Scottish & Southern Electricity Networks

RIIO ED2 Engineering Justification Paper (EJP)

Loch A'Choire North – Asset Replacement

Investment Reference No: 457_SHEPD_LOCH_A'CHOIRE_NORTH

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Definitions and Abbreviations

Acronym	Definition
EJP	Engineering Justification Paper
CBA	Cost Benefit Analysis
CBRM	Condition Based Risk Management
IDP	Investment Decision Pack
EfW	Energy from Waste
ESA	Electricity Supply Area
EV	Electric Vehicle
FES	Future Energy Scenarios
GIS	Geographic Information System
GW	Gigawatt
kW(h)	kilowatt (hour)
MW	Megawatt
OHL	Overhead Line
PEV	Pure Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PV	Photovoltaics
BSP	Bulk Supply Point
GSP	Grid Supply Point
LRE	Load Related Expenditure
LCT	Low Carbon Technology
SSEN	Scottish and Southern Electricity Network
UG	Underground Cable

1 Executive Summary

This Engineering Justification Paper (EJP) for Scottish Hydro Electric Power Distribution (SHEPD) covers the investment required to manage the risk and performance of the Loch A'Choire North 33kV subsea cable.

A number of subsea cable circuits have failed during RIIO-ED1, causing significant impact on customer interruptions, constrained generation, and have resulted in impact costs for temporary generation and CO2 emissions. There has been a review of the approach taken to attempt to identify and pre-empt the impact of subsea cable failure by using a 'monetised risk-based approach' alongside a traditional CBRM approach, which was not viewed as identifying the critical circuits for the strategic programme effectively on its own.

The Loch A'Choire North 33kV subsea cable is 34 years old and has a health index rating of HI5 in the CNAIM asset model. This health rating means that the cable is considered to be end of life. SSEN has taken the view that HI5 cables present a significant risk to customer supplies, and as such the intention is to replace HI5 cables on the network. Furthermore, the parallel Loch A'Choire South feeder also has a health index of HI5. This represents a significant risk to the supplies of the connected customers connected to these circuits. Each ciruit provides a back feed to the other, in the even of an outage or fault. The Loch A'Choire South circuit will be detailed in a separate EJP and CBA.

Following optioneering and detailed analysis, as set out in this paper, the proposed scope of works for the Loch A'Choire North 33kV subsea cable are:

- Install a new 33kV subsea cable to replace the existing Loch A'Choire North 33kV subsea cable.
- Disconnect the existing Loch A'Choire North 33kV subsea cable.
- Tie new cable in to existing 33kV network.

The anticipated cost to deliver the preferred solution is £[redacted]. The delivery programme for all subsea cables in ED2 will be determined through detailed planning and engagement with marine installation contractors and cable procurement opportunities. For simplicity, where required, the delivery year is assumed as 2026/27 in this EJP and this will be refined as our programme develops.

This scheme delivers the following outputs and benefits:

- Improves reliability and reduces the potential for customer interruptions due to a subsea cable fault.
- Reduces the risk of incurring impact costs, including costs for constrained generation.
- Reduces the monetised risk forecast by the end of ED2 from £8,491 with no intervention, to £484.
- Improves onshore network access, safety and resiliance
- This project can be delivered in tandum with the Loch A'Choire South replacement (detailed in a separate EJP), gaining efficiencies and removing two end of life cables, which support each other, at the same time.

Option 2, replacement with a similar sized cable, is the preferred option providing the least cost and best NPV option.

All subsea cable EJPs should be read in conjunction with the ***Scottish Islands (Annex 8.1)*** of our RIIO-ED2 Business Plan.

2 Investment Summary Table

Table 1 below provides a high-level summary of the key information relevant to this Engineering Justification Paper (EJP).

Table 1: Investment Summary

Name of Programme	Loch A'Choire North Asset Replacement		
Primary Investment Driver	The Primary Investment Driver described within this EJP is the requirement to reduce the overall monetised risk associated with the loss of the existing Loch A'Choire North 33kV subsea cable, which is also an end of life asset.		
Investment reference/mechanism or category	Cost Benefit Analysis reference: 457_SHEPD_LOCH_A'CHOIRE_NORTH		
Output reference/type	As above		
Cost (£m)	£[redacted]		
Delivery year	ED2 (2026/27)		
Reporting Table	CV7: Asset Replacement		
Outputs included in RIIO ED1 Business Plan	No		
CV7: Asset Replacement RIIO ED2 Spend (£m)	**Asset Category**	**ED2 (£m)**	**Total (£m)**
	EHV Subsea Cable	[redacted]	[redacted]

3 Introduction

This Engineering Justification Paper (EJP) for Scottish Hydro Electric Power Distribution (SHEPD) covers the investment required to manage the performance of the Loch A'Choire North 33kV subsea cable.

Primary Investment Driver described within this EJP is based on reducing the overall monetised risk associated with this circuit which has been determined from the "Strategic Subsea Cable CBA Model" developed to determine the overall replacement / augmentaiton strategy for all subsea cables by mitigating the monetised risk associated with the subsea cable assets. The model evaluates the probabilty of failure, the cost of intervention and the impact cost and used this assesment across the asset population to determine the initial investment method to be considered. Further detail on the Strategic Subsea Cable CBA Model is provided in the ***Scottish Islands (Annex 8.1).***

The Loch A'Choire North 33kV subsea cable provides supplies to Glensanda Quarry, however in the event of a fault will affect 1,495 customers supplies.

The monetised risk value for the Loch A'Choire North 33kV subsea cable is currently £2,998 and without intervention may increase to £8,419 at the end of ED2. This subsea cable has been identified for pre-emptive investment as it is installed parallel to a second 33kV submarine cable which supplies the same customers and is in the same HI5 end of life condition. Both circuits are used to support each other and are also the strategic back feed for each other. Both were installed at the same time, are of the same size and construction and same health condition.

The Loch A'Choire South cable has a higher monetised risk value and is listed higher on the generic CBA in priority for intervention, nonetheless it makes commercial sense to replace both cables at the same time to gain efficiencies, minimise environmental impact and secure supplies for the customers which utilise supply from these circuits.

This EJP evaluates the appropriate options to provide the required mitigation for the Loch A'Choire North cable. There is a significant risk to the customers, supplied from this North cable and the South cable, of losing both grid connections at a similar time. This could affect their supplies and export capabilities for a prolonged period and require mobile diesel generation to restore supplies whilst the cables are repaired or replaced under fault conditions. These cables also supply the largest granite quarry in Europe at Glensanda.

In addition, the HI5 health index rating of this cable means that it is considered to be end of life. The view has been taken that HI5 cables present a significant risk to customer supplies, and as such the intention is to replace HI5 cables on the network.

Section 4 provides high-level background information for this subsea asset category and explains the importance of this asset for our electricity distribution network and our network customers, and the motivation for ensuring our subsea cables are in good health over the course of RIIO-ED2 and beyond.

Sections 5 and 6 provide a summary of the corresponding intervention options which can be deployed as a solution to these condition related investment drivers.

Section 7 provides a detailed analysis 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.

Section 8 provides an overview of the deliverability and risk management considerations being adopted for the transition from RIIO-ED1 in to RIIO-ED2, and the delivery of subsea cable asset replacement projects.

Section 9 provides an overview of the information presented throughout the EJP and concludes a proposed solution recommended to manage the business case presented.

4 Background Information and Analysis

4.1 How Do We Determine Our Intervention Priorities

We introduced our Condition Based Risk Management (CBRM) system in 2014 following the RIIO-ED1 Business Plan submission. However, since August 2017, we switched over fully to maximise utilisation of the Common Network Assets Indices Methodology (CNAIM) modelling for all asset classifications applicable for the RIIO-ED1 requirements with the data inputs outlined in the Information Gathering Plan (IGP).

The RIIO-ED2 Business Plan submission has been based on the latest version of the industry standard CNAIM v2.1 which was approved for use in RIIO-ED2 by Ofgem in April 2021. The supporting data used in the modelling of this submission is based on the reported position of our asset condition for RIIO-ED1 Year 6 at the end of August 2021.

The full details of the Energy Network Association's NARMs Electricity Distribution Working Group (NEDWG) publication on CNAIM v2.1 is available on Ofgem's website. For further detail on our RIIO-ED2 NARMS strategy please see ***Safe and Resilient (Annex 7.1).***

Our proposed investment programme in ED2 is asset data led; refined and iterated by overlaying the industry standard risk management methodology with enhanced risk modelling and cable specific cost benefit analysis. We are proposing planned replacement of cables where the certainty of need is highest driven by high probability and impact of failure in ED2.

We have adopted a four-step funnel approach, as shown below, to determine the interventions required on the network. This approach allows us to filter from an initial examination of the complete list of subsea cables we operate to a credible and deliverable list of interventions which are supported by robust analysis. Steps 1 to 3 are set out in detail within our ***Scottish Islands (Annex 8.1).***

This EJP covers Step 4 for the Loch A'Choire North cable which has qualified as requiring intervention. We set out here our approach to clearly justify why the circuit design approach being proposed and associated costs are the most economic and efficient and what work would be required to deliver on these investments.

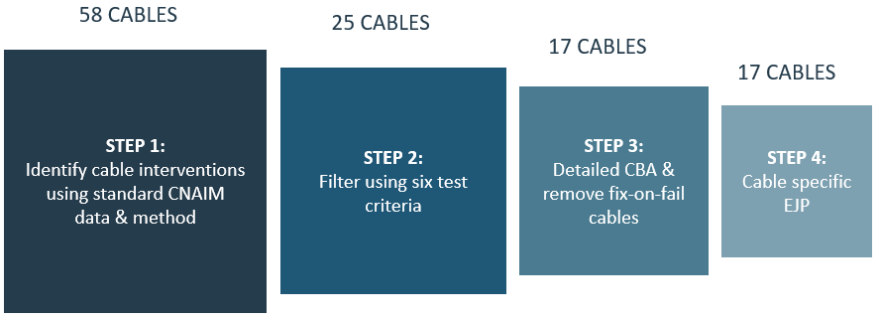

Figure 1: Filter approach to cable selection

4.2 Existing Network Arrangement

The subsea cable under investigation is located under Loch A'Choire, approximately 33.7 km southwest from Fort William 132/33kV GSP. The existing subsea cable is 1.9 km long.

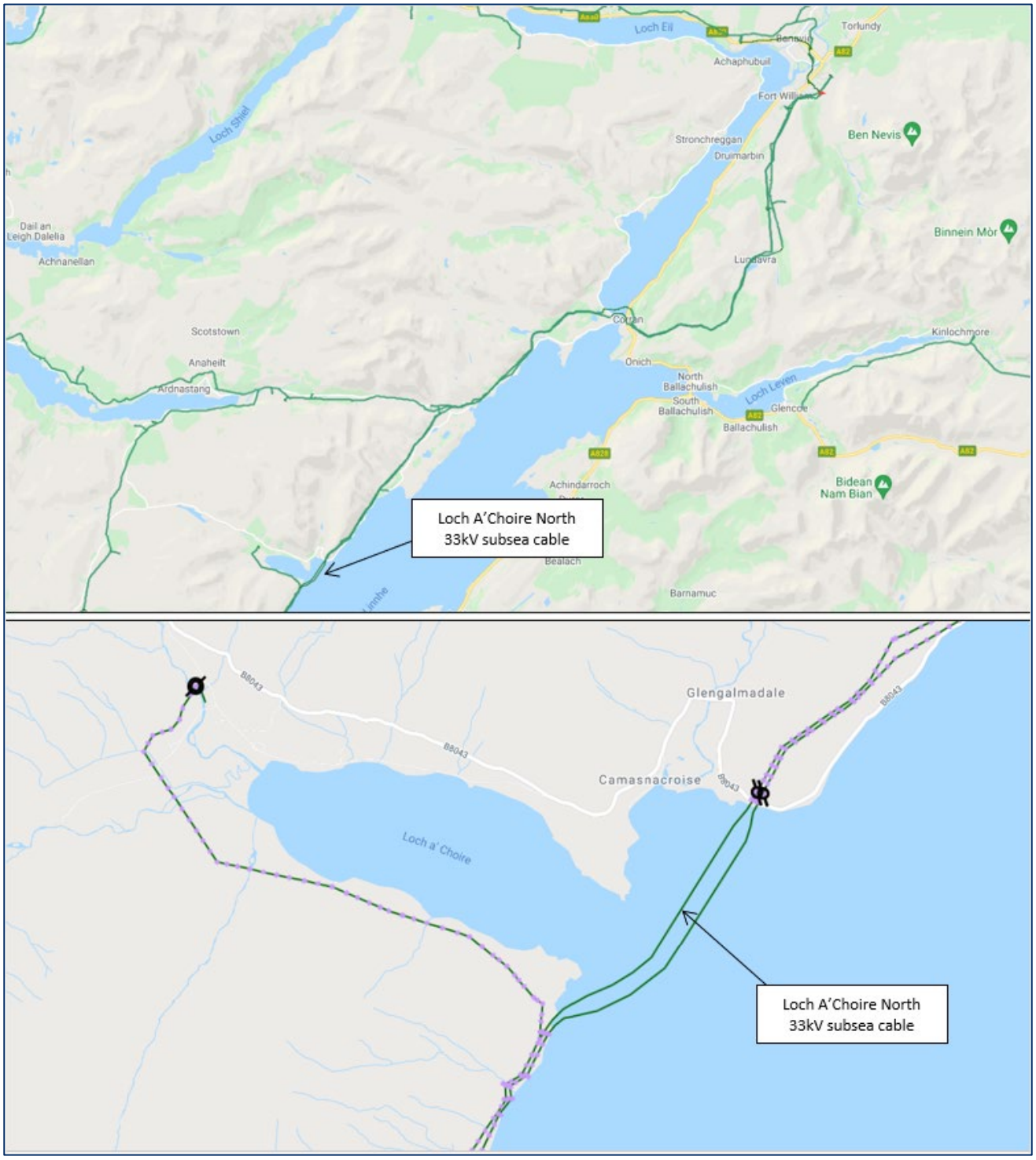

Figure 2: Location of Loch A'Choire Cables

Running adjacent to Loch A'Choire North cable is the Loch A'Choire South subsea cable. The existing 33kV network configuration is shown in figure 3 below.

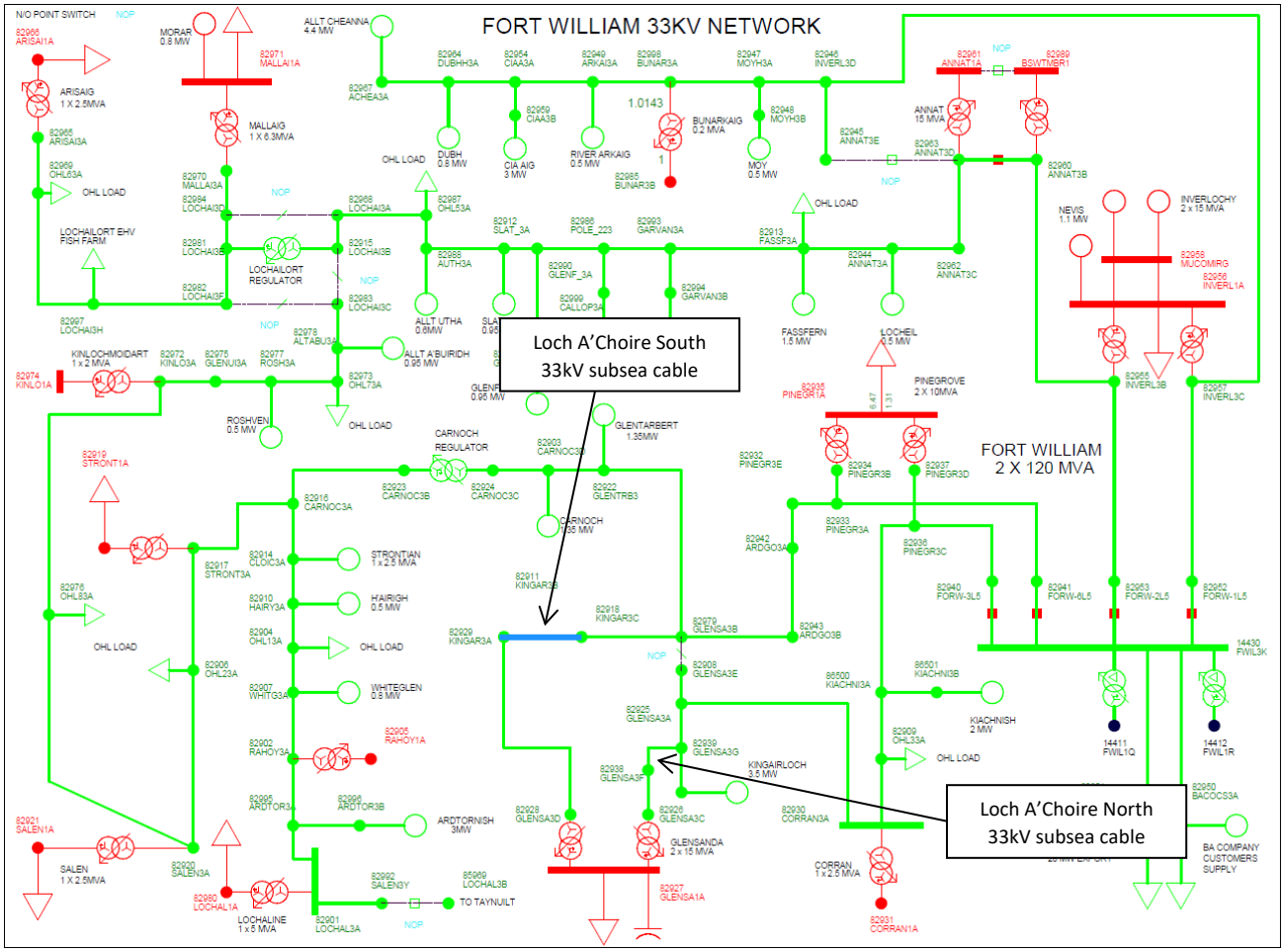

Figure 3: *Fort William 33kV Network Arrangement SLD*

4.3 Existing Asset Condition

The Common Network Asset Indices Methodology (CNAIM) models maintained by SHEPD provide a Health and Criticality Index for each individual asset. This is calculated using a variety of asset-specific data which includes basic parameters in addition to the observed and measured condition (where available) of each asset.

The subsea cable is EHV 95 PILC 'HSL' SWA AEI type and has been in service for 34 years. The health index of the subsea cable is HI5 with a criticality index of C2. The PoF is 0.0776 at the start of ED2, rising to 0.2198 at the end of ED2 with no intervention.

This health rating means that the cable is considered to be at the end of its operational life. The view has been taken that HI5 cables present a significant risk to customer supplies, and as such the intention is to replace HI5 cables on the network.

4.4 Demand Forecast and Generation

The Loch A'Choire North 33kV subsea cable is a feeder circuit fed from Fort William 132/33kV BSP. It provides supplies to Glensanda 33/11kV primary S/S, including Glensanda Quarry.

In the event of an outage on the Loch A'Choire North 33kV subsea cable, downstream customers would maintain supply through the Loch A'Choire South cable, the South cable has the same characteristic as the North cable and is also an HI5 cable.

The subsea cable is rated at 14MVA. The current demand on the subsea cable is 6.6MVA, 47.0% of the cable rating. The forecasted demand growth is 3.8% per year on average and the forecasted demand at the end of ED2 is expected to be 8.9MVA, 63.4% of the cable rating.

The south subsea cable supports 2.4MW of distributed generation. The Loch A'Choire South cable may be able to support this generation in the event of a failure on Loch A'Choire North, however contractually under an N-1 scenario this generation would be constrained. Detailed systems studies and negotiations with the customer could take place to see if any of the generation could be allowed to export through an alternative network route.

5 Summary of Options Considered

This section of the report sets out the investment options that have been considered as possible interventions to address the identified monetised risk associated with this cable. The approach taken has been to ensure investment options demonstrate best value for money for network customers.

5.1 Summary of Options

The table below provides a high-level summary of the investment options that have been considered along with the advantages and disadvantages associated with each. A more detailed description of each option is then provided within the following sub-sections.

Table 2: Summary of Investment Options

Option	Description	Advantages	Disadvantages	Results
1. Do Minimum	Replace on failure	Low initial cost.	Availability of material and resource when required. High cost associated with an emergency replacement. Does not address the risk of a failure until after failure occurs and cable replaced. PoF remains high.	Rejected
2. Replace similar size	Replace the cable with a similar sized cable	Improved HI and PoF. Low initial cost.		Recommended option
3. Replace larger size	Replace the cable with a larger sized cable	Improved HI and PoF.	Higher initial cost than above. The similar sized cable would be sufficient for the forecasted load growth, a larger cable would be superfluous.	Rejected
4. Augmentation similar size	Augmentation of the route with a second similar sized cable	Improved HI and PoF. Improved security of supply for the remainder of the existing cable life.	Higher initial cost than replacement option. Increased cable monitoring and maintenance costs. Existing adjacent cable already provides n-1 security of supply, therefore an augmentation is unnecessary.	Rejected
5. Augmentation larger size	Augmentation of the route with a second larger sized cable	Improved HI and PoF. Improved security of supply for the remainder of the existing cable life.	Higher initial cost than above. The similar sized cable would be sufficient for the forecasted load growth, a larger cable would be superfluous.	Rejected
6. Two cable replacement	Replace the cable with two new cables	Improved HI and PoF. Improved security of supply.	Significantly higher initial cost than other options. Existing adjacent cable already provides n-1 security of supply, therefore two cables is unnecessary.	Rejected

6 Analysis and Cost

6.1 Option 1: Do Minimum – Replace on Failure

The "Do Minimum" Option is for the repair or replacement of the cable on failure. Based on the age, health index and length of the cable, repair would be by replacement of the entire subsea section of the cable of similar size following a similar route to that of the existing cable shown previously.

This option avoids any initial cost of intervention and, should the cable not fault during the next price control, may defer expenditure beyond ED2. However, the cost of an emergency replacement would be higher than a planned replacement if the cable fails and it would incur impact costs.

For the purposes of assessing this option using the Cost Benefit Analysis (CBA), it was assumed that the subsea cable would fail at the end of ED2, in 2028. Given that the Loch A'Choire South cable is planned to be replaced in ED2 in a parallel location to this North cable, it would be very inefficient to return a few years later to replace a cable in the same location which SHEPD knew to be in poor condition at the time of replacing the South cable.

After replacing the cable there would be an improvement in the PoF and a reduction in the monetised risk. The anticipated capital cost of this option is:

- Option cost: £[redacted]

This option was rejected as it would incur impact costs, constrained generation costs and reputational damage. In addition, the replacement in an emergency would be [redacted] % higher than the cost of an equivalent planned replacement.

6.2 Option 2: Replace the cable with a similar sized cable

This option involves replacing the cable with a new, similar sized subsea cable. This would improve the HI and Probability of Failure of the circuit, resulting in a change to the characteristics set by the age and condition.

The proposed replacement cable would be 95mm^2 with a 16MVA capacity which would be sufficient to support demand for over 20 years based on the current forecasted load growth. The existing cable would be disconnected and capped.

After replacing the cable there would be an improvement in the PoF and a reduction in the monetised risk. The anticipated capital cost of this option is:

- Option cost: £[redacted] k

This option has the lowest initial outlay cost, the best NPV and will offer sufficient network security alongside the Loch A'Choire South cable. This is the preferred solution.

6.3 Option 3: Replace the cable with a larger sized cable

This option is similar to option 2, however a larger sized cable would be installed.

After replacing the cable there would be an improvement in the PoF and a reduction in the monetised risk. The anticipated capital cost of this option is:

- Option cost: £[redacted] k

This option does not provide any additional benefits compared to the previous one as the load growth is not expected to be a concern at this location, therefore this option was rejected.

6.4 Option 4: Augmentation of the route with a second similar sized cable

This option involves laying a new 95mm^2 subsea cable, similar to option 2, but also retaining the existing connection. The existing cable would remain connected and continue to be maintained. New switchgear would be installed to enable switchover of the circuits in the event of a fault on one of them.

The existing cable would continue to operate until it develops a fault, at which point there would be another evaluation as to the possible options for that cable, however at the time of the fault the supplies would still be maintained through the new cable.

This option would improve the security of supply to the connected customers until the existing cable fails. The cost of this option is as option 2, plus the added cost of connection into the network.

After installing the new cable there would be an improvement in the PoF and a reduction in the monetised risk. The anticipated capital cost of this option is:

- Option cost: £[redacted] k

Whilst this option does provide an improvement to the security of supply it is considered unnecessary as there is already an existing adjacent cable that provides n-1 security. It also has a higher initial outlay cost than a replacement option, hence this option was rejected.

6.5 Option 5: Augmentation of the route with a second larger sized cable

This option is similar to option 4, however a larger sized cable would be installed. The cost of this option is as option 3, plus the added cost of connection into the network.

After installing the new cable there would be an improvement in the PoF and a reduction in the monetised risk. The anticipated capital cost of this option is:

- Option cost: £[redacted] k

This option does not provide any additional benefits compared to the previous one as the load growth is not expected to be a concern at this location, therefore this option was rejected.

6.6 Option 6: Replace the cable with two new cables

This option involves replacing the cable with two new similar sized cables. The laying of the two cables together under the same contract is expected to allow cost saving of 10% on the second cable compared to the first. The existing cable would be disconnected and capped.

After installing the new cables there would be an improvement in the PoF and a reduction in the monetised risk. The anticipated capital cost of this option is:

- Option cost: £[redacted] k

This option has a significantly higher initial outlay cost than the others, and whilst this option does provide an improvement to the security of supply it is considered unnecessary as there is already an existing adjacent cable that provides n-1 security; therefore, this option was rejected.

7 Summary of Cost Benefit Analysis

This section of the report provides an overview for each option from the Cost Benefit Analysis (CBA). A detailed exercise has been undertaken to support the investment strategy that is described within this EJP for the six options, as described below:

7.1 Option Costs

Our RIIO-ED2 Business Plan costs are derived from our outturn RIIO-ED1 expenditure. For our Subsea cable projects, our Unit Costs have been derived from analysing costs pertaining to delivered projects completed during RIIO-ED1 and are therefore based on actual costs. For cable installation activities the delivered projects were competitively tendered utilising our Subsea Cable Installation Framework and cable costs have been benchmarked against recently completed tender events. By tying our costs back to reported, outturn, real life data this approach provides multiple data points and provides a high level of cost confidence in our Business Plan cost forecast for RIIO-ED2.

As our Business Plan has developed, project scopes and costs have been refined, especially with the input of valuable stakeholder feedback on our draft proposals. This final Business Plan submission cost forecast contains that refinement, and the changes are captured within our supporting plan documentation. The generic Unit Cost rates used in the draft Business Plan have now been revised following extensive analysis. This is further defined within ***Scottish Islands (Annex 8.1).***

The anticipated cost to implement each option and the year when the investment is expected is indicated in Table 3 below.

Table 3: Summary of Option Costs

Options	Unit	2023/24	2024/25	2025/26	2026/27	2027/28	Total
1. Do minimum	£m	-	-	-	-	[redacted]	[redacted]
2. Replace similar size	£m	-	-	-	[redacted]	-	[redacted]
3. Replace larger size	£m	-	-	-	[redacted]	-	[redacted]
4. Augmentation similar size	£m	-	-	-	[redacted]	-	[redacted]
5. Augmentation larger size	£m	-	-	-	[redacted]	-	[redacted]
6. Two cable replacement	£m	-	-	-	[redacted]	-	[redacted]

7.2 Cost Benefit Analysis Comparisons

The results of the 45 year NPV from the CBA for the different options are presented in Table 4 below.

Table 4: Summary of Option NPVs

Options	45 Year NPV (£m)
1. Do minimum	-£3.38
2. Replace similar size	-£3.28
3. Replace larger size	-£3.45
4. Augmentation similar size	-£3.34

5. Augmentation larger size	-£3.50
6. Two cable replacement	-£6.33

Option 2 has the best NPV and addresses the issues around risk and impact associated with the existing cable and is therefore selected as the preferred option. It is also proposed to install a longer length of subsea cable as part of the replacement to avoid the need to maintain an inaccessible section of OHL which feeds the existing cable. This OHL runs over the top of some very steep, cliffy terrain. This will improve operator safety and improve network resilience.

The monetised risk value for the Loch A'Choire North 33kV subsea cable is currently £2,998 and without intervention may increase to £8,419 at the end of ED2. With the intervention proposed in this EJP the monetised risk value will reduce to £484.

7.3 Volume of Preferred Option

The preferred option requires a replacement cable to be installed in the marine environment. The volume of new assets anticipated to be required for this option are indicated in Table 5. Additional onshore infrastructure may be required following detailed site investigations and designs. It is not anticipated these would be significant additions.

Table 5: Volume of Assets for Preferred Option

Asset Category	Unit	2023/24	2024/25	2025/26	2026/27	2027/28	Total
EHV Subsea Cable	km	-	-	-	[redacted]	-	[redacted]

8 Deliverability & Risk

Our ***Deliverability Strategy (Annex 16.1)*** describes our approach to evidencing the deliverability of our overall plan as a package, and its individual components. Testing of our EJPs has prioritised assessment of efficiency and capacity, and this has ensured that we can demonstrate a credible plan to move from SSEN's RIIO-ED1 performance to our target RIIO-ED2 efficiency.

We have also demonstrated that SSEN's in house and contractor options can, or will through investment or managed change, provide the capacity and skills at the right time, in the right locations. This assessment has been part of the regular assessment of our EJPs, IDPs and BPDTs. For the investment proposed under our subsea cable related EJPs, we have been developing our RIIO-ED2 Commercial & Deliverability Strategy and engaging with our supply chain to ensure we can deliver the solutions proposed, while identifying and managing the risks presented by the complex and challenging nature of the projects.

Our deliverability testing has identified major strategic opportunities which is relevant to all subsea EJPs.

- In RIIO-ED2, SSEN will change the way Capital Expenditure is delivered, maximising synergies within the network to minimise disruptions for our customers. This is particularly relevant for a Price Control period where volumes of work are increasing across all work types.
- The principle is to develop and deliver programmes of work, manage risk and complexity at programme level and to develop strategic relationships with our suppliers and partners to enable efficiency realisation. This potentially includes refining our contracting strategies to improve our risk profiles.
- Transparency with the supplier in terms of constraints, challenges, outage planning and engineering standards will capitalise on efficiencies, supported by a robust contracting strategy.

The delivery programme for all subsea cables in RIIO-ED2 will be determined through detailed planning and engagement with marine installation contractors and cable procurement opportunities. In addition, early stakeholder engagement will significantly de-risk project schedules and deliver value.

We are already identifying opportunities for improved efficiency and improved risk management of our projects and associated programmes. As part of the planning for our final Business Plan submission, we have explored subsea cable project 'bundling' by cable type and geographic location. Our delivery year for each EJP is based on this initial assessment, which will be further explored and then refined with our supply chain in early 2022 to identify the optimal equilibrium of project deliverability and risk management.

9 Conclusion

The purpose of this Engineering Justification Paper (EJP) has been to provide the investment justification and option selection for the Loch A'Choire North 33kV subsea cable.

Due to the number of subsea cable faults in RIIO-ED1, including the Pentland Firth East Cable, the approach taken for EIIO-ED2 has been to pre-empt failures where possible. The creation of the monetised risk CBA model allows for the circuits which are likely to have the biggest impact, should a failure occur, to be addressed. This approach considers the subsea population within the generic CBA model to help identify the appropriate circuits to be replaced. This cable should be replaced alongside the Loch A'Choire South Cable.

The monetised risk value for the Loch A'Choire North 33kV subsea cable is currently £2,998 and without intervention may increase to £8,419 at the end of ED2.

In addition, the HI5 Health Index rating of this cable means that it is considered to be in poor health condition and is deemed end of operational life. The view has been taken that HI5 cables present a significant risk to customer supplies, and as such the intention is to replace HI5 cables on the network.

Having identified the need for intervention, six options were considered as shown:

- Option 1: Do minimum – replace on failure
- Option 2: Replace the cable with a similar sized cable
- Option 3: Replace the cable with a larger sized cable
- Option 4: Augmentation of the route with a second similar sized cable
- Option 5: Augmentation of the route with a second larger sized cable
- Option 6: Replace the cable with two new cables

These options were considered to cover the least cost option, the enhanced capacity option, the enhanced security option, and the most secure and reliable option with duplicate new feeders.

Option 2, replace the cable with a similar sized cable, has been selected as the preferred solution. This option has the lowest initial cost and the best NPV.

With the intervention proposed in this EJP the monetised risk value will reduce to £484.

The anticipated cost of the preferred option is £[redacted] k.

CV Table	Asset Category	ED2 (£m)
CV7 Asset Replacement	EHV Subsea Cable	[redacted]