RIIO ED2 Engineering Justification Paper (EJP)

Eriskay – Barra 2 – Asset Replacement

Investment Reference No: 390_SHEPD_SUBSEA_ERISKAY_BARRA_2

Scottish & Southern Electricity Networks

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

1 Executive Summary

This Engineering Justification Paper (EJP) for Scottish Hydro Electric Power Distribution (SHEPD) covers the asset replacement investment required to manage the Eriskay – Barra 2 11 kV subsea cable which provides supplies to 1,052 customers on Barra and Vatersay with the single circuit. There were previously two subsea cables, one of which has failed. This EJP will address this failure and restore the second circuit.

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.

Delivering a safe, resilient and responsive network

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

- Augment the existing Eriskay – Barra 2 11kV subsea cable by laying a new 11kV submarine cable between Eriskay and Barra.
- Retain the existing 11kV Eriskay – Barra 2 subsea cable to create an augmented solution and give a dual subsea connection to Barra.
- Tie in the new submarine cable to the existing 11kV network where previous Eriskay - Barra 1 cable was connected but is now abandoned following a fault.

The anticipated 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 for 1,052 customers with two - 11 kV cables supplying Barra until the original cable fails.
- Improves reliability and reduces the potential for customer interruptions due to a subsea cable fault.
- Reduces the risk of incurring impact costs, constrained generation, temporary generation, and CO2 impacts.
- Restores the two-cable supply to the island.
- The CBA benefit assumes the original cable will fail in 2026, but additional benefit will be realised if the cable lasts longer.
- Reduces the monetised risk on the Eriskay - Barra 2 cable, forecast to be £849,624 by the end of ED2 with no intervention, to zero whilst both cables are in commission, but after the failure of the existing cable the value would be £44,839.

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	Eriskay – Barra 2 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 subsea cable from Eriskay to Barra 2.		
Investment reference/mechanism or category	Cost Benefit Analysis reference: 390_SHEPD_SUBSEA_ERISKAY_BARRA		
Output reference/type	As above		
Cost (£m)	£[redacted]		
Delivery year	ED2 (2027/28)		
Reporting Table	CV7: Asset Replacement		
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) covers the investment required to manage the performance of the Eriskay – Barra 2 11 kV subsea cable which provides supplies to 1,052 customers on Barra and Vatersay in the Western Isles.

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).***

The Eriskay - Barra 2 11 kV cable is 8 years old, supplies 1,052 customers and has 0.9 MW of generation which is constrained when the supply is interrupted. The cable is currently Health Index 3 and Criticality Index 2. The second subsea cable shown in Figure 1 was previously decommissioned following a fault.

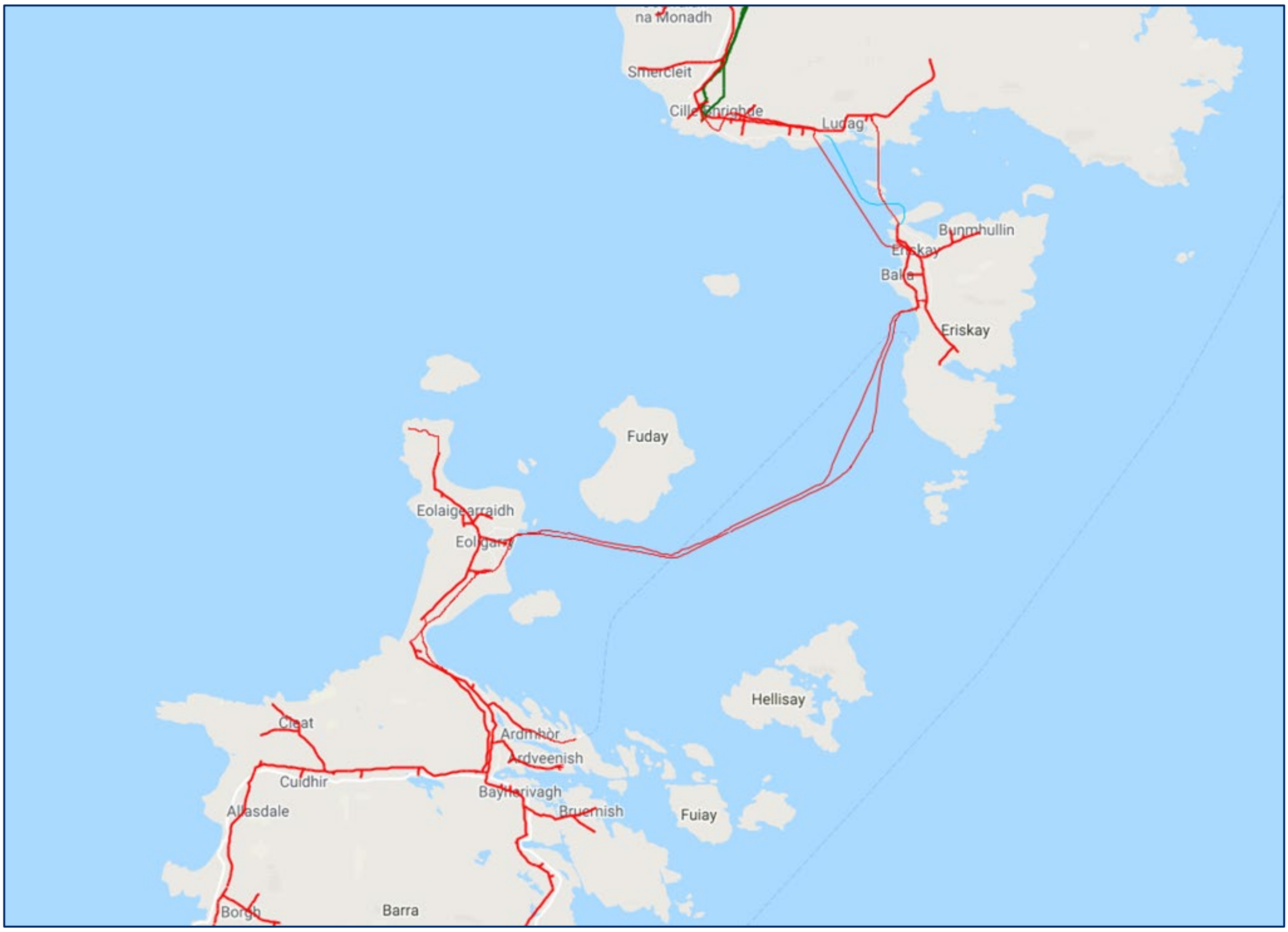


Figure 1 Eriskay Barra 2- 11 kV Feeder

Although the Eriskay – Barra 2 cable is only 8 years old. The cable has already been found through visual inspections to be in poor condition and additionally, of the six cables that were installed with this cable type, three have failed during the RIIO-ED1 period. This gives cause for concern that this cable could fail in the near future. This cable also has a high impact cost given the nature of the radial circuit, the number of customers supplied and that Barra power station will be required to run to maintain supplies in the event of a failure. There is currently no second connection to the island for restoration.

The monetised risk on this cable is currently £153,331 and would increase to £849,624 by the end of ED2 without intervention. The monetised risk would reduce to zero while both cables are in commission, and after the failure of the existing cable the value would be £44,839.

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).

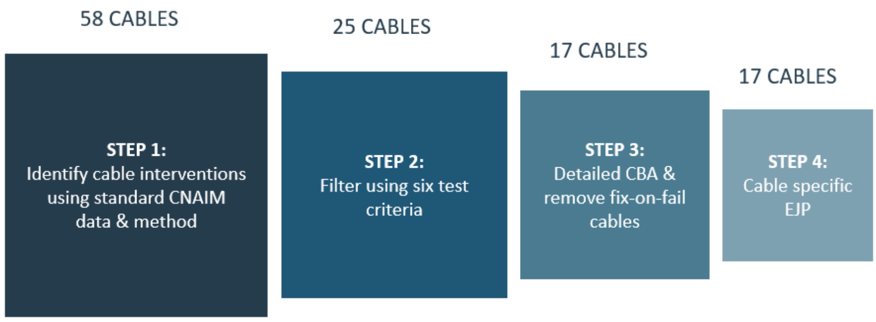
The RIIO-ED2 Business Plan submission has been based on the latest version of the industry standard CNAIM v2.1 which was approved for use in RIIO-ED2 by Ofgem in April 2021. The supporting data used in the modelling of this submission is based on the reported position of our asset condition for RIIO-ED1 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 Eriskay to Barra 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 existing 11kV network configuration is shown in Figure 1. There are two subsea cables shown on the network; Eriskay Barra and Eriskay Barra 2. The Eriskay – Barra cable is out of commission, however, the onshore connection points on Eriskay and Barra remain so therefore could be reused to connect a new cable. This 11kV network is fed from Pollachar Primary S/S on South Uist via Eriskay.

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 Eriskay – Barra 2 11kV subsea cable is HV 95 XLPE SWA FULGOR - HELLENIC type and has been in service for 8 years. Visual inspections have already confirmed the cable is in poor condition and additionally, of the six cables that were installed with this cable type, three have failed during the RIIO-ED1 period. The cable has a current Health Index of HI3 with a Criticality index of C2. The PoF is 0.118 at the start of ED2, rising to 0.654 by the end of ED2 assuming no intervention takes place.

4.4 Demand and Generation Forecast

The 11 kV Eriskay - Barra 2 subsea cable is currently loaded to 1.79 MVA (43% of the cable rating). The cable is a 33 kV 95 mm² XLPE SWA FULGOR - HELLENIC operating at 11kV and is rated at 4.1 MVA. The forecast demand growth projection is shown in Figure 2.

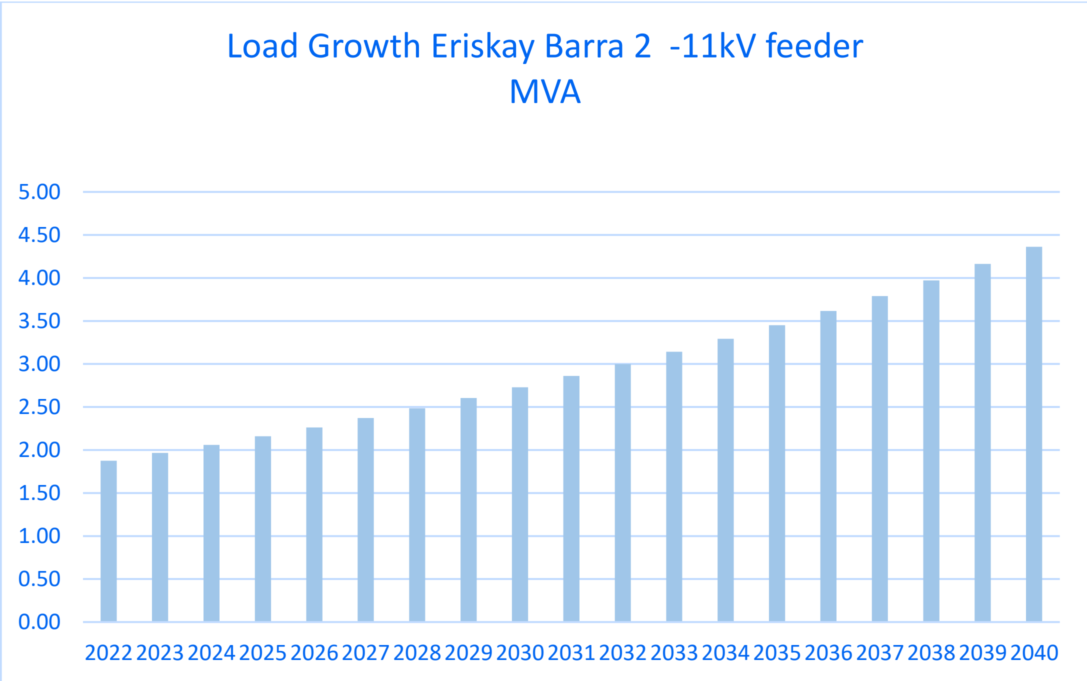


Figure 1 Load Forecast on Eriskay Barra 2- 11 kV Feeder

The load forecast for the island of Barra, is 4.815%, and forecast demand at the end of ED2 is expected to be 2.5 MVA (61% of the cable rating). The demand on the cable will potentially exceed its rating by 2039 and would need replacing due to demand if the cable remained in service till that time. The demand growth forecasts are based on the growth anticipated at a Primary S/S level and the growth percentage has been applied to this existing demand on this feeder so the load growth may not be as high as anticipated in the high level analysis. In depth detailed demand assessments will be made at the time of cable engineering to ensure a suitable cable size and rating is selected for the lifetime of any new assets.

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 summary of the six 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 2: Summary of Primary 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 of repair where practical with unknown resolution of the fault	Rejected
2. Replace	Replace the cable with the same size cable on the same route	Improves HI provides new life cycle and allows reduced probability of failure	Remains single circuit security. Improves the reliability with the new circuit	Rejected
3. Replace with larger cable	Replace the cable with a larger cable on the same route	Improves HI provides new life cycle and allows greater protection of cable. Provides for future load and generation growth	Remains single circuit security. And risk of impact costs despite improving the reliability with the new circuit.	Rejected
4. Augmentation	Lay a new cable and retain the old cable connecting new cable into the 11 kV network in parallel	Similar cost to replacement Provides N-1 for the remainder of the existing cable life. This re-instates the two cables previously.	Improves the reliability with two cables in commission. However, would fall back to single circuit following the failure of the existing circuit. This would then revert to the equivalent of option 2.	Recommended Option
5. Augmentation larger cable	Lay a new cable and retain the old cable. Will provide greater capacity for future growth in generation and load.	Similar cost to replacement Provides N-1 for the remainder of the existing cable life Provides for future load and generation growth	Improves the reliability with two cables in commission, however, would fall back to single circuit following the failure of the existing circuit. This would then revert to option 3.	Rejected
6. Two new cables existing route	Lay two new cables along the known route of the existing cable and provide a firm connection.	Provides full N-1 security and removes the impact of a failure for a single circuit increasing reliability.	Higher cost and maintains the length of the existing route, which is a critical component of the probability of failure	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 in Figure 1.

6.1 Option 1: Do-Minimum replace on failure

The total cost with this option is based on a planned replacement cost uplifted by [redacted] % to reflect the premium paid in an emergency replacement situation. This gives a total option cost of £[redacted] m (the [redacted] % is based on the experience of previous cable fault contracts). This is estimated to be the cost when the replacement is performed under emergency conditions without sufficient time to plan and procure the replacement in an efficient manner. This provides for an equivalent size cable (95mm²) to provide capacity of 4.1 MVA. This option would incur the impact costs and would remain with single circuit security once replaced with a risk of future failure. The additional costs that would be incurred in this option are shown below. The impact cost includes CI/CML, Generators, Fuel and CO_2 cost

Costs incurred would be the following

- Constrained generation £0.132m
- Capital cost £[redacted]
- Impact cost £1.168m

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

This option was rejected, as it would incur impact cost, constrained generation cost and reputational damage. The replacement cost in an emergency would be around [redacted] % higher than a planned replacement cost.

6.2 Option 2: Replace the cable with the same size cable 95 mm²

Replacing the cable with a new 95mm², subsea cable would be the lowest capital cost solution and will improve the HI and Probability of Failure resulting in a change to the characteristics set by the age and condition. The new cable will be connected to the existing network points on Eriskay and Barra, and the old cable disconnected.

The initial capital cost would be £[redacted].

There would be no impact cost, and this is the least capital cost option.

The Probability of Failure is forecast to increase from 0.118 at the start of ED2 to 0.653 by the end of ED2 without intervention. Installing a replacement cable would reduce the PoF along this route to 0.0345 with a new replacement cable.

This option was rejected as it does not provide the best NPV and abandoning the cable which is 8 years old would potentially write off an asset in advance of need. It would also remain a single circuit security supply, with the inherent risk of incurring all of the impact costs.

6.3 Option 3: Replace with a larger 185 mm² cable

This option involves laying a 185 mm² (8 MVA) subsea cable rather than the like for like replacement in option 2. This cable has a higher initial cost. The advantage this has over option 2 is that it would cater for more future demand and generation growth on this circuit, but at higher initial cost. This option retains a single circuit security and potential risk of an interruption and the impact costs.

The capital cost of this option would be £[redacted].

This was rejected due to higher cost and the single circuit security.

6.4 Option 4: Augmentation with a similar sized cable.

This option is similar to option 2, laying a similar cable to the existing 95mm², but retaining the existing cable until it becomes faulty. This would incur additional costs for connection into the 11 kV network on Eriskay and Barra however, there has previously been a second cable on the subsea route and the 11 kV overhead connection would allow a relatively simple low-cost connection.

This option will provide enhanced security with two circuits until the existing cable faults, at which time the supply would revert to a single circuit as in option 2. The existing circuit is not old at 8 years meaning there is a possibility it may provide a full N-1 supply for a number of years. However, the existing cable has been found through visual inspection to be in a poor condition and another three cables of this cable type and specification have failed during RIIO ED1, two due to electrical failure and another due to mechanical damage. So, the existing Eriskay-Barra 2 cable is thought to be at high risk of failure.

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.

The cost of this option is as option 2 plus the added cost of connection into the network.

The cost of this option is £[redacted].

This is the preferred option as it provides enhanced security and reliability over the other options and the potential benefit will increase if the existing cable remains healthy. This option also provides that highest NPV of all options.

6.5 Option 5: Augmentation with a larger cable.

This option is similar to option 4 but utilising a 185mm² cable instead of the 95mm².

This option would cater for any additional potential demand growth above the rating of a 95mm² cable, however on existing growth analysis, this level of requirement would not be necessary until around 2039 but is based on high level substation predictions. This like option 4 provides N-1 security until the failure of the existing cable. This option was rejected due to the additional cost of the cable and confidence in load growth.

Detailed capacity requirements will be conducted at the detailed engineering phase of the project to determine the cable is suitable over the lifetime of the asset.

The cost of this option would be £[redacted].

6.6 Option 6: Installation of two new cables on the existing route

This was considered due to the improvement in reliability and security provided by two new cables which would ensure that in the event of a subsea cable fault supplies would be maintained and avoid impact costs and constraint costs. The laying of the two cables together under the same contract is expected to allow cost saving of 15% on the second cable compared to the first.

This has been costed on 95 mm² cables and would provide firm N-1 capacity and cater for future load growth.

The overall cost of this option was £[redacted].

This option was rejected as although there were benefits over options 1-5, there was a significantly higher initial cost.

7 Summary of Cost Benefit Analysis (CBA)

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 Summary of 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.

Summary of Capital Cost

Options	Unit	2023/24	2024/25	2025/26	2026/27	2027/28	Total
1. Do Minimum	£m	0	0	0	[redacted]	0	[redacted]
2. Replace	£m	0	0	0	0	[redacted]	[redacted]
3. Replace with larger cable	£m	0	0	0	0	[redacted]	[redacted]
4. Augmentation	£m	0	0	0	0	[redacted]	[redacted]
5. Augmentation larger cable	£m	0	0	0	0	[redacted]	[redacted]
6. Two new cables existing route	£m	0	0	0	0	[redacted]	[redacted]

7.2 Cost Benefit Analysis comparisons

Although there is little difference between options 2 and 4 on NPV over 45 years, the potential for the extended life of the existing cable will increase the long-term benefit, by improving supply security and reducing impact costs. This will further improve with an extension of the life of the existing cable.

Options	NPV After 45 Years (£m)
Option 1 – Do Minimum	**12.83**
Option 2 – Replace	**16.35**
Option 3 – Replace Larger Cable	**15.96**
Option 4 – Augment	**16.40**
Option 5 – Augment Larger Cable	**16.00**
Option 6 – Replace Two New Cables Along Existing Route	**10.88**

The monetised risk value for the Eriksay to Barra 2 11 kV subsea Cable is £153,331 at the start of ED2 and without intervention will increase to £849,624 at the end of ED2. With the intervention proposed in this EJP the value will reduce to zero when both cables are in service and increase to £44,839 only when the existing cable fails.

7.3 Volume of Preferred Option

The option selected requires a new cable to be laid along the existing cable route and connected into the current 11 kV network. The approach taken has included the cost of additional aerial switches connecting the cable.

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 Switchgear Other	each	0	0	0	0	[redacted]	[redacted]
6.6/11kV UG Cable	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 11 kV subsea cable from Eriskay to Barra 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 Eriskay to Barra 2 11 kV subsea Cable is £153,331 at the start of ED2 and without intervention will increase to £849,624 at the end of ED2. With the intervention proposed in this EJP the value will reduce to zero when both cables are in service and increase to £44,839 only when the existing cable fails.

6 options were considered as shown:

- Option 1: Do Minimum – replace on failure
- Option 2: Replace the cable with the same size cable
- Option 3: Replace the cable with a larger cable
- Option 4: Augment by laying a similar sized cable and retaining the existing cable.
- Option 5: Augment by laying a larger cable and retaining the existing cable.
- Option 6: Lay two new cables along the existing route

The recommended solution is option 4, augment by laying a similar sized cable and retaining the existing cable at a cost of £8.85m. The NPV for option 4 was £16.4m. This option provides enhanced security and reliability which will ensure N-1 security while the existing cable remains in service.

CV Table	Asset Category	ED2 (£m)
CV7 Asset Replacement	HV Subsea Cable	[redacted]
CV7 Asset Replacement	11kV Switchgear Other	[redacted]
CV7 Asset Replacement	6.6/11kV UG Cable	[redacted]