RIIO ED2 Engineering Justification Paper (EJP)

Hoy – Flotta – Asset Replacement

Investment Reference No: 331_SHEPD_SUBSEA_HOY_FLOTTA

Contents

Definitions and Abbreviations

Acronym	Definition
EJP	Engineering Justification Paper
CBA	Cost Benefit Analysis
CBRM	Condition Based Risk Management
CNAIM	Common Network Asset Indices Methodology
IDP	Investment Decision Pack
ESA	Electricity Supply Area
EV	Electric Vehicle
FES	Future Energy Scenarios
GIS	Geographic Information System
GW	Gigawatt
HDD	Horizontal Directional Drilling
kW(h)	kilowatt (hour)
MW	Megawatt
OHL	Overhead Line
PV	Photovoltaics
BSP	Bulk Supply Point
GSP	Grid Supply Point
LRE	Load Related Expenditure
LCT	Low Carbon Technology
SSEN	Scottish and Southern Electricity Network
UGC	Underground Cable

1 Executive Summary

This Engineering Justification Paper (EJP) for Scottish Hydro Electric Power Distribution (SHEPD) covers the investment required to manage the performance of the Hoy - Flotta subsea cable which is fed from Scorradale 33kV substation on Mainland Orkney and provides supplies to 388 customers on Flotta.

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 Hoy - Flotta subsea cable was installed in 1973 and has been in service for 43 years. It currently has a heath index HI3 and criticality index of CI2, and is anticipated to become an HI4 C2 by the end of RIIO ED2 with no intervention.

Following optioneering and detailed analysis, as set out in this paper, the proposed scope of works for the existing Hoy to Flotta circuit are as follows:

- Augment the exisiting Hoy – Flotta 33kV subsea cable by laying a new 33 kV submarine cable between Hoy and Flotta
- Retain the exisiting 33kV Hoy - Flotta subsea cable to create an augmented solution and give a dual subsea connection to Flotta.
- Tie in the new submarine cable to the exisiting 33kV network.

The estimated cost to deliver the preferred solutionis £[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 2024/25 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 388 customers with two 33kV cables supplying Flotta 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 CO_2 impacts.
- Reduces the monetised risk on the Hoy - Flotta cable, forecast to be £204,642 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 £64,585.

Option 4, augment the existing subsea cable with a new similar sized cable, was selected as the preferred option providing a low 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	Hoy – Flotta 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: *331_SHEPD_SUBSEA_HOY_FLOTTA*		
Output reference/type	As above		
Cost (£m)	£[redacted]		
Delivery year	ED2 (2024/25)		
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 Hoy - Flotta subsea cable which is fed from Scorradale 33kV substation and provides supplies to Flotta. The 95 mm² PILC 'HSL' SWA 33kV cable is 2.267 km long and provides a connection from Tower House on Hoy to Flotta Air Terminal on Flotta.

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).

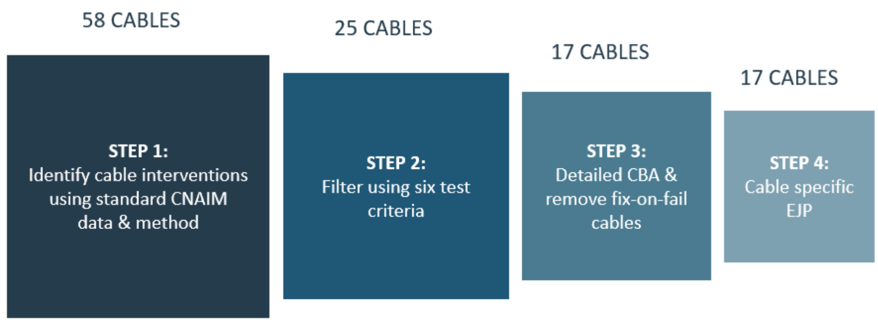
The RIIO-ED2 Business Plan submission has been based on the latest version of the industry standard CNAIM v2.1 which was approved for use in RIIO-ED2 by Ofgem in April 2021. The supporting data used in the modelling of this submission is based on the reported position of our asset condition for RIIO-ED1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

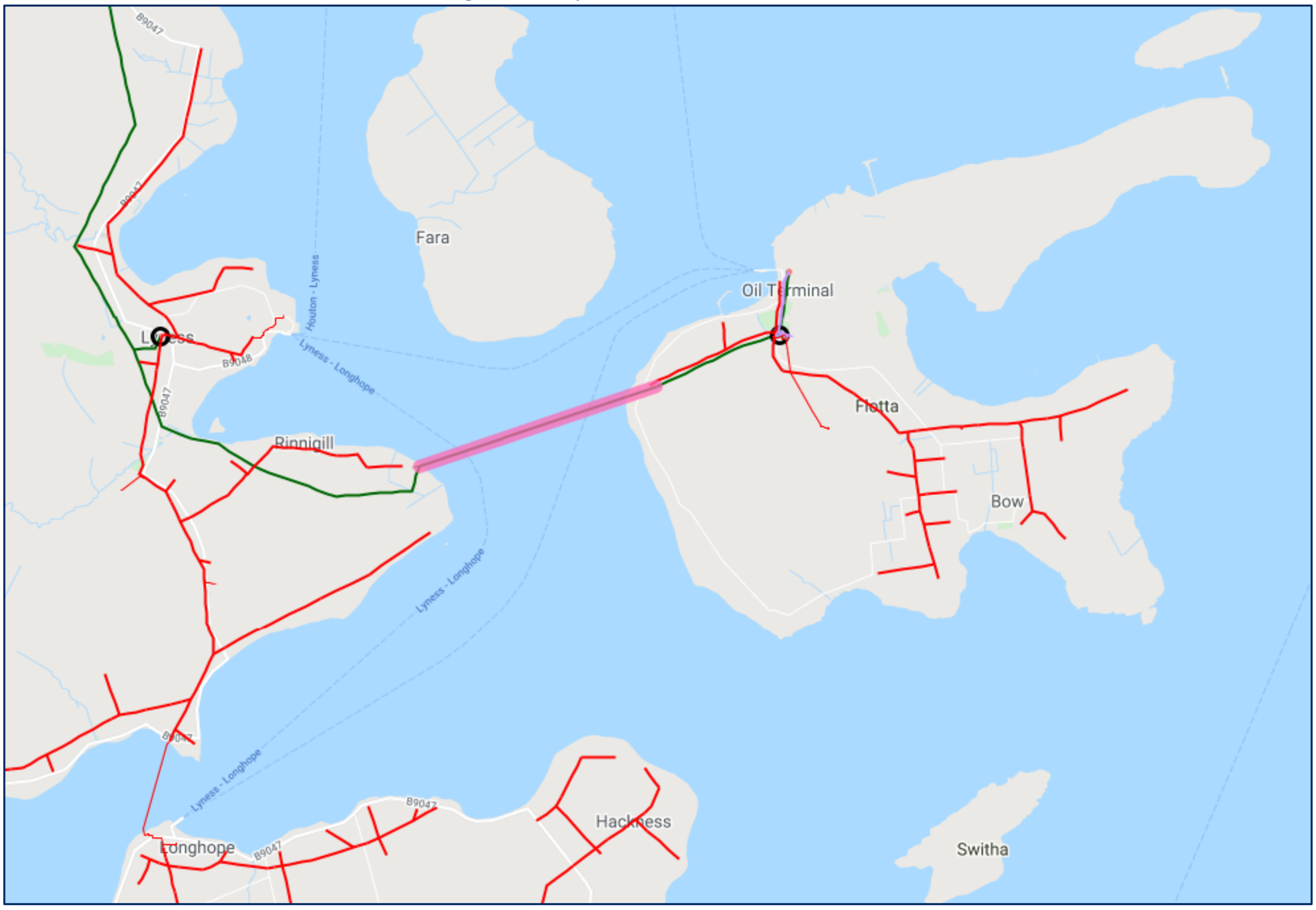
This EJP covers Step 4 for the Hoy – Flotta 33kV cable which has qualified as requiring intervention. We set out here our approach to clearly justify why the circuit design approach being proposed and associated costs are the most economic and efficient and what work would be required to deliver on these investments.



4.2 Demand and Generation Forecast

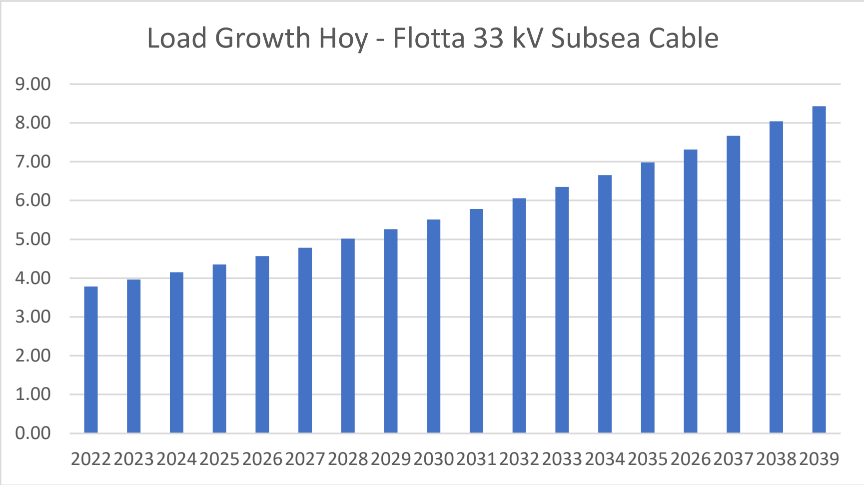
The Hoy - Flotta subsea cable, which is part of the 33kV network fed from Scorradale 33kV substation on Mainland Orkney, provides supplies to 388 customers on Flotta. The 33 kV 95 mm^2 PILC 'HSL' cable is 2.27 km long and provides a connection from Tower House on Hoy to Flotta Oil Terminal on Flotta as shown in Figure 1 below. There is currently 3.2 MW of generation from the island of Flotta.

Figure 1 – Hoy - Flotta Subsea Cable Route



The cable is a 33kV 95 mm^2 PILC 'HSL' rated at 14 MVA. The current maximum demand on the Hoy - Flotta cable is 3.699 MVA (26.4% of the cable rating). The average DFES for the area, is 2.448%, and forecast demand at the end of ED2 is expected to be 4.48 MVA (32.0% of the cable rating). The demand projection is shown in Figure 2 below.

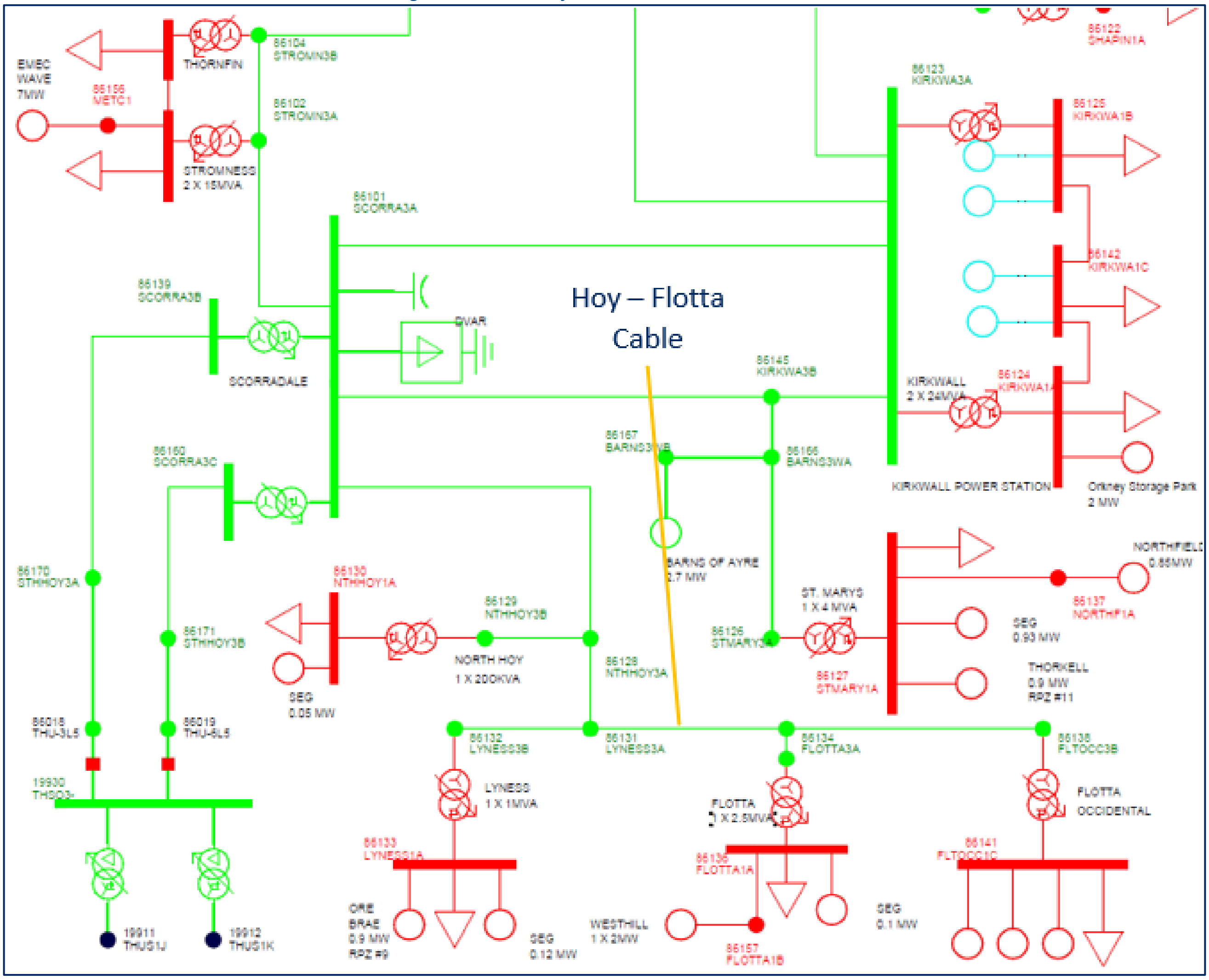
Figure 2- Load Forecast Hoy - Flotta - 33 kV Feeder



4.3 Existing Network Arrangement

The subsea cable from Tower House on Hoy to Flotta Air Terminal on Flotta forms part of the 33 kV network fee from Scorradale 33 kV Substation on Mainland Orkney as shown in Figure 3 below.

Figure 3 - Extract of Scorradale 33 kV Network



4.4 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 Hoy - Flotta subsea cable was installed in 1973 and has been in service for 43 years it currently has a Heath Index HI3 and Criticality Index of CI2, and is anticipated to become an HI4 C2 by the end of RIIO-ED2 with no intervention. The cable has a Probability of Failure of 0.02769 at the start of RIIO ED2 rising to 0.05258 at the end of RIIO-ED2.

5 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

Table 2 below a provides a summary of the six (6) 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 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 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 greater protection of cable.	Remains single circuit security of supply.	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.	Rejected
4. Augmentation	Lay a new cable and retain the old cable connecting new cable into the 33 kV network in parallel	Similar cost to replacement. Provides N-1 for the remainder of the existing cable life	Improves the reliability with two cables in commission, however, would fall back to single circuit following the failure of the existing circuit.	Recommended option
5. Augmentation larger cable	Lay a new cable and retain the old cable will provide greater capacity for future growth	Similar cost to replacement Provides N-1 for the remainder of the existing cable life.	Improves the reliability with two cables in commission, however, would fall back to single circuit following the	Rejected

Option	Description	Advantages	Disadvantages	Results
	in generation and load.	Provides for future load and generation growth	failure of the existing circuit.	
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.	Highest cost	Rejected

6 Analysis and Cost

The details of each option are described below:

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 following a similar route to that of the existing cable shown in figure 1. It would be proposed to install a 95 mm^2 cable and whilst this would allow an increase in the potential capacity of the circuit it is currently not envisaged that this would be required.

In the event of a cable failure supplies to 388 customers would be interrupted and 3.2 MW of generation constrained off. To supply the demand requires the deployment of mobile generation for the duration of the outage. The generic model has assumed this will be for a period of six months to allow the mobilisation resources to replace the cable.

The CI/CML, temporary generation costs, CO_2 costs and constrained generation costs during the outage are estimated at £3,422 k.

The emergency replacement [redacted] km of subsea cable following a similar route to the existing cable as shown in Figure 1 above has been estimated based on a planned replacement cost uplifted by [redacted] % to reflect the premium which is paid when replacing in an emergency situation. This gives a total cost of fault replacement at [redacted]. This provides for an equivalent size cable (95 mm²) with a rating of 14 MVA which would satisfy the current forecast demand to 2039 and beyond.

This gives an estimated total cost of failure of [redacted] k

This option avoids any initial cost and depending on how long the cable lasts 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 incurs the impact and environmental cost. The NPV over 45 years for this option is -£4,880 k

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

6.2 Option 2: Planned replacement during ED2

Replacing the cable with a new 95 mm², subsea cable will impact the Health Index 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 and the old cable disconnected. This option is the planned replacement of the cable during ED2 with a new 95 mm^2 cable to reduce the risk of failure and incurring costs associated with loss of supply.

The replacement 2.27 km of subsea cable following a similar route to the existing cable as shown in Figure 1 above has been estimated at a cost of £[redacted].

The Probability of Failure is anticipated to increase from 0.028 to 0.053 by the end of ED2 without intervention, reducing to 0.017 with replacement. This drives the NPV calculation which in this case is -£1,240k.

While this option offers the best NPV and would reduce the probability of failure, it would also remain a single circuit security of supply, with the inherent risk.

This option is rejected because of the risk posed by a single circuit supply.

6.3 Option 3: Replace with a larger 185 mm² cable

This option is similar to option 2, laying a new 185 mm² (24 MVA) subsea cable rather than the like for like replacement in option 2. This option retains a single circuit security and potential risk of an interruption and the impact costs.

The cost of this option is estimated at £[redacted].

As in Option 2, the reduction in Probability of Failure and availability of the original circuit drives the NPV calculation which in the case is -£1,400k.

This option was rejected as the higher cost does not provide any additional benefits to Option 2 and it would also remain a single circuit security supply, with the inherent risk.

6.4 Option 4: Augmentation with a similar sized cable.

This option is similar to option 2, laying 95 mm², but retaining the existing cable until it becomes faulty. This would incur additional costs for connection into the 33kV network on Hoy and Flotta.

This would provide enhanced security of supply with two circuits until the existing cable became faulty at which time the supply would revert to a single circuit as in option 2.

The cost of this option is estimated at £[redacted] k.

As in Option 2, the reduction in the Probability of Failure and availability of the original circuit drives the NPV calculation which in this case is -£1,050k.

This option would improve the resilience by both improving the reliability and providing an alternative supply until the cable fails and is the preferred option.

6.5 Option 5: Augmentation with a larger cable.

This option is similar to option 4 but utilising a 185 mm² cable instead of the 95 mm². This would cater for any potential growth, however on existing growth levels this would not be necessary at this time.

This like option 4 provides N-1 security until the failure of the existing cable.

The cost of this option is estimated at £[redacted] k.

As in Option 4 the reduction the in Probability of Failure and availability of the original circuit drives the NPV calculation which in the case is -£1,210k.

This option was rejected as the higher cost does not provide any additional benefits to Option 4 to justify the additional investment.

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 10% on the second cable compared to the first. This option has been costed on 95 mm² cables.

The cost of this option is estimated at £[redacted] k.

As with other options the reduction in probability of failure by replacing the existing subsea cable drives the NPV calculation, which in this case is -£2,350k.
This option was rejected as the higher cost does not provide any additional benefits to justify the investment.

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 6 options, as described below:

7.1 Summary of Cost

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 table 3 below.

Table 3 - Summary of Costs

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

7.2 Cost Benefit Analysis comparisons

For comparison purposes, it has been assumed in the CBA that the existing cable fails in 2028. Therefore, the augmentation options will have the benefits of N-1 operation until this time. However, the benefits of N-1 operation will increase if the existing circuit remains in service beyond this time.

Although there is little difference between options 2 to 5 on NPV over 45 years, of the options considered in the CBA, Option 4 has been selected as it provides greater resilience and better NPV than Option 2. Additionally, it has the potential to provide a dual subsea circuit beyond 2028 dependant on cable performance.

Table 4 – Summary of NPV

Options	NPV After 45 Years (£m)
1. Do Minimum	-4.88
2. Replace	-1.24
3. Replace with larger cable	-1.40
4. Augmentation	-1.05
5. Augmentation larger cable	-1.21
6. Two new cables existing route	-2.35

7.3 Volume on Adopted Option

The option selected requires a new cable to be laid along the existing cable route and connected into the current 33kV network, the existing cable would also remain in service.

Table 5 – Volume for Preferred Option

Asset Category	Unit	2023/24	2024/25	2025/26	2026/27	2027/28	Total
33 kV subsea	km	-	[redacted]	-	-	-	[redacted]
33 kV Switchgear	No	-	[redacted]	-	-	-	[redacted]
33kV Switch (PM)	No	-	[redacted]	-	-	-	[redacted]
33kV Switchgear Other	No	-	[redacted]	-	-	-	[redacted]
33kV Pole	No	-	[redacted]	-	-	-	[redacted]
33kV OHL Conductor	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 33kV subsea cable between Hoy and Flotta. Due to the number of subsea cable faults in RIIO ED1 the approach 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 to be addressed. This approach considers the subsea population within the generic CBA model to identify the appropriate circuits to be replaced.

The Hoy - Flotta subsea cable, for which the monetised risk value was evaluated as £107,770 at the start of RIIO ED2 and without intervention, will increase to £204,642 at the end of RIIO ED2. With the intervention proposed in this EJP the value of monetised risk will reduce to zero during the operation both cables. The Probability of Failure is increasing significantly over RIIO ED2 and the total consequences of failure are £[redacted] million including £[redacted] million, to replace the cable on failure.

This EJP proposes Option 4 as the preferred option for intervention, augmenting the existing cable with a similar sized cable at a cost of £[redacted] million.

Table 6 – Spend for Preferred Option

CV7 Asset Replacement	Asset Category	ED2 (£m)
CV7 RIIO ED2 Spend (£m)	EHV Subsea Cable	[redacted]
CV7 RIIO ED2 Spend (£m)	33kV Switch (PM)	[redacted]
CV7 RIIO ED2 Spend (£m)	33kV Switchgear Other	[redacted]
CV7 RIIO ED2 Spend (£m)	33kV Pole	[redacted]
CV7 RIIO ED2 Spend (£m)	33kV OHL Conductor	[redacted]