Scottish & Southern Electricity Networks

RIIO ED2 Engineering Justification Paper (EJP)

Laxay – Kershader 2 – Asset Replacement

Investment Reference No: 405_SHEPD_SUBSEA_LAXAY_KERSHADER2

Contents

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
HDD	Horizontal Directional Drilling

1 Executive Summary

This Engineering Justification Paper (EJP) for Scottish Hydro Electric Power Distribution (SHEPD) covers the asset replacement investment required to manage the Laxay – Kershader 2 11kV 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.

Following optioneering and detailed analysis, as set out in this paper, the proposed scope of works for the Laxay – Kershader 2 circuit are as follows:

- Augmentation of the route with a second, similar sized, subsea cable.

The estimated cost to deliver the preferred solution is £[redacted] m. 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 2027/28 in this EJP and this will be refined as our programme develops.

This scheme delivers the following outputs and benefits:

- Enhanced security of supply, with two 11kV cables supplying the connected customers in the short term.
- Improves reliability, reducing potential of customer interruptions.
- Reduces the risk of incurring impact costs, including costs for constrained generation, temporary generation and CO_2 impacts.
- Reduces the monetised risk forecast by the end of ED2 from £138,231 with no intervention, to zero while both cables are in commission, and £13,819 after the failure of the existing cable.

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	Laxay – Kershader 2 Asset Replacement		
Primary Investment Driver	The Primary Investment Driver described within this EJP is to reduce the overall monetised risk associated with the loss of the existing subsea cable.		
Investment reference/mechanism or category	Cost Benefit Analysis reference: 405_SHEPD_SUBSEA_LAXAY_KERSHADER2		
Output reference/type	As above		
Cost (£m)	£[redacted]		
Delivery year	ED2 (2027/28)		
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)**
	HV 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 Laxay – Kershader 2 11kV subsea cable.

The Laxay – Kershader 2 11kV subsea cable provides supplies to 597 customers and has 0.05MW of generation connected which is constrained when the supply is interrupted.

The monetised risk value for the Laxay – Kershader 2 11kV subsea cable is currently £39,743 and without intervention may increase to £138,231 at the end of ED2. If there were a failure on the subsea cable a large number of customers would lose their supply and short-term temporary generation would need to be implemented in order to restore supplies. This would incur an impact cost totalling £2,115,701. Therefore, this subsea cable has been identified for pre-emptive investment to mitigate this risk. This EJP evaluates the appropriate options to provide the required mitigation.

The 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).***

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).

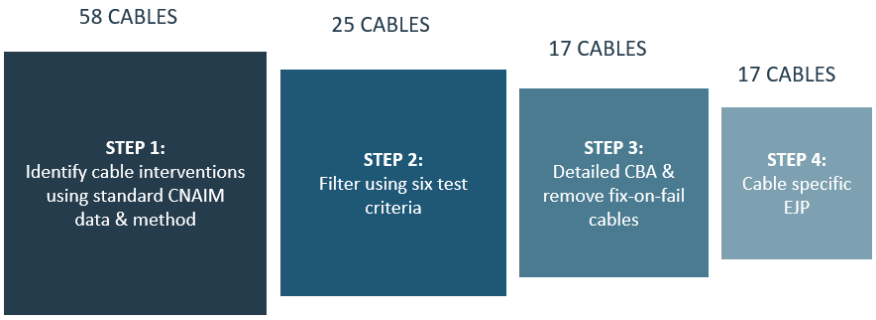
The RIIO-ED2 Business Plan submission has been based on the latest version of the industry standard CNAIM v2.1 which was approved for use in RIIO-ED2 by Ofgem in April 2021. The supporting data used in the modelling of this submission is based on the reported position of our asset condition for RIIO-ED1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

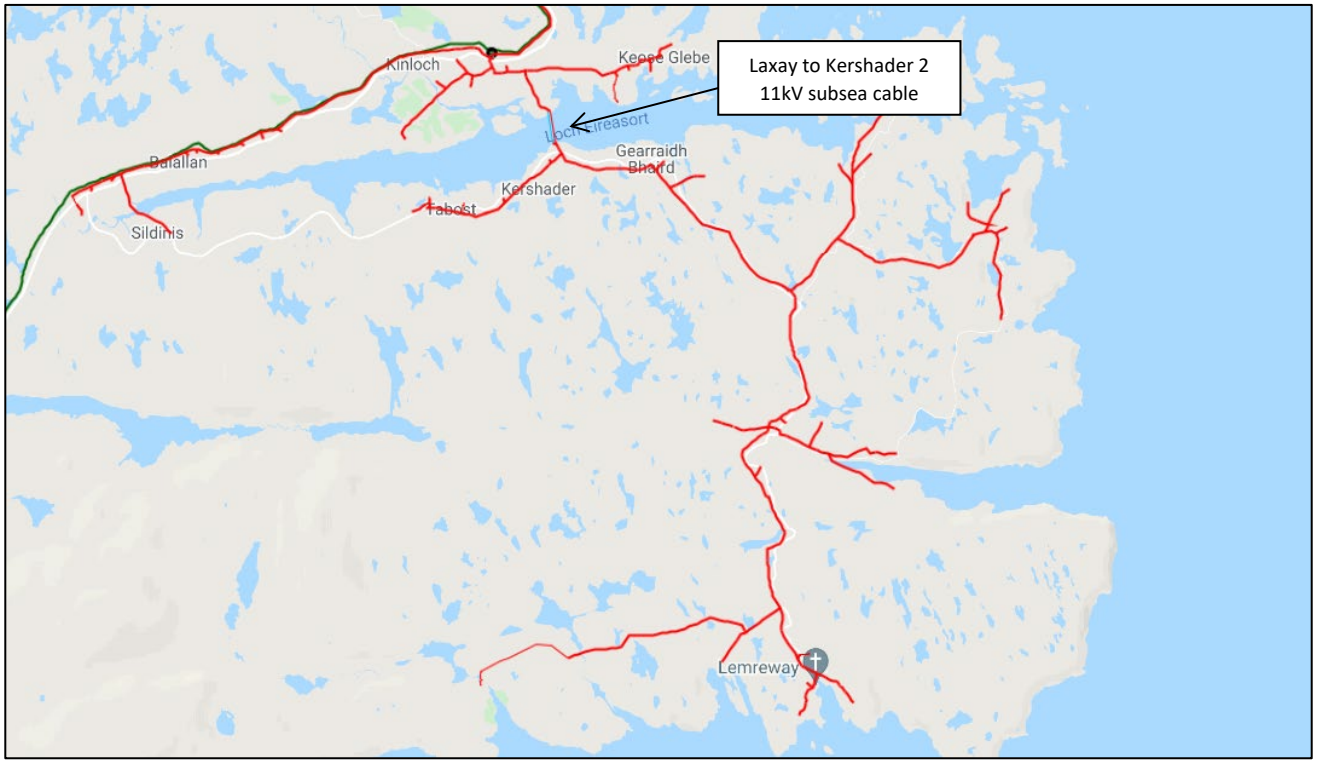
We have adopted a four-step funnel approach, as shown below, to determine the interventions required on the network. This approach allows us to filter from an initial examination of the complete list of subsea cables we operate to a credible and deliverable list of interventions which are supported by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

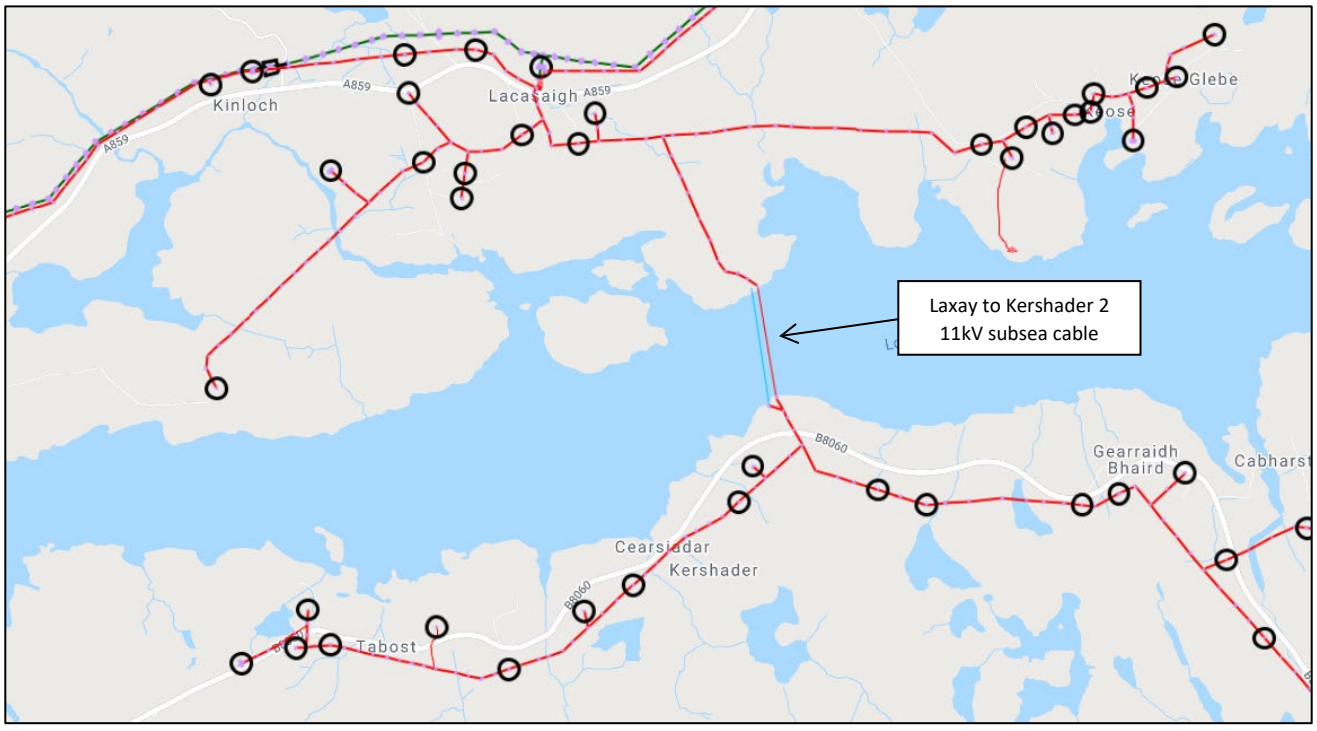
This EJP covers Step 4 for the Laxay to Kershader 2 cable which has qualified as requiring intervention. We set out here our approach to clearly justify why the circuit design approach is being proposed and associated costs are the most economic and efficient and what work would be required to deliver on these investments.



4.2 Existing Network Arrangement

The subsea cable under investigation is located under Loch Eireasort on the Western Isles of Lewis and Harris, approximately 1.3 km southeast from Laxay 33/11kV primary. The subsea cable is 590m long, as shown below.





Previously, a second subsea cable was in operation adjacent to the existing cable. That cable has been decommissioned following an electrical fault from abrasive wear, however the 11kV onshore switching assets remain in place.

4.3 Existing Asset Condition

The Common Network Asset Indices Methodology (CNAIM) models maintained by SSEN 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 Laxay – Kershader 2 11kV subsea cable is HV 35 PILC 'H' SWA AEI type and has been in service for 26 years. The Health Index of the subsea cable is HI5 with a Criticality Index of C2.

4.4 Demand Forecast and Generation

The Laxay – Kershader 2 11kV subsea cable is a feeder circuit fed from Laxay 33/11kV primary. It provides supplies to a number of distribution secondary substations on the southern side of Loch Eireasort, serving 597 customers in total.

In the event of an outage on the Laxay – Kershader 2 11kV subsea cable, there is no alternative supply for downstream customers. Temporary generation would need to be implemented in order to provide a short-term solution for restoring supply to customers.

The subsea cable is rated at 2.9MVA. The current demand on the subsea cable is 1.8MVA, 61.8% of the cable rating. The forecasted demand growth is 4.8% per year on average, based on growth figures assessed for Laxay Primary S/S. Therefore, the forecasted demand at the end of ED2 is expected to be 2.6MVA, 90.1% of the cable rating.

The subsea cable also supports 0.05MW of distributed generation.

In the event of an outage of the cable the following impact and constrained generation costs would be incurred:

- Constrained generation cost: £7,344
- Impact cost: £2,115,701

5 Summary of Options Considered

This section of the report sets out the investment options that have been considered for intervention on the existing 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. Remains single circuit security. Does not address the risk of a failure. Impact costs would be high in the event of a failure.	Rejected
2. Replace similar size	Replace the cable with a similar sized cable	Improved HI and PoF. Low initial cost.	Remains single circuit security.	Rejected
3. Replace larger size	Replace the cable with a larger sized cable	Improved HI and PoF.	Higher initial cost than above. Remains single circuit security. 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. Onshore switching assets already exist.	Similar cost to option 2 due to existing onshore infrastructure already being in place for a second cable. Increased cable monitoring and maintenance costs.	Recommended option
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. HDD replacement	Replace the cable with an underground HDD cable installation	Improved HI and PoF. Higher initial cost than other options due to the length of HDD required. Lower PoF compared to a simple subsea cable replacement.	Remains single circuit security. Subject to an HDD feasibility study being conducted to determine if this is feasible.	Rejected

6 Analysis and Cost

For all options considered it is anticipated that any new cable installed would follow a similar route to the existing cable route shown previously.

6.1 Option 1: Do minimum – replace on failure

Under this option the subsea cable would not be proactively replaced. Instead, the cable would continue to operate as it has been with minimal repairs being made as required until the point where the subsea cable fails in service.

At the time of failure, the subsea cable would then be replaced with a new subsea cable of similar size to the existing one.

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 the following impact and constrained generation costs:

- Constrained generation cost: £7,344
- Impact cost: £2,115,701

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.

After replacing the cable there would be an improvement in the Probability of Failure 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 Health Index 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 4.7MVA capacity which will 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]

This option was rejected as the risk of loss of supply to customers due to a single subsea cable fault would remain high due to the single circuit security.

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]

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. Additional 11kV onshore infrastructure would be needed to connect the second cable however, this would require minimal alterations as some of the infrastructure is already in place from a previously connected cable.

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. For the purposes of assessing this option using the CBA, it was assumed that the existing subsea cable would fail at the end of ED2, in 2028.

The cost of this option is as option 2, and it would usually include added costs for connection into the network, however as the infrastructure to connect the second cable is already in place these added costs would not be required.

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]

This option provides an improvement to the security of supply and has a low initial outlay, therefore this is the preferred solution. This option also provides the best NPV of all options.

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, and no added costs for connection into the network are needed as the existing infrastructure can be used.

This option would improve the security of supply to the connected customers until the existing cable fails. For the purposes of assessing this option using the CBA, it was assumed that the existing subsea cable would fail at the end of ED2, in 2028.

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]

This option does not provide any additional benefits compared to option 4 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 an underground HDD cable installation

This option involves replacing the cable with a land based cable installed via Horizontal Directional Drilling (HDD) underneath the loch. The improvement in the PoF of the circuit after these works would be better than the previous options, as an HDD cable installation is considered to have the same failure rates as a buried cable, rather than a subsea cable.

HDD solutions can often be more expensive compared to subsea cable replacement solutions, however when the length of cable needed is small, then the HDD solution becomes viable.

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]

This option has the highest initial outlay cost, and the risk of loss of supply to customers would remain high due to the single circuit 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).***

A summary of the costs for each option is given in the table 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. HDD replacement	£m	-	-	-	-	[redacted]	[redacted]

7.2 CBA 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	-1.26
2. Replace similar size	1.01
3. Replace larger size	0.94
4. Augmentation similar size	1.03
5. Augmentation larger size	0.96

6. HDD replacement	0.16

Option 4 has the best NPV and addresses the issues around risk and impact associated with the existing cable and is therefore the preferred option.

The NPV for option 4 assumes that the existing cable would fail in 2028, however it is possible that the existing cable would remain in service past 2028, in which case the benefits of operating two cables in parallel would continue to be accrued and the NPV would end up being higher than indicated in the table above.

The monetised risk value for the Laxay – Kershader 2 11kV subsea cable is currently £39,743 and without intervention may increase to £138,231 at the end of ED2. With the intervention proposed in this EJP the monetised risk value will reduce to zero while both cables are in commission, and £13,819 after the failure of the existing cable.

7.3 Volume of Preferred Option

The preferred option requires a new cable to be laid alongside the existing cable and connected into the 11kV network. The volume of new assets needed for this option are indicated in Table 5.

Table 5: Volume of Assets for Preferred Option

Asset Category	Unit	2023/24	2024/25	2025/26	2026/27	2027/28	Total
HV Subsea Cable	km	0	0	0	0	[redacted]	[redacted]
11kV Switch (PM)	each	0	0	0	0	[redacted]	[redacted]
11kV Switchgear Other	each	0	0	0	0	[redacted]	[redacted]
11kV Pole	each	0	0	0	0	[redacted]	[redacted]
11kV OHL Conductor	km	0	0	0	0	[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 11kV subsea cable from Laxay – Kershader 2.

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.

The monetised risk value for the Laxay – Kershader 2 11kV subsea cable is currently £39,743 and without intervention may increase to £138,231 at the end of ED2.

If there were a failure on the subsea cable a large number of customers would lose their supply and short-term temporary generation would need to be implemented in order to restore supplies to those customers, with the impact cost totalling £2,115,701. Therefore, this subsea cable has been identified for pre-emptive investment to mitigate this risk.

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 an underground HDD cable installation

These options were considered to cover the least cost option, the enhanced capacity option, and the enhanced security option.

The preferred option is option 4, augmentation of the route with a second similar sized cable. This option has one of the lowest initial costs, the best NPV and provides an improvement to the security of supply.

With the intervention proposed in this EJP the monetised risk value will reduce to zero while both cables are in commission, and £13,819 after the failure of the existing cable.

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

CV Table	Asset Category	ED2 (£m)
CV7 Asset Replacement	HV Subsea Cable	[redacted]
CV7 Asset Replacement	11kV Switch (PM)	[redacted]
CV7 Asset Replacement	11kV Switchgear Other	[redacted]
CV7 Asset Replacement	11kV Pole	[redacted]
CV7 Asset Replacement	11kV OHL Conductor	[redacted]