Scottish & Southern Electricity Networks

RIIO-ED2 Engineering Justification Paper (EJP)

HV Automation

Investment Reference No: 397_SSEPD_NLR_HV_AUTOMATION

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1 Executive Summary

Our ***Safe & Resilient (Annex 7.1)*** and ***Reliability Strategy (Annex 7.2)*** set out the methodology used to determine the Non-Load baseline for capital expenditure. This encompasses capital investment to invest in assets with enhanced network performance and reliability. The baseline encompasses all activities and investments required during the RIIO-ED2 period where there is compelling evidence of need in terms of asset replacement and improvements to Quality of Service (QoS).

The primary driver for this category is network QoS. This paper identifies the need to provide Ex-Ante allowance for automation to be installed on the High Voltage (HV) network to improve network performance and drive performance in line with Ofgem's Interruption Incentive Scheme (IIS) targets. The HV circuits targeted for automation have been identified using the National Faults and Interruptions Reporting Scheme (NAFIRS) which provides historic network fault performance for circuits across our network. Using the NAFIRS data and reviewing network connectivity, automation is proposed to be installed on circuits that can be supported via alternative supplies and those circuits that have a fault history over the previous 5 years.

We have developed a calculation methodology to determine the HV circuits where customer would benefit from the installation of automation. This calculation methodology is based on our understanding of the automation schemes installed to date and the fault performance of the circuits that we are targeting. This enhanced methodology enables us to identify and improve circuit performance to reduce the impact of unplanned outages on customers. We can achieve this through automation as it reduces the response time for faults, reduces the number of customers initially impacted by a fault and drives an affordable solution to improve network performance to aid meeting IIS targets.

This investment represents a total spend of **£22.63m** throughout RIIO-ED2 which sits within our Reliability TOTEX expenditure.

Following the entirety of optioneering and all detailed analysis, as set out in this paper, the proposed scope of works is to target **145 circuits in SHEPD** and **426 circuits in SEPD** to improve the QoS to those associated customers in line with stakeholder and Ofgem expectations.

The cost to deliver the preferred solution is **£5.42m in SHEPD** and **£17.21m in SEPD**; the proposed works are planned for completion within the ED2 regulatory period.

2 Introduction

This Engineering Justification Paper (EJP) describes our proposed non-load related investment plan for High Voltage (HV) network automation during RIIO-ED2.

The primary driver considered within this paper is QoS as measured through the National Faults and Interruptions Reporting Scheme (NAFIRS).

Section 3 provides high-level background information for this investment and explains the importance of automation for our electricity distribution network and our network customers, and the motivation for using it to improve QoS over the course of RIIO-ED2 and beyond. A high-level example of the application of automation is also provided to demonstrate the improvement that can be realised.

Section 4 establishes an overview of the drivers associated with this investment.

Section 5 sets out how the chosen RIIO-ED2 investment strategy has been informed through our stakeholder engagement activities. With reference to this EJP, our stakeholders have informed the investment strategy chosen for this asset category by indicating the level of risk they are willing to accept when balancing two key metrics; network reliability and affordability. The key learnings from this engagement and its relevance to QoS improvements are described within this report.

Section 6 provides a summary of the corresponding intervention options which can be deployed as a solution to improve network performance.

Section 7 provides detailed analysis, walking through how we calculate the anticipated benefits of automation using a circuit example, then describes the cost and volumes arising from the preferred intervention options as supported by the Cost Benefit Analysis (CBA) results which complements this EJP. The results of the CBA show the overall benefit associated with the chosen solution.RIIO-ED2

Section 8 concludes the EJP and confirms RIIO-ED2 the overall strategy that we plan to drive during RIIO-ED2 to install automation on circuits with a focus on improving the associated customers QoS.

3 Background Information

This section of the EJP provides background information on our Automation strategy. This includes a description of what automation is, what the importance of automation is for network customers and the approach used to identify the circuits that require intervention during RIIO-ED2.

3.1 Automation

There are approximately 2,222 and 5,524 automated switches and circuit breakers on SHEPD and SEPDs network respectively; see Table 2 below. Automation has been installed on numerous circuits across the network where there are viable alternative supplies via other network connections, also known as backfeeds, to support part, or all, of a circuit when a fault occurs. Where automation is installed, it responds within 3 minutes to restore power supplies to customers that are not within the section of network that has failed. Although automation does not mitigate faults, it does enable us to restore most customer supplies within 3 minutes; therefore, reducing the impact on Customer Interruptions (CI). With a fault narrowed down to a single section it enables response staff to locate the fault location quicker thus reducing the time that customers are off supply; therefore, reducing the impact of Customer Minutes Lost (CML).

Table 2 shows the number of circuits that are automated and the number of switches that are fully automated within our licenced areas.

Table 2: Number of Automated Circuits and Switches

SEPD		SHEPD	
No. of Circuits	**No. of Automated Switches**	**No. of Circuits**	**No. of Automated Switches**
1571	5524	601	2222

Automation is most effective on circuits where there is a backfeed available that can support part, or all of a circuit. Most of the existing automation has been installed on urban networks where the network is designed in a meshed system.

As part of the automation policy there are different levels of automation and fault indication that can be installed on the network. Examples of automation devices and fault identification equipment are Pole Mounted Circuit Breakers (PMCBs), Ring Main Units (RMUs) and Fault Passage Indicators (FPIs).

The assets installed for the purpose of automation are linked through our operational telecoms infrastructure to communicate with our Adaptive Power Restoration Switching (APRS) system. APRS is a powerful tool that uses logic to instantaneously determine how to restore network supplies when a fault occurs. The APRS system utilises the data provided by automated infrastructure and FPIs on the network to quickly determine the segment of the circuit where the fault is likely to be. By isolating the segment with the fault identified, those customers in other network segments will be restored automatically.

Since commencing the installation of automation we have tracked the performance to determine the overall benefit that customers have seen in terms of reduced power outages and the time off supply. The analysis has shown that there has been a positive impact on those circuits when automation has been installed in terms of CI and CML.

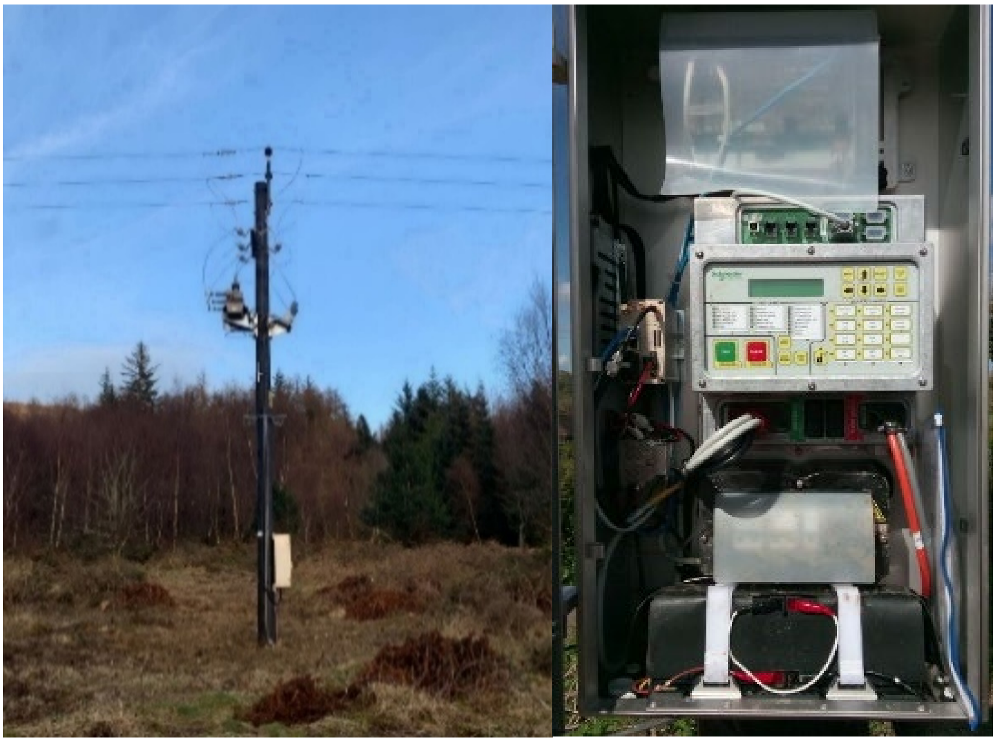


Figure 1: PMCB & Control Panel

Figure 2: Automated RMU with Actuators & FPIs

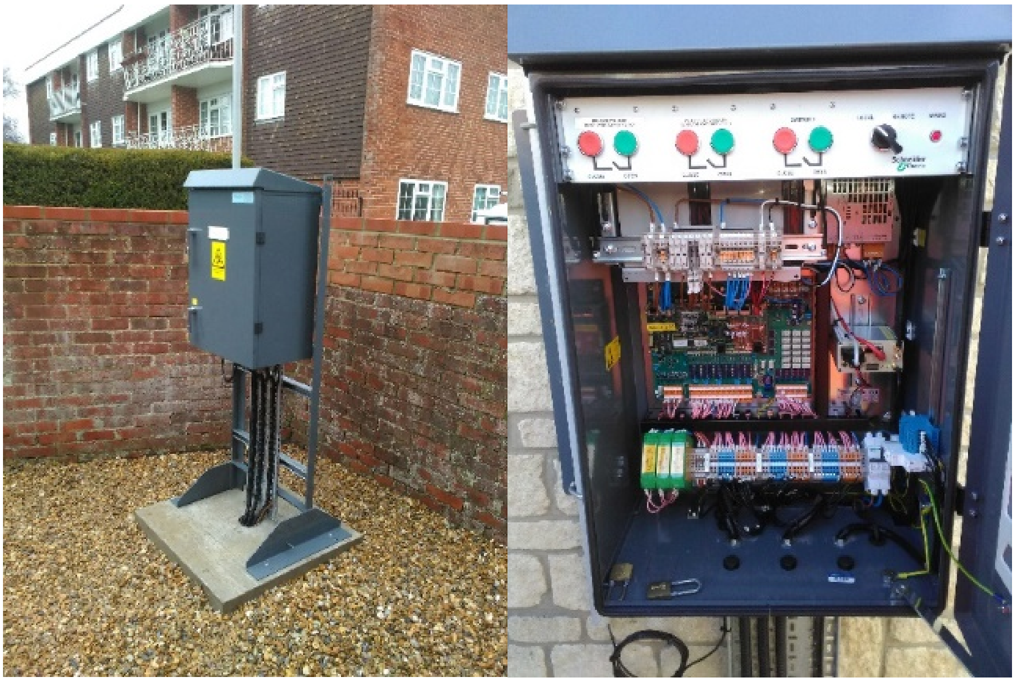


Figure 3: Free Standing Automated RMU Control Panel

3.2 Automation Policy

Automation improves network performance in response to an unplanned event by reducing the number of customers impacted by the fault. Using data from the National Faults and Interruptions Reporting Scheme (NAFIRS) database, we are proposing to undertake targeted investment through Ex-Ante allowance for the purposes of QoS (CV15) to improve network performance.

With a drive to improve network reliability and reduce the number of interruptions customers experience, we are proposing to increase the installation and use of automated equipment throughout the network. The Automation Strategy proposes investment on existing network assets and drives the requirements for new networks or new connections.

3.2.1 Existing Networks

As part of our automation policy the type of network must be confirmed to determine the overall solution. There are three types of feeder on our network and specific criteria has been proposed as part of our automation strategy. The feeder types are Urban, Rural and Complex.

Urban and Rural feeders with no more than 2,000 connected customers, the total number of customers within an automated section should not exceed 500 customers in SEPD and 250 customers in SHEPD.

Complex feeders where the supply restoration time exceeds the average (e.g. due to the geographical location or complexity of the circuits), customer numbers within an automated section should not exceed 250 customers.

For **any type of feeder** with more than 2000 customers, a protection enabled circuit breaker will be installed at the automated midpoint of the circuit.

Where an underground circuit feeds an overhead line, a protection enabled circuit breaker may be installed to minimise the impact of transient faults of the overhead section onto the underground section of the circuit. The overhead line section will form part of the section whether this is complex, urban or rural.

The minimum design requirement for any automated switch is for it to have telecontrol functionality and have associated FPI's fitted to the incoming and outgoing switches.

3.2.2 New Networks, Assets & Connections

As the network expands and changes through new connections, we are managing the new connections process to ensure that our network performance is maintained and our new standards are being adopted to ensure that the network continues to perform in line with our sustainable improvement ambition.

When connecting a new substation to an existing HV feeder, we will confirm whether the switchgear needs to be automated; this will be dependent on the conditions set out above and in TG-NET-NPL-010. If the switchgear does require automation, motors/actuators and FPI's will be fitted to the outgoing switch as a minimum.

New networks must follow the requirements of the automation planning standard and must install automation ready equipment where applicable. As part of our wider network improvement projects, such as Asset Health Replacement & Load Reinforcement, when assets are being replaced or newly installed, the equipment must be automation ready.

The design and delivery of these schemes is in accordance with TG-NET-NPL-010.

3.2.3 ED2 Calculation Methodology

As part of the policy, we have developed a methodology to calculate the benefits associated with the installation of automation schemes against the associated cost. This methodology is used to rank schemes in order of the overall network improvement benefits to target automation installation according to those circuits that would benefit the most. To ensure that the cost of the automation schemes is economic and efficient, we will target investments that can achieve an overall benefit in terms of network performance and return in investment.

The automation methodology targets circuits that meet the following criteria:

1. The circuit has a fault history over the past 5 years (using NAFIRS data)
2. A backfeed is available to support the network under abnormal feeding arrangements
3. Number of customers is above a specific threshold (as determined by policy)
4. Is supported by Cost Benefit Analysis (CBA)

NAFIRS Data

NAFIRS data is used to identify circuits that have had fault history over the past 5 years. NAFIRS provides detail on the network reference number (NRN), the number of customers interrupted, how long it took to restore supplies, the cause of fault, the date that the fault occurred and other key information relating to each fault that has occurred on the network.

Network Connectivity

Using the NAFIRS data to determine the circuits that have had fault history over the past 5 years, an assessment is undertaken on our network connectivity using electric office and PowerOn to determine if there is an appropriate alternative backfeed that can support part or all of the circuit under abnormal feeding arrangements. This is a critical part of the assessment as without an alternative supply automation would not be proposed.

Automation Example

To better understand how automation can impact network performance and reduce customer interruptions, the following guide can be used as an example. It must be noted that network configurations do differ from circuit to circuit; however, the principle of automation remains the same.

Taking an example of a circuit with a suitable backfeed, see figure 4, where there is interconnectivity between Circuit 1 and Circuit 2 with each circuit only being separated by a normally open point. In Figure 4 there is no automation installed on the network and the circuits are run independently from one another. For this example, it can be assumed that each High Voltage (HV) substation supplies 250 customers.

If a fault were to occur between the second and third HV substation on Circuit 2, see figure 5, then the full circuit would be impacted by the fault. Every customer connected to Circuit 2 from the source circuit breaker (CB) to the Normally Open Point (NOP) would lose supplies as the protection would instruct the source CB at the Primary Substation to trip. Under this scenario, customer supplies would be restored by an engineer attending site to undertake manual switching operations to restore supplies and isolate the fault between HV Substations. This would have 1250 customers off supply up until the first manual switching operation which will include the engineers call out, travel, operational instruction, undertaking the switching until the fault is isolated. In this case all associated customers would be off supply for >3 minutes, therefore the CI would be 1,250. For every minute that passes, the CML for this fault would increase by the number of customers that are off supply, only when the customers supply is restored will their associated CML stop contributing. In this example it can be assumed that it takes 30 mins to restore 500 customers, 15 minutes to restore 250 customers, 15 minutes to restore the next 250 customers and another 15 minutes to restore the final 250 customers using Circuit 1 as a backfeed through manual switching operations. This would give a total of 60,000 CMLs. Section 7.2 details the specific calculation to derive total CMLs.

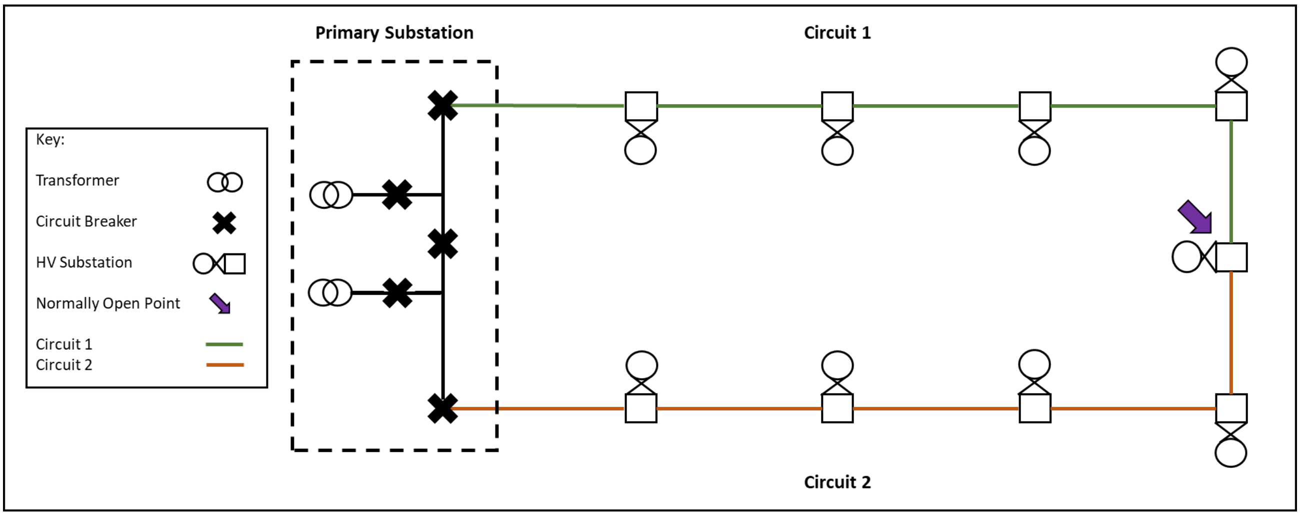


Figure 4: Interconnect Circuits with no Automation

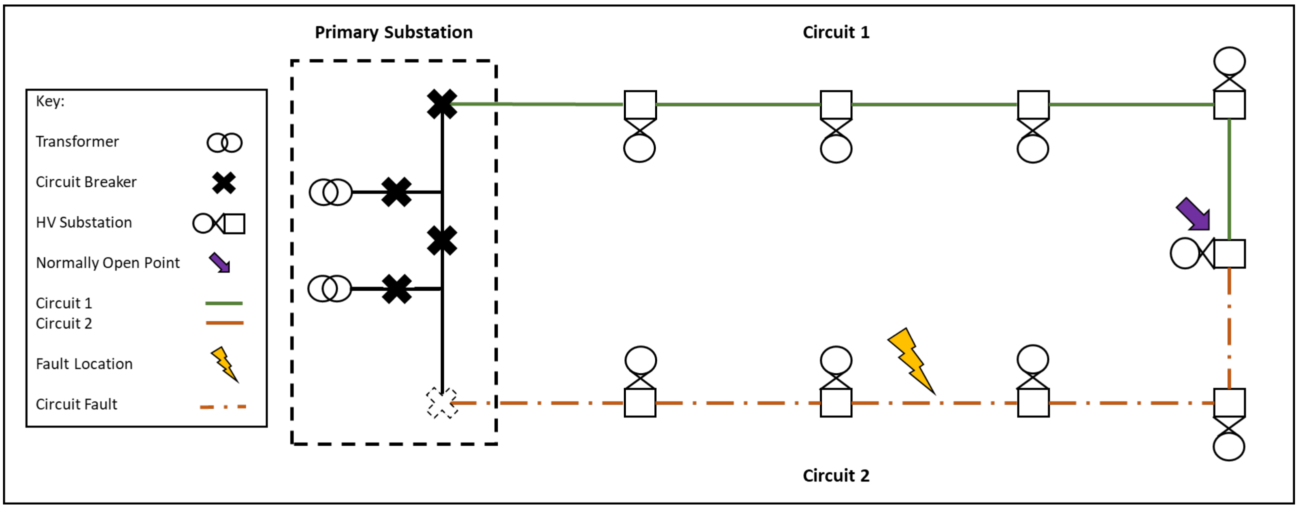


Figure 5: Fault on Circuit 2 – No Automation

If the same network example is taken but this time with automation installed on the network, see figure 6, then the number of customers impacted by the fault is reduced. This is due to the automated switches splitting each circuit into segments to reduce the number of customers impacted by any given fault. If the fault were to occur in the same location as per Figure 5, the resulting automatic switching arrangement would result in a single HV substation being off supply within the first 3 minutes; see figure 7. As the automated switching sequence restores 1,000 customer supplies within 3 minutes by using the backfeed from Circuit 1 and isolating a small section of network on circuit 2 the CI is now reduced to 250 customers.

As per the original assessment an engineer will be required to attend site to isolate the fault and restore supplies to the remaining 250 customers. In this instance the original switching operation can restore the customers within the first 30 mins. As a result, the total CMLs is 7,500.

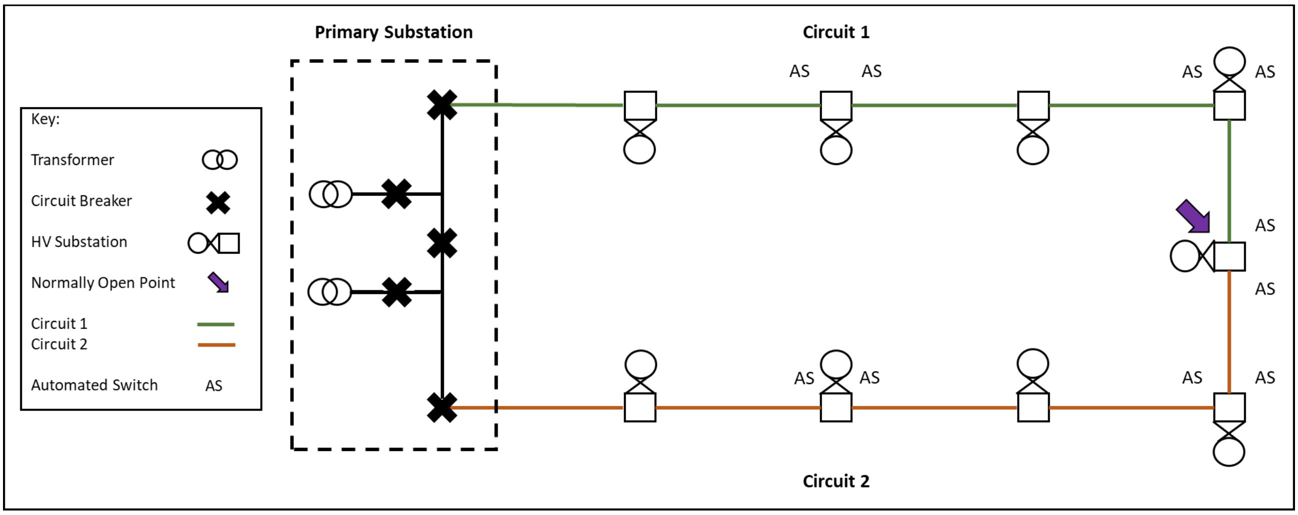


Figure 6: Interconnected Circuits with Automation

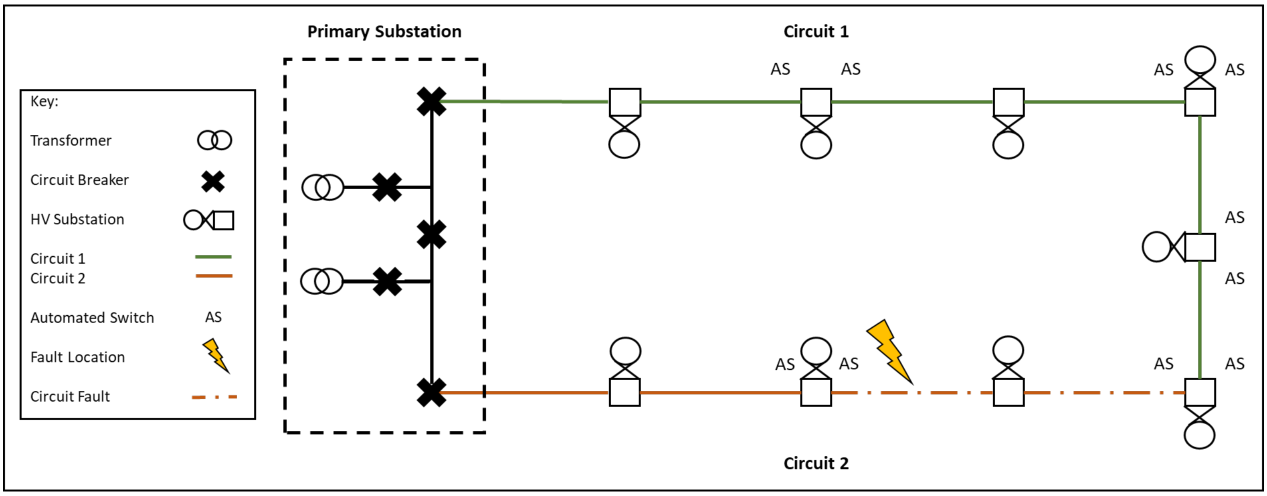


Figure 7: Fault on Circuit 2 with Automation

When taking both examples into consideration there is a clear benefit to customers when automation is installed. The results from the example are as follows:

Table 3: CI and CML Benefit from Automation

	CI	CML	£
Without Automation	1,250	60,000	£32,795
With Automation	250	7,500	£4,822
Associated Benefit/Saving	**1,000**	**52,500**	**£27,973**

*Cost based on SEPD IIS Incentive/Penalty

Although automation does not stop the fault from occurring, it does enable the network to be restored very quickly to most customers and also allows the control room to better understand the section of network that has the fault within it. Having this data will then allow network control and the site engineer to identify the fault location quicker and restore the remaining customers.

4 Investment Drivers

This EJP is intended to inform the proposed interventions to improve QoS during RIIO-ED2 for in terms of automation.

4.1 Primary Investment Drivers

The primary investment driver for automation is to minimise disruption to customers when a fault on the network occurs by driving the most economic cost solution for customers. This primarily relates to existing network performance across our HV network as recorded within the yearly NAFIRS submission.

Although every fault is recorded within NAFIRS regardless of the number of customers being impacted, not every fault can be resolved by automation. Therefore, the assessment of automations suitability is based on faults that impact more customers than would be within an automated segment. Going a step further, any fault recorded in NAFIRS that was due to an exceptional event or due to a deliberate switching disconnection for safety reasons has been removed. This is due to exceptional events being removed from the IIS targets and deliberate disconnections being within our control i.e. not an unplanned fault.

The primary investment driver described above correlates to the following Cost and Volumes (CV) table within the RIIO-ED2 Business Plan Data Tables (BPDT).

- **CV15 – QoS:** The installation of assets with the primary driver to improve network reliability and QoS.

Our automation methodology, in conjunction with a CBA, determines the need for investment for automation to be installed across the network. The methodology calculates the benefits of automation by using historic fault trends, network connectivity, number of customers supplied and total cost of installation.

Table 4 lists the data that may be used to inform whether automation is applicable for QoS improvement purposes. As seen below, this data is mainly driven by data within NAFIRS.

Table 4: Primary Data Relevant to QoS Investment into Automation

Category	Data	Drives Automation Methodology
Key Data Sets	NAFIRS Data	Y
	Network Connectivity	N
Supplementary Data	Network Reference Number (NRN)	N
	Number of Customers per circuit	Y
	No. of faults per circuit	Y
	Customer Interruptions per circuit	Y
	Customer Minutes Lost per circuit	Y
	Current automated switches	Y

4.2 Secondary investment drivers

Whilst this investment pack is intended to inform the management of automation for QoS related purposes, the investment options described within this EJP are also coordinated with several secondary investment drivers that may influence the final investment option that is selected for each automation project.

It is important to ensure that these secondary investment drivers are also considered carefully alongside the primary drivers to identify potential efficiencies and to prevent double counting within our RIIO-ED2 business plans.

This includes the analysis of future network trends to ensure sustainable investment decisions are identified which represent best value for money for our network consumers and customers, whilst enabling the transition to Net Zero.

The secondary investment driver which influence this EJP and the investment options that are chosen include asset health replacement. This secondary driver correlates to the following additional CV table within the BPDT:

- **CV7a – Asset Replacement NARM:** The replacement of assets due to health related investment. The automation stratgey requires viable assets to be automation ready and where there is benefit, to fully automate the site.

When selecting the investment option for each individual project, the following factors and secondary investment drivers are also considered to ensure the optimal solution is identified which best represents value for money for network consumers and customers:

- **Number of Customers and Network Outages:** When assessing the investment options available it is also important to consider the number of consumers and customers associated with HV substation that is being automated and the number of network outages and IIS penalties that have been incurred during previous years. This will inform the need for investment to improve QoS and inform the most appropriate investment solution.

- **Asset Replacement**: Understanding the detail of planned asset replacement will ensure that automation is not double counted where units are due for immediate replacement; this will ensure that our investment is efficient and co-ordinated throughout ED2 and beyond.

5 Stakeholder Engagement

In preparation for our RIIO-ED2 business plans several stakeholder engagement exercises have been undertaken to better understand what will be important to our network customers during RIIO-ED2 and to ensure the views of our stakeholders are reflected in the cost and volumes we are proposing for each asset category in line with our ***Enhanced Engagement (Chapter 3)***.

Below is a summary of the key outcomes from this engagement from some of our critical stakeholders. The summary below provides details of our stakeholder feedback on our Asset Management Strategy and their views on the importance of improving network reliability.

Consumer Feedback

- 88% of stakeholders in SEPD and 72% in SHEPD either agreed or strongly agreed with our asset management proposal to target assets with the highest probability of failure for ED2.
- 71% consumers thought it was very important SSEN are committed to reliability, which was the second highest priority for them (after affordability).
- In terms of reliability, domestic and SME customers' top priorities were 'Restoring the electricity supply as quickly as possible in the event of a power cut' (particularly for those aged 65+ or in vulnerable situations) and 'Keeping my power on with minimal power cuts'.

Local Authority and Government

- Stakeholders strongly urged us to strike a balance between maintain a reliable network by simply fixing older assets now and replacing assets (at a higher cost now) so that the network is ready for future use.
- SSEN needs to ensure reliability and disruptions are minimised, suggesting proactive actions such as providing generators during bad weather and new technologies to 'master' the network.
- Resilience partnerships are a good start for mitigating issues.

Community Energy Groups and Interest Groups

- Both old and new communities need to be resilient - must ensure the transition does not leave people behind.
- SSEN needs to think about current and future populations in areas now in order to plan its investments most effectively.

Summary of Findings

A wide range of stakeholders confirmed that they stakeholders strongly support our proposed approach of prioritising assets with a higher likelihood of failure as part of the asset management strategy. In addition, stakeholders also highlighted that network reliability was a high priority, greater than sustainability but below value for money.

Stakeholders communicated that reliability is expected as they depend on electricity for so many things in everyday life, and this is increasing, for example, with more households working from home and the electrification of heating and transport. These expectations and views validate Ofgem's IIS targets and Guaranteed Standards, so on this basis we have set our ambition to meet these levels of network performance.

6 Summary of Options Considered

This section of the report sets out the investment options that are considered when assessing the investment options to improve QoS. As described below, this approach is taken to ensure the correct investment options are chosen to reflect both least regret and represent best value for money for network customers.

The investment options described below range from no additional investment to full network replacement. By analysing the primary investment drivers in a holistic manner for each individual project, we can arrive at the optimal investment decision which avoids unnecessary spend and stranding of network assets.

The options described below are chosen with the aim to achieve an optimal balance of intervention throughout RIIO-ED2 to minimise the cost whilst delivering improvements in network performance.

6.1 Summary of Options

Table 5 below provides a high-level summary of the investment options under consideration along with the advantages and disadvantages associated with each. A more detailed description of each option is then provided within the proceeding sub-sections.

Table 5: Summary of Investment Options for Automation

Option	Description	Advantages	Disadvantages	Results
1. Do Nothing (Baseline)	Undertake no further installation of automated switches.	No additional CAPEX expenditure.	Unplanned outages will still require manual intervention which takes time.	Not considered a viable option for RIIO-ED2 for qualifying circuits
2. Install automation	Replace strategic network Pole Mounted Circuit Breakers (PMCBs) that cannot be retrofitted with comms and automation. Install actuators to RMUs at strategic sites across the network. Install FPIs on the network.	Cost is reduced when retrofitting devices instead of replacing them. Automation will improve network performance when targeting specific circuits.	Additional space will be required in HV substations for the Remote Telecoms Unit.	Chosen investment option for RIIO-ED2 deployment
3. Replace the main circuit	Replace the main underground cables and overhead line (OHL) section on the network entirely. Where faults have been known to occur on the old circuit mitigate them i.e. bird strikes, underground the OHL.	The full circuit would be new. Faults are likely to be reduced as mitigations have been included in the design and build.	Very Expensive. The time to deliver full end to end replacement of the main circuit will be extensive and subject to obtaining Landowner Consents where applicable. Possible major disruption to third parties i.e. road works. No guarantee that faults will reduce.	Not considered a viable option for RIIO-ED2

6.2 Option 1: Do Nothing

In this option a decision is made to accept the risk associated with each circuit that has a history of faults without any additional CAPEX or OPEX investment.

Whilst this option avoids additional CAPEX investment, it does not improve the QoS for customers. For those circuits that have a high fault rate or large number of customers impacted by faults, there could be reputational and financial consequences to the associated customers and us.

For this reason, during RIIO-ED2 the do-nothing option applies to circuits with no fault history. All other circuits will require additional investment to manage the risk of unplanned outages by reducing the impact on customers and the time they are off supply to acceptable levels.

In relation to automation, the do-nothing approach incorporates the impact resulting from reactive manual supply restoration following a fault on the network; this includes the increased CI/CML impact.

6.3 Option 2: Install Automation

For this option, specific strategic sites across the circuits are being targeted to improve QoS by replacing assets or retrofitting automation to existing assets. The replacement of assets will only be required where the specific asset, i.e. a PMCB, is in a key location as part of the automation scheme and cannot be automated without physical replacement. For other assets, such as RMUs, it is possible to fit actuators and install a comms unit to enable automation on the site.

If there are other primary drivers either working on site or requiring the same asset to be intervened on then there would be efficiencies and cost savings made through co-ordination of works.

6.4 Option 3: Replace the main circuit

Automation provides a quick restoration solution for most customers; however, it does not prevent the fault from occurring in the first instance. This option considers full replacement of the main circuit to minimise the likelihood of failure due to asset age and condition. The full end to end replacement would reduce the likelihood of failure on the circuit being replaced; although there are still instances out of our control that could cause failure i.e. third-party interference. By replacing the main circuit and incorporating automation into the delivery plan the network would improve in overall performance. It must be noted that this proposal would significantly increase costs associated with network reliability improvement.

However, we have separately identified several HV circuits that are truly end-of-life and require overlay during RIIO-ED2. This volume of cable overlay is accounted for within CV7 (Asset Replacement) and is limited by the resource available, supply chain, contracting resource etc to us. As such, no additional proactive overlay volumes are possible without a significant increase in our resource and the ability of our supply chain to deliver during RIIO-ED2. As such, for the purposes of this EJP, this option is not deemed to be technically viable as there will be no resource available to deliver any additional volumes. For this reason, this option has not been progressed to analysis within our Cost Benefit Analysis (CBA). However, given that automation is significantly cheaper and less carbon intensive than the full overlay of an existing circuit, the preferred investment option for the circuits shortlisted in this EJP is to automate these circuits.

7 Detailed Analysis

This section of the report provides further detail on the investment strategy that we have designed for automating the network over RIIO-ED2 through consultation with stakeholders.

7.1 Overview

As previous discussed, the primary driver for investment is to improve the QoS on circuits that have a history of faults. It is proposed that Ex-Ante allowance will be used to target specific circuits to improve network performance where benefits can be realised for customers and enable us to drive towards meeting the targets that Ofgem have set in terms of ED2 IIS performance.

This section of the report describes the investment strategy that SSEN has chosen for improving network reliability through targeted investment. We have developed its own calculation methodology to determine the anticipated benefits of installing automation on the network using a variety of datasets, as discussed previously within this document. The main criterion for investment is to bring circuits that have a fault history in-line with our policy to improve overall network performance for the circuits identified in the analysis.

7.2 Automation Calculation Methodology

Using the NAFIRS data to derive all the circuits that have a history of faults over past 5 years, we then analyse the data and associated circuits to confirm whether automation is viable. To determine viability prior to calculating automation investment the following is required:

1. The number of customers on the circuit must be great than the customers segments proposed in our policy. SEPD = 500 customer segments and SHEPD = 250 customer segments.
2. If the circuit meets the requirements of 1, we then assess the existing network to determine the viability of backfeeding the circuit. The important factors at this stage are:

    a. Need confirmation that the circuit is interconnected with others through existing open point(s)
    b. Confirm the maximum capacity of the circuit(s) to be used as a backfeed
    c. Confirm the load that the backfeed will need to support under abnormal feeding arrangements

3. If the backfeed can support the network the next stage is to determine the number of switching points required to meet policy for customer segments.

Once the above has been confirmed the remaining list is then assessed against NAFIRS data to understand the past 5-year performance in terms of number of faults, CIs and CMLs. NAFIRS provides the actuals for each circuit over the period, the actuals define the circuits known performance. This actual performance is used as the benchmark to understand the improvement that automation can provide when installed.

To calculate the CI and CML improvement that automation will bring the following stages are methodology is applied:

1. Determine the number of customers that will be in each segment as per policy i.e. 1250 customers on a circuit will be segmented to ~416 per segment for SEPD.

2. Determine the number of faults over the past 5 years that have resulted in more than a single customer segment. i.e. any fault with a recorded CI > 416 (from above example). This determines the fault rate for the circuit.

3. From NAFIRS data confirm the average time customer are off supply during a fault that meets the criteria sets out in 1 & 2 above. i.e. the average of the CMLs for every fault. This defines the average fault repair time to get customers back on supply (known as R3).

4. Using the average fault repair time an assumption is made on the first switching instruction when an engineer attends site; this is deemed to be 30% of the average fault repair time (known as R1). The subsequent switching is deemed to be 15% of the average fault repair time (known as R2).

Based on the above the following formula is used to determine the response associated with automation:

$$\text{Customer in Segment (CS)} = \frac{\text{No. Customers on Feeder}}{\text{No. of automated switches+1}}$$

$$\text{CI} = \text{CS x Fault Rate}$$

$$\text{CML} = ((\text{CSxR1})+(\text{CSx50\%xR2})+(\text{CSx25\%xR2})+(\text{CSx12.5\%x(R3–(R1+(R2x2)))}) \text{ x Fault Rate}$$

The calculation for CML assumes that each switching operation restores the next half portion of customers i.e. 250 customers off supply, first switch restores 125, next switch restores ~62 etc until all customers are restored within the average fault restoration time.

Network Performance targets are determined through Ofgem's target setting methodology and this drives the CI and CML target for each Distribution Network Operator (DNO). To understand current network performance and the calculated automation performance we need to convert the CI and CMLs into Ofgem's Ratio for Cis and CMLs. This is done using the following formula:

$$\text{CI Ratio} = \frac{\text{No. Customers Interrupted}}{\text{Total Customer Base}} \times 100$$

$$\text{CML Ratio} = \frac{\text{No. Customer Minutes Lost}}{\text{Total Customer Base}}$$

Once actual performance and the calculated performance when automation is installed are converted into the Ofgem Ratios the following calculation is used to determine the overall benefit from automation:

$$\text{CI Improvement} = (CI_{actual} - CI_{automation}) \text{ x Automation Success Rate}$$

$$\text{CML Improvement} = (CML_{actual} - CML_{automation}) \text{ x Automation Success Rate}$$

The automation success rate is based on our current success rate associated with automation that has already been installed on the network. Due to communications issues and other delays we have found that the automation success rate is not 100%; it is >73%. With advances in communication technology and investment in ED2 in IT/OT this success rate is anticipated to increase; however, to ensure that we are not incorrectly accounting for future improvements our calculation methodology uses actual performance.

7.3 Example of Automation Calculation Methodology

To give context to the above an example is presented which uses the calculation methodology on a specific circuit to demonstrate what the output is like for each assessment that is undertaken across all the circuits that are viable for automation.

Taking an example from SEPD, Feeder BEAC F3L5, the following table represents actual performance where the CI and CML are converted into the Ofgem Ratio:

Table 6: Actual Network Performance from NAFIRS data

Feeder	Customers	CI	CML
BEAC F3L5	1042	0.068	0.034

Using the methodology discussed in section 7.2, the following table provides the customer segments, repair time, total customer base and calculated performance if automation was installed:

Table 7: Calculated Performance if Automation was Installed

							Automated	
Feeder	Customers in Segment (CS)	Yearly Fault Rate > CS	Response Time (R1)	Response Time (R2)	Average Repair Time (R3)	No. SEPD Cust	CI	CML
BEAC F3L5	347	2.00	15	7	49	3110203	0.0223	0.0051

By taking the actual performance and assessing it against calculated automated performance, with the inclusion of automation success rate, the following improvement is anticipated for BEAC F3L5:

Table 8: Performance Improvement with Automation

	Actuals		Automated			Improvement	
Feeder	CI	CML	CI	CML	Automation Success Rate (%)	CI	CML
BEAC F3L5	0.0683	0.03373	0.0223	0.0051	84.0%	0.0390	0.0240

Using the methodology, the following graphs represent the year on year improvement that automation could have provided had it been installed. This is based on the number of faults recorded since 2015/16 to 2019/20, as per the table below:

Table 9: Fault History on BEAC F3L5

	2015/16	2016/17	2017/18	2018/19	2019/20
No. of Faults	0	1	5	2	2

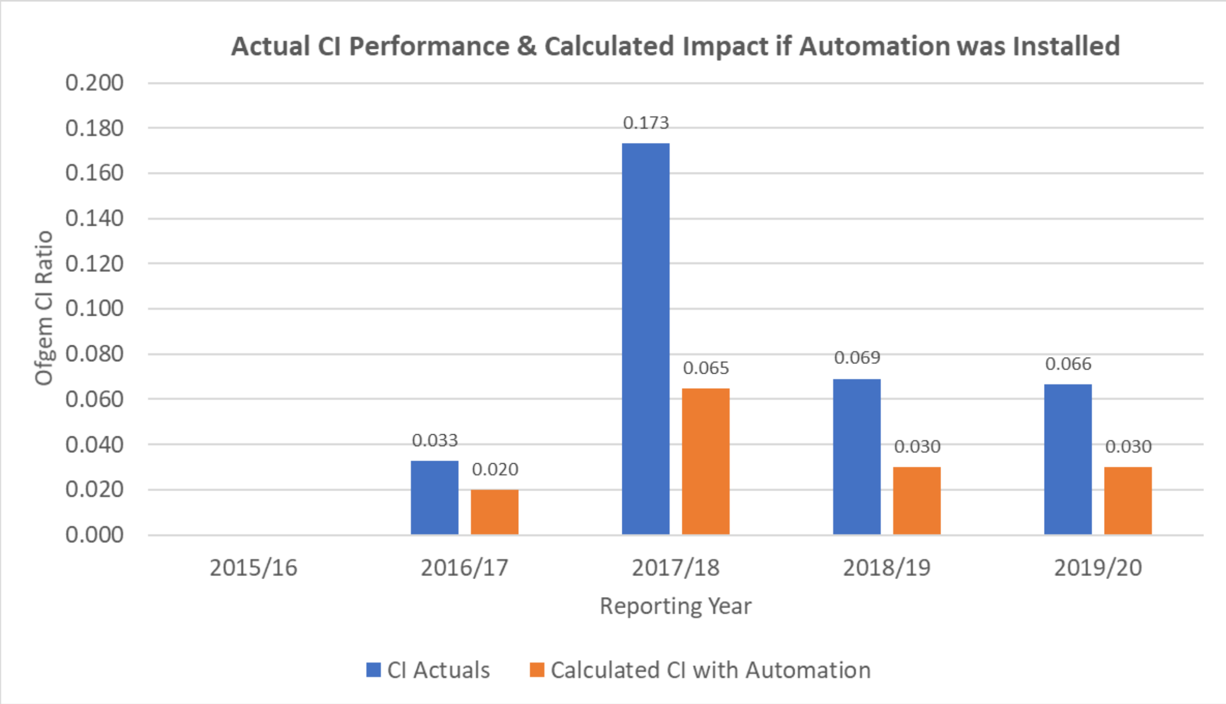


Figure 8: Example of Calculated CI Impact if Automation was Installed

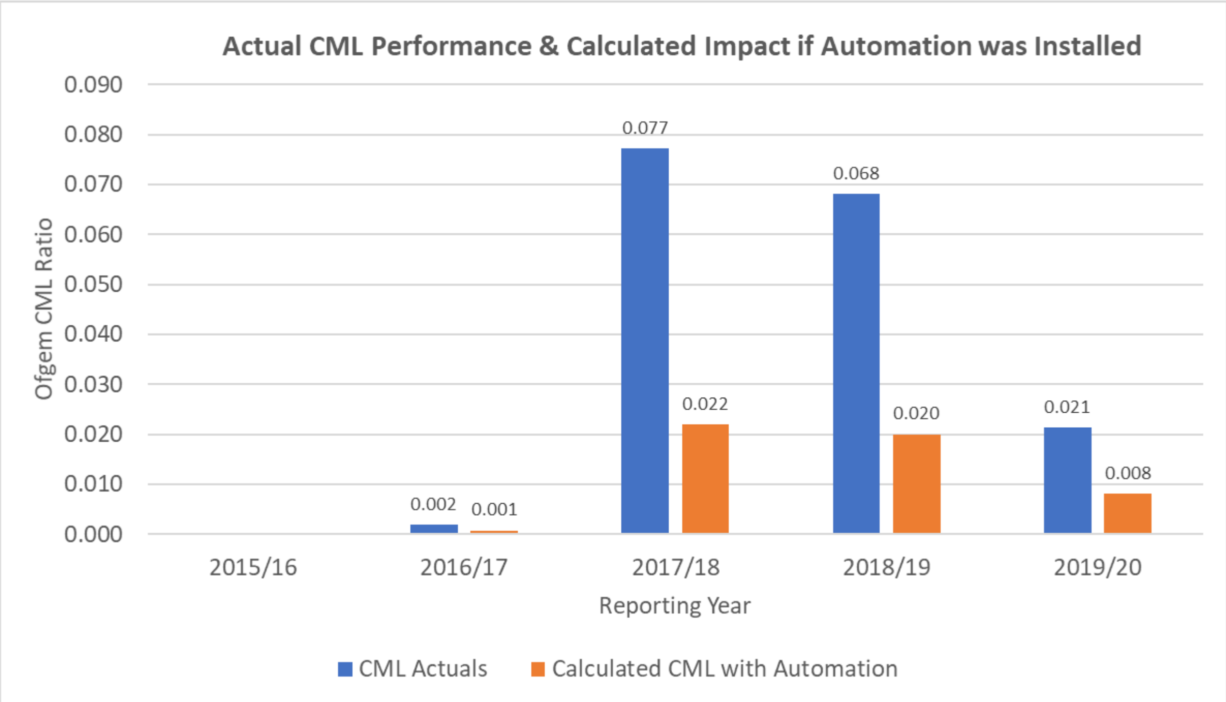


Figure 9: Example of Calculated CML Impact if Automation was Installed

7.4 Proposed Circuits Requiring Intervention

There are numerous circuits on SEPD and SHEPDs network that would benefit from intervention to improve QoS for customers. Using NAFIRS data we have selected the key circuits that would benefit from intervention to improve network performance. The proposed scope of works is to target **145 circuits in SHEPD** and **426 circuits in SEPD** to improve the QoS to those associated customers in line with stakeholder and Ofgem expectations.

7.5 Forecasted Network Performance Improvement

Based on our assessment of NAFIRS data the following table highlights the number of circuits that we plan to invest in, total cost and calculated yearly benefit by the end of ED2.

Table 10: Forecasted Automation Spend and Calculated Yearly Improvement by end of ED2

Licence Area	No. of Circuits	Cost (£)	Calculated CI Benefit	Calculated CML Benefit
SHEPD	145	£5.42m	2.65	1.72
SEPD	426	£17.21m	2.82	2.35

The CI and CML benefit calculated is based on the difference between actual performance and the calculated performance of automation. The deployment of automation on the network will provide improvements in network performance for the associated customers; however, the exact benefit could differ from the calculation due to several variables i.e. new customer connections, network configuration changes, changing fault trends, weather etc.

7.6 Cost Benefit Analysis

A detailed Cost Benefit Analysis (CBA) exercise has been undertaken to support the investment strategy that is described within this EJP. Within the CBA an analysis has been undertaken on the costs and benefits associated with the installation of automation over the lifetime of the proposed investment.

7.6.1 CBA Methodology

The Ofgem CBA tool has been used to build a thorough CBA which accurately represents the costs and benefits associated with the installation of automation. The CBAs have been used to identify the most cost-effective investment option for the installation of automation which have been identified as requiring intervention due to fault performance over the past 5 years.

The install automation option has included the following inputs within the calculation of £m NPV associated with each investment option.

- **Replacement Cost:** The CAPEX associated with each asset replacement option as per the unit cost analysis undertaken by us for this asset category

- **Inspection & maintenance cost:** The OPEX cost associated with inspecting and maintain new automated switchgear as per our policy.

- **Network Reliability:** The IIS performance (annual CML/CI) associated with each option.

As the Do-Nothing option represents the current performance on the network there is no change to account for, therefore has not been populated as part of the CBA.

The **installation of automation option** instead models the CI / CML improvement based on current network performance against the calculated improvement associated with the automation calculation methodology. The CBA also accounts for the cost incurred for installing automation and maintaining those sites.

7.6.2 CBA Results

Table 11 shows the results of the CBA analysis that has been undertaken in support of this EJP. The results of the CBA indicate that the installation delivers clear benefits to network customers and consumers.

Table 11: Cost Benefit Analysis (CBA) Results

Option #	CBA Investment Option	CBA Results (£m NPV) – after 45 years	
Option 2	Install Automation	95,47 (SEPD)	16.84 (SHEPD)

Figure 10 and Figure 11 shows how the £m NPV progresses over 45 years for the installation of automation option that has been considered.

Figure 10: Install Automation CBA Results – SEPD

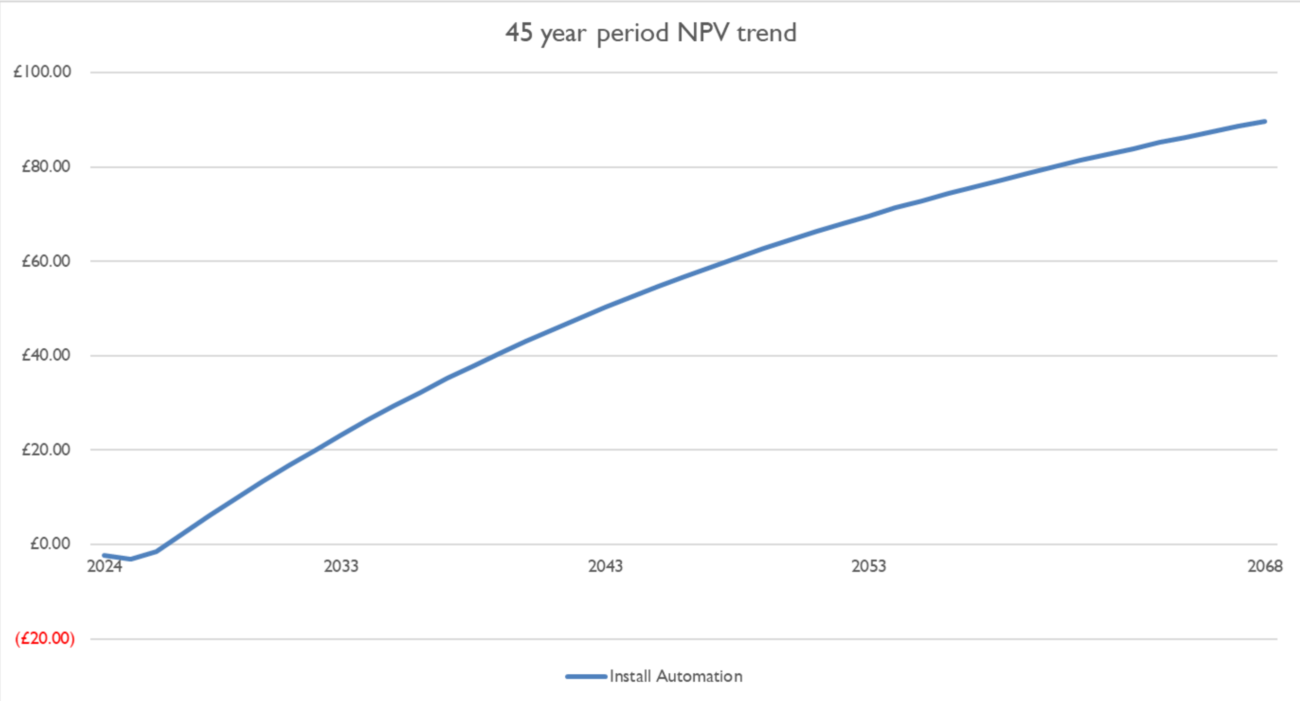
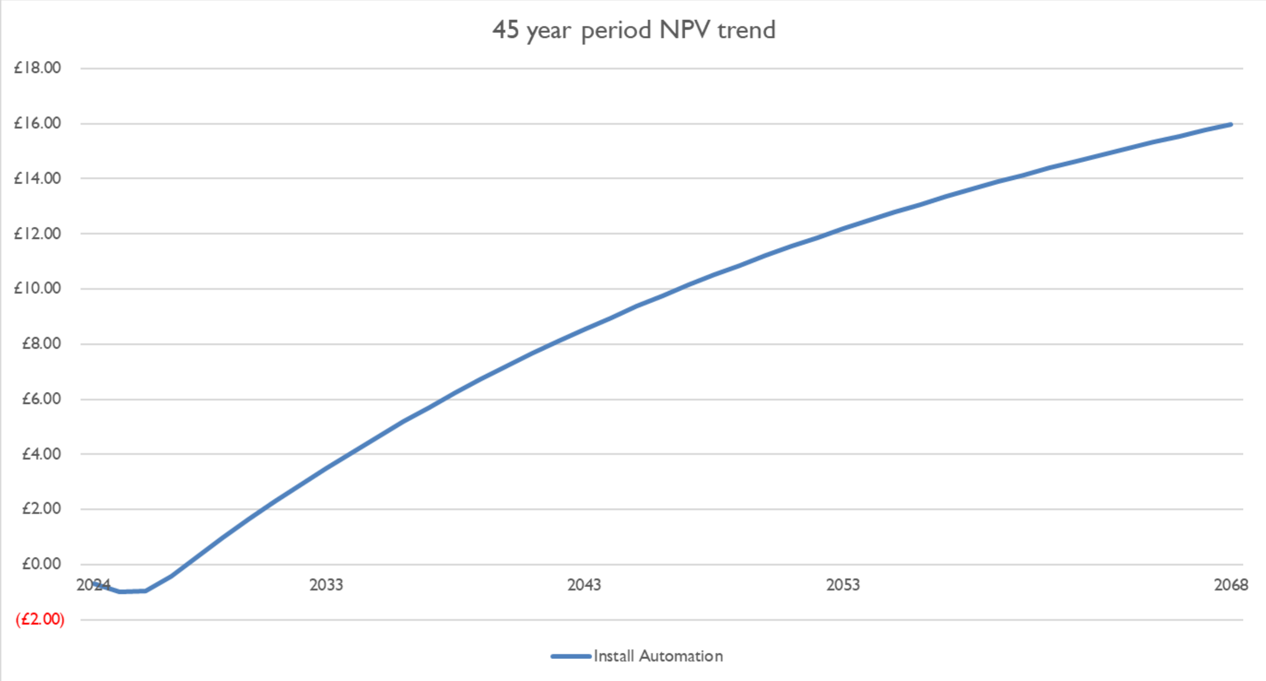


Figure 11: Install Automation CBA Results – SHEPD



7.7 Proposed RIIO-ED2 Investment

This section of the EJP sets out the costs and volumes that have been calculated for the installation of automation after our detailed CBA analysis and our RIIO-ED2 stakeholder engagement.

7.7.1 Circuits, Volumes and Costs

Table 12 to Table 17 show the number of circuits being automated, the volumes of asset additions & disposals and the costs associated with automating the circuits for SEPD and SHEPD. These costs and volumes have been determined by our automation calculation methodology, is aligned to the ***Reliability Strategy (Annex 7.2)*** and incorporates feedback gathered from the RIIO-ED2 stakeholder engagement activities.

Table 12: Number of Circuits being Automated in RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
Circuits to be Automated (SEPD)	#	150	150	126	-	-	**426**
Circuits to be Automated (SHEPD)	#	45	45	45	10	-	**145**
Total	**#**	**195**	**195**	**171**	**10**	**-**	**571**

Table 13: SEPD Automation Asset Additions – CV15 Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
LV Main (UG Plastic)	km	3.5	3.3	2.6	-	-	**9.4**
6.6/11kV Poles	#	46.0	20.0	7.0	-	-	**73**
6.6/11kV UG Cable	km	0.9	0.8	0.6	-	-	**2.3**
6.6/11kV CB (PM)	#	46.0	20.0	7.0	-	-	**73**
6.6/11kV RMU	#	87.0	83.0	64.0	-	-	**234**

Table 14: SEPD Automation Asset Disposals – CV15 Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
LV Main (UG Plastic)	km	3.5	3.3	2.6	-	-	**9.4**
6.6/11kV Poles	#	46.0	20.0	7.0	-	-	**73**
6.6/11kV UG Cable	km	0.9	0.8	0.6	-	-	**2.3**
6.6/11kV CB (PM)	#	13.0	5.0	2.0	-	-	**20**
6.6/11kV Switch (GM)	#	261.0	249.0	192.0	-	-	**702**

Table 15: SHEPD Automation Asset Additions – CV15 Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
LV Main (UG Plastic)	km	0.4	1.5	0.4	0.5	-	**2.8**
6.6/11kV Poles	#						
6.6/11kV UG Cable	km	0.8	1.2	2.0	0.3	-	**4.3**
6.6/11kV CB (PM)	#	5.0	4.0	5.0	1.0	-	**15**
6.6/11kV Switch (GM)	#	12.0	9.0	19.0	-	-	**40**
6.6/11kV RMU	#	14.0	13.0	13.0	5.0	-	**45**
6.6/11kV Transformer (GM)	#	12.0	13.0	11.0	5.0	-	**41**

Table 16: SHEPD Automation Asset Disposals – CV15 Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
LV Main (UG Plastic)	km	0.4	1.5	0.4	0.5	-	**2.8**
6.6/11kV Poles	#						
6.6/11kV UG Cable	km	1.0	1.4	1.7	0.3	-	**4.4**
6.6/11kV CB (PM)	#	4.0	2.0	3.0	2.0	-	**11**
6.6/11kV Switch (GM)	#	23.0	28.0	25.0	4.0	-	**80**
6.6/11kV RMU	#	10.0	8.0	10.0	3.0	-	**31**
6.6/11kV Transformer (GM)	#	12.0	14.0	11.0	5.0	-	**42**

It must be noted that there are wider works that contribute to the spend associated with automation installation that cannot be accounted for within CV15 additions and disposals. The additional works include the installation of a Communications unit, Fault Passage Indicators, Actuators, commissioning etc.

Table 17 below provides a breakdown of the total cost associated with all elements that are required as part of an automation scheme.

Table 17: Automation Installation – CV15 Cost for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
Circuits to be Automated (SEPD)	£m	6.46	6.41	4.34	-	-	**17.21**
Circuits to be Automated (SHEPD)	£m	1.95	1.51	1.52	0.44	-	**5.42**
Total	**£m**	**8.41**	**7.92**	**5.86**	**0.44**	**-**	**22.63**

Please note that in CV15 – QoS, the total cost associated with QoS delivery is a combination of Automation and Lightning protection. As such, there is an additional £0.43m in SEPD and £1.13m in SHEPD associated with Lightning protection.

7.8 Unit Costs

We have a successful track record of delivering automation schemes on the network. As every automation scheme is specific to the circuit being automated, we have undertaken a review of the circuits identified for automation and undertaken bespoke assessments on each circuit. The assessments consider the type of automation required for the circuit and the number of sites that need to be automated. This assessment uses our past delivery experience and drives cost efficiencies through our procurement contracts and contracting agreements.

7.9 Deliverability of Proposed Volumes

Between our draft and final Business Plans we have carried out a more detailed deliverability assessment of our overall plan as a package and its component investments. Using our draft Business Plan investment and phasing as a baseline we have followed our deliverability assessment methodology. We have assessed any potential delivery constraints to our plan based on:

- In-house workforce capacity and skills constraints based on our planned recruitment and training profile and planned sourcing mix as well as the efficiencies we have built into our Business Plan (detailed in ***Ensuring Deliverability and a Resilient Workforce (Chapter 16)***)
- Assessment of the specific lead and delivery timelines for the asset classes in our planned schemes
- We have evaluated our sourcing mix where there were known delivery constraints to assess opportunities to alleviate any constraints through outsourcing
- We have engaged our supply chain (detailed in ***Ensuring Deliverability and a Resilient Workforce*** **(Chapter 16)**) to explore how the supply chain could support us to efficiently deliver greater volumes of work and how we could implement a range of alternative contracting strategies to deliver this
- We have also engaged with the supply chain on the delivery of work volumes that sit within Uncertainty Mechanisms to ensure we have plans in place to deliver this work if and when the need arises
- We have assessed the synergies between our planned load, non-load and environmental investments to most efficiently plan the scheduling of work and minimise disruption to consumers
- Based on our assessment of delivery constraints and potential solutions to resolve them, we have revised our investment phasing accordingly to ensure our Business Plan is deliverable, meets our consumers' needs and is most cost efficient for our consumers

8 Conclusion

The purpose of this Engineering Justification Paper (EJP) has been to describe the overarching investment strategy that we intend to take during RIIO-ED2 to improve QoS to our customers through the installation of automation on the network.

The background into the use of automation and the options under consideration has been provided including our automation calculation methodology and cost benefit analysis.

As described within Section 6, a holistic approach is taken when selecting the most viable option for improving QoS on circuits with a fault history. This includes fault trend analysis and careful consideration of stakeholder feedback, holistic financial impact and deliverability of each investment option. In relation to improving the QoS the only option to considered is highlighted in bold below:

- Option 1: Do Nothing
- **Option 2: Install Automation**
- Option 3: Replace the main circuit

The installation of automation on the HV network is considered where there is a need and will also be installed as part of our Strategy for automation rollout as per TG-NET-NPL-010. The installation of automation is required to provide customer with improved network performance whilst driving an investment that is cost efficient and affordable.

This investment represents a total spend of **£22.63m** throughout RIIO-ED2 with a calculated network performance improvement of **2.65 CI** and **1.72 CML** in SHEPD **and 2.82 CI** and **2.35 CML** in SEPD, as supported by our stakeholders. The calculated benefits can differ from the calculation due to several variables i.e. new customer connections, alterations to network configuration, changing fault trends, weather etc.

Appendix 1: Acronyms Table

Table 18: Acronym Used within Document

Acronym	**Description**
APRS	Adaptive Power Restoration Switching
BPDT	Business Plan Data Table
CB (GM)	Circuit Breaker (Ground Mounted)
CI	Customer Interruptions
CML	Customer Minutes Lost
CV	Cost & Volumes
CV7a	Asset Replacement NARM
CV15	Quality of Service Cost and Volume Table
DNO	Distribution Network Operator
DPCR5	Distribution Price Control Review 5 (2010-15)
EJP	Engineering Justification Paper
HV	High Voltage
IDP	Investment Decision Pack
IIS	Interruptions Incentive Scheme
NAFIRS	National Faults and Interruptions Reporting Scheme
PMCB	Pole Mounted Circuit Breaker
RIIO-ED1	Distribution Price Control Review (Electricity Distribution 1) 2015-23
RIIO-ED2	Distribution Price Control Review (Electricity Distribution 2) 2023-28
RMU	Ring Main Unit
SEPD	Southern Electric Power Distribution
SHEPD	Scottish Hydro Electric Power Distribution
SSEN	Scottish and Southern Electricity Networks

Appendix 2: Relevant Policy, Standards, and Operational Restrictions

The policies, manuals and standards and operational restrictions which govern the management of automation are listed below in Table 18.

Table 19: Relevant Documents for Automation

Policy Number	Policy Name / Description
ST-NET-ENG-006	Distribution Automation
WI-NET-PAC-004	Urban Automation – Inspection and Maintenance Instruction
TG-NET-NPL-010	Planning Standards for 11kV and 6.6kV Distribution Networks