vegetation management guidance and overhead line designs, and industry practices across distribution and transmission networks, such as tree cutting procedures, should be reviewed to reflect the damage inflicted on the network by Storms Arwen and Eunice and determine how best to improve future network resilience to similar scale events.*

Page 7 of the BEIS Storm Arwen report states:

> *The storm damage was predominantly caused directly by strong winds or falling trees in both storms [Storm Arwen and Storm Eunice].*

Paragraph 3.11 of the Ofgem Storm Arwen Report states:

> *Figure 3 also shows that some variation in the parts of the network DNOs focus their tree cutting activities on, with WPD and ENWL targeting their activities on their extra high voltage networks. In Storm Arwen, the majority of faults (68%) occurred on the high voltage network. Whilst we recognise that DNOs may have implemented resilience measures other than tree clearance on their high voltage networks, some companies may want to review the benefit of undertaking further resilience tree cutting on these areas of their network.*

Recommendation 1 of the Ofgem Storm Arwen Report states:

> *E3C should review current network infrastructure standards and guidance, including those for vegetation management and overhead line designs, to identify economic and efficient improvements that could increase network resilience to severe weather events.*

NGED has previously focused its resilience tree cutting on the EHV network. Analysis in the Storm Arwen reports show that most customers were affected on the HV network. This proposal therefore starts to implement resilience tree clearance on the HV network, targeting clearance in the first protection zone from Primary substations, as faults in this section of HV circuits impact all customers on the feeders.

(8) Application of Pre-Fix detection for fault location

Background

NGED has been carrying out an innovation project (using Network Innovation Allowance funding) called Pre-Fix, which is developing an approach to identifying disturbances on the network being caused by potential faults, in order to target removal of defective components before they actually cause a fault.

The methodology is aiming to be vendor-agnostic, looking at using technology from a variety of providers to develop a more flexible way of utilising existing monitoring equipment, alongside new devices.

The Pre-Fix innovation project is gaining more experience of predicting the location of potential faults, but a spin off benefit has emerged which enables the location of actual faults. This is especially beneficial for overhead line faults that may arise during storms, as it provides a narrower area where the network needs to be patrolled. By having a more targeted area to investigate, the location of faults can be carried out more quickly, thus reducing the time customers are off supply.

Since the application of the technology for storms is primarily related to the location of overhead line faults, we are proposing to install it on substations where the outgoing circuits have more than 80% of the network constructed on overhead lines.

More information about the technical details of the Pre-Fix technology is provided in Appendix B

Rationale for levels of expenditure

The solution relies upon monitors at primary substations, supported by devices installed on the feeders. The approach to implementation is therefore based upon rolling out the solution to substations and the associated outgoing circuits, rather than just individual specific circuits.

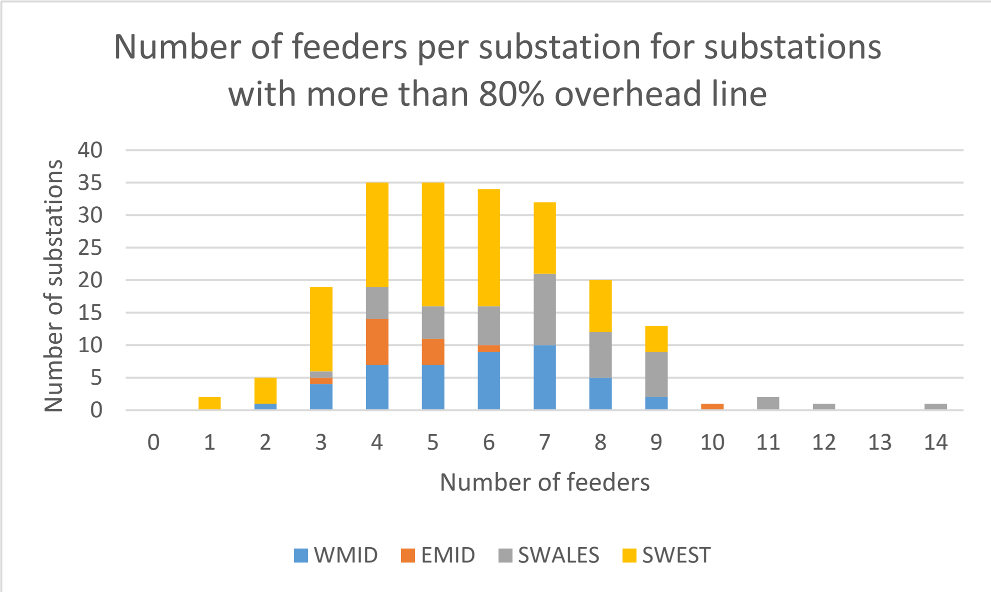
The substations have been identified from the HV disaggregated performance data submitted to Ofgem as part of Interruption Incentive Scheme reporting. This provides information about each circuit that includes the amount of underground cable and overhead line. The amount of overhead line associated with a primary substation has been determined from this data by considering all the circuits associated with primary substations.

Analysis of the HV disaggregated data submitted in November 2022 shows that there are 200 primary substations that have 80% or more overhead lines, which represents approximately 20% of substations that have HV feeders. These substations are listed in Appendix E.

The average cost per installation of [redacted] is a blend of different approaches that may be required depending on the number of feeders from a primary substation and the amount of branching on the network. More branching requires more devices to detect which parts of the network the faults are in.

The chart below shows that the number of feeders per substation (for substations with more than 80% overhead line) ranges between 3 and 8, with a small number of substations outside this range.

Typical costs have therefore been derived for three feeders and eight feeders and the average of [redacted] has been used in the forecast.



Delivery

Since the technology is still under-development, the installation of the monitoring equipment in 200 substations has been spread across the last three years of RIIO-ED2 and all five years of RIIO-ED3. The rollout of the programme volumes is in the ratio of 1:2:3 across the RIIO-ED2 years, then continuing at the year 5 rate for RIIO-ED3. This allows for lower volumes in the earlier part of the rollout to evolve the most effective and efficient ways of deploying the devices that can then be applied to higher volumes later in the price control and RIIO-ED3.

The monitors at substations and devices on circuits can be easily installed by internal resources.

The delivery profile is shown in the table below:

Volumes of Pre-Fix installations

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
EMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	-	-	[redacted]	[redacted]	[redacted]	[redacted]
NGED	**-**	**-**	[redacted]	[redacted]	[redacted]	[redacted]

Expenditure

The overall costs derived from the proposed volumes and average unit costs leads to the values shown in the table below.

Cost of Pre-Fix installations (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	0.19	0.38	0.67	**1.24**
EMID	-	-	0.10	0.10	0.19	**0.38**
SWALES	-	-	0.19	0.38	0.67	**1.24**
SWEST	-	-	0.48	0.86	1.24	**2.57**
NGED	**-**	**-**	**0.95**	**1.71**	**2.76**	**5.43**

Link to Storm Arwen reports/recommendations

The conclusions on page 17 of the BEIS Storm Arwen report state:

> *Fault identification mechanisms should be improved as shortening customer restoration times is heavily dependent on accurately and comprehensively identifying faults on the network.*

Recommendation R1 on page 18 the BEIS Storm Arwen report states:

> *E3C to review and update industry best practice to ensure DNOs can quickly identify faults and safely assess the extent of network damage earlier in a severe weather event.*

Recommendation 6 of the Ofgem Storm Arwen report states:

> *E3C should review and update industry best practice for identifying faults and assessing the extent of network damage, to reduce customer restoration times.*

Pre-Fix allows faster identification of the location of faults. This narrows down the time taken to patrol lines to pinpoint the exact location of faults, thus speeding up the identification of faults and the consequential repair time.

(9) Torque tooling for LV fuses

Background

LV fuses associated with pole mounted transformers are installed at heights that require either overhead line teams or a means of access such as a ladder to operate the fuses. In order to speed up the replacement of fuses by a single person operating from the ground, a torque tool that fits onto live line rods has been developed in collaboration with a manufacturer who has designed and manufactured the tool.

The tool uses torque wrench technology to prevent overtightening of the fuse tightening wing nuts. If the wing nuts are overtightened they can break and expose live parts, which then requires an overhead line team to replace the broken fuse carriers with new carriers, delaying restoration of supplies.

The new tool torque setting is set to a value equivalent to finger tightening, mimicking the torque that would be applied if the fuses were tightened by hand. This enables a single person working from ground level to replace fuses without damaging them.

The new torque tool for tightening LV overhead fuses forms part of tool kit required by operational technicians, single person team and overhead line teams. These tools are personally issued, so all relevant operational staff will be issued a tool. More information about the technical details of the torque tooling is provided in Appendix B.

Rationale for levels of expenditure

The tool has been developed in collaboration with a manufacturer and there is a fixed unit price that has been negotiated for each unit. The cost of the tool is [redacted]. These tools have been procured during 2023/24 and all costs are being incurred in 2023/24.

The tools have been designed to be robust units and will not require replacement for a number of years.

The volumes of units vary by licence area, dependent upon the number of relevant operational staff who will have authorisation for replacement of overhead LV fuses. The volumes are shown below.

Volumes of torque tools required in each licence area

	Volumes
West Midlands	[redacted]
East Midlands	[redacted]
South Wales	[redacted]
South West	[redacted]
Total	[redacted]

Delivery

All relevant operational staff will be issued with a tool during 2023/24.

Expenditure

The overall cost derived from the proposed volumes and price per unit leads to the values shown in the table below.

Cost of torque tooling(£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	0.03	-	-	-	-	**0.03**
EMID	0.02	-	-	-	-	**0.02**
SWALES	0.02	-	-	-	-	**0.02**
SWEST	0.02	-	-	-	-	**0.02**
NGED	**0.10**	**-**	**-**	**-**	**-**	**0.10**

Link to Storm Arwen reports/recommendations

Page 12 of the BEIS Storm Arwen report states:

> *Irrespective of the level of investment, no physical system can ever be made 100% failsafe, therefore restoration efforts remain an integral part of electricity network resilience.*

The adoption of the torque tool enables operational staff to remove and replace low voltage overhead line fuses from the ground, negating the need for overhead line teams to attend and work at height. This will improve the restoration time for customers.

(10) Reducing customers in a protection zone to 1000

Background

HV circuits are mainly designed to operate as radial feeds; this means that the flow of power is from the source primary substation to open points at the ends of the feeder, where the open points are inter-connected to other circuits. The main protection device for the circuit is a circuit breaker positioned at the source primary substation, which can interrupt the flow of power when a fault is detected on the circuit. Relying solely on this circuit breaker means that all the customers on a feeder will be interrupted.

The number of customers impacted by a fault can be reduced by subdividing circuits into smaller zones by installing additional protection devices (such as reclosing circuit breakers, intelligent fuses) along the circuits to prevent customers upstream of the devices from being affected by faults downstream of the devices.

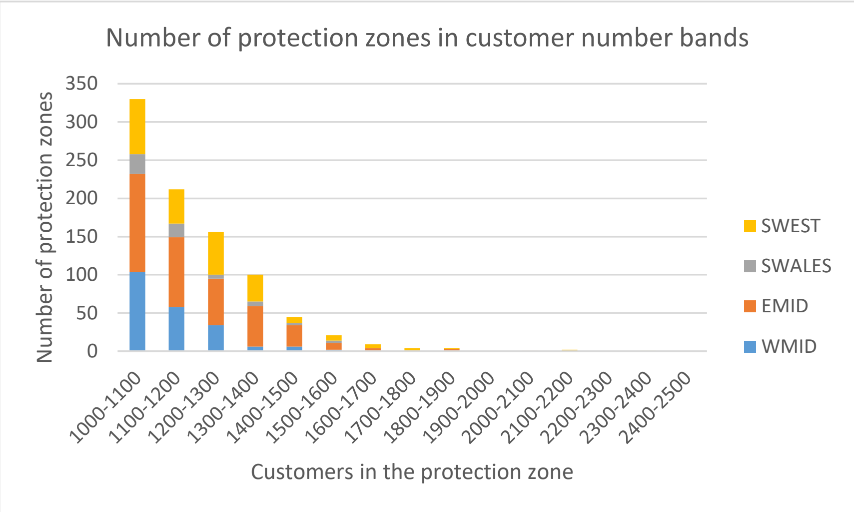
Applying remote control to switchgear such as ring main units, reclosing circuit breakers and switches and incorporating automation logic in control systems allows power to be quickly rerouted or 'switched' without the need to send a person to site. The automation algorithms use information from fault passage sensors to identify which section of the network contains the fault and then communicate with remotely controlled devices to restore supplies to the maximum number of customers possible.

While such investment does not prevent faults during storms, it can reduce the impact and automatically restore more customers, minimising the impact of faults that occur.

The proposal relates to subdividing the network into smaller protections zones, targeting the zones with highest customer numbers. More information about the technical details of reducing the number of customers in protections zones is provided in Appendix B

Rationale for levels of expenditure

The proposed volumes of activity under the Storm Arwen re-opener are based upon reducing the maximum number of customers to 1,000. At June 2023 there were [redacted] protection zones with more than 1000 customers, with a profile as shown in the chart below (a tabular breakdown in customer number bands in shown in Appendix B).



Prioritisation would be focused on the zones with highest customer numbers, progressively working down towards the 1000-1100 customer number band.

The protection zones to be addressed are a combination of urban and rural situations. Rural overhead line circuits can utilise pole-mounted reclosers, while in urban situations ground-mounted switchgear (such as ring main units) with actuators are used. Analysis of the number of substations in each protection zone suggests that 85% of installations will be on urban installations and therefore the unit cost used [redacted] is a blend of 15% pole-mounted and 85% ground-mounted switchgear installation costs.

Delivery

It is proposed to address the [redacted] protection zones during RIIO-ED2 with volumes spread evenly over the last three years as shown in the table below.

Volumes						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
EMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	-	-	[redacted]	[redacted]	[redacted]	[redacted]
NGED	**-**	**-**	[redacted]	[redacted]	[redacted]	[redacted]

The installation of the devices, remote control and links to control centres to enable automation will be carried out by NGED staff, who already have experience of installing and commissioning the equipment.

Expenditure

The overall cost derived from the proposed volumes and average cost per unit leads to the values shown in the table below.

Cost (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	1.03	1.03	1.03	**3.09**
EMID	-	-	1.82	1.82	1.82	**5.47**
SWALES	-	-	0.29	0.29	0.29	**0.88**
SWEST	-	-	1.13	1.13	1.13	**3.39**
NGED	**-**	**-**	**4.28**	**4.28**	**4.28**	**12.84**

Link to Storm Arwen reports/recommendations

Page 12 of the BEIS Storm Arwen report states:

> *Irrespective of the level of investment, no physical system can ever be made 100% failsafe, therefore restoration efforts remain an integral part of electricity network resilience.*

Recommendation 3 of the Ofgem Storm Arwen report states:

> *E3C should assess the feasibility and benefits of developing a standard-based approach to organisational resilience to improve the speed of customer restoration during severe weather events.*

The subdivision of the network into smaller automated protection zones means that fewer customers are affected by faults. Those customers that are outside the faulted zone have their supplies restored in under three minutes by automatic switching. This significantly improves restoration time for these customers, who may otherwise be waiting for manual switching to restore supplies.

(11) Automation of spur protection

Background

The topography of overhead networks includes main lines that are interconnected to other circuits and spurs that have no alternative interconnection.

Remote control and automation has been installed on source circuit breakers and along the main lines. This allows networks to be subdivided into smaller protection zones and enables the rerouting of power from alternative sources.

Protection equipment has also been installed on spurs. Without this protection, faults on the spurs can affect customers on the main line and other spurs within a protection zone. Historical practice has included reusing non-remote control auto-reclosers, installing intelligent fuses (automatic sectionalising links that operate within the deadtime of main line protection) and using pole mounted fuses (especially in the South West). All these methods are effective at preventing faults on the spurs from impacting customers on the rest of the circuit (to different degrees). There are however drawbacks, especially for fuses, where staff need to be sent to site to replace the fuses when they operate. This leads to protracted restoration times, especially during storms.

NGED has been trialling single phase circuit breakers, called TripSaver II, that can be installed in the same fittings used for fuses. The use of such circuit breakers means that for transient faults the spurs are restored automatically, rather than relying on someone visiting site to replace fuses. During storms, this enables resources to be available for other permanent faults that have occurred.

There is a further benefit by using single phase circuit breakers. They are more sensitive to low current faults, which means that they will operate for more faults than fuses, preventing the need for upstream devices to operate. This means that customers upstream of the spur will be affected by fewer faults on the spur.

More information about the TripSaver II devices and learning from the trials is provided in Appendix B

Rationale for levels of expenditure

The application of this technology will be focused on spurs with high numbers of customers to take advantage of the automatic restoration functionality benefitting the greatest number of customers. There is a secondary focus, where long spurs, with a greater likelihood of faults will also be targeted to take advantage of the extra sensitivity of these devices so that customers upstream are not affected by faults on the spurs.

We are proposing a very targeted programme to install TripSaver II devices to replace fuses on spurs that have either more than 150 customers or are longer than 10km. In some cases, both situations apply.

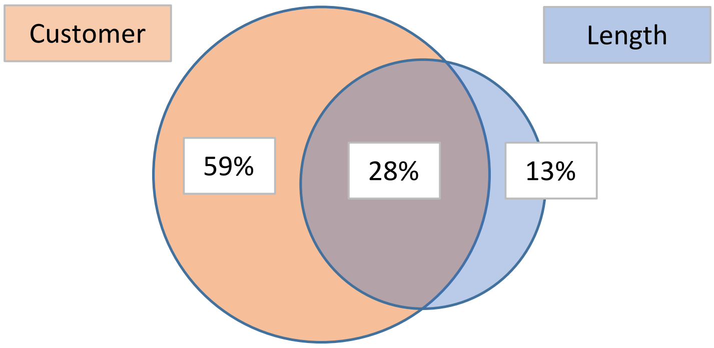
The volumes proposed represent approximately [redacted] % of spurs that are currently protected by fuses.

Application of TripSaver II

Licence Area	Number of fused spurs	Customer and length	Customer only	Length only	Total application	% age of fused spurs
WMID	2,183	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
EMID	4,772	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	1,869	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	21,397	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NGED	**30,221**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

While the volumes of proposed installations are highest in SWEST, this still only represents around 1% of the volumes of fused spurs.

The Venn Diagram below illustrates the spread of drivers for the application of the TripSaver II devices with 28% being driven by both the customer and length criteria, 59% being driven by the customer criteria and the remaining 13% being driven by network length.



The unit costs used for the expenditure represent a typical cost which considers installation of three TripSaver II devices, because long circuits with higher numbers of customers will be a three phase arrangement requiring three sets of fuses.

Delivery

It is proposed to spread the volumes evenly over the last three years as shown in the table below.

Volumes

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
EMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	-	-	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	-	-	[redacted]	[redacted]	[redacted]	[redacted]
NGED	**-**	**-**	[redacted]	[redacted]	[redacted]	[redacted]

The installation of the devices will be carried out by NGED overhead line staff. These devices are self-powered and do not need communication links. The installation is therefore simple and straightforward, allowing the proposed programme to be completed in the remainder of RIIO-ED2

Expenditure

The overall cost derived from the proposed volumes and unit costs leads to the values shown in the table below.

Automation of spur protection (£m)

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	0.02	0.02	0.02	**0.06**
EMID	-	-	0.07	0.07	0.07	**0.21**
SWALES	-	-	0.07	0.07	0.06	**0.19**
SWEST	-	-	0.46	0.46	0.45	**1.38**
NGED	**-**	**-**	**0.62**	**0.62**	**0.60**	**1.84**

Link to Storm Arwen reports/recommendations

The conclusions on page 17 of the BEIS Storm Arwen report states:

> *Storm Arwen brought unacceptably long power cuts to some households, especially those in rural areas.*

Recommendation 3 of the Ofgem Storm Arwen report states:

> *E3C should assess the feasibility and benefits of developing a standard-based approach to organisational resilience to improve the speed of customer restoration during severe weather events.*

The proposal to automate spur lines currently protected by fuses, means that customers will be restored more quickly for transient network faults, removing the need for operators to go to site to replace fuses. This speeds up restoration of supplies, especially for rural communities that are predominantly supplied from network spurs.

(12/13) LineSIGHT detectors to identify nested and low conductor faults

Background

Monitoring equipment and software called LineSIGHT has been developed, under an ENWL innovation project, which continuously monitors the network and establishes a normal running 'signature'. When faults occur, there is a disturbance to the signature and a location of the fault can be estimated. This removes the need for time consuming line patrols, by narrowing down the search area for faults.

The equipment can identify the location of individual network issues, but it can also be used to identify multiple nested faults or low hanging conductors.

Ofgem has provided allowances to ENWL to install [redacted] LineSIGHT devices in RIIO-ED2 under a price control deliverable arrangement. NGED does not have any funding for adopting this technology and therefore it is included in the Storm Arwen re-opener submission. The NGED proposal considers a targeted programme aimed at circuits that have a propensity to fault during storms.

Nested Faults

During storms, multiple faults can occur on the same part of the network at the same time. DNOs will generally be aware that an outage has happened, but will not be aware that multiple faults exist unless the multiple faults are obvious (e.g. in close proximity with clear evidence of two sites of damage or from two separate reports from members of the public).

Restoration and repair teams will focus on repairing the first fault found and only once this is repaired and the circuit is being returned to service that the second fault may be identified, either as part of the testing process or when a circuit breaker is closed and it trips again.

These multiple or "nested" faults lead to protracted outage times, because the faults tend to be repaired sequentially instead of in parallel. During storms this also has the impact of tying up resources for longer periods of time, thus delaying restoration from other parts of the network.

Low conductors

Overhead line conductor components such as binders and jumpers can sometimes fail allowing conductors to fall from insulators, causing the conductors to hang low (below statutory ground clearance).

Since the conductors are not in contact with ground, network protection is unlikely to operate, thus leaving the conductors live and in a dangerous state, with risk to members of the public and livestock.

LineSIGHT technical details

More information about the LineSIGHT technology is provided in Appendix B.

Rationale for levels of expenditure

We have identified that there are [redacted] circuits that have had 10 or more faults during exceptional events since the start of RIIO-ED1. Since these circuits have a greater propensity to fault during storms they are higher risk circuits which are more likely to gain benefit from LineSIGHT monitoring.

It is assumed that monitoring devices will be installed at an average of eight per circuit (based upon advice from Kelvatek, the manufacturer of LineSIGHT).

The unit costs represent a typical cost of the monitoring devices. For consistency with existing arrangements in the RIIO-ED2 price control we have used a unit cost derived from ENWL's Special Licence Condition 3.15 for installation of LineSIGHT technology (i.e. total allowance of [redacted] for [redacted] installations leading to a unit cost of [redacted]).

Delivery

It is proposed to install LineSIGHT on the [redacted] circuits during RIIO-ED2 with volumes of devices spread evenly over the last three years as shown in the table below. Details of the specific circuit are provided in Appendix D.

Volumes						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	[redacted]	[redacted]	[redacted]	[redacted]
EMID	-	-				
SWALES	-	-				
SWEST	-	-				
NGED	**-**	**-**				

The installation of the devices will be carried out by overhead line staff and part of the installation will be a requirement to install the necessary communications links to provide data from the monitors to centrally hosted analysis software.

Expenditure

The overall costs derived from the proposed volumes and unit costs leads to the values shown in the table below.

LineSIGHT (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	0.51	0.51	0.51	**1.53**
EMID	-	-	-	-	-	**-**
SWALES	-	-	0.20	0.20	0.20	**0.59**
SWEST	-	-	0.51	0.51	0.51	**1.53**
NGED	**-**	**-**	**1.21**	**1.21**	**1.21**	**3.64**

Link to Storm Arwen reports/recommendations

The conclusions on page 17 of the BEIS Storm Arwen report states:

> *Fault identification mechanisms should be improved as shortening customer restoration times is heavily dependent on accurately and comprehensively identifying faults on the network.*

Recommendation R1 on page 18 the BEIS Storm Arwen report states:

> *E3C to review and update industry best practice to ensure DNOs can quickly identify faults and safely assess the extent of network damage earlier in a severe weather event.*

Recommendation 6 of the Ofgem Storm Arwen report states:

> *E3C should review and update industry best practice for identifying faults and assessing the extent of network damage, to reduce customer restoration times.*

LineSIGHT allows faster identification of the location of faults and can also identify the type of fault. This narrows down the time taken to patrol lines to pinpoint the exact location of faults and by having an indication of the type of fault can inform what resources, vehicles and materials are prepared for the network repair.

(14) Increased volumes of mobile generation

Background

NGED has utilised mobile generation for temporary restoration of power for a number of years. There is an existing fleet of NGED owned mobile generation of differing sizes that can be utilised for a range of different outage situations. They are dispersed across all depots and teams are trained on how to connect them.

The NGED fleet is supplemented with commercial arrangements with third party providers and these services are utilised when specific generator sizes are required or extra generators are needed. However, during storms these supplementary services may not be available or the generators may already be being used for other commercial customers, so they are not a fully reliable source of alternative provision.

NGED treats the restoration of supplies as a priority. This is especially important during storm situations because of the high volumes of customers that can be affected. Where customers can be restored by switching on the network, this is carried out either automatically or through manual operations on site. Where it is not possible to restore supplies by switching (such as faults on parts of the network without interconnection), mobile generation can be used to provide temporary power supplies.

While there are good existing arrangements in place, they can be supplemented by having more mobile generation available, enabling more customers to be provided with temporary supplies during storms.

Rationale for levels of expenditure

The forecast is based upon providing an additional two generators per depot, leading to the procurement of an additional [redacted] mobile generators across the four NGED licence areas. This will lead to around a [redacted] increase in the population of mobile generators.

The unit cost used for the forecast [redacted] is based upon a blend of unit costs for different sizes of generators, some of which require to be trailer mounted. The proposals are based upon the following mix of sizes:

- 60% 100kVA
- 20% 200kVA
- 20% 500kVA

The costs are consistent with the NGED ED2 EJP002, submitted as part of NGED's ED2 business plan submission which sought to replace the most polluting generators on the fleet.

The expenditure proposals also cover the annual maintenance costs for the years after the procurement of the generators. These costs have been based upon existing maintenance contract schedule of rates and also represent the blend of different sizes that are proposed resulting in an average maintenance cost per unit of [redacted] per annum. These maintenance costs are shown as being incurred in the years that follow the procurement of the units.

Delivery

It is proposed to procure the [redacted] generators as soon as possible after the reopener concludes and funding is provided. This means that the costs are likely to fall within the third year of RIIO-ED2 with volumes as shown in the table below.

Volumes of procurement of generators

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	[redacted]	-	-	[redacted]
EMID	-	-	[redacted]	-	-	[redacted]
SWALES	-	-	[redacted]	-	-	[redacted]
SWEST	-	-	[redacted]	-	-	[redacted]
NGED	**-**	**-**	[redacted]	**-**	**-**	[redacted]

The generators will be distributed to all operational depots for use by local teams.

The ongoing annual maintenance costs are shown as being incurred in the years after the procurement of the generators.

Volumes of maintenance of generators

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	-	[redacted]	[redacted]	[redacted]
EMID	-	-	-	[redacted]	[redacted]	[redacted]
SWALES	-	-	-	[redacted]	[redacted]	[redacted]
SWEST	-	-	-	[redacted]	[redacted]	[redacted]
NGED	**-**	**-**	**-**	[redacted]	[redacted]	[redacted]

Expenditure

The overall costs of procurement derived from the proposed volumes and unit costs leads to the values shown in the table below.

Cost of new generators (£m)

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	1.30	-	-	**1.30**
EMID	-	-	1.49	-	-	**1.49**
SWALES	-	-	0.75	-	-	**0.75**
SWEST	-	-	1.49	-	-	**1.49**
NGED	**-**	**-**	**5.03**	**-**	**-**	**5.03**

The ongoing maintenance costs associated with the new generators is shown below.

Cost of ongoing generator maintenance (£m)

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	-	0.01	0.01	**0.02**
EMID	-	-	-	0.01	0.01	**0.03**
SWALES	-	-	-	0.01	0.01	**0.01**
SWEST	-	-	-	0.01	0.01	**0.03**
NGED	**-**	**-**	**-**	**0.05**	**0.05**	**0.09**

Link to Storm Arwen reports/recommendations

Page 16 of the BEIS Storm Arwen report states:

> *DNOs should review the requirement for generator capacity, considering the growing dependency on electricity and the increased uptake of electric vehicles in houses and communities.*

The conclusions on page 17 of the BEIS Storm Arwen report states:

> *Mobile generators are a critical part of the solution to reducing the length of power cuts and getting customers back on supply before full repairs can be completed. There are limitations to the value and practicality of their use. The number accessible to DNOs and the strategies for resourcing and deploying enough generators should be reviewed by the industry.*

Recommendation R2 on page 18 of the BEIS Storm Arwen report states:

> *E3C to identify options to enhance the use of mobile generators in reducing the length of power disruption, covering the population of mobile generators held by the DNOs and resourcing options to transport, install, refuel and remove.*

Recommendation 8 of the Ofgem Storm Arwen report states:

> *E3C should identify options to enhance the use of mobile generators in reducing the length of power disruptions.*

While NGED has an existing fleet of mobile generation, this proposal seeks a marginal 10% increase to the fleet to provide additional capacity. This will enable more parts of the network to have temporary supplies provided, while repairs are being carried out. This will mean that customers will have the equivalent of normal supplies, albeit they will be being provided by mobile generation. Customers will be restored sooner, even though the faults caused by the storm are still being repaired.

(14a) Using suitcase generators

Background

Suitcase generators are small compact generators that are normally used for leisure pursuits such as camping and caravanning. They come in a variety of ratings and can be used to provide the power to use a microwave, keep fridges running and power up communications such as broadband routers/mobile phones.

They can be used during power cuts to provide supplies for essential requirements for a domestic property. Trials in the South West have shown that they are easy to connect and quick to install.

Ideally, during power cuts we would utilise larger mobile generators to provide adequate power for numerous customers. But where this is not practical or mobile generation is already being utilised (as may be the case in storm situations), the provision of a suitcase generator would provide temporary, albeit limited, power.

NGED has not used such suitcase generators, apart from for trials and their use would be a new approach to providing support for customers, specifically for customers in vulnerable situations. This would ensure that vulnerable customers have some form of temporary supply for basic essential requirements.

Rationale for levels of expenditure

The forecast is based upon providing five suitcase generators per depot, leading to the procurement of [redacted] suitcase generators across NGED. The number per depot is quite low, but where necessary we anticipate utilising suitcase generators from adjacent depots for larger incidents.

The unit cost based upon the trial units is [redacted] each and therefore the total cost of this initiative is [redacted].

Delivery

It is proposed to procure the [redacted] suitcase generators as soon as possible after the reopener concludes and funding is provided. This means that the costs are likely to fall within the third year of RIIO-ED2 with volumes as shown in the table below.

Volumes

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	[redacted]	-	-	[redacted]
EMID	-	-	[redacted]	-	-	[redacted]
SWALES	-	-	[redacted]	-	-	[redacted]
SWEST	-	-	[redacted]	-	-	[redacted]
NGED	**-**	**-**	[redacted]	**-**	**-**	[redacted]

The generators will be distributed to all operational depots for use by local teams.

Expenditure

The overall costs derived from the proposed volumes and unit costs leads to the values shown in the table below.

Suitcase generators (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	0.04	-	-	**0.04**
EMID	-	-	0.05	-	-	**0.05**
SWALES	-	-	0.02	-	-	**0.02**
SWEST	-	-	0.05	-	-	**0.05**
NGED	**-**	**-**	**0.17**	**-**	**-**	**0.17**

Link to Storm Arwen reports/recommendations

Page 16 of the BEIS Storm Arwen report states:

> *DNOs should review the requirement for generator capacity, considering the growing dependency on electricity and the increased uptake of electric vehicles in houses and communities.*

Recommendation R2 on page 18 of the BEIS Storm Arwen report states:

> *E3C to identify options to enhance the use of mobile generators in reducing the length of power disruption, covering the population of mobile generators held by the DNOs and resourcing options to transport, install, refuel and remove.*

Recommendation 8 of the Ofgem Storm Arwen report states:

> *E3C should identify options to enhance the use of mobile generators in reducing the length of power disruptions.*

The use of suitcase generators is not intended to provide significant power capacity to provide the equivalent of a network supply. They are intended to be used to provide basic power requirements that enables vulnerable customers the means to charge phones and use a microwave to heat water for a warm drink. They are intended for use for short periods of time, while network repairs are being carried out.

(17) Pre-emptive movement of resources

Background

NGED has resources across its geographic footprint, distributed across 27 local distribution areas, with some areas having sub-depots to place resources in the communities that we serve. Under normal operations the local resources can deliver new connections, load reinforcement work, asset replacement work, inspections, maintenance and faults. However, under storm situations where the volume of faults can be high, additional support may be required from other teams.

The utilisation of staff from other parts of the company to assist local teams with response and restoration activities is a well-established practice within NGED. We also have established processes for sharing resources across DNOs. This mutual support is nothing new and demonstrates a willingness by staff to work collaboratively to restore power supplies.

When a storm is forecast we carry out a range of preparedness actions, such as cancelling planned work, boosting stand-by resources, resourcing local depots out of hours, etc.

When the storm hits and faults start to occur, local teams are deployed to investigate the causes and restore customers. The focus is getting customers back on supply, either through temporary arrangements, mobile generation or a permanent repair. Ideally, permanent repairs would be carried out, but these may tie-up resources that could be being used for other restoration activities. Hence alternatives such as safe temporary repairs may be made, which require follow up actions to make a permanent repair.

As a storm progresses, its impact is regularly reviewed to identify if additional resources are required in a specific 'busy' area and whether resources in less impacted areas can be released to assist. This currently happens once the storm has started.

For certain storms, such as Storm Ciaran in early November 2023, the weather forecast predicted that very high winds would impact a specific localised area (i.e. the English Channel) and that other areas would have minimal impact. Consequently, for NGED, there was a high volume of faults concentrated in the South West peninsular affecting Cornwall and Devon.

On review of the storm, it was identified that performance could have been improved if resources from other teams had been available sooner. In order to achieve this it would require resources to be mobilised ahead of the storm 'landing'. This would require hotels and subsistence to be arranged for the staff that were being mobilised.

Rationale for levels of expenditure

This proposal is for funding for pre-emptive mobilisation of staff. It assumes that there is one localised storm in each licence area per annum, where early movement of resources would be helpful. It also recognises that for larger storms, affecting a wider area, such pre-emptive movement of resources is unlikely to take place until each area assesses the impact of a more widespread storm.

The costs relate to providing accommodation for [redacted] staff for three nights, predominantly for overhead line craft teams.

The forecast is therefore based on [redacted] person-nights of accommodation and subsistence per licence area per-annum, using a cost per person-night of [redacted] for hotel bills and food expenses. The costs are based upon using budget hotels, being booked at short notice, derived from a sample of 32 hotels across NGED's four licence areas, plus typical costs for a breakfast, lunch and evening meal.

Delivery

Since this pre-emptive approach to preparing resources for storms is reliant upon weather forecasts, resources will be deployed when a localised severe weather is forecast.

The number of storms can vary from year to year and therefore it is difficult to predict the actual volumes of storms that will require pre-emptive resources to be deployed. The delivery profile therefore assumes a flat profile, but in reality higher volumes in some years will be offset with lower volumes in others.

Volumes (person-nights)

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
EMID	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
SWALES	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
SWEST	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NGED	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Expenditure

The overall costs derived from the proposed volumes and unit costs leads to the values shown in the table below.

Pre-emptive movement of resources (£m)

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	0.02	0.02	0.02	0.02	0.02	**0.08**
EMID	0.02	0.02	0.02	0.02	0.02	**0.08**
SWALES	0.02	0.02	0.02	0.02	0.02	**0.08**
SWEST	0.02	0.02	0.02	0.02	0.02	**0.08**
NGED	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.32**

Link to Storm Arwen reports/recommendations

Page 12 of the BEIS Storm Arwen report states:

> *All DNOs should review their severe weather escalation plans to ensure that all relevant factors, including wind direction, are taken into consideration.*

Recommendation R7 on Page 19 of the BEIS Storm Arwen report states:

> *Each DNO to review their severe weather escalation plans, trigger points and resulting preparatory actions, to ensure all relevant factors that can influence scale of impacts are considered, e.g., wind direction.*

Paragraph 3.15 of the Ofgem Storm Arwen report states:

> *During Storm Arwen, we found that some DNOs had far fewer resources deployed initially, which may have affected the time taken to repair and restore supplies.*

This proposal is based upon a review of escalation plans, informed by experience during storms. By mobilising resources sooner to areas that are likely to have greatest impact from the severe weather, they are in place to start dealing with storm damage as soon as it occurs, speeding up restoration of supplies and reducing the impact on customers.

(18) Enhancements to telephony servers

Background

NGED uses a variety of interconnected telephone systems to answer calls from customers, provide outgoing communications to customers and enable internal business communications.

During storms, these communication systems handle high volumes of calls, and the experience during Storm Arwen showed that improvements can be made to both messaging systems and server capacity.

Improvements already made to messaging and telephony systems

There are a number of areas where improvements have already been made (and do not feature as part of this Storm Arwen re-opener submission). They are part of continual improvements to telephony and messaging, which lead to improved information for customers and enhanced telephony system resilience.

Event driven messaging

NGED has been using proactive messaging for some time using an in-house platform called Proactive Incident Contact Systems (PICS). PICS takes data from incidents in the Power On control system to identify which Priority Services Register (PSR) customers need to be contacted to be informed that they are off supply. PICS enables automated text messages to be sent to the PSR customers and also generates lists of customers who prefer to be contacted by phone. Historically, the generation of the text messages and call lists was done on a batch basis, picking up the data from Power On at a set intervals of time.

An enhancement has been implemented into PICS to now make it event driven. This means that customers are made aware of an incident within 30 seconds of the incident being logged within Power On. This provides the benefit of speeding up the notification of faults to customers, which also reduces the number of incoming calls (because customers are aware that we already know about their incidents).

Estimated time of restoration

Previously, proactive messaging about incidents did not include an estimated time of restoration (ETR).

This has now changed and we provide information about when we expect customers to be back on supply, which also includes updates should the ETR change.

We now send three distinct messages as part of communicating proactively with customers. This includes

- We know you are off supply
- This is the ETR for your incident (including updates if the ETR changes)
- We believe that you are back on supply, get in contact if you're not.

Auto-dialler replacement

Some customers prefer to receive a phone call instead of a text and we use an auto-dialler system to get in contact with them.

We have implemented a new auto-dialler system, replacing an end of life product called Rostrvm, which is no longer supported by Cisco. The new product takes advantage of huge advancements in text to speech using Google Natural speech to take a 100% code generated message and read it to the customer.

This allows us to quickly and easily provide additional information and a more bespoke service for customer messaging.

Application resilience

To ensure that the contact centre does not experience software issues, we have upgraded all the contact centre applications. This makes sure that we are operating the latest versions of applications, they are compatible with the latest operating systems and vendor support is available should we need it.

Enhancement required to telephony servers

During Storm Arwen contact centre advisors experienced a number of applications becoming unresponsive. On investigation it was found that this was down to telephony servers running at 100% capacity for a prolonged period of time and they had to be shut down and restarted to enable communications to resume.

This has required the allocation of dedicated server capacity to specific telephony systems to offer application stability during peak usage. The knock-on impact has been limited server capacity for other telephony systems, necessitating early upgrade of server capacity. This early upgrade requires funding under the Storm Arwen reopener.

Reallocation of server resources

Prior to 2017, NGED operated a variety of internet protocol (IP) telephony systems on individual servers. When these servers reached the end of life, they were replaced with virtual servers operating all the systems. The virtualisation involved re-creating the physical servers in a virtual form then exporting the existing configuration from the physical servers, shutting them down and resuming service on the virtual servers. This resulted in three pairs of new physical HP servers running VMware ESX dedicated to the IP Telephony environment.

When the virtual servers were implemented, the hardware was specified to be able to provide enough CPU and memory resources for the environment as it stood at the time with a modest amount spare for future expansion. The configuration of CPU and memory resources on the servers meant that CPU and memory resources were not reserved for specific virtual servers. The system relied upon there being enough overall resources for all hosted servers. Over time upgrades to the software and operating system in the environment have utilised this spare capacity.

The high volumes of calls during Storm Arwen meant that the servers were operating at full capacity. Calls that had made it into the NGED call management system were waiting for a response by an agent. But the call management system could not accept any more calls from the BT in-bound call platform. These rejected calls were rerouted to a messaging system telling customers that we could not take their calls and to call back later.

As the CPU and memory resources for these servers where not reserved and the rest of the telephony system was also under heavy use it caused the virtual servers to fail, requiring a reboot of the servers.

In order to prevent this happening again the CPU and memory of the contact centre media servers and contact centre application servers have been reserved in the virtual environment.

Early upgrade of servers

The allocation of dedicated server resources to the contact centre applications means that there is less server resource available for other vital functions in the IP telephony infrastructure. This impacts the IP telephony cluster used for voice communications which could impact contact centre voice communications.

It is therefore proposed to bring forward hardware refresh (which would have otherwise been done in RIIO-ED3) and increase server capacity for greater CPU and memory resource allocation to the various telephony systems.

Rationale for levels of expenditure

The levels of expenditure relate to the procurement and installation of larger virtual servers for IP telephony applications at three locations. The requirements have been submitted to various suppliers to obtain competitive costs. The costs cover the servers, enclosures, Ethernet switches and other components required for the installation and operation of the larger servers to enable the necessary capacity to manage high volumes of incoming calls from customers as well as other telephony requirements during storms.

Delivery

Given the issues that were experienced during Storm Arwen, this work is progressing and the delivery of the new servers is planned for 2024/25. All costs are anticipated to be incurred during the second year of RIIO-ED2.

Expenditure

The overall cost of the system enhancements is allocated across the licence areas using the standard corporate cost allocation of 30% WMID, 30% EMID, 15% SWALES and 25% SWEST and leads to the values shown in the table below.

Enhancement to telephony servers (£m)

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	0.12	-	-	-	**0.12**
EMID	-	0.12	-	-	-	**0.12**
SWALES	-	0.06	-	-	-	**0.06**
SWEST	-	0.10	-	-	-	**0.10**
NGED	**-**	**0.41**	**-**	**-**	**-**	**0.41**

Link to Storm Arwen reports/recommendations

Page 15 of the BEIS Storm Arwen report states:

> *DNOs also rely on customers to report loss of electricity as a way of identifying faults. This was especially challenging during Storm Arwen for those operators whose call centres were overwhelmed, preventing customers from reporting their power cut.*

Recommendation 10 of the Ofgem Storm Arwen report states:

> *DNOs should stress test their telephony systems and websites to ensure adequate capacity during severe weather events.*

The enhancement to telephony servers seeks to prevent the NGED call centres becoming overwhelmed to ensure customers can get in contact with NGED call centre staff.

(20) Inter-DNO interconnection

Background

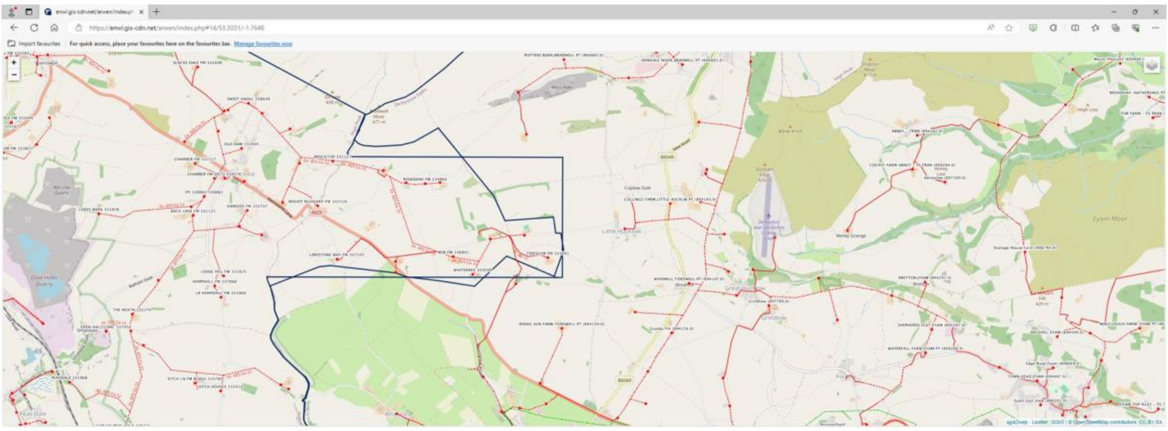
Each DNO has developed its own network within its geographical boundaries.   Most circuits at the boundaries of the network will be at the ends of feeders from primary substations, with many being on spurs without interconnection.

Two adjacent DNOs may have developed network towards their own boundaries and have network in close proximity. Both of these networks may be on spurs and not have interconnection to alternative sources.

However, it may be possible to provide alternative feeds from the adjacent DNO to make the supplies at remote ends of network more resilient with alternative sources of power.

ENWL, SP, NPG and NGED have worked collaboratively to identify cross border inter-DNO interconnection opportunities.

To achieve this, the DNOs have uploaded HV network mapping data into a common system (including data on HV overhead lines, HV underground cable, pole mounted transformers and ground mounted transformers).   An example of the data is shown below with the NGED EMID network (in Derbyshire) on the right and ENWL network on the left.



The borders have then been reviewed collaboratively to identify where networks are close together. This review has identified initial interconnection candidates, which have then been assessed and given a high/medium/low benefit rating for each DNO. The benefit has been derived by considering the number of substations on the spur as a proxy for the number of customers benefitting.

Each DNO has assessed the interconnection opportunity which has provided a combined rating for each location. For example, some interconnections can provide a high benefit for each DNO, whereas others may provide a low benefit for one DNO, but a high benefit for the other DNO. Opportunities are taken forward with treatment of benefits as per the table below.

Cross Border Interconnection Decision to Progress

Benefit Scores	Progress	Benefit Allocation
High – High	Yes	Shared 50%:50%
High – Medium	Yes	Shared 50%:50%
High – Low	Yes	100% to High DNO
Medium – Medium	Yes	Shared 50%:50%
Medium – Low	No (unless low cost)	100% to Medium DNO
Low – Low	No	n/a

Rationale for levels of expenditure

Where there is a medium or better benefit for either DNO, then the interconnection opportunity has been costed. Each interconnection opportunity has costs for both DNOs for the work required on each side of the border, but the cost submissions have been based upon which DNO is getting the benefit, or where the benefit is shared, the DNO carrying out the linear network installation. Reinforcement costs are submitted by the DNO required to do the reinforcement costs. This is summarised below:

Re-opener cost submission by NGED		
NGED DNO benefit	**Interconnection cost**	**Reinforcement cost**
100%	Full cost included	Cost of NGED specific reinforcement
50%	Full cost included if NGED installing the linear network, No cost included if NGED not installing the linear network	Cost of NGED specific reinforcement
0%	No cost included	Cost of NGED specific reinforcement

The costings for NGED are based upon Ofgem RIIO-ED2 disaggregated benchmarking unit costs for asset replacement for the main assets that are required.

The volumes of interconnection opportunities and those being proposed are summarised in the table below. A more detailed list of proposed interconnection locations and costs is provided in Appendix F.

Cross Border Interconnection Opportunities		
Licence Area	**Stage 1 border review**	**Proposed**
NGED (SWALES) – SP (SPMW)	8	3
NGED (WMID) – SP (SPMW)	10	6
NGED (WMID) – ENWL	6	1
NGED (EMID) – ENWL	7	3
NGED (EMID) – NPG (NPGY)	0	0

Delivery

The amount of work required to deliver the interconnections is relatively small scale and therefore should be deliverable with existing resources or support from contractors.

However due to these being interconnections across licence areas, the delivery of the work will require collaboration across DNO borders for network planning, work coordination, cost sharing and operational control.

Expenditure

The costs represent the proportion of the costs allocated to NGED for the interconnections, which depending on the benefit allocation (100%, 50%/50%, 0%) and which DNO is carrying out the linear network installations (for shared benefit interconnectors), may also have costs in the other DNOs. The costs also cover any network reinforcement required on the existing NGED network to enable the interconnections to be made. The costs below are for NGED only.

Cross Border Interconnection NGED costs

Licence Area	£m
NGED (SWALES) – SP (SPMW)	0.48
NGED (WMID) – SP (SPMW)	0.31
NGED (WMID) – ENWL	0.10
NGED (EMID) – ENWL	0.06
TOTAL	**0.94**

Inter DNO interconnections NGED cost profile (£m)

Licence Area	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
WMID	-	-	0.20	0.20	-	**0.41**
EMID	-	-	0.03	0.03	-	**0.06**
SWALES	-	-	0.24	0.24	-	**0.48**
SWEST	-	-	-	-	-	**-**
NGED	**-**	**-**	**0.47**	**0.47**	**-**	**0.94**

Link to Storm Arwen reports/recommendations

The conclusions on page 17 of the BEIS Storm Arwen report states:

> *Storm Arwen brought unacceptably long power cuts to some households, especially those in rural areas.*

Recommendation E2 of the BEIS Storm Arwen report states:

> *Review and update as required the current distribution and transmission network infrastructure and standards (including ERT132, OHL designs and vegetation management) to ensure they are fit for purpose, especially for spur lines in rural areas.*

Recommendation 3 of the Ofgem Storm Arwen report states:

> *E3C should assess the feasibility and benefits of developing a standard-based approach to organisational resilience to improve the speed of customer restoration during severe weather events.*

The network at the extreme ends of the network near DNO geographical boundaries tends to be at the end of spurs. Since these spurs are not interconnected to alternative supplies customers tend to be off supply until the network is repaired. This proposal to interlink networks across DNO boundaries will provide alternative supplies that can be used to restore power while the repairs are being completed.

(20a) Inter-NGED DNO interconnection

Background

Having identified the external inter-DNO boundaries in collaboration with other DNOs, a similar analysis has been carried out for NGED DNO boundaries.

Historically, the four NGED licence areas have been independent and development of each DNO network has also occurred within its geographical boundaries. This means that similar opportunities exist where two adjacent NGED DNOs may have developed network towards their own boundaries and have network in close proximity that can be interconnected.

We have utilised the same approach to identifying interconnection opportunities, using the mapping data uploaded for the inter-DNO analysis.

This review has identified initial interconnection candidates, which have then been reviewed and given a high/medium/low benefit rating for each DNO. The benefit has been derived by considering the number of substations on the spur as a proxy for the number of customers benefitting.

As per the inter-DNO analysis, opportunities are taken forward with treatment of benefits as per the table below.

Cross Border Interconnection Decision to Progress		
Benefit Scores	**Progress**	**Benefit Allocation**
High – High	Yes	Shared 50%:50%
High – Medium	Yes	Shared 50%:50%
High – Low	Yes	100% to High DNO
Medium – Medium	Yes	Shared 50%:50%
Medium – Low	No (unless low cost)	100% to Medium DNO
Low – Low	No	n/a

Rationale for levels of expenditure

Where there is a medium or better benefit for either NGED DNO, then the interconnection opportunity has been costed. Each interconnection opportunity has costs for both NGED DNOs for the work required on each side of the border, but the cost submissions have been based upon which NGED DNO is getting the benefit, or where the benefit is shared, the NGED DNO carrying out the linear network installation. Reinforcement costs are submitted for the specific NGED DNO required to do the reinforcement costs. This is summarised below:

Re-opener cost submission for NGED DNOs		
NGED DNO benefit	**Interconnection cost**	**Reinforcement cost**
100%	Full cost included	Cost of NGED DNO specific reinforcement
50%	Full cost included if NGED DNO installing the linear network, No cost included if NGED DNO not installing the linear network	Cost of NGED DNO specific reinforcement
0%	No cost included	Cost of NGED DNO specific reinforcement

The costings for NGED DNOs are based upon Ofgem RIIO-ED2 disaggregated benchmarking unit costs for asset replacement for the main assets that are required.

The full list of interconnection location is listed in Appendix G and the volumes of interconnection opportunities and those being proposed are summarised in the table below:

Cross NGED Border Interconnection Opportunities		
Licence Area	**Stage 1**	**Proposed**
NGED (SWALES) – NGED (WMID)	4	4
NGED (SWALES) – NGED (SWEST)	0	0
NGED (WMID) – NGED (EMID)	3	3
NGED (WMID) – NGED (SWEST)	0	0

Delivery

The amount of work required to deliver the interconnections is relatively small scale and therefore should be deliverable with existing resources. It is anticipated that the interconnections will be delivered across two years in 2025/26 and 2026/27, with the costs split evenly across the two years.

Expenditure

The costs represent the proportion of the costs incurred by each NGED DNO for the interconnections.

Inter-NGED DNO interconnections (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	0.21	0.21	-	**0.43**
EMID	-	-	0.05	0.05	-	**0.10**
SWALES	-	-	0.10	0.10	-	**0.20**
SWEST	-	-	-	-	-	**-**
NGED	**-**	**-**	**0.36**	**0.36**	**-**	**0.73**

Link to Storm Arwen reports/recommendations

The conclusions on page 17 of the BEIS Storm Arwen report states:

> *Storm Arwen brought unacceptably long power cuts to some households, especially those in rural areas.*

Recommendation E2 of the BEIS Storm Arwen report states:

> *Review and update as required the current distribution and transmission network infrastructure and standards (including ERT132, OHL designs and vegetation management) to ensure they are fit for purpose, especially for spur lines in rural areas.*

Recommendation 3 of the Ofgem Storm Arwen report states:

> *E3C should assess the feasibility and benefits of developing a standard-based approach to organisational resilience to improve the speed of customer restoration during severe weather events.*

The network at the extreme ends of the network near DNO geographical boundaries tends to be at the end of spurs. Since these spurs are not interconnected to alternative supplies customers tend to be off supply until the network is repaired. This proposal to interlink networks across NGED DNO boundaries will provide alternative supplies that can be used to restore power while the repairs are being completed.

(20b) Intra-NGED DNO spur interconnection

Background

At present, customers affected by faults on spurs are off supply until the fault can be repaired (because there is no alternative route for power to restore customers beyond the fault location). By providing an interconnection, customers at the remote ends of spurs can have their power restored ahead of the repair being completed. This will speed up restoration of supplies during storms for customers on those spurs.

Such interconnection opportunities can arise anywhere across the geographic licence area, not just at boundaries. Since there may be numerous opportunities for such interconnection, we have proposed a programme to link the spurs with higher numbers of customers.

Since there are numerous opportunities, we have limited the programme to ten schemes per licence area. These will be selected by considering spurs with over 100 customers and selecting those that do not require any reinforcement of the existing network.

Rationale for levels of expenditure

Since there are many spurs with more than 100 customers, we are limiting the scale of the programme to [redacted] interconnectors per licence area, focusing on those with high numbers of customers and where no additional reinforcement is required for the interconnection, thus limiting the costs.

The costs of the schemes are based upon an average of all the individual specific scheme that have been costed for the inter-DNO and Inter-NGED DNO proposals. This gives a reasonable average informed by costing of 20 schemes.

The NGED costs for those schemes are based upon Ofgem RIIO-ED2 disaggregated benchmarking asset replacement unit costs.

The following tables shows the volumes of scheme per licence area.

Spur Interconnection Opportunities

Licence Area	Schemes
WMID	[redacted]
EMID	[redacted]
SWALES	[redacted]
SWEST	[redacted]

Delivery

The amount of work required to deliver the interconnections is relatively small scale and therefore should be deliverable with either existing resources or be supplemented by contractors.

Expenditure

The costs represent an even profile of delivery of the projects across the last three years of RIIO-ED2.

Intra-NGED DNO spur interconnections (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	0.26	0.26	-	**0.52**
EMID	-	-	0.26	0.26	-	**0.52**
SWALES	-	-	0.26	0.26	-	**0.52**
SWEST	-	-	0.26	0.26	-	**0.52**
NGED	**-**	**-**	**1.04**	**1.04**	**-**	**2.08**

Link to Storm Arwen reports/recommendations

The conclusions on page 17 of the BEIS Storm Arwen report states:

> *Storm Arwen brought unacceptably long power cuts to some households, especially those in rural areas.*

Recommendation E2 of the BEIS Storm Arwen report states:

> *Review and update as required the current distribution and transmission network infrastructure and standards (including ERT132, OHL designs and vegetation management) to ensure they are fit for purpose, especially for spur lines in rural areas.*

Recommendation 3 of the Ofgem Storm Arwen report states:

> *E3C should assess the feasibility and benefits of developing a standard-based approach to organisational resilience to improve the speed of customer restoration during severe weather events.*

Certain parts of legacy DNO networks have been constructed on spurs without interconnection. Since these spurs are not interconnected to alternative supplies customers tend to be off supply until the network is repaired. As networks have evolved and been extended certain spurs have networks in close proximity that provide opportunity for interconnection. This proposal to interlink spurs will provide alternative supplies that can be used to restore power while the repairs are being completed.

(21) Network geospatial mapping

Background

NGED has employed helicopter-mounted LiDAR technology for data capture on the High Voltage (HV) and 132kV overhead networks since 2020. By the end of 2024, a full cycle of data collection will be complete for the HV network and four cycles of data capture will have been carried out for the 132kV network. Moving forward, we are broadening the scope of LiDAR to also encompass the EHV network (33kV and 66kV).

LiDAR uses lasers to measure the time taken to reflect the light. This enables distances to be measured. The raw LiDAR data undergoes a systematic conversion from a series of points into a three-dimensional geospatial representation (or digital twin) of the overhead network, encompassing surrounding trees and vegetation.

By using LiDAR to assess overhead lines, we can identify the height of the lines and nearby structures, and the distance to those structures. The converted data allows us to enhance the evaluation of both safety and network reliability risks and therefore evolve our vegetation management contracts to be more targeted, enabling NGED to direct tree cutting to parts of the network in most need of cutting.

LiDAR data capture using helicopters is more suited to rural networks where the helicopters don't need to get close to properties. There are also other parts of the higher voltage networks where there are no fly areas, restricted airspace and noise sensitive areas, so while most of the network is represented in the geospatial data, there are some gaps where helicopters cannot fly.

The Proposal

NGED proposes to build on the geospatial visualisation and reporting systems currently deployed on the higher voltage overhead networks.

It is intended to extend the use of existing LiDAR capability (where feasible) supplemented by data sourced from satellites. The integration of LiDAR data with satellite imagery will form a powerful digital data set. It will enable the opportunity to uniquely identify each individual tree (assigning an ID) facilitating precise tracking and management of trees near overhead lines. It will also enable more comprehensive data to be assigned, such as tree species (to support tree growth projections), tree age, tree health and fall / contact risk, providing a comprehensive understanding of the vegetation near overhead lines, enabling improved management of vegetation to enhance resilience to significant weather events.

Implementing this approach will establish a unified geospatial system applicable to the HV network. The extension of the data capture represents a focused digitalisation strategy to enhance the safety, reliability, and resilience of the HV overhead network.

Rationale for levels of expenditure

It is proposed to establish the collection of HV data that is currently not captured by the helicopter teams (as outlined above) by the end of RIIO-ED2.

Delivery

There are no foreseen issues with acquiring the additional data capture and integrating the data sources.

Expenditure

The RIIO-ED2 costs are shown in the table below.

Network geospatial data capture (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	0.45	0.08	-	-	**0.52**
EMID	-	0.45	0.08	-	-	**0.52**
SWALES	-	0.22	0.04	-	-	**0.26**
SWEST	-	0.37	0.06	-	-	**0.44**
NGED	**-**	**1.49**	**0.25**	**-**	**-**	**1.74**

Link to Storm Arwen reports/recommendations

Page 7 of the BEIS Storm Arwen report states:

> *The storm damage was predominantly caused directly by strong winds or falling trees in both storms [Storm Arwen and Storm Eunice].*

Recommendation 1 of the Ofgem Storm Arwen Report states:

> *E3C should review current network infrastructure standards and guidance, including those for vegetation management and overhead line designs, to identify economic and efficient improvements that could increase network resilience to severe weather events.*

Enhanced data capture and visualisation will provide better identification of where trees are close to overhead lines, enabling prioritisation of both tree clearance activities and other resilience activities such as conversion of open wire overhead lines to more resilient covered conductors.

Supplementary work to be completed by NGED

The value of the data capture proposed with this initiative allows NGED to approach vegetation management with a focus on risk based, resilience targeted work. There are opportunities to take this work further and significantly enhance the visualisation and reporting system to introduce dynamic modelling of historical and forecasted storms to proactively identify network assets at potential risk of damage during stormy weather.

The development of storm modelling capability will combine with the LiDAR geospatial digital twin, along with supporting asset data to provide a risk based model that will assess the likelihood of vegetation effecting the network and the consequential impact on numbers of customers.

This integrated digitalised approach will play a crucial role to identify network risks, enabling prioritisation of activities including various Storm Arwen related initiatives listed below.

- It will inform decisions related to directing HV resilience cutting by identifying the HV feeders most at risk of vegetation related damage.
- It will help to identify the HV overhead network located within wooded areas that should be targeted for undergrounding to prevent damage from trees.
- It will help to identify low voltage open wire overhead lines that are affected by trees, to target which lines get converted to covered aerial bundled conductor.

There is no request as part of the reopener submission for funding to cover these supplementary activities. NGED proposes to develop this capability in-house to support the additional work being developed to enhance storm resilience.

Closely associated indirects (CAIs)

Background

A number of NGED's Storm Arwen reopener proposals are programmes of capital work that will require coordination, planning and project management. The costs provided for the specific initiatives are for the direct work that will be carried out on site and do not include the costs associated with indirect activities. There are ten initiatives that will require supporting indirect activities and these are shown in the table below:

Activity	CAIs
Undergrounding HV overhead lines in wooded areas	Yes
Replacing LV open wire overhead lines impacted by trees	Yes
Resilience tree cutting on HV circuits	Yes
Application of Pre-Fix detection for fault location	Yes
Torque tooling for LV fuses	-
Reducing customers in a protection zone to 1000	Yes
Automation of spur protection	Yes
LineSight detectors to identify nested and low conductor faults	Yes
Increased volumes of mobile generation	-
Using suitcase generators	-
Pre-emptive movement of resources	-
Enhancements to telephony servers	-
Inter-DNO interconnection	Yes
Inter-NGED DNO interconnection	Yes
Intra-NGED DNO spur interconnection	Yes
Network geospatial mapping	-

These initiatives are all additional material works, over and above those provided for by RIIO-ED2 baseline allowances, and therefore there is also no associated allowance for the related Closely Associated Indirects (CAIs).

Special Licence Condition 3.12 provides an Indirects Scaler to scale up allowances for CAIs as and when load related activities flex through uncertainty mechanisms. This provides indirect allowances using a rate of 0.108 of the direct costs.

Rationale for levels of expenditure

Since there is no existing defined Indirects Scaler for non-load activities, we propose that a similar approach (to that used for load) is used for the non-load related activities that attract CAI costs as part of this Storm Arwen re-opener. We propose the use of a multiplier of 0.108, consistent with Special Licence Condition 3.12, to the total costs of the ten initiatives that require supporting CAIs. We understand that the modelling that drove the calculation of the 0.108 in the licence was based on an input of capex which included load, non load and non-op capex, so the application of this to Storm Arwen (which are non load capex activities) is valid.

Expenditure

Applying the multiplier provides the following values of CAI costs.

Closely Associated Indirects (£m)						
Licence Area	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
WMID	-	-	0.47	0.49	0.45	**1.40**
EMID	-	-	0.40	0.40	0.37	**1.18**
SWALES	-	-	0.29	0.31	0.27	**0.86**
SWEST	-	-	0.56	0.60	0.61	**1.77**
NGED	**-**	**-**	**1.71**	**1.80**	**1.71**	**5.22**

10 Cost information

Expenditure profiles for initiatives for each licence area

The following tables provide an overview of the expenditure profiles for each of the proposed initiatives for each NGED licence area. The total of these values equates to the specific values that will be required for the SARt term in accordance with Part J, paragraph 3.2.69(b) of Special Licence Condition 3.2. The values are also provided in the supplementary Excel workbook submitted alongside this document.

West Midlands

WMID	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
(2a) Undergrounding HV overhead lines in wooded areas	-	-	0.51	0.51	0.51	**1.54**
(5a) Replacing LV open wire overhead lines impacted by trees	-	-	0.94	0.94	0.94	**2.81**
(6) Resilience tree cutting on HV circuits	-	-	0.46	0.46	0.46	**1.37**
(8) Application of Pre-Fix detection for fault location	-	-	0.19	0.38	0.67	**1.24**
(9) Torque tooling for LV fuses	0.03	-	-	-	-	**0.03**
(10) Reducing customers in a protection zone to 1000	-	-	1.03	1.03	1.03	**3.09**
(11) Automation of spur protection	-	-	0.02	0.02	0.02	**0.06**
(12/13) LineSight detectors to identify nested and low conductor faults	-	-	0.51	0.51	0.51	**1.53**
(14) Increased volumes of mobile generation	-	-	1.30	0.01	0.01	**1.33**
(14a) Using suitcase generators	-	-	0.04	-	-	**0.04**
(17) Pre-emptive movement of resources	0.02	0.02	0.02	0.02	0.02	**0.08**
(18) Enhancements to telephony servers	-	0.12	-	-	-	**0.12**
(20) Inter-DNO interconnection	-	-	0.20	0.20	-	**0.41**
(20a) Inter-NGED DNO interconnection	-	-	0.21	0.21	-	**0.43**
(20b) Intra-NGED DNO spur interconnection	-	-	0.26	0.26	-	**0.52**
(21) Network geospatial mapping	-	0.45	0.08	-	-	**0.52**
Closely associated indirects	-	-	0.47	0.49	0.45	**1.40**
Total	**0.05**	**0.59**	**6.24**	**5.04**	**4.61**	**16.52**

East Midlands

EMID	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
(2a) Undergrounding HV overhead lines in wooded areas	-	-	0.40	0.40	0.40	**1.20**
(5a) Replacing LV open wire overhead lines impacted by trees	-	-	0.48	0.48	0.48	**1.45**
(6) Resilience tree cutting on HV circuits	-	-	0.51	0.51	0.51	**1.52**
(8) Application of Pre-Fix detection for fault location	-	-	0.10	0.10	0.19	**0.38**
(9) Torque tooling for LV fuses	0.02	-	-	-	-	**0.02**
(10) Reducing customers in a protection zone to 1000	-	-	1.82	1.82	1.82	**5.47**
(11) Automation of spur protection	-	-	0.07	0.07	0.07	**0.21**
(12/13) LineSight detectors to identify nested and low conductor faults	-	-	-	-	-	**-**
(14) Increased volumes of mobile generation	-	-	1.49	0.01	0.01	**1.52**
(14a) Using suitcase generators	-	-	0.05	-	-	**0.05**
(17) Pre-emptive movement of resources	0.02	0.02	0.02	0.02	0.02	**0.08**
(18) Enhancements to telephony servers	-	0.12	-	-	-	**0.12**
(20) Inter-DNO interconnection	-	-	0.03	0.03	-	**0.06**
(20a) Inter-NGED DNO interconnection	-	-	0.05	0.05	-	**0.10**
(20b) Intra-NGED DNO spur interconnection	-	-	0.26	0.26	-	**0.52**
(21) Network geospatial mapping	-	0.45	0.08	-	-	**0.52**
Closely associated indirects	-	-	0.40	0.40	0.37	**1.18**
Total	**0.04**	**0.59**	**5.75**	**4.15**	**3.87**	**14.40**

South Wales

SWALES	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
(2a) Undergrounding HV overhead lines in wooded areas	-	-	0.52	0.52	0.52	**1.55**
(5a) Replacing LV open wire overhead lines impacted by trees	-	-	0.33	0.33	0.33	**0.99**
(6) Resilience tree cutting on HV circuits	-	-	0.45	0.45	0.45	**1.35**
(8) Application of Pre-Fix detection for fault location	-	-	0.19	0.38	0.67	**1.24**
(9) Torque tooling for LV fuses	0.02	-	-	-	-	**0.02**
(10) Reducing customers in a protection zone to 1000	-	-	0.29	0.29	0.29	**0.88**
(11) Automation of spur protection	-	-	0.07	0.07	0.06	**0.19**
(12/13) LineSight detectors to identify nested and low conductor faults	-	-	0.20	0.20	0.20	**0.59**
(14) Increased volumes of mobile generation	-	-	0.75	0.01	0.01	**0.76**
(14a) Using suitcase generators	-	-	0.02	-	-	**0.02**
(17) Pre-emptive movement of resources	0.02	0.02	0.02	0.02	0.02	**0.08**
(18) Enhancements to telephony servers	-	0.06	-	-	-	**0.06**
(20) Inter-DNO interconnection	-	-	0.24	0.24	-	**0.48**
(20a) Inter-NGED DNO interconnection	-	-	0.10	0.10	-	**0.20**
(20b) Intra-NGED DNO spur interconnection	-	-	0.26	0.26	-	**0.52**
(21) Network geospatial mapping	-	0.22	0.04	-	-	**0.26**
Closely associated indirects	-	-	0.29	0.31	0.27	**0.86**
Total	**0.04**	**0.30**	**3.75**	**3.16**	**2.81**	**10.06**

South West

SWEST	**2023/24**	**2024/25**	**2025/26**	**2026/27**	**2027/28**	**Total ED2**
(2a) Undergrounding HV overhead lines in wooded areas	-	-	0.70	0.70	0.70	**2.09**
(5a) Replacing LV open wire overhead lines impacted by trees	-	-	1.04	1.04	1.04	**3.11**
(6) Resilience tree cutting on HV circuits	-	-	0.61	0.61	0.61	**1.82**
(8) Application of Pre-Fix detection for fault location	-	-	0.48	0.86	1.24	**2.57**
(9) Torque tooling for LV fuses	0.02	-	-	-	-	**0.02**
(10) Reducing customers in a protection zone to 1000	-	-	1.13	1.13	1.13	**3.39**
(11) Automation of spur protection	-	-	0.46	0.46	0.45	**1.38**
(12/13) LineSight detectors to identify nested and low conductor faults	-	-	0.51	0.51	0.51	**1.53**
(14) Increased volumes of mobile generation	-	-	1.49	0.01	0.01	**1.52**
(14a) Using suitcase generators	-	-	0.05	-	-	**0.05**
(17) Pre-emptive movement of resources	0.02	0.02	0.02	0.02	0.02	**0.08**
(18) Enhancements to telephony servers	-	0.10	-	-	-	**0.10**
(20) Inter-DNO interconnection	-	-	-	-	-	**-**
(20a) Inter-NGED DNO interconnection	-	-	-	-	-	**-**
(20b) Intra-NGED DNO spur interconnection	-	-	0.26	0.26	-	**0.52**
(21) Network geospatial mapping	-	0.37	0.06	-	-	**0.44**
Closely associated indirects	-	-	0.56	0.60	0.61	**1.77**
Total	**0.03**	**0.49**	**7.36**	**6.19**	**6.32**	**20.39**

Special Licence Condition 3.2 SAR_t values

The following tables provide the expenditure profiles for the total of all the initiatives for each NGED licence area. These relate to the specific values that will be required for the SARt term in accordance with Part J, paragraph 3.2.69(b) of Special Licence Condition 3.2.

West Midlands

WMID	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
SAR_t	0.05	0.59	6.24	5.04	4.61	**16.52**

East Midlands

EMID	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
SAR_t	0.04	0.59	5.75	4.15	3.87	**14.40**

South Wales

SWALES	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
SAR_t	0.04	0.30	3.75	3.16	2.81	**10.06**

South West

SWEST	2023/24	2024/25	2025/26	2026/27	2027/28	Total ED2
SAR_t	0.03	0.49	7.36	6.19	6.32	**20.39**

11 Appendix A – Optioneering

Counterfactual – current operational arrangements

NGED has a range of existing arrangements for preventing faults, managing faults and ramping up response during a storm.

Preventative Asset Management

We carry out all inspection and maintenance that is due to ensure that we have up-to-date information about the condition of the network and carry out maintenance work within defined timescales. Where access issues prevent work taking place we put in place risk based actions to manage the sites until the work is complete, but this only applies to a very small number of locations each year.

Our asset replacement programme aims to remove poor condition assets from the network, with a specific focus on poor condition wooden poles. We aim to remove all wooden poles that are classified as decayed from the network within 12 months of the poor condition being identified. This ensures that we have minimal number of poor condition poles that could fail during a storm.

Damage from falling trees and tree related debris is more likely during stormy weather. We have a cyclical routine tree clearance programme across all voltages of the network which has recently been enhanced by the adoption of LiDAR information that allows us to prioritise clearance and manage work delivery more effectively.

We have focused our resilience tree clearance programme on the EHV network, making the majority of the 33kV and 66kV networks resilient by the end of RIIO-ED1.

Our flood defence programme has been in place since the start of DPCR5 and over the last 13 years we have been installing a variety of flood defence solutions at primary substations at greatest risk of flooding. We have further sites to protect during RIIO-ED2.

Network Protection

Inevitably network faults will occur. Across NGED we have around 50,000 faults per annum across all voltages. The greatest customer impact arises from the HV network and therefore we have had a number of existing initiatives that either limit the number of customers impacted or speed up restoration of supplies.

HV circuits can feed several thousand customers and therefore subdividing the network into smaller protection zones reduces the number of customers interrupted. This subdivision has been achieved by installing additional protection devices such as circuit breakers and auto-reclosers.

We have incorporated remote control communications into protection devices and switches to enable remotely controlled switching to quickly re-route power to parts of the network outside the faulted zone. This removes the need to send individuals to site for switching

The remote control has been further advanced through the application of automation, which assesses the network status and carries out switching operations based upon a rule set without the need for intervention from a control engineer.

Across all these activities we have targeted reducing the number of customers in a protection/remotely controlled switching zone to a maximum of 1,500 customers.

Field Resources

NGED uses internal resources for most activities, which includes responding to faults. The staff are based at local depots and therefore there is limited travel time to get to the location of faults.

During storms, teams from areas that are not affected can be redeployed to areas with high volumes of faults to provide cross-team support.

Where necessary, we can call upon the assistance from other DNOs, through the NEWSAC arrangements.

Contact centre resources

NGED has a track record of answering calls quickly. We have two contact centres based in East Midlands and South Wales that are sufficiently resourced for fast telephone response in normal weather.

We have the facility to work from home, especially if bad weather prevents getting into the office.

There are also provisions for additional resources from around the business to be re-deployed to take calls, should the need arise.

Materials availability

There are stores at each of the local depots, which have a stock of materials that can be utilised for storm response.

We also have 'quarantined' emergency stores which hold a stock of materials typically required during storm conditions, which can be utilised when there is a shortage of materials in the main local store.

Mobile generation fleet & fuelling

Where it is not possible to restore power from an alternative source or repairs may take a protracted amount of time we can deploy mobile generation to provide temporary power supplies. We have a range of different sizes of generators that can be used and also have contractual arrangements in place to get additional generators if required.

We primarily use our own generators, which if necessary can be re-deployed to different depots. This limits our reliance upon external contractual arrangements.

To ensure that we have adequate fuel stocks for the generators we have a fleet of bowsers and have fuel tanks at most depots. This makes us self-sufficient for supplies of diesel fuel, reducing our reliance upon commercial petrol stations, which could have supplies impacted during inclement weather.

Specialist vehicles and transport

NGED has a range of specialist vehicles, some of which are specifically for response after storms.

We have our own helicopter fleet that can be deployed to survey overhead lines to identify damage to speed up the location of faults. The helicopters can also be used to carry generators to remote locations and carry provisions to support stranded customers.

We have amphibious vehicles that can be used to access across flooded land and staff receive specialist training for working in floods.

Former fire engines have been re-purposed to provide large capacity pumps that can be utilised to remove water from substations.

Options for consideration following Storm Arwen recommendations

NGED has a considered twenty eight different initiatives as a response to Storm Arwen recommendations. The remainder of this appendix contains details of each of the proposals, with proposed initiatives being described in more details in section 9.

The following table lists the range of different options considered.

No	Description	Status
1	Undergrounding all LV & HV overhead lines	Rejected
2	Undergrounding overhead lines in wooded areas	Rejected
2a	Undergrounding HV overhead lines in wooded areas	Proposed
3	Undergrounding HV overhead lines with restricted cutting	Rejected
4	Replacing all HV overhead lines with covered conductor	Rejected
5	Replacing all LV open wire overhead lines with ABC	Rejected
5a	Replacing LV open wire overhead lines impacted by trees	Proposed
6	Resilience tree cutting on HV circuits	Proposed
7	Fund solar panel and battery storage in domestic properties	Rejected
8	Application of Pre-Fix detection for fault location	Proposed
9	Torque tooling for LV Fuses	Proposed
10	Reducing customers in a protection zones to 1000	Proposed
11	Automation of spur protection	Proposed
12	Nested fault detection using LineSight *	Proposed
13	Low conductor detection using LineSight *	Proposed
14	Increased volumes of mobile generation	Proposed
14a	Using suitcase generators	Proposed
15	Additional in-house resources	Rejected
16	Contracted additional resources	Rejected
17	Pre-emptive movement of resources	Proposed
18	Enhancements to telephony servers	Proposed
19	National Energy Outage Platform (NEOP)	Deferred
20	Inter-DNO interconnection	Proposed
20a	Inter-NGED DNO interconnection	Proposed
20b	Intra-NGED DNO spur interconnection	Proposed
21	Network geospatial mapping	Proposed
22	Visualisation and modelling of vegetation and network impact	ED2 baseline
23	Private LTE network	Deferred

Option 1 - Undergrounding all LV & HV overhead lines

Background

One of the reasons for protracted restoration of supplies following Storm Arwen was the amount of damage that had been sustained to overhead lines.

Strong winds, snow and ice accretion can lead to damage to wooden poles, conductors and associated equipment. Poles can be snapped, conductors brought down and windborne debris can cause flashovers.

Placing the conductors underground can avoid such damage and make the networks very resilient to storms.

However, the vast extent of overhead conductors currently used on the network means that undergrounding would be prohibitively expensive and delivery of the change would take many years. A practical timescale would be 50 years and therefore resilience would take a long time to establish.

Estimated volumes and costs

The following costs are based upon volumes of overhead line taken from network data as at 31 March 2023 and unit costs taken from Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement.

The indicative cost forecasts only consider the undergrounding of LV mains, LV services and HV conductor, assuming the same length will be required. In practice there would need to be a consideration of the installation routes of cables as they would not be able to follow the same routes as overhead lines and longer cable lengths would be required. There would also be significant additional costs for converting pole mounted switchgear and substations into ground mounted substations. Both longer routes and substation costs have not been costed.

Undergrounding all LV & HV overhead lines (excluding converting substations)

Licence Area		Total 50-year programme expenditure (£m)	RIIO-ED2 expenditure (£m)
WMID		2,804.0	168.2
EMID		2,127.9	127.7
SWALES		2,330.1	139.8
SWEST		3,486.6	209.2
NGED		**10,748.6**	**644.9**

Status

Rejected

Considering the cost of replacing the overhead lines alone suggests an investment of over £10.7bn over 50 years. The costs for the first three years of the programme in RIIO-ED2 would be £645m.

There would also be significant additional costs associated with taking more practical routes and converting overhead switchgear and transformers into ground mounted substations.

More targeted options are considered in options 2 and 2a.

Option 2 - Undergrounding overhead lines in wooded areas

Background

Approximately 510km of LV and HV overhead lines pass through designated wooded areas.

While strong winds can snap wooden poles and cause conductors to clash, damage is also caused by windborne debris, such as falling branches, and falling trees. Removing overhead lines from wooded areas means that the risk of damage from trees is significantly reduced during storms.

This option is aimed at undergrounding all LV mains overhead lines, LV overhead services and HV overhead lines in wooded areas and results in a focused undergrounding programme that is more targeted than option 1 which seeks to underground all LV and HV overhead lines.

Estimated volumes and costs

The following volumes are based upon the length of overhead line that goes through defined woods and forests (ancient woodlands, National Forest estate, local nature reserves and national nature reserves). It has been extracted from information held within NGED mapping systems. The volumes proposed for RIIO-ED2 are based upon a 20 year programme starting in 2025/26.

The unit costs are the same as those used in option 1, which are taken from Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement.
As per the wholesale undergrounding proposal (as per option 1), this programme would require substations and switchgear to be converted to being ground mounted. These costs have not been factored into the costs below.

Undergrounding of overhead lines in wooded areas (excluding converting substations)

Licence Area	Total 20-year Programme Expenditure (£m)	Total RIIO-ED2 Expenditure (£m)
WMID	16.1	2.4
EMID	12.3	1.8
SWALES	14.4	2.2
SWEST	23.0	3.5
NGED	**65.8**	**9.9**

Status

Rejected

The wholesale undergrounding of overhead lines in wooded areas would provide resilience benefits, but there are diminishing benefits from undergrounding LV circuits and services.

There would also be significant additional costs associated with converting overhead switchgear and transformers into ground mounted substations.

A further more targeted approach is considered in option 2a where undergrounding of HV focusses on circuits that impact greater numbers of customers. Also, options 5 and 5a (converting to covered conductor) provide a lower cost resilience solutions for LV circuits.

Option 2a – Undergrounding/diverting HV overhead lines in wooded areas

Background

This option is more targeted that options 1 and 2. Approximately 340km of HV overhead lines pass through designated wooded areas. Removing overhead lines from wooded areas means that the risk of damage from trees is significantly reduced during storms and focusing on the HV network will improve resilience for circuits that impact higher numbers of customers.

The opportunity to underground HV overhead lines may be constrained by the availability of routes through the wooded area and landowners may not grant permission due to concerns about damage to tree roots. This means that it is likely that routes will either have to follow established roads through wooded areas or have to be diverted around the wooded areas. There will also have to be consideration about the impact on substations within the wooded areas if cable routes are diverted.

By having the programme spread over 20 years, the initial years in RIIO-ED2 can be used to evolve the approach, which satisfies landowners and maintains existing supplies, whilst also improving network resilience.

Estimated volumes and costs

The following volumes are based upon the length of HV overhead line that goes through defined woods and forests (ancient woodlands, National Forest estate, local nature reserves and national nature reserves). It has been extracted from information held within NGED mapping systems which allows network assets to be associated with designated areas. The volumes proposed for RIIO-ED2 are based upon a 20 year programmed starting in 2025/26.

The unit costs are the same as those used in option 1, which are taken from Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement.

This programme may require substations and switchgear to be converted to being ground mounted. The targeted approach of the first stages of the programme will seek to avoid the need for such work and therefore the following costs only relate to undergrounding.

Undergrounding/diverting of HV overhead lines in wooded areas

Licence Area	Total 20-year Programme Expenditure (£m)	Total RIIO-ED2 Expenditure (£m)
WMID	10.3	1.5
EMID	8.0	1.2
SWALES	10.3	1.5
SWEST	14.0	2.1
NGED	**42.5**	**6.4**

Status

Proposed

The targeted undergrounding of HV overhead lines in wooded areas will provide resilience benefits, impacting circuits that feed hundreds of customers.

Option 3 - Undergrounding HV overhead lines with restricted tree cutting

Background

Permissions are obtained from landowners before cutting trees near overhead lines. In most cases landowners are happy to grant these permissions, but in some cases the landowner restricts the amount of cutting that can take place. This means that, while safety clearance are achieved, the trees may be closer to the line compared to where we have full permission to carry out the required cutting.

In the cases of restricted cuts there is a greater risk of damage during storms, due to the closer proximity of trees to the overhead lines.

This option considers undergrounding the spans of overhead line that are subject to restricted cutting. It is focused on the HV network, because at LV, restricted cuts are more common due to overhead lines passing near customer's gardens.

Estimated volumes and costs

The following volumes are based upon the number of spans with restricted cuts as a proportion of the total number of spans (~[redacted]). The proportion is applied to total network length to generate the length equivalent to the restricted cut spans and is based upon a 10 year programme.

The unit costs are taken from Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement. The specific cost used for the calculation is [redacted] per km for installing HV underground cable.

While wholesale undergrounding (as per option 1) would require substations and switchgear to be ground mounted, the focused undergrounding on spans with restricted cuts would not require this except in limited circumstances.

Undergrounding HV overhead lines with restricted cutting

Licence Area	Total 10-year Programme Expenditure (£m)	RIIO-ED2 Expenditure (£m)
WMID	13.1	3.9
EMID	0.4	0.1
SWALES	5.8	1.7
SWEST	5.4	1.6
NGED	**24.6**	**7.4**

Status

Rejected

While this initiative could reduce the risk of tree related damage in areas where trees are close to overhead lines, undergrounding spans with restricted cuts could lead to landowners defaulting to only granting restricted cuts, expecting more lines to be undergrounded.

The approach would also result in a stitch-like network alternating from underground to overhead which would introduce operational complexity and possible delays.

Option 4 - Replacing all HV overhead lines with covered conductor

Background
HV overhead lines can be made more resilient to windborne debris by converting them to covered conductors. This prevents flashovers that could be caused by items such as twigs coming into contact across phases. While covered conductor does offer some increased resilience from windborne debris, it will not prevent damage from a tree falling on the line. Covered conductors can also introduce other issues, for example small branches can lie on the conductor and gradually abrade the outer covering causing the conductor to fail at some time in the future. There are also safety, operational and installation considerations. For example it is not possible to simply replace the existing bare conductor with covered conductor. The sags, tensions, operating temperatures and electrical capabilities would be different from the original bare conductor resulting it potential statutory clearance infringements and mechanical over-loading of poles. Because of this the whole line route would need to be surveyed with the likelihood that many of the poles would need to be moved or replaced because they are either not strong or tall enough. As at March 2023, there is over [redacted] of bare HV conductors across all four NGED licence areas. It is impractical to re-conductor all this network in a short period and therefore it would take many years to obtain a significant improvement in resilience. Due to the amount of bare conductor it is proposed that the conversion of bare conductor to covered conductor would be a long term (e.g. 40 year) programme.

Estimated volumes and costs
The volumes are based upon network data as at 31 March 2023 and unit costs [redacted] are based upon Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement. The following cost forecast only considers the conductor changes and does not include the additional costs associated with replacing poles.

Replacing all HV overhead lines with covered conductor

Licence Area		Total 40-year Programme Expenditure (£m)	RIIO-ED2 Expenditure (£m)
WMID		406.4	30.5
EMID		330.2	24.8
SWALES		337.5	25.3
SWEST		456.5	34.2
NGED		**1,530.7**	**114.8**

Status	
Rejected	While some resilience would be gained by installing covered conductor, this type of conductor is still susceptible to some damage by trees. This option is rejected due to the high overall costs of over £1.5bn and associated operational and safety drawbacks. Even spreading this programme over 40 years would lead to costs of £115m in RIIO-ED2.

Option 5 - Replacing all LV open wire overhead lines with ABC

Background

LV overhead open wire lines can be made more resilient to windborne debris by converting them to Aerial Bundled Conductors (ABC) which are covered conductors twisted together to form a single multi-phase arrangement. Using ABC prevents flashovers that could be caused by items such as twigs coming into contact across phases, which can be more likely on LV networks due to the proximity to customers' gardens.

ABC covered conductors will not prevent the damage that would be caused by a tree falling on the line, but would give some protection from smaller windborne items.

Estimated volumes and costs

The conductor volumes are based upon network data as at 31 March 2023, which identifies the amount of conductor that is open wire (which ranges from 52% in East Midlands to 75% in West Midlands). This derives overall volumes that form a 20 year programme. Three years of the programme is to be delivered in RIIO-ED2.

As part of the work there will be a requirement to change some poles. It is assumed that 10% of poles associated with the open wire being changed will need to be replaced.

The unit costs for the replacement poles and conductor are based upon Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement.

Replacing all LV open wire overhead lines to ABC

Licence Area	Total 20-year volumes of conductor (km)	Total 20-year volumes of poles (units)	Total 20-year programme costs (£m)	RIIO-ED2 Expenditure (£m)
WMID	[redacted]	[redacted]	109.2	16.4
EMID	[redacted]	[redacted]	55.8	8.4
SWALES	[redacted]	[redacted]	46.7	7.0
SWEST	[redacted]	[redacted]	118.4	17.8
NGED	[redacted]	[redacted]	**330.0**	**49.5**

Status

Rejected

While resilience would be gained by installing covered conductor, this option is rejected since it considers replacing all LV open wire, even if it not directly affected by trees. Option 5a is a more targeted option that considers LV open wire specifically impacted by trees.

Option 5a - Replacing LV open wire overhead lines impacted by trees

Background

While it may not be necessary to replace all LV overhead open wire lines with Aerial Bundled Conductors (ABC), as per option 5, a more targeted programme focused on spans near trees, would make LV circuits more resilient to windborne debris.

ABC prevents flashovers that could be caused by items such as twigs coming into contact across phases, which can be more likely especially where LV networks are in close proximity to trees in customers' gardens. ABC covered conductors will not, however, prevent the damage that would be caused by a tree falling on the line, but would give some protection from smaller windborne items and tree contact that can arise in strong winds.

Estimated volumes and costs

The volumes of open wire conductor are derived from NGED mapping data that records the types of conductor, which identifies the amount of conductor that is open wire ranges from 52% in East Midlands to 75% in West Midlands. These lengths of open wire conductors are then multiplied by the proportion of LV lines subject to trees taken from data in table CV29 in the annual RRP return for 2022/23. This gives the length of open wire conductor that is subject to trees.

It is assumed that [redacted] % of this length would give a performance benefit if converted to ABC, because while the remaining [redacted] % is subject to trees they are less likely to cause an issue during a storm. This derives overall volumes that form a 20 year programme. Three years of the programme is to be delivered in RIIO-ED2.

In addition to changing the conductor, there may also be a requirement to relocate or change some poles. It is assumed that [redacted] % of poles associated with the open wire being changed will need to be replaced.

The unit costs for the replacement poles and conductor are based upon Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for asset replacement.

Replacing LV open wire overhead lines impacted by trees

Licence Area	Total 20-year volumes of conductor (km)	Total 20-year volumes of poles (units)	Total 20-year programme costs (£m)	RIIO-ED2 Expenditure (£m)
WMID	[redacted]	[redacted]	18.8	2.8
EMID	[redacted]	[redacted]	9.6	1.4
SWALES	[redacted]	[redacted]	6.6	1.0
SWEST	[redacted]	[redacted]	20.8	3.1
NGED	[redacted]	[redacted]	**55.8**	**8.4**

Status

Proposed

This is a focused programme, addressing LV open-wire conductor that is in proximity to trees and susceptible to damage from them. Since the proposed programme is spread over 20 years, the cost in RIIO-ED2 is £8.4m.

Option 6 - Resilience tree cutting on HV circuits

Background

The government mandated resilience tree clearance through the changes implemented into the Electricity Safety Quality and Continuity Regulations made in 2006. The associated documentation suggested that the work should be targeted at strategic circuits. NGED has therefore been focusing its reliance tree clearance activities on EHV networks. NGED's price control submissions have been solely focused on clearance at EHV.

This option considers expanding the scope of resilience clearance to cover a proportion of the HV overhead line network. The prime reason for carrying out the resilience clearance at HV is to reduce the number of faults during storms.

The proposed approach for the work is to target main lines in the first protection zone from primary substations. This is because faults in the first protection zone cause the source circuit breaker to trip, interrupting supplies to all the customers on the circuit, whereas faults in subsequent protection zones impact fewer customers. While automation will restore supplies outside the faulted zone from alternative sources, focusing on the first protection zone will lead to fewer customers being impacted by short interruptions.

Estimated volumes and costs

Approximately [redacted] % of the overhead network falls within the first protection zone of HV circuits, with the remainder being downstream of the first protection zone. The following volumes are based upon the overhead network as at 31 March 2023.

The unit costs are the same as the benchmark values used for HV resilience cutting, which are based upon Ofgem values from RIIO-ED2 final determination disaggregated cost benchmarking for tree clearance. The specific cost used for the calculation is [redacted].

The total programme shown below would be challenging to deliver over a single 5 year price control and therefore it is proposed that this is a 20-year programme in a similar way to the EHV programme being carried out over 20 years.

Resilience tree cutting on HV circuits

Licence Area	Total HV Network Length	Length associated with first protection zone	Total 20-year programme expenditure (£m)	RIIO-ED2 expenditure (£m)
WMID	14,453	[redacted]	9.1	1.4
EMID	11,742	[redacted]	10.1	1.5
SWALES	12,002	[redacted]	9.0	1.3
SWEST	16,234	[redacted]	12.1	1.8
NGED	**54,431**	[redacted]	**40.4**	**6.1**

Status

Proposed

This proposal will provide resilience benefits by reducing the risk of tree related damage during storms. The HV network has not previously been a focus of resilience clearance in NGED and therefore such activity would be additional to what has formed the basis of the ED2 price control settlement.

Option 7 - Fund solar panel and battery storage in domestic properties

Background

Domestic properties can be made virtually self-sufficient for power by installing solar panels to generate electricity and battery storage to store any excess that is generated, but not immediately required. The battery storage can be used to provide supplies when the solar panels are not generating (e.g. at night) or when mains supplies are interrupted.

One way of removing reliance on the resilience of the network is to make the properties resilient instead of the network. This moves investment from the network to individual properties.

Such an approach would require agreement from customers to have installations of solar panels and battery storage. Not all properties may be suitable or have space for such installations. Furthermore, property owners may not want them installed (as demonstrated by people not accepting less intrusive smart meter installations). The consequences would be intermittent resilience of properties that may also require network resilience for those customers without a resilient property.

NGED has over 8 million customers, most of which are domestic properties.

Estimated volumes and costs

The following volumes are based upon customer numbers as reported on 31 March 2023 (based on customer numbers at 30 September 2022) and estimated unit costs of [redacted] per property [redacted] for the solar panels and [redacted] for the battery storage).

Rolling out the programme would take time and the forecast assumes a 20-year programme. It considers all customer numbers and therefore represent an upper limit on the expenditure, which could be lower for more targeted investment on properties fed by overhead lines.

Installing solar panels and battery storage in properties

Licence Area	Customer numbers	Total 20-year expenditure (£m)	RIIO-ED2 expenditure (£m)
WMID	2,522,965	25,229.7	3,784.4
EMID	2,696,717	26,967.2	4,045.1
SWALES	1,155,365	11,553.7	1,733.0
SWEST	1,653,816	16,538.2	2,480.7
NGED	**8,028,863**	**80,288.6**	**12,043.3**

Status

Rejected

The solution is dependent upon customer uptake and willingness, which will lead to intermittent domestic resilience.

Furthermore, the overall cost of £80bn is prohibitively expensive, even over 20 years. Just targeting a single HV feeder with [redacted] customers would lead to costs of £50m.

Option 8 - Application of Pre-Fix detection for fault location

Background

NGED has been carrying out an innovation project called Pre-Fix, which is seeking to develop an approach to identify disturbances on the network being caused by potential faults, in order to target removal of defective components before they actually cause a fault.

The methodology is aiming to be vendor-agnostic, looking at using technology from a variety of providers to develop a more flexible way of utilising existing monitoring equipment, alongside new devices.

The Pre-Fix innovation project is gaining more experience of predicting the location of potential faults, but a spin off benefit has emerged which enables the location of actual faults. This is especially beneficial for overhead line faults that may arise during storms, as it is provides a narrower area where the network needs to be patrolled. By having a more targeted area to investigate, the location of faults can be carried out more quickly, thus reducing the time customers are off supply.

Estimated volumes and costs

The solution relies upon monitors at primary substations and monitors installed on feeders. The approach to implementation is therefore based upon rolling out to substations and the associated outgoing circuits, rather than just for specific circuits.

Since the application of the technology for storms is primarily related to the location of overhead line faults, we are proposing to install it on substations where the outgoing circuits have more than 80% of the network constructed on overhead lines.

Analysis of the HV disaggregated data shows that there are [redacted] primary substations that meet this criteria, which represents approximately 20% of substations that have HV feeders. The volumes have been spread across RIIO-ED2 and RIIO-ED3 with the last three years of RIIO-ED2 in the ratio of 1:2:3 across the years and RIIO-ED3 carrying on at the same rate as the last year of RIIO-ED2. This allows for lower volumes in the earlier part of the rollout to evolve the best ways of deploying the devices.

The cost per installation [redacted] is a blend of different approaches that depend upon the number of feeders from a primary substation and amount of branching on the network.

Application of Pre-Fix detection for fault location

Licence Area	Total Number of substations	Forecast total costs (£m)	ED2 Number of substations	ED2 costs (£m)
WMID	[redacted]	4.3	[redacted]	1.2
EMID	[redacted]	1.3	[redacted]	0.4
SWALES	[redacted]	4.4	[redacted]	1.2
SWEST	[redacted]	9.0	[redacted]	2.6
NGED	[redacted]	**19.1**	[redacted]	**5.4**

Status

Proposed

The technical solution allows us to use equipment from different vendors in combination to provide a lower cost solution compared to some vendor specific offerings.

Targeting the application of the technology to overhead lines would speed up restoration during storms.

Option 9 - Torque tooling for LV fuses

Background

During the storms in 2021, sections of LV overhead network could not be isolated because the LV fuses could not be removed without the aid of line teams. It has been identified that LV fuses are being overtightened to an extent that when removal is required, the fuses are being damaged. This exposes live components below statutory height, which then requires overhead line teams to attend to replace the fuses, utilising resources that could be deployed elsewhere.

To prevent over-tightening, a new torque tool has been designed and manufactured. The two-way torque head prevents over tightening either when tightening the fuse or when removing the fuse as it limits the torque applied to the wing nut, thus preventing damage.

The new tool forms part of the tool kit for operational technicians and overhead lines teams.

Estimated volumes and costs

The tool has been manufactured and procured at a unit cost of [redacted]. The costs incurred are as detailed below.

Application of pre-fault technology

Licence Area		Number of devices	Forecast total costs (£m)
WMID		[redacted]	0.03
EMID		[redacted]	0.02
SWALES		[redacted]	0.02
SWEST		[redacted]	0.02
NGED		[redacted]	**0.10**

Status

Proposed

The tools have been procured and will be distributed to staff during the first year of RIIO-ED2.

Option 10 - Reducing customers in a protection zone to 1000

Background

HV circuits are mainly designed to operate as radial feeds; this means that the flow of power is from the source primary substation to open points at the ends of the feeder, where the open points are inter-connected to other circuits.

The main protection device for the circuit is a circuit breaker positioned at the source primary substation, which can interrupt the flow of power when a fault is detected on the circuit. Relying solely on this circuit breaker means that all the customers on a feeder will be interrupted.

The number of customers impacted by a fault can be reduced by subdividing circuits into smaller zones by installing additional protection devices (such as reclosing circuit breakers, intelligent fuses) along the circuits to prevent customers upstream of the devices from being affected by faults downstream of the devices.

Applying remote control to these devices and incorporating automation logic in control systems allows power to be quickly rerouted or ‘switched’ without the need to send a person to site. The automation algorithms use information from fault passage sensors to identify which section of the network contains the fault and then communicate with remotely controlled devices to restore supplies to the maximum number of customers possible.

While such investment does not prevent faults during storms, it can reduce the impact and automatically restore more customers, minimising the impact of faults that occur. In RIIO-ED1 we targeted 1,500 customer as the maximum remaining off supply after automation had operated.

Estimated volumes and costs

The proposed volumes of activity is based upon reducing the maximum number of customers to 1,000.

The protection zones to be addressed are a combination of urban and rural situations. Rural overhead line circuits can utilise pole-mounted reclosers, while in urban situations ground-mounted switchgear with actuators are used. Analysis of the number of substations in each protection zone suggests that [redacted] % of installations will be on urban installations and therefore the unit cost used is a blend of [redacted] % pole-mounted and [redacted] % ground-mounted switchgear costs.

Protection zones

Licence Area		Number of installations	RIIO-ED2 expenditure (£m)
WMID		[redacted]	3.1
EMID		[redacted]	5.5
SWALES		[redacted]	0.9
SWEST		[redacted]	3.4
NGED		[redacted]	**12.8**

Status

Proposed

By subdividing the network into smaller protection zones, automatic switching can restore more customers in less than 3 minutes, reducing the number of customers impacted by longer duration outages. The overall programme cost is based upon delivering the programme within RIIO-ED2.

Option 11 - Automation of spur protection

Background

Historical practice, especially in the South West, has been to install fuses on spurs to prevent faults on the spurs from impacting customers on the rest of the circuit. This has been effective, but during storms it requires staff to be sent to site to replace the fuses. This leads to protracted restoration times.

NGED has been trialling single phase circuit breakers than can be installed in the same fittings used for fuses. The use of such circuit breakers would mean that for transient faults the spurs can be restored automatically, rather than relying on someone visiting site.

There is a further benefit by using single phase circuit breakers. They are more sensitive to low current faults, which means that they will operate for more faults than fuses, preventing the need for upstream devices to operate. This means that customers upstream of the spur will be affected by fewer faults on the spur.

The application of this technology would be focused on spurs with high numbers of customers to take advantage of the automatic restoration functionality benefitting the greatest number of customers. There is a secondary focus, where long spurs, with a greater likelihood of faults will also be targeted to take advantage of the extra sensitivity of these devices so that customers upstream are not affected by faults on the spurs.

Estimated volumes and costs

The volumes have been derived by analysing network data for the number of customers and network length downstream of existing HV fuses and applying the criteria of spurs having more than 150 customers and 10km length.

The unit costs represent a typical cost which considers installations on three phase spurs.

Automation of spur protection

Licence Area		**Number of installations**	**RIIO-ED2 expenditure (£m)**
WMID		[redacted]	0.06
EMID		[redacted]	0.21
SWALES		[redacted]	0.19
SWEST		[redacted]	1.38
NGED		[redacted]	**1.84**

Status

Proposed

The automation of spur protection will reduce the impact of transient faults on customers on the spur and the increased sensitivity of the devices will prevent some faults on the spurs affecting customers on the main line.

The RIIO-ED2 cost of £1.8m is based upon delivering the whole programme within RIIO-ED2.

Option 12 - Nested fault detection using LineSIGHT

Background

During storms multiple faults can occur on the same part of the network at the same time. DNOs will generally be aware that an outage has happened, but will not be aware that multiple faults exist unless the multiple faults are obvious (e.g. in close proximity with clear evidence of two sites of damage or from two separate reports from members of the public).

Restoration and repair teams will focus on repairing the first fault found and only once this is repaired and the circuit is being returned to service that the second fault may be identified, either as part of the testing process or when a circuit breaker is closed and it trips again.

These multiple or "nested" faults lead to protracted outage times, because the faults tend to be repaired sequentially instead of in parallel. During storms this also has the impact of tying up resources for longer periods of time, thus delaying restoration from other parts of the network.

Monitoring equipment and software called LineSIGHT has been developed, under an ENWL innovation project, that continuously monitors the network and establishes a normal running 'signature'. When faults occur, there is a disturbance to the signature and a location of the fault can be estimated. The equipment can identify the location of individual network issues, but it can also be used to identify multiple nested faults.

Estimated volumes and costs

The volumes have been derived by considering the number of circuits that have a propensity to fault during storms. We have identified that there are [redacted] circuits that have had 10 or more faults during exceptional events since the start of RIIO-ED1. Since these are high risk circuits, it is assumed that monitoring devices will be installed at an average of eight per circuit.

The unit costs represent a typical average cost of the monitoring devices. For consistency with existing arrangements in the RIIO-ED2 price control we have used the unit cost from ENWL's Special Licence Condition 3.15 for installation of LineSIGHT technology (i.e. [redacted]).

Nested fault detection using LineSIGHT

Licence Area		Number of installations	RIIO-ED2 expenditure (£m)
WMID		[redacted]	1.5
EMID		[redacted]	-
SWALES		[redacted]	0.6
SWEST		[redacted]	1.5
NGED		[redacted]	**3.6**

Status

Proposed

Since this is nascent technology, it is proposed to install it on a limited number of circuits that have a propensity to fault during exceptional events.

The overall programme delivers [redacted] sensors across [redacted] circuits and will be completed in RIIO-ED2. This is a duplication of the costs shown in option 13 and only one lot of the allowances is required.

Option 13 - Low conductor detection using LineSIGHT

Background

Overhead line conductor components such as binders and jumpers can sometimes fail allowing conductors to fall from insulators, causing the conductors to hang low (below statutory ground clearance).

Since the conductors are not in contact with ground, network protection is unlikely to operate, thus leaving the conductors live and in a dangerous state, with risk to members of the public and livestock.

Monitoring equipment and software called LineSIGHT has been developed, under an ENWL innovation project, that continuously monitors the network and establishes a normal running 'signature'. When faults occur, there is a disturbance to the signature and a location of the fault can be estimated. The equipment has been shown to also be able to detect when low conductor situations arise, due to specific changes to the impedance characteristics.

Estimated volumes and costs

While low conductors can occur anywhere on the overhead line network, the volumes have been derived by considering the number of circuits that have a propensity to fault during storms. The data used is the same as per option 12, but is repeated again below.

We have identified that there are [redacted] circuits that have had 10 or more faults during exceptional events since the start of RIIO-ED1. Since these are high risk circuits, it is assumed that monitoring devices will be installed at an average of four per circuit.

The unit costs represent a typical cost of the monitoring devices. For consistency with existing arrangements in the RIIO-ED2 price control we have used the unit cost from ENWL's Special Licence Condition 3.15 for installation of LineSIGHT technology (i.e. [redacted]).

Automation of spur protection using LineSIGHT

Licence Area		Number of installations	RIIO-ED2 expenditure (£m)
WMID		[redacted]	1.5
EMID		[redacted]	-
SWALES		[redacted]	0.6
SWEST		[redacted]	1.5
NGED		[redacted]	**3.6**

Status

Proposed

Since this is nascent technology, it is proposed to install it on a limited number of circuits that have a propensity to fault during exceptional events.

The overall programme is based upon delivering [redacted] sensors across [redacted] circuits and will be completed in RIIO-ED2. This is a duplication of the costs shown in option 12 and only one lot of the allowances is required.

Option 14 - Increased volumes of mobile generation

Background

NGED has utilised mobile generation for temporary restoration of power for a number of years. There is an existing fleet of NGED owned mobile generation or differing sizes that can be utilised for a range of different outage situations. They are dispersed across all depots and teams are trained on how to connect them.

The NGED fleet is supplemented with commercial arrangements with third party providers and these services are utilised when specific generator sizes are required or extra generators are needed. However, during storms these supplementary services may not be available or the generators may already be being used for other commercial customers, so they are not a fully reliable source of alternative provision.

NGED treats the restoration of supplies as a priority. This is especially important during storm situations because of the high volumes of customers that can be affected. Where customers can be restored by switching on the network, this is carried out either automatically or through manual operations on site. Where it is not possible to restore supplies by switching, mobile generation can be used to provide temporary power supplies.

While there are good existing arrangements in place, they could be supplemented by having more mobile generation available, enabling more customers to be provided with temporary supplies during storms.

Estimated volumes and costs

The forecast is based upon providing an additional two generators per depot, leading to the procurement of an additional [redacted] mobile generators. This will lead to around a [redacted] % increase in the population of mobile generators.

The unit cost used [redacted] for the forecast is based upon a blend of unit costs for different sizes of generators, some of which require to be trailer mounted. The costs are consistent with the ED2 EJP002, submitted at part of the ED2 price control submission which sought to replace the most polluting generators on the fleet.

Increased volumes of mobile generation

Licence Area		**Number of generators**	**RIIO-ED2 expenditure (£m)**
WMID		[redacted]	1.3
EMID		[redacted]	1.5
SWALES		[redacted]	0.8
SWEST		[redacted]	1.5
NGED		[redacted]	**5.1**

Status

Proposed

The proposed capital expenditure will increase the generator fleet by [redacted] %, allowing more customers to be kept on supply not only during storms, but also during faults in normal weather and for planned work. The equipment will be utilised more widely than just for storms and therefore will provide a useful addition to the restoration capability of NGED.

Option 14a – Utilising suitcase generators

Background
Suitcase generators are small compact generators that are normally used for leisure pursuits such as camping and caravanning. They come in a variety of ratings and can be used to provide the power to use a microwave, keep fridges running and power up communications such as broadband routers/mobile phones. They can be used during power cuts to provide supplies for essential requirements for a domestic property. They are easy to connect and quick to install. Ideally, during power cuts we would utilise larger mobile generators to provide adequate power for numerous customers. But where this is not practical or mobile generation is already being utilised (as may be the case in storm situations), the provision of a suitcase generator would provide temporary, albeit limited, power. We propose to utilise these specifically for customers in vulnerable situations. This would ensure that vulnerable customers have some form of supply for basic essential requirements.

Estimated volumes and costs
The forecast is based upon providing five suitcase generators per depot, leading to the procurement of [redacted] suitcase generators across NGED. The number per depot is quite low, but we anticipate utilising suitcase generators from adjacent depots for larger incidents. The unit cost for such units is around [redacted] each and therefore the total cost of this initiative is £170k.

Utilising suitcase generators

Licence Area		Number of generators	RIIO-ED2 expenditure (£m)
WMID		[redacted]	0.04
EMID		[redacted]	0.05
SWALES		[redacted]	0.02
SWEST		[redacted]	0.05
NGED		[redacted]	**0.17**

Status	
Proposed	The proposed capital expenditure will allow us to target the provision of temporary power supply for basic essential requirements of vulnerable customers. Furthermore, these devices could also be used for routine fault restoration during normal weather, where we could use them in a targeted manner for vulnerable customers.

Option 15 - Additional in-house resources

Background

NGED has a well-trained in-house resource for jointing, fitting, overhead-line works and network operation. These teams are based across 27 regional distribution areas some of which have sub-depots for further local focus. This dispersed resource means that we can respond quickly to local faults.

Under normal weather conditions, the resources are adequate to manage without assistance from other teams. However, when storms arise, causing high volumes of faults, assistance may be required from other teams.

It is rare for storms to affect all parts of NGED (e.g. as evidence by Storm Ciaran on 2 November 2023 which mainly affected the South West area) and therefore teams from geographic areas that are not directly affected can be redirected to provide assistance. Depending on the scale of the impact, this assistance could be from adjacent areas, other parts of the impacted licence area or from other NGED licence areas.

In most storm circumstances, NGED has sufficient levels of resources to be self-sufficient, but where there is more widespread impact, NGED has the opportunity to call upon the industry NEWSAC arrangements and get assistance from other DNOs.
Even with these arrangements in place, response could be improved if there were additional resources.

However there is a drawback. There is an ongoing cost for additional resources and having them available just for storms is inefficient. Storms happen infrequently and therefore additional resources would be under-utilised if they were employed simply to bolster resources for storm events.

It is more appropriate to evolve and grow in-house resources to deliver required levels of routine activity. This additional resource is driven by the need to deliver non-storm activities and then once available can add to the pool of people available to assist during storms.
It is therefore better to grow staff for routine work delivery, rather than have additional resources simply to manage during storms.

Estimated volumes and costs

Due to the inefficiency of this option, we reject it without providing a costing.

Status

Rejected

Option 16 - Contracted additional resources

Background
As described in option 15, NGED has a well-trained in-house resource, dispersed across 27 regional distribution areas that provides a fast response to local faults. In storm situations resources from other teams can be redeployed to assist in areas affected by storms and if necessary assistance can be called upon from other DNOs under the industry NEWSAC arrangements. These arrangements have worked well for historical storms. There are however, third party contractors that have resources that could be utilised during storm situations. Where it is necessary to supplement existing resources to carry out routine works, NGED establishes contracts for such arrangements. NGED therefore has commercial experience of using additional resources. Should it be viewed as being necessary to have additional resources to assist in storms, NGED will pursue this under normal working arrangement outside of the Storm Arwen re-opener.

Estimated volumes and costs
None

Status	
Rejected	Since such an option would be considered under normal operations, it is rejected for the Storm Arwen re-opener.

Option 17 – Pre-emptive movement of staff

Background

The utilisation of staff from other parts of the company to assist local teams with response and restoration activities is a well-established practice within NGED. We also have established processes for sharing resources across DNOs. This mutual support is nothing new and demonstrates a willingness by staff to work collaboratively to restore power supplies.

When a storm is forecast we carry out a range of preparedness actions, such as cancelling planned work, boosting stand-by resources, resourcing local depots out of hours, etc.
When the storm hits and faults start to occur, local teams are deployed to investigate the causes and restore customers. The focus is getting customers back on supply, either through temporary arrangements, mobile generation or a permanent repair. Ideally, permanent repairs would be carried out, but these may tie-up resources that could be being used for other restoration activities. Hence alternatives such as safe temporary repairs may be made, which require follow up actions to make a permanent repair. As a storm progresses, its impact is regularly reviewed to identify if assistance is required in a specific 'busy' area and which resources in less impacted areas can be released to assist. This currently happens once the storm has started.

For certain storms, such as Storm Ciaran in early November 2023, the weather forecast predicted that very high winds would impact a specific area (i.e. the English Channel) and that other areas would have less impact. Consequently, for NGED, there was a high volume of faults concentrated in the South West peninsular affecting Cornwall and Devon. On review of the storm, it was identified that performance could have been improved if resources from other teams had been available sooner. In order to achieve this it would require resources to be mobilised ahead of the storm 'landing'. This would require hotels and subsistence to be arranged for the staff that were being mobilised ahead of the need.

This option considers providing funding for such pre-emptive mobilisation for one concentrated storm in each licence area per annum. The costs relate to providing accommodation for 50 staff for three nights.

Estimated volumes and costs

The forecast is based [redacted] person-nights of accommodation and subsistence per licence area per-annum, assuming a cost per person-night of [redacted].

Pre-emptive movement of staff

Licence Area		Number of person-nights	RIIO-ED2 expenditure (£m)
WMID		[redacted]	0.08
EMID		[redacted]	0.08
SWALES		[redacted]	0.08
SWEST		[redacted]	0.08
NGED		[redacted]	**0.32**

Status

Proposed

The proposed £600k opex expenditure will allow us to respond more quickly during certain types of localised storms.

Option 18 – Telephony system enhancements

Background

NGED uses a variety of interconnected telephone systems to answer calls from customers, provide outgoing communications to customers and enable internal business communications.

During storms, these communication systems handle high volumes of calls and experience during Storm Arwen showed that improvements can be made to both messaging systems and server capacity.

A number of enhancements have already been implemented including changing the system to provide event driven messaging, incorporating a time of restoration for proactive calls and upgrade of auto dialling systems.

It has been identified that the overall capacity of telephony servers has impacted the operation of the software and therefore early upgrade of the server is proposed to provide the necessary capacity to prevent issues during periods of high call volumes.

Estimated volumes and costs

The levels of expenditure relate to the procurement and installation of larger virtual servers for IP telephony applications. These will provide the necessary capacity to manage high volumes of incoming calls from customers as well as other telephony requirements during storms.

Telephony system enhancements			
Licence Area			**RIIO-ED2 expenditure (£m)**
WMID			0.12
EMID			0.12
SWALES			0.06
SWEST			0.10
NGED			**0.41**

Status

Proposed

The proposed £410k expenditure will ensure that telephony systems are resilient under circumstances of high call volumes.

Option 19 – National Energy Outage Platform (NEOP)

Background

In June 2023 the Government Department of Energy Security and Net Zero (DESNZ) put forward proposals for a National Energy Outage Platform (NEOP). The original intent and scope of the project was to gather data from individual company application programming interfaces (APIs) and present them through a common dashboard.

The DNOs are working collaboratively through the Energy Networks Association (ENA) to determine what data is available, how the data can be aligned into a consistent format and work on the development of a platform.

The platform will bring together information from all GB DNOs through their APIs into one place. The dashboard will be designed to pull data at appropriate intervals that is relevant to its practicality and urgency. Currently it is expected that the dashboard data would be automatically updated, but development work is ongoing to determine what is possible.

It is not intended for NEOP to replace DNOs own systems. It is to facilitate government departments having an overview of outages across GB.

The feasibility of the system is yet to be determined and therefore the final scope and costs are uncertain.

Estimated volumes and costs

The ENA has contracted with a supplier to work on the development of NEOP. The DNOs are supporting the work through ENA arrangements and will incur their usual allocation of costs based upon customer numbers.

NGED has 26.5%% of GB customers and therefore its proportion of the project costs are currently £0.16m out of the total anticipated costs to date of £0.6m. These costs are allocated across the NGED licence areas using the standard NGED costs allocations of 30% WMID, 30% EMID, 15% SWALES, 25% SWEST.

The following only represents the initial ENA project costs. More costs will emerge as the project develops.

NEOP system development

Licence Area			RIIO-ED2 expenditure (£m)
WMID			0.05
EMID			0.05
SWALES			0.02
SWEST			0.04
NGED			**0.16**

Status

Deferred

Since the scope and requirements of NEOP project are not developed enough and the final costs are unknown, it is not possible at this stage to put forward a view on the amount that should be included in the Storm Arwen Reopener. Funding may therefore be requested as part of the Digitalisation reopener in January 2026.

This option is therefore deferred (note that it has not been rejected).

Option 20 – Inter-DNO Interconnection

Background

Each DNO has developed its own network independent of other DNOs, within their geographical boundaries. Most circuits at the boundaries of the network will be at the ends of feeders from primary substations, with many being on spurs without interconnection.

Two adjacent DNOs may have developed network towards their own boundaries and have network in close proximity. Both of these networks may be on spurs and not have interconnection to alternative sources. However, it may be possible to provide alternative feeds from the adjacent DNO to make the supplies at remote ends of network more resilient with alternative sources of power.

ENWL, SP, NPG and NGED have worked collaboratively to identify cross border inter-DNO interconnection opportunities.

To achieve this the DNOs have uploaded HV network mapping data into a common system (HV overhead, HV underground, pole mounted transformers and ground mounted transformers). The borders have been manually analysed to identify interconnection opportunities.

Estimated volumes and costs

The assessment of interconnection candidates has given a high/medium/low benefit rating for each DNO.

Interconnections that provide a medium or better benefit for either DNO, have been costed using Ofgem disaggregated benchmarking unit costs for asset replacement for the main assets that are required.

Inter-DNO interconnections

Licence Area			**RIIO-ED2 expenditure (£m)**
WMID			0.41
EMID			0.06
SWALES			0.48
SWEST			-
NGED			**0.94**

Status

Proposed

There are a limited number of inter DNO interconnection opportunities that will provide a resilience benefit for customers at the ends of feeders.

DNOs have worked collaboratively to identify the best locations for interconnection.

Option 20a – Inter-NGED DNO Interconnection

Background

Each DNO has developed its own network independent of other DNOs, within their geographical boundaries. This also applies to the four NGED licence areas where prior to amalgamation the four areas were managed independently in legacy organisations.

Consequently, within NGED DNOs, circuits at the boundaries of the geographic areas will be at the ends of feeders from primary substations, with many being on spurs without interconnection.

In a similar way to option 20, two adjacent DNOs may have developed network towards their own boundaries and have network in close proximity. Both of these networks may be on spurs and not have interconnection to alternative sources. However, it may be possible to provide alternative feeds from the adjacent DNO to make the supplies at remote ends of network more resilient with alternative sources of power.

This option considers the potential for interconnection at the NGED DNO boundaries (e.g. WMID-SWALES, WMID-EMID)

Having carried out similar analysis with external DNOs, we have extended the analysis to consider Inter NGED DNO interconnection opportunities using the same data set and approach as used for option 20.

Estimated volumes and costs

The assessment of interconnection candidates has given a high/medium/low benefit rating for each NGED DNO.

Interconnections that provide a medium or better benefit for either DNO, have been costed using Ofgem disaggregated benchmarking unit costs for asset replacement for the main assets that are required.

Inter-NGED DNO interconnections

Licence Area			RIIO-ED2 expenditure (£m)
WMID			0.43
EMID			0.10
SWALES			0.20
SWEST			-
NGED			**0.73**

Status

Proposed

There are a small number of inter NGED DNO interconnection opportunities that will provide a resilience benefit for customers at the ends of feeders, who would otherwise be interrupted for long periods of time until repairs were carried out..

Option 20b – Intra-NGED DNO Spur Interconnection

Background

Electricity distribution networks have evolved to be a mix of interconnected main lines and spurs without interconnection. Customers beyond a fault on spurs are off supply until the fault can be repaired, because there is no alternative route to restore customers.

While Options 20 and 20a consider cross DNO border interconnection, there are many opportunities within the networks to consider interconnection of spurs.

Since there are numerous opportunities to interconnect spurs, the programme proposes ten scheme per licence area, focussing on spurs with more than 100 customers. In some cases interconnection may also require reinforcement of the existing network (e.g. conversion of 2 wire to 3 wire), so to avoid these costs the interconnections will be made where the network does not require such reinforcement.

Estimated volumes and costs

The costs of the interconnection schemes are based upon an average derived from the more detailed assessments of 20 scheme carried out for options 20 and 20a.

Intra-NGED DNO spur interconnections

Licence Area	Number of spur interconnections		RIIO-ED2 expenditure (£m)
WMID	[redacted]		0.52
EMID	[redacted]		0.52
SWALES	[redacted]		0.52
SWEST	[redacted]		0.52
NGED	[redacted]		**2.08**

Status

Proposed

While there are numerous interconnection opportunities with each NGED DNO licence area, the programme considers spurs with high numbers of customers.

This approach provides storm resilience benefit, by providing customers with an alternative source of power when a fault occurs on a spur.

Option 21 – Network geospatial data capture

Background

NGED has been using helicopter mounted LiDAR data capture technology to build a geospatial representation of the network and nearby structures such as trees and vegetation. The helicopter mounted equipment is being used to capture data at HV, EHV and 132kV and this data capture will take place as part of routine helicopter patrols.

LiDAR data capture using helicopters is more suited to rural networks where the helicopters don't need to get close to properties. LiDAR data capture more difficult where the overhead lines are near to houses or where there are restricted flying zones.

NGED proposes to extend the geospatial visualisation and reporting system currently deployed on the higher voltage overhead networks. It is intended to extend the use of existing LiDAR capability (where feasible) but incorporate data sourced from suitable satellite data capture (especially where helicopter flying is inappropriate).

It would enable a more targeted approach for managing safety, reliability and resilience of the network.

Estimated volumes and costs

It is proposed to acquire and overlay the satellite data during RIIO-ED2.

The expenditure forecast is based upon acquiring satellite data and embedding the satellite data into existing visualisation data sets, to enable tree species identification and data overlays to be produced.

Inter-DNO interconnections

Licence Area			RIIO-ED2 expenditure (£m)
WMID			0.52
EMID			0.52
SWALES			0.26
SWEST			0.44
NGED			**1.74**

Status

Proposed	Comprehensive tree and vegetation information will enable better prioritisation of tree clearance works improving safety, reliability and storm resilience.

Option 22 – Visualisation and modelling of storms on vegetation and network impact

Background

NGED has been using helicopter mounted LiDAR technology to capture data for the HV and 132kV overhead networks since 2020. Consequently we have the experience and capabilities for capturing large volumes of geospatial data and understand the benefits it can provide to network asset management and customer service.

Having captured the data about the network and the proximity of trees, NGED proposes to further enhance the visualisation and reporting system to introduce dynamic modelling of historical and forecasted storms to proactively identify network assets at potential risk of damage from stormy weather.

This approach will allow the existing data used for management of routine tree cutting to be extended to better identify prioritisation of resilience tree cutting that will improve network performance during storms.

Estimated volumes and costs

The expenditure forecast represents the initial development of the model in 2024/25. It is envisaged that there will be ongoing evolution of the model as it is implemented and therefore some costs roll over into 2025/26 and 2026/27.

Modelling storm impacts on vegetation and networks

Licence Area			RIIO-ED2 expenditure (£m)
WMID			0.77
EMID			0.77
SWALES			0.44
SWEST			0.66
NGED			**2.64**

Status

ED2 baseline

This modelling expands the utilisation of LiDAR data, combining it with storm information to identify parts of the network more prone to damage during storms and therefore allows better targeting of resilience tree clearance to prevent power interruptions during storms.

It will be developed using ED2 baseline funding and therefore is not being included in the Storm Arwen reopener submission.

Option 23 – Private LTE Network

Background

Reliability of the telecommunication network is critically important to enable remote control operations and data acquisition. This is even more critical during storms where numerous electrical network faults occur in a short period of time.

Recommendation R4 in the BEIS Energy Emergencies Executive Committee (E3C) Storm Arwen Review stated:

"Energy Network Operators should continue to engage with DCMS and Ofcom to secure the utility spectrum so that the energy sector can develop its own resilient data/voice networks in the future."

NGED has conducted numerous desktop and practical studies in support of proving the technology of private Long Term Evolution (LTE) network, should spectrum be made available by OFCOM.

We continue to pursue radio spectrum for the utilisation of a private LTE network under the auspices of ENA's and E3C's Strategic Telecoms Group.

Estimated volumes and costs

NGED is not requesting funding for the LTE network under the Storm Arwen reopener.

Depending upon progress made in the Strategic Telecoms Group, future funding requests are likely to be made under the Digitalisation Re-opener as specified in part I of special licence condition 3.2. This reopener has a window for applications in January 2026.

Status

Deferred	The request for funding of an LTE communications network is deferred until spectrum is made available by OFCOM. Funding requests are likely to be made under the Digitalisation Re-opener in January 2026.

12 Appendix B – Technical details

LineSIGHT circuit monitoring

The issue being addressed

Overhead line circuits can be many km in length and locating faults has typically required a patrol of the circuit to find where damage has occurred. These patrols introduce delays to the restoration of power for customers.

Using technology to narrow down the search area can speed up the location of a fault and therefore speed up the restoration of supplies.

Furthermore, monitoring technology has been shown to be able to identify where there are multiple faults or faults that have not caused protection to operate, such as low hanging conductors, which pose a safety risk to people and livestock.

Development, innovation and regulatory allowances for other DNOs

During RIIO-ED1, ENWL has worked with Kelvatek on development and application of LineSIGHT technology using innovation funding.

The innovation work carried out by ENWL has proven the technology and it is now commercially available. As a result of the performance and safety benefits, ENWL has been provided with a RIIO-ED2 price control deliverable to install [redacted] devices.

NGED's proposal under the Storm Arwen reopener is to have a more focused programme targeting the installation of LineSIGHT on overhead circuits that have a propensity to fault under storm conditions.

How the technology works to locate faults

LineSIGHT uses a range of different monitors (3 phase voltage and current nodes, 3 phase voltage nodes and single phase voltage nodes) in combination to monitor the main lines and spurs of HV networks. The devices use a combination of time domain reflectometry (TDR) and impedance to fault measurements to identify the location and type of faults.

The devices have battery supplies which enables them to continue to monitor the network using TDR even once the electricity network has tripped. This enables them to identify further disturbances associated with additional nested faults. Each device can reliably monitor the network for around 2km, so a typical circuit typically requires 8 devices.

The equipment which is installed across a circuit continuously monitors the network, sending data back to an analysis server which establishes a normal running 'signature'. When faults occur, there is a disturbance to the signature and the characteristics of disturbance can used to identify the type of fault. The data collated during the disturbance and the ongoing TDR can then be used to provide a location of the fault, with the technology pinpointing fault locations to within 300 metres.

Better location of individual faults enables more efficient utilisation of field teams, by avoiding the need to patrol large areas on foot to identify damaged equipment. This is particularly beneficial in storm conditions, which mainly impact rural areas predominantly made-up of long overhead lines.

Identifying nested faults

An added benefit of the monitoring equipment is that it can also be used to identify multiple nested faults on the same circuit.

During storms multiple faults can occur on the same part of the network at the same time. DNOs will generally be aware that an outage has happened, but will not be aware that multiple faults exist unless the multiple faults are obvious (e.g. in close proximity with clear evidence of two sites of damage or from two separate reports from members of the public).

Restoration and repair teams will focus on repairing the first fault found and only once this is repaired and the circuit is being returned to service that the second fault may be identified, either as part of the testing process or when a circuit breaker is closed and it trips again.

These multiple or “nested” faults lead to protracted outage times, because the faults tend to be repaired sequentially instead of in parallel. During storms this also has the impact of tying up resources for longer periods of time, thus delaying restoration from other parts of the network.

The LineSIGHT devices monitor the network using their own unique codified signals. This enables the devices to work together to identify the location of the same faults or identify whether there are multiple nested faults in different parts of the network.

Since the devices have the capability to continue monitoring even when circuits trip, they can continue to identify additional faults that emerge as the poor weather continues to cause damage to the network. By identifying multiple faults on tripped circuits, work to repair multiple faults can take place at the same time, speeding up restoration for customers.

Identifying low changing conductors

Damage to overhead conductors can cause conductors to hang low. In these circumstances, the network can remain live and pose a danger to people and livestock.

Since there is no electrical fault, protection will not operate and there is a reliance upon members of the public reporting the situation. The equipment can remain live until this notification is made posing a danger to the public.

A further benefit is that LineSIGHT can detect the location of low hanging conductors. It achieves this as a result of identifying disturbances associated with the normal signature.

The monitoring devices can detect minor disturbances to the electrical characteristics of overhead lines. Such disturbances can be caused by traffic passing under the lines, weather such as fog and rain, or a changes to the distance between spans and between spans and earth.

The training of the normal signature accounts for disturbances caused by traffic, weather patterns cause specific types of disturbances that can be discounted and low conductors results in a consistent shift in the electrical characteristics being obtained from the devices.

Low hanging conductor causes a specific type of change in characteristics, allowing LineSIGHT to identify dangerous situations and improve the public safety risk associated with low hanging overhead lines.

Scope of NGED application

Since this is nascent technology, we are proposing a targeted approach to the scale of activity.

We have identified the circuits that have a propensity to fault during storms, by considering the faults during storms since the start of RIIO-ED1. This has identified [redacted] circuits with 10 or more incidents, leading to a requirement for [redacted] devices.

Applying the monitoring to these circuits should mean that we get a benefit from better identification of the location of a faults (to speed up restoration) and gain experience of the accuracy and effectiveness of the technology.

Pre-Fix monitoring

The issue being addressed

NGED has been carrying out an innovation project called Pre-Fix, which is seeking to develop an approach to identify disturbances on the network being caused by potential faults, in order to target removal of defective components before they actually cause a fault.

The methodology is aiming to be vendor-agnostic, looking at using technology from a variety of providers to develop a more flexible way of utilising existing monitoring equipment, alongside new devices and software. By being vendor-agnostic the approach is not tied to any specific technology, manufacturer or service provider.

Innovation development objectives

NGED is using Network Innovation Allowance funding to trail different monitoring equipment and develop the algorithms to interpret data from the monitors. The Pre-Fix project is being delivered in partnership with Nortech Management Limited.

The project was first registered with Ofgem on October 2021 and has the current duration ending in March 2024. The NGED website provides updated information about the progress of the innovation project at the following link:

https://www.nationalgrid.co.uk/projects/pre-fix

The objectives of innovation project are to develop and validate:

- a process to enable pre-fault capable devices from different manufacturers to contribute information onto the same platform.
- processes to enable pre-fault information to be drawn out of this platform.
- standard reports that enable a consistent and effective pre-fault policy driven decision making to be made in an operational environment.

While the main focus of the project has been developing the capability to detect defects before they turn into faults, it has been found that the technology and analysis techniques allow the location of actual faults.

This has been shown to be particularly effective on HV overhead line networks and therefore can be used to narrow down search locations to speed up restoration of supplies during storms.

The project has been the subject of two papers that were presented by NGED and Nortech at the CIRED 27th International Conference on Electricity Distribution in June 2023.

The Technology

The project relies upon power quality monitors installed at primary substations and fault detection devices installed on outgoing feeders, as well as data from other devices already installed on the network.

The power quality monitors at substations are installed on the 11kV transformer feeds to 11kV boards, such that one power quality device is monitoring a number of outgoing circuits.

The individual circuit affected is identified from fault passage indicators installed on outgoing circuit breakers and intelligent fault detection devices installed on overhead networks.

These devices all provide data to a data platform and calculation tool hosted on an iHost server that allows interrogation of the data to identify network anomalies. This enables fault events to be identified alongside calculation of distance to fault.

The specific technology being trailed as part of the Pre-Fix project includes:

- PQube power analysers manufactured by Powerside,
- NX44 smart fault passage indicators manufactured by Nortech,

- Smart Navigator 2.0 - Intelligent fault detection for 11kV and 33kV overhead networks manufactured by Nortech.

Disturbance ‘pecks’

The power quality monitor and the devices installed on the network continuously monitor the network. Under normal operations there is a ‘clean; sinewave on voltage and current monitoring. However, when a disturbance occurs there is a deformation of the wave. The type of deformation gives an indication of the type of defect that may exist on the network. Each of these deformations is referred to as a ‘signature peck’.

Data analysis including distance to fault determination

A core part of the project is the development of a Common Disturbance Information Platform (C-DIP). This is software hosted on iHost (a vendor-agnostic platform for gathering data from field devices) that allows information from multiple sources and manufacturers to be brought together in a single place.

The software processes the data to identify the location of faults using Distance-to-Defect algorithms. These utilise information about voltage and current, alongside data about the network components, to determine impedance to fault, which is then converted to distance to fault measurement.

Furthermore, artificial intelligence algorithms using convolutional neural networks are being trained to classify the type of defect by their electrical signature pecks. It is intended to enable the algorithms to automatically determine whether the signature pecks are consistent with tree contact or different types of component deterioration.

This data processing is currently processed manually with a time lag, but is intended to be carried out continuously under business as usual operations. It will therefore provide analysis during the build up to a fault as well as once a fault has happened.

Through the analysis of actual faults the project is gaining confidence in the identification and location of pre-fault signature pecks by correlating observed data with actual fault locations.

Work is continuing within the Pre-Fix project to continue validating and refining the Distance-to-Defect algorithms for a range of different types of fault (for example phase-to-earth and phase-to-phase faults) as well as investigating the characteristics of different HV component failures.

Positive results

The approach applies to both underground and overhead circuits and good results are being obtained for both applications. The method is especially effective for phase-to-phase faults due to known circuit parameters. For phase-to-earth faults, the impedance of the earth path can be variable and therefore further work is required to develop better models for these types of fault.

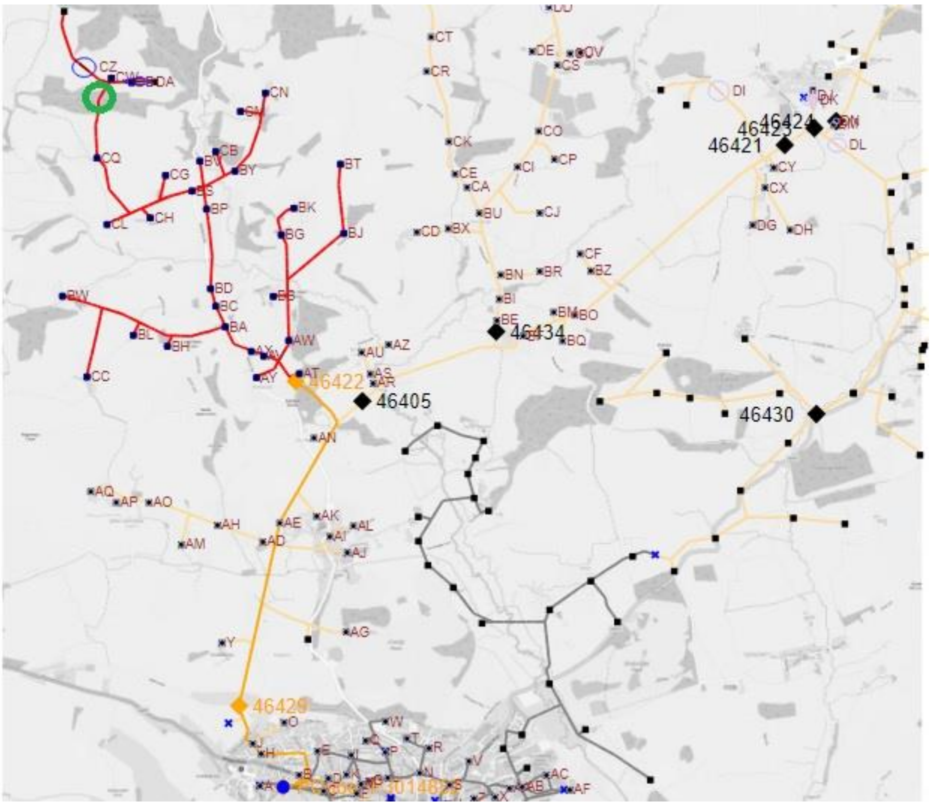
Specifically considering overhead line faults the following two examples illustrate how the distance to fault algorithm can narrow down the search area.

The first figure shows a circuit from Crediton and second is from a circuit in Okehampton.

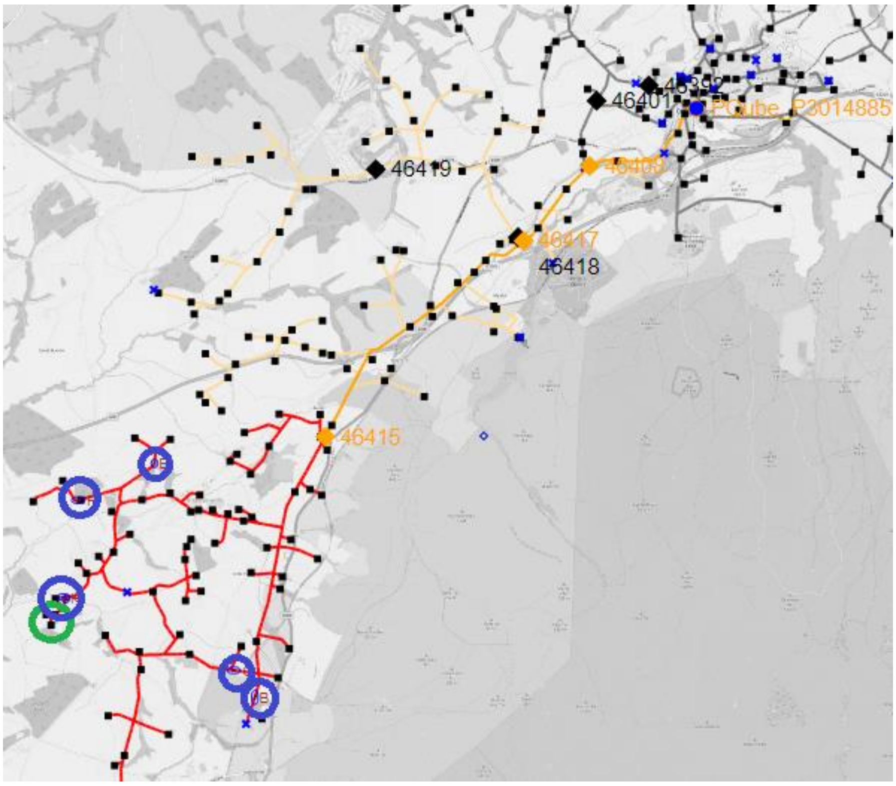
The red coloured circuit is downstream of a fault passage indicator. Under current operational methods the whole red area would need to be patrolled to find the faulty components (i.e. the FPI search zone).

The distance to fault algorithm in C-DIP provides a narrower search area indicated by the blue circles. For the Crediton circuit, there is a single DTF search zone, but on the more branched Okehampton circuit, there are five DFT search zones.

The actual location of the faults are indicated by the green circles, which in both examples are close to one of the DTF search zones, illustrating that the application of the algorithm could save significant time in locating faults during storms.



Crediton example



Okehampton example

CIRED papers

NGED and Nortech jointly presented two papers at the 27th International Conference on Electricity Distribution in Rome in June 2023 about project Pre-Fix.

The first paper covered the development of the C-DIP platform and the derivation of impedance to fault which provides Distance-To-Defect locations, enabling a more localised search area. The paper can be found here:

https://www.nationalgrid.co.uk/downloads-view-reciteme/638659

The second paper covered the development of the artificial intelligence algorithms that are being trained to identify the different signatures from different types of network disturbances. The paper can be found here:

https://www.nationalgrid.co.uk/downloads-view-reciteme/638658

Rollout to business as usual

Since the monitoring of power quality is associated with a transformer infeed to a substation, the implementation of Pre-Fix to business as usual is based upon rolling out to substations and the associated outgoing circuits, rather than just for specific circuits.

Since the application of the technology for storms is primarily related to the location of overhead line faults, we are proposing to install it on substations where the outgoing circuits have more than 80% of the network constructed on overhead lines. This is derived by summing up all the underground cable and overhead lines HV disaggregated data associated with circuits at a primary substation to determine the percentage of overhead line per substation.

Analysis of the HV disaggregated data shows that there are 200 primary substations that meet this criteria, which represents approximately 20% of substations that have HV feeders.

Since this is nascent technology, still in the innovation phase, rollout to business as usual for the 200 substations is proposed to be spread across the last three years of RIIO-ED2 and RIIO-ED3, with the number of substations addressed progressively increasing in the ratio of 1:2:3 across the RIIO-ED2 years, with the rate of installation continuing at the same rate as year five of RIIO-ED2. This allows for lower volumes in the earlier part of the rollout to enable further evolution of the most practical approach to deploying the devices. This leads to the delivery profile as shown below.

Profile of roll-out of Pre-Fix

Licence Area	ED2 2025/26	ED2 2026/27	ED2 2027/28	ED3 2028/29	ED3 2029/30	ED3 2030/31	ED3 2031/32	ED3 2032/33
Proportion each year	5%	10%	14%	14%	14%	14%	14%	14%
Cumulative proportions	5%	14%	29%	43%	57%	71%	86%	100%
Number of substations	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Cumulative substations	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Reducing customer numbers in protection zones

Protection, automation and subdivision of protection zones

HV circuits are mainly designed to operate as radial feeds; this means that the flow of power is from the source primary substation to open points at the ends of the feeder, where the open points are inter-connected to other circuits.

The main protection device for the circuit is a circuit breaker positioned at the source primary substation, which can interrupt the flow of power when a fault is detected on the circuit. Relying solely on this circuit breaker means that all the customers on a feeder will be interrupted. To reduce the number of customers impacted by a fault, additional protection devices (e.g. reclosing circuit breakers, intelligent fuses) have been installed along the circuits to subdivide the circuits into smaller protection zones. This protects customers upstream of the devices from faults downstream of the devices. Such devices prevent the upstream customers from being impacted by any interruption, including short interruptions.

Prior to the advent of remote control capability, the reconfiguration of supply arrangements would have required a person to travel to the substations (e.g. at the open points) and carry out manual switching to enable re-routing of power from an adjacent circuit. Advances to remote control communications allow remote operation of switches. The installation of additional remotely controlled devices allows electricity supplies to be quickly rerouted or ‘switched’ without the need to send a person to site. These switching operations can be initiated by staff in our control centre or automatically by computer algorithms which allow switching actions to take place without the intervention of a control engineer. The algorithms use information from fault passage sensors to identify which section of the network contains the fault and then communicate with remotely controlled devices to restore supplies to the maximum number of customers possible.

Reductions in the number of customers affected by HV faults are achieved by increasing the number of remotely controlled switches which can be operated automatically to subdivide circuits into smaller protection zones with fewer customers. For example, subdividing a protection zone with 1,300 customers will result in two protection zones with 650 customers in each.

During RIIO-ED1, NGED has focused on reducing the number of customers in a protection zones to 1,500 customers; a small number remain.

This proposals as part of the Storm Arwen re-opener is to address protection zones with more than 1,000 customers.

Customers interrupted per fault - Determining the scope of improvements

We have analysed data from NGED control systems to identify the number of customers that would be left unrestored after all automated switching has taken place.

This has identified [redacted] protection zones with more than 1,000 customers split across the licence areas as shown below:

Number of protection zones with more than 1,000 customers

Licence Area	WMID	EMID	SWALES	SWEST	NGED
Zones	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Number of protection zones per band of customer numbers

The following table shows the number of protection zones that fall into specific bands of customer numbers. For example there are [redacted] protection zones in East Midlands that have between [redacted] customers.

This data shows that there are [redacted] zones where there are more than [redacted] customers. The remaining [redacted] zones relate to zones with [redacted] and [redacted] customers.

Number of Protection Zones per Customer Number Banding					
Customers in protection zone banding	**WMID**	**EMID**	**SWALES**	**SWEST**	**NGED**
0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
0-100	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
100-200	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
200-300	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
300-400	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
400-500	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
500-600	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
600-700	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
700-800	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
800-900	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
900-1000	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1000-1100	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1100-1200	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1200-1300	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1300-1400	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1400-1500	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1500-1600	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1600-1700	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1700-1800	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1800-1900	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1900-2000	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2000-2100	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2100-2200	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2200-2300	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2300-2400	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2400-2500	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Single phase reclosers for spur protection (TripSaver II)

The issue being addressed

Historical practice, especially in the South West, has been to install fuses on spurs to prevent faults on the spurs from impacting customers on the rest of the circuit. This has been effective, but when they operate it requires staff to be sent to site to replace the fuses. This leads to protracted restoration times, especially during storms.

We have been working with S&C Electrical to trial their TripSaver II single phase circuit breakers. These can be installed in the same fittings used for fuses. The use of such circuit breakers means that for transient faults the spurs could be restored automatically, rather than relying on someone visiting site.

The recloser accomplishes this by testing the line when fault current is detected and closing back in if the source of the problem is temporary. The TripSaver II can coordinate with other smart devices and possesses a four-shot recloser design. This means the TripSaver II recloser will test the line for fault current four times, allowing more time for temporary causes to become clear.

When a temporary fault occurs, it eliminates short interruptions for customers on the main feeder (upstream customers) by only interrupting supplies on the affected spurs. This is in contrast to an intelligent fuse (automatic sectionalising link) approach which relies on an upstream (main line) recloser to interrupt the transient fault which in turn also affects all the other spurs (non-faulted spurs), downstream of the mainline protection device.

If a permanent fault occurs, then the TripSaver II will drop-out into a “locked out position” and provides a visible indication of a permanent fault. For a permanent fault, field operation of the TripSaver II is treated like a fuse, and once dropped out it can only be re-inserted manually using hot sticks (the same way you would re-insert a fuse). So operational staff are only required to visit site when there is a permanent fault that needs repairs.

There is a further benefit by using the TripSaver II single phase circuit breakers. They are more sensitive to low current faults, which means that they will operate for more faults than fuses, further preventing the need for upstream devices to operate. This means that customers upstream of the spur will be affected by fewer faults on the spur.

Equipment trials and learning

NGED has carried out a trial of 27 TripSaver II reclosers in 10 separate South-West locations. These lines were selected because they represented a mix of spur lines, some of which had experienced a large number of temporary faults and others that had more average-performing spurs.

Operational data from the trial period (between September 2020 and March 2022) has shown that 80% of the sites operated during the period with 32 transient faults and 2 permanent faults. Analysis, of how the system would have operated with the original fuses present, determined that 25 of the transient faults would have previously caused the fuses to operate leading to a permanent fault. Therefore, over the year of the trial the operation of TripSaver II has saved 25 site visits by clearing transient faults and reducing the impact on customers by automatically restoring supplies for transient faults.

The trial period occurred during the time period of Storms Franklin and Eunice. Despite the severity of these events, the TripSaver II devices operated effectively during this period with no impact on service. This highlights the effectiveness of devices during extreme weather events and hence forms part of NGED's storm resilience strategy.

Proposed application

The application of this technology will be focused on spurs with high numbers of customers to take advantage of the automatic restoration functionality benefitting the greatest number of customers, especially during storms where there is more risk of temporary faults through contact with trees or windborne debris.

There is a secondary focus, where long spurs, with a greater likelihood of faults will also be targeted to take advantage of the extra sensitivity of these devices so that customers upstream are not affected by faults on the spurs.

This means that, in combination, the devices will be applied to long spurs with high numbers of customers. In these situations the spurs are going to be three phase spurs requiring three single-phase reclosers to be installed.

Estimated Volumes

The volumes have been derived by assuming that 10% of existing sets of fuses will be replaced by sets of single phase fuses. The programme is targeted at the South West licence area due to the historical practice of utilising fuses more extensively.

Torque tooling

The issue being addressed

Given the large amount of faults that can arise in a storm, the deployment of overhead line teams is determined by safety issues or faults affecting high numbers of customers. With resources deployed into these areas, there may be a delay before overhead line teams are free to assist with isolating or replacing fuses.

We have therefore been looking for solutions that gives operational staff the ability to replace fuses without the need for an overhead line team or the need for access equipment such as ladders.

The approach has been to seek tooling that can be affixed to operating rods that enables the same pressure to be applied as if the fuses were being tightened by hand. Applying too much pressure can introduce additional issues such as the wing nuts being broken and exposing live parts.

The impact of the issue

Without a solution, some LV circuits encounter delays to restoration until overhead line teams become available.

Using non torque tooling on the end of live line rods could lead to damage to the fuses requiring further work for overhead line teams to remove and replace broken fuse carriers. The knock on impact of this is further delays to supply restoration and occupying a line team that could be dealing with other faults.

The solution

A new torque tool has been designed and manufactured.

The two-way torque head prevents over tightening either when tightening the fuse or when removing the fuse as it limits the torque applied to the wing nut. It affixes to live line rods which allows the action to be carried out from the ground.

A tool has had to be developed because the requirement is to have a torque setting that equates to finger tightness (3 Nm) but available tools on the market did not have a torque setting and therefore torques upwards of 15-20Nm could be applied, causing damage.

Implementation

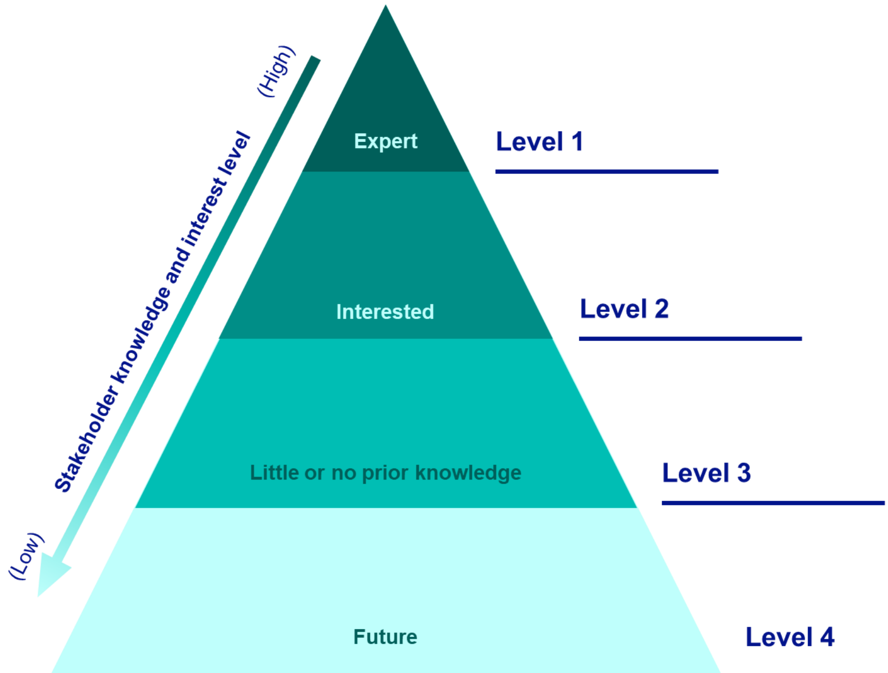
The new tool forms part of the tool kit for operational technicians and overhead lines teams. The relevant staff have sufficient technical knowledge for the roll out to be based on a tool box briefing complementing the manufacturer’s instructions.

13 Appendix C – Stakeholder engagement

NGED's stakeholder engagement programmes

NGED uses regular stakeholder engagement to identify opportunities to improve day to day operations and inform business priorities. There are approximately 5,500 stakeholder contacts, categorised into customer segments, allowing targeted engagement on specific issues.

We engage with stakeholders on a variety of levels, dependent upon their knowledge and level of interest as demonstrated in the diagram and table below.



Stakeholder Level	Engagement methods	
Level 1: Expert Stakeholders we work closely with to build their knowledge to an 'expert' level, or those who already have an indepth knowledge of connections activities.	Customer Connection Steering Group Stakeholder workshops Consultations Bilateral meetings	Industry working group External industry events
Level 2: Interested Stakeholders who interact regularly with NGED for connections activities and have a sizeable knowledge and interest in the area.	Stakeholder workshops Consultations Bilateral meetings Distributed Generation Suvey	Connection Surgeries Community energy events
Level 3: Little or no prior knowledge Stakeholders who may only interact once or occasionally for connections activities and have little knowledge of NGED or this area.	Distriuted generation & customer surveys Connection Surgeries Annual stakeholder & ICE reports	Website Media awareness campaign Social Media
Level 4: Future Stakeholders who may want connections in the future and may have no knowledge of NGED or this area.	Connection Surgeries Annual stakeholder & ICE reports Community energy events & guide	Media awareness campaign Social media Website

Customer Engagement Group

In preparation for the RIIO-ED2 price control, Ofgem set expectations for enhanced engagement, requiring DNOs to design, establish and resource Customer Engagement Groups (CEGs) to scrutinise Business Plans. During 2018/19 NGED appointed an independent Chair, agreed terms of reference and membership role descriptions, confirmed contracts with 14 members and started holding regular meetings.

In developing the RIIO-ED2 business plan, a number of CEG sub-groups were established to make better use of the knowledge of CEG members to provide more focused assessment of Business Plan proposals.

Following the submission of the RIIO-ED2 business plan, NGED has continued to work with the CEG, addressing a range of Business Plan topics.

Customer Panel (previously known as the Customer Collaboration Panel)

NGED has had a Customer Panel for many years and currently has members with expertise in low carbon technologies, DSO transition, Local Enterprise Partnerships representing regional concerns, consumer representatives and wider stakeholders from key segments including businesses, utilities, charities and the health sector.

The Customer Panel meets quarterly, led by a NGED Director or the President. It critically reviews NGED's current performance, provides strategic steer on NGED's priorities for the future and acts as a sounding board for new ideas.

The Panel exists to provide expert advice and opinions and to work collaboratively with NGED to devise effective solutions and improvements for customers. The Customer Panel debates a broad range of activities - from the impact of EVs in the future, to power cut response times.

Each meeting of the Customer Panel includes a session focusing on a different strategic priority. The topics covered during 2022/23 included factors that affect network resilience, such as demand on the network, asset replacement, increasing load on the network and fault detection technology.

Generic stakeholder workshops

In addition to the Customer Panel, NGED engages with a wider audience through an annual round of generic stakeholder workshops. These have been carried out each year for the last 12 years and in 2022/23 we hosted six workshops with stakeholders from a range of backgrounds, covering all customer groups.

In September 2022, we hosted four in person workshops and two hybrid events (where stakeholders could attend either online or in person) in: Birmingham; Bristol; Milton Keynes; Nottingham; Cornwall and Cardiff. Each workshop included four sessions covering:

- A smart and flexible network, connections, community energy and innovation;
- Environment and sustainability;
- Customers in vulnerable situations, the Social Contract and customer service;
- Network resilience, safety, business IT and cyber security, and workforce resilience.

The workshops are designed to encourage dynamic roundtable discussions allowing stakeholders to share their views.

Targeted stakeholder workshops

As well as the generic stakeholder workshops we also hold a range of different targeted workshops, engaging with more specialist stakeholders to have more focused and detailed discussions on specific subjects.

In June 2022, we hosted three virtual workshops focused on the RIIO-ED2 themes of Connectability, Sustainability, and Vulnerability and Affordability. Each workshop had a discreet theme covering one of the topics. Customer service during severe weather events was specifically discussed at the Vulnerability and Affordability workshop.

Engagement leading into RIIO-ED2 plans

NGED carried out a multi-year comprehensive programme of stakeholder engagement ahead for RIIO-ED2. This programme included seven major stages of engagement including:

- Preliminary engagement
- Business plan development
- Defining outputs
- Business Plan refinement
- Business Plan Acceptance and gap analysis
- Post submission engagement
- Post draft determinations engagement

Each stage considered factors for 'maintaining a safe and reliable network' and the following summarises what we heard from 2019 to 2022.

In 2019, stakeholders emphasized the importance of network performance as the top priority for NGED. Upgrades to infrastructure, implementation of new technologies, and quick response to unforeseen events were highlighted to ensure network reliability and the safety of staff and the public.

In 2020, stakeholders stressed the need for continuous and reliable electricity flow, with a focus on reducing power cuts, their duration, and improving supply quality. The aging network and its ability to handle increasing electricity demand were concerns, and stakeholders called for improved asset monitoring and data utilisation.

In 2021, network performance remained crucial, especially with the increased reliance on electricity due to remote working. Stakeholders wanted NGED to be more ambitious in reducing power cut frequency and duration. Maintaining a reliable network, addressing supply quality and implementing measures like LIDAR for tree-related faults were emphasised.

Grid capacity and support for low-carbon technologies has been an increasing area of focus. Energy security and the importance of network resilience and reliability in the context of Net Zero was also highlighted.

Stakeholders felt that NGED could improve its approach to extreme weather events by providing more up-front information and better data-sharing among planning bodies.

Stakeholders suggested improvements to NGED's communication with customers during outages, particularly regarding advanced warning. The need to provide additional support for vulnerable customers was also highlighted.

Engagement since Storm Arwen

In June 2022 we held some targeted workshops, one of which looked specifically at customer service during severe weather events.

These were followed a series of six generic stakeholder workshops where there were discussions on network resilience and whether priorities had to be changed based upon Ofgem's draft determination for RIIO-ED2 and as a consequence of recent storms.

Targeted storm discussions

There was a targeted workshop, held on 28 June 2022, that looked at customer service during severe weather events.

The targeted workshop provided details of Storms Arwen, Eunice and Franklin, which together saw NGED (at that time called WPD) dealing with 8,000 incidents, impacting 850,000 customers.

We described current practice for storm preparedness covering: providing reassurance for vulnerable customers by contacting them ahead of the storm, ramping up resources, discussions with resilience partners and increased capacity for the website to be able to handle higher volumes of traffic.

We also described how we responded during the storms, how we redeployed operational staff to areas with high fault volumes including providing staff to other DNOs, the number of incoming and outgoing calls made and how we communicated via the website, social media, web chats and emails.

As part of the engagement we posed two specific questions, focused on the support that we can provide and the provision of data about restoration times:

Question: What could we do, and what would you expect to see in the support we provide, either prior, during, or after these extreme weather events?

Stakeholders were largely satisfied with our approach to customer support during severe weather events and praised the speed and scope of the communications in particular. However, they were also keen to put forward suggestions about what they thought could be done in future storms. One of the key areas was helping to build community self-resilience before, during and after storms.

Stakeholders were generally of the view that we could go further in signposting the support available to communities. In particular, they strongly urged the company to make local communities aware of what exactly is available on the ground should there be a prolonged blackout, before a storm happens. By doing so, it was hoped that this would provide a sense of reassurance during storms and would ease pressure on the emergency services.

No clear trend emerged around a preferred communications channel for contacting customers during major storms. However, the key message from the discussions was that the full range of communication methods available should be used to provide up-front information prior to storms so that people can prepare. Stakeholders were strongly of the view that information about any support available is proactively disseminated so that customers do not need to seek it out in a panic during or after a storm.

During discussions about how to promote the customer care package, delegates were strongly of the view that communication should be as clear as possible about the assistance available through the package and spread the word more widely through community-facing channels. Stakeholders identified local figures, bodies and infrastructure as potential partners for this approach, such as community centres, community first responders and parish councils. These were suggested as it was felt that they are trusted figures within their communities to whom people would turn for assistance, therefore making them ideally placed to promote it.

Question: What are your views on the provision of ETRs during major incidents such as severe storms?

Stakeholders unanimously appreciated that calculating ETRs is a major challenge during fast-evolving storm situations, irrespective of whether a best-case scenario or worst-case scenario is given. As a result, some were happy with whatever timeframe was specified, as they trust that the company is doing whatever it can to restore their power as quickly as possible under difficult circumstances. They felt that being given a sense of reassurance about progress and realistic timeframes would be enough.

Large numbers of delegates were of the view that honesty is the best policy and that customers would prefer to have the worst-case scenario so that they can plan appropriately. Although some cited the potential irritation of making plans and then having the power restored far ahead of the stated timeframe, there was an overwhelming feeling that it would be preferable to under-promise and over-deliver. This feeling was also reflected in online voting, where 85% of stakeholders preferred to have the worst-case ETR scenario.

Generic stakeholder workshops

In September 2022, we held a series of six generic stakeholder events that included discussions on network resilience. These were held in Birmingham, Bristol, Cardiff, Cornwall, Milton Keynes and Nottingham.

The main objective of the sessions was to review RIIO-ED2 commitments in light of potentially lower allowances. As part of this, one of the themes for discussion was network resilience which also reflected on comments from the workshop in June where stakeholders had suggested that "resilience has become a more critical priority after the storms".

The majority of stakeholders continued to support the objective to improve network reliability with those in favour of maintaining ambition highlighting that a reliable network was part of NGED's core operations, and therefore non-negotiable, and with rising numbers of people working from home and living in rural communities, this commitment had actually become more important since RIIO-ED1.

14 Appendix D – LineSIGHT locations

The following list of [redacted] circuits are those that have a propensity to fault in storms and are the proposed circuits for the installation of LineSIGHT. The number of faults is based upon the faults during exceptional events since the start of RIIO-ED1.

DNO	DNO Area	Primary	Feeder	Faults
WMID	Hereford & Ludlow	Craven Arms	DALE ST.	11
WMID	Hereford & Ludlow	Kington	SPRINGFIELD ABI 74 1052 (11kV)	10
WMID	Hereford & Ludlow	Knighton	PRESTEIGNE RD.	10
WMID	Hereford & Ludlow	Ross 11kV	OLD MARKET CL.	13
WMID	Hereford & Ludlow	Ross 11kV	ROSS LOCAL	11
WMID	Hereford & Ludlow	St. Weonards	WORMELOW (11kV)	10
WMID	Hereford & Ludlow	Star Aluminium	SEVERN BRIDGE TEE	16
WMID	Hereford & Ludlow	Tenbury	BORDERWAY/SPRING COTT./ABLE BURFORD TEED	14
WMID	Stoke	Cauldon	WINDY ARBOUR SECT. SW.	10
WMID	Stoke	Market Drayton	CB09 MARKET DRAYTON GOLF CLUB ABI/PELLWALL ABI (11kV)	12
WMID	Worcester	Kenswick	MARTLEY AND TEES	10
WMID	Worcester	Stourport	Redstone Lane / Barnfield Rd	10
WMID	Worcester	Stourport	THE BIRCHES	10
SWALES	East Wales	BUILTH WELLS	BUILTH WELLS: PARK ROAD LLANDRINDOD	14
SWALES	East Wales	MONMOUTH	WYE PUMPING STATION: PENALLT	12
SWALES	East Wales	ST ARVANS	ST ARVANS: DEVAUDEN	12
SWALES	Swansea	WESTFA	WESTFA: TY BYTURN	10
SWALES	West Wales	BRAWDY	BRAWDY: LLANDELOY/HOUSE TX	13
SWEST	Barnstaple	Clovelly	Clovelly 0017	15
SWEST	Barnstaple	Great Torrington	Great Torrington 0045	10
SWEST	Barnstaple	Hatherleigh	Hatherleigh 0198	10
SWEST	Barnstaple	Middle Barlington	Middle Barlington 0113	11
SWEST	Barnstaple	Park Lane	Park Lane 4008	10
SWEST	Barnstaple	Shebbear	Shebbear 0018	10
SWEST	Barnstaple	Stratton	Stratton 4044	10
SWEST	Barnstaple	Tinkers Cross	Tinkers Cross 0105	10
SWEST	Bodmin	Davidstow	Davidstow 0041	10
SWEST	Bodmin	Liskeard	Liskeard 0041	10
SWEST	Bodmin	St Mawgan	St Mawgan 0042	10
SWEST	Redruth	Camborne Holmans	Camborne Holmans 0042	10
SWEST	Taunton	Exebridge	Exebridge 0150	13

15 Appendix E – Pre-FIX substations

The following list of 200 substations that have more than 80% of overhead line associated with the substation. These are the locations where the application of Pre-FIX will be prioritised, with [redacted] sites having installations in RIIO-ED2, and the remainder in RIIO-ED3.

West Midlands

Primary Substation	Customer numbers	Length of Overhead	Length of UG	% overhead
Bearstone	1350	68.04	8.41	89%
Berkeley	2745	86.23	16.23	84%
Berrington	1012	53.59	8.31	87%
Bishops Castle	2648	177.71	10.37	94%
Bodenham	2857	160.48	12.49	93%
Bromyard	5112	263.51	23.01	92%
BROTHERIDGE GREEN	4680	150.29	27.94	84%
Cauldon	2254	196.04	31.77	86%
CLEOBURY MORTIMER	3072	156.11	9.03	95%
Craven Arms	4424	242.66	15.44	94%
Dymock	2500	175.12	8.45	95%
Easthope	1626	161.67	11.68	93%
Elton	2869	101.99	11.08	90%
Epwell	4917	179.66	31.89	85%
Gnosall	2893	82.44	12.36	87%
Hammerley Down	7655	187.56	44.21	81%
High Offley	1226	71.84	9.00	89%
Hinstock	1619	83.75	14.94	85%
Kenswick	3403	180.81	14.69	92%
Kington	3588	184.33	10.55	95%
Knighton	3323	254.49	13.13	95%
Leaton	2292	118.13	18.72	86%
Leebotwood	4837	193.06	28.11	87%
Lower Chadnor	2249	164.80	9.47	95%
Ludlow	8716	238.60	36.47	87%
Madley	1980	52.62	10.34	84%
Malehurst	3817	143.61	21.53	87%
Naishcombe Hill	4779	108.33	19.51	85%
Netherhills	2713	66.64	15.72	81%
Newent	5825	180.97	38.83	82%
Peterchurch 66/11kV	2599	252.04	7.76	97%
Pontrilas	1802	187.91	6.83	96%
Presteigne	2452	121.48	21.52	85%
Priestweston	2055	197.66	8.16	96%
Quatt	3582	110.77	16.6	87%
Rowton	1167	90.43	6.65	93%
St. Weonards	2307	158.26	9.96	94%
Stockton	2647	141.77	9.26	94%
STOW	3271	133.71	29.12	82%
Stowfield	1198	49.58	7.25	87%
Tean	3111	99.94	18.60	84%
Tenbury	4325	232.48	16.52	93%
Tewkesbury	2038	91.03	6.35	93%
Woofferton	2715	156.98	11.34	93%
Worfield	1458	78.56	15.49	84%

East Midlands

Primary Substation	Customer numbers	Length of Overhead	Length of UG	% overhead
BILLINGBOROUGH 11KV	3352	142.38	18.51	88%
DOWSBY FEN 11KV	2607	99.32	19.60	84%
HORNCASTLE 11KV	6067	175.46	43.77	80%
LANGRICK 11KV	1527	120.48	18.4	87%
LEADENHAM 11KV	3638	135.55	25.23	84%
MARKET OVERTON 11KV	2147	69.13	16.87	80%
OLD DALBY 11KV	1734	55.99	12.28	82%
RAVENSDALE PARK 11KV	1452	74.22	16.45	82%
SOUTH CROXTON 11KV (*BOARD CHANGE*)	598	39.45	6.54	86%
WEST HADDON 11KV	3100	105.23	24.72	81%
WESTBOROUGH 11KV	2719	76.75	18.17	81%
WHAPLODE DROVE 11KV	1759	97.34	13.89	88%
WRAGBY 11KV	2596	109.36	23.07	83%
WRANGLE 11KV	2931	112.65	25.58	81%

South Wales

Primary Substation	Customer numbers	Length of Overhead	Length of UG	% overhead
ABERAERON	2231	64.44	8.24	89%
BLAENPORTH	3027	169.72	9.30	95%
BRAWDY	2852	196.54	11.16	95%
BRECON	9054	520.89	65.26	89%
BRIDELL	2846	242.79	7.31	97%
BUILTH WELLS	4401	428.62	24.25	95%
CARDIGAN	4447	65.07	16.20	80%
COWBRIDGE	4115	97.92	22.35	81%
CRICKHOWELL	3250	138.06	25.74	84%
FISHGUARD	5841	252.00	23.84	91%
GLASBURY	5133	263.11	21.80	92%
HAVERFORDWEST TOWN	5553	174.66	30.28	85%
KIDWELLY	3066	81.42	9.91	89%
LAMPETER GRID	4255	261.65	13.02	95%
LLANARTH GRID	3187	161.43	11.83	93%
LLANDEILO	3185	230.18	14.32	94%
LLANDOVERY	2067	205.05	6.45	97%
LLANDRINDOD WELLS	6512	418.41	28.76	94%
LLANFIHANGEL YSTRAD	1966	230.46	9.93	96%
LLANFYRNACH	1051	107.08	8.4	93%
LLANGADOG	1560	216.46	1.19	99%
LLANILAR (MANWEB)	9	3.54	0.00	100%
LLANLLWNI	1975	216.98	1.55	99%
LLANRHIDIAN	2771	125.64	14.82	89%
MEINCIAU	617	69.04	1.72	98%
MONMOUTH	8272	257.52	49.63	84%
MORLANGA FARM	1330	53.05	7.96	87%
NANTGAREDIG	1466	192.64	3.52	98%
NEVERN	1821	108.27	6.83	94%
NEWCASTLE EMLYN SOUTH	4040	257.2	12.28	95%

Primary Substation	Customer numbers	Length of Overhead	Length of UG	% overhead
OLD RADNOR	1112	143.19	10.73	93%
PENBLEWIN	4666	319.7	29.68	92%
PENDINE	1284	59.72	13.69	81%
PONT-AR-ANNELL	1095	181.25	0.84	100%
PONTYATES	2045	44.19	5.20	89%
RHAYADER	1978	161.04	15.9	91%
RHOS GRID	4504	325.23	11.34	97%
ST ARVANS	1387	68.07	12.71	84%
ST CLEARS	3395	288.43	17.86	94%
ST DAVIDS	1339	41.80	5.61	88%
ST FLORENCE	1691	99.51	10.50	90%
ST TWYNELLS	1199	102.12	10.05	91%
TREGARON	2665	281.16	7.18	98%
TUMBLE	6438	118.82	20.12	86%
USK	4431	232.39	22.41	91%
WHITLAND	1842	136.16	12.04	92%

South West

Primary Substation	Customer numbers	Length of Overhead	Length of UG	% overhead
Ashburton	3450	86.08	21.23	80%
Ashwater	1051	112.68	3.15	97%
Axminster	5071	106.2	16.58	86%
Beaminster	3999	137.5	15.57	90%
Blackawton	796	39.45	4.74	89%
Blagdon 33/11kv S/S	1215	58.75	5.63	91%
Bowhays Cross	6005	122.99	24.74	83%
Bratton Fleming	1299	134.60	6.54	95%
Bridge Mills	3339	102.90	12.82	89%
Bristol International Airport	1121	36.97	8.69	81%
Bugle	4135	85.90	17.48	83%
Burlescombe	1054	79.54	3.27	96%
Callington	4734	113.65	19.47	85%
Chew Stoke	1700	37.47	9.03	81%
Chewton Mendip	1291	86.51	7.94	92%
Clovelly	2730	108.80	8.03	93%
Coker	1850	45.55	5.77	89%
Compton Martin 33/11kv S/S	2247	70.29	5.93	92%
Constantine 33kv	2522	98.81	6.93	93%
Creech St Michael	5591	143.96	19.37	88%
Culmhead	1370	111.34	12.43	90%
Curry Mallet	1713	68.64	7.52	90%
Davidstow	1655	105.74	4.11	96%
Delabole	5109	113.87	22.76	83%
Dinder	1476	61.03	6.05	91%
Dowlish Ford	5705	98.53	17.68	85%
Drinnick	4089	63.74	13.21	83%
East Brent	2268	68.53	12.13	85%
East Chinnock Primary	1527	44.64	3.64	92%
East Curry	2484	207.09	10.36	95%
Evercreech	2421	96.46	13.48	88%

Primary Substation	Customer numbers	Length of Overhead	Length of UG	% overhead
Exebridge	2442	183.61	11.16	94%
Folly Bridge	2694	150.38	9.20	94%
Geevor	3103	54.18	10.51	84%
Great Torrington	4419	144.04	15.85	90%
Gunnislake	3688	58.99	10.56	85%
Hatherleigh	3736	285.15	14.55	95%
Heddon Cross	1292	120.52	6.96	95%
Hemyock	2451	108.51	8.03	93%
High Littleton	3750	73.30	10.74	87%
Holford	730	38.47	4.58	89%
Holsworthy	4088	200.78	21.49	90%
Laneast	2135	148.14	4.95	97%
Lanner	5556	80.27	11.26	88%
Lanreath	1751	89.18	12.28	88%
Lapford	2577	123.15	10.09	92%
Lifton	1533	108.54	9.61	92%
Liskeard	9663	177.97	27.54	87%
Luckwell Bridge	1615	139.76	11.31	93%
Lydeard St.Lawrence	2181	118.95	17.43	87%
Marazion	3960	54.19	10.22	84%
Marsh Green	2827	102.54	9.66	91%
Martock	7855	111.48	20.9	84%
Mary Tavy Gen Stn	1476	97.56	12.98	88%
Mevagissey	3052	69.46	16.50	81%
Middle Barlington	1107	74.62	4.06	95%
Modbury	2428	80.81	16.98	83%
Moretonhampstead	2025	132.06	14.99	90%
Morwenstow	1164	112.04	17.79	86%
Mousehole	1514	33.72	4.00	89%
Nether Stowey	3276	107.07	20.31	84%
Newbury	3311	70.36	17.22	80%
Newton Poppleford	1710	34.98	7.65	82%
Newton St Cyres	2028	68.11	9.57	88%
North Street Lang.	4331	80.18	19.84	80%
North Tawton	1514	55.37	6.42	90%
Offwell	2070	149.41	5.92	96%
Pensilva	2622	106.12	5.92	95%
Perranporth	4465	94.75	20.03	83%
Probus 33	2542	91.19	12.15	88%
Roseland	2781	71.68	16.14	82%
Saltash Whity Cross	3108	100.67	8.90	92%
Shapwick	2867	87.64	7.16	92%
Shebbear	1784	176.19	4.34	98%
South Brent	3052	101.44	17.81	85%
South Molton	4803	216.22	40.41	84%
St Buryan	1952	72.14	12.26	85%
St Columb Major	2912	91.55	19.85	82%
St Keverne	2462	135.13	12.93	91%
St Neot	2340	152.66	11.28	93%
St Tudy	2337	123.85	12.41	91%
Stokenham	1969	49.88	8.30	86%
Tinkers Cross	3118	229.24	13.47	94%

Primary Substation	Customer numbers	Length of Overhead	Length of UG	% overhead
Tiverton Moorhayes	5436	172.87	27.03	86%
Torpoint Antony	4047	77.97	17.84	81%
Twelveheads	3358	60.04	11.72	84%
Waterlake 250330	2843	136.72	8.00	94%
Wedmore	1641	46.61	4.54	91%
Wellington Primary	1988	48.43	8.77	85%
Wheal Reeth	2234	68.60	6.38	91%
Whiddon Down	2602	137.93	7.49	95%
Whitchurch M	2178	52.53	10.59	83%
Witheridge	1999	182.71	6.14	97%
Wiveliscombe	3036	144.00	11.14	93%
Woodbury	2862	42.11	9.08	82%

16 Appendix F – Inter-DNO Interconnection opportunities

The following tables list the locations for interconnection between NGED DNOs and SP, ENWL and NPG. The Total NGED costs include the interconnector costs where NGED benefit is 100% or where NGED is carrying out the linear installation when the NGED benefit is 50%. In other situations the other DNO is proposing the expenditure.

NGED (South Wales) – SP (SPMW)

Name	NGED Benefit %	Interconnector Linear Installation	Interconnector (£m)	NGED Reinforcement (£m)	Total NGED cost (£m)
Garth Fawr - Glanyrafon	50%	NGED	0.09	0.13	0.22
Chapel House - Dernol Bungalow	50%	SPEN	0.04	0.21	0.21
Maen Arthur Cottage - Pontrhydygroes	100%		0.05	0.00	0.05
			0.18	**0.34**	**0.48**

NGED (West Midlands) – SP (SPMW)

Name	NGED Benefit %	Interconnector Linear Installation	Interconnector (£m)	NGED Reinforcement (£m)	Total NGED cost (£m)
Sandyford Beurton - Sandyford	100%		0.04	0.01	0.05
Blackhurst Farm - Middle Morrey	50%	SPEN	0.03	0.09	0.09
Calverhall - Pool farm	100%		0.04	0.00	0.04
Vyrnwy cottage - Cross lane cottage tran	50%	NGED	0.04	0.00	0.04
Railway Bungalow - Glyn Farm	50%	SPEN	0.06	0.04	0.04
Pen-y-borfa - Sarn Poultry	100%		0.05	0.00	0.05
			0.26	**0.14**	**0.31**

NGED (West Midlands) - ENWL

Name	NGED Benefit %	Interconnector Linear Installation	Interconnector (£m)	NGED Reinforcement (£m)	Total NGED cost (£m)
Danebridge	50%	NGED	0.10	0.00	0.10
			0.10	**0.00**	**0.10**

NGED (East Midlands) - ENWL

Name	NGED Benefit %	Interconnector Linear Installation	Interconnector (£m)	NGED Reinforcement (£m)	Total NGED cost (£m)
Tideslow	0%		0.04	0.00	0.00
Millers Dale	0%		0.06	0.00	0.00
Knotbury Common	50%	ENWL	0.08	0.06	0.06
			0.18	**0.06**	**0.06**

NGED (East Midlands) – NPG (NPGY)

None proposed

17 Appendix G – Inter-NGED DNO Interconnection opportunities

The following tables list the locations for interconnection between NGED DNOs. The Total NGED costs only include the interconnector costs where NGED benefit is 100% or where NGED is carrying out the linear installation when the NGED benefit is 50%.

here are a small number of interconnection opportunities across NGED DNO boundaries, that can provide the capability for alternative sources of power during faults.

NGED (West Midlands) – NGED (South Wales)

Name	DNO benefit WMID	DNO benefit SWALES	Interconnector Linear Installation	Interconnector (£m)	Reinforcement (£m)
Pye Finch Cottage - Buckholt	0%	100%		0.03	0.06
Rydspence	50%	50%	SWALES	0.03	0.17
Ditch Yeld Cottage - Knill Quarry Cottage	50%	50%	WMID	0.05	0.03
The Corner - Fron Ladies	0%	100%		0.07	0.12
				0.17	**0.37**

NGED (West Midlands) – NGED (East Midlands)

Name	DNO benefit WMID	DNO benefit SWALES	Interconnector Linear Installation	Interconnector (£m)	Reinforcement (£m)
River Lodge - Ilam Hall	0%	100%		0.07	0.04
Woodhouse Fields Solar - Woodhouse Field Fm	100%	0%		0.05	0.00
Bowling Green Farm - Nethercote La.	0%	100%		0.03	0.00
				0.15	**0.04**

NGED (West Midlands) – NGED (South West)

None proposed

18 Glossary

BEIS
The government Department for Business Energy and Industrial Strategy in place at the time of Storm Arwen. In 2023, this department was split and replaced by the Department for Business and Trade (DBT), Department for Energy Security and Net Zero (DESNZ) and Department for Science, Innovation and Technology (DSIT).

E3C
A partnership between the Government, the Regulator (Ofgem) and industry, which ensures a joined up approach to emergency response and recovery.

Inter-DNO
Activities that are shared across DNOs where the DNO licence areas are owned by different ownership groups.

Inter-NGED DNO
Activities that are shared across DNOs where the DNO licence areas are owned by NGED.

Intra-NGED DNO
Activities that are carried out within a specific single DNO licence area owned by NGED.

LineSIGHT
Circuit monitoring equipment developed by Kelvatek used to identify the location of faults including nested faults and low hanging conductor.

Low Voltage (LV)
This refers to voltages up to, but not including, 1kV.

High Voltage (HV)
Voltages from 1kV up to, but not including, 22kV.

Mobile Generation
Devices that can produce electrical power, transported on trailers to locations where power has been interrupted and temporary supplies are required.

NEOP
The National Energy Outage Platform is a proposed system that collates outage data from DNOs' systems and presents a national view.

Pre-Fix
An innovation project carried out by NGED for location of faults ahead of failure which can also be deployed to identify the location of actual faults.

Protection Zone
A subdivision of an electrical circuit that has devices at its point of infeed to interrupt supplies in the event of a fault within or downstream of the subdivision.

Resilience Tree Clearance
Enhanced tree clearance to prevent trees falling into and damaging overhead lines during storms.

Spur Protection
Circuits are made up of main lines that are interconnected to other main lines and spurs that have no interconnection. Spur protection is a device that interrupts power to the spur for faults on the spur so that the faults don't impact customers on the main lines.

Suitcase Generators
Small sized devices that can produce electrical power sufficient to power low energy devices such as mobile phones. They can be used to provide temporary power for essential devices, but they are not sufficiently powered to provide heating and power high energy devices such as cookers and kettles.

TripSaver II
A type of protection device that operates as a single phase circuit breaker that can interrupt supplies for transient faults and reenergise supplies automatically, locking out for permanent faults.

Undergrounding
The process of replacing overhead line conductors with underground cables.

For more general glossary items refer to the Glossary included in our RIIO-ED2 Business Plan (Supplementary Annex 10 - Glossary - December 2021), as published on our website and submitted to Ofgem.

nationalgrid