RIIO ED2 Engineering Justification Paper (EJP)

Loch Long (Dornie) – Asset Replacement

Investment Reference No: 335_SHEPD_SUBSEA_LOCH_LONG

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 Loch Long (Dornie) subsea cable which is fed from Nostie Bridge 33/11 kV Primary substation and provides supplies to 395 customers in Dornie and the area around Loch Duich.

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

The Loch Long (Dornie) subsea cable was installed in 1981 and has been in service for 40 years, it currently has a Heath Index HI5 and Criticality Index of CI1. This represents a risk to the security of supply.

Following optioneering and detailed analysis, as set out in this paper, the proposed scope of works for the existing Loch Long (Dornie) circuit is as follows:

- Repalcement of exisiting subsea cable with a land based solution. However, detailed investigations will be required to be conducted in ED2 to determine if a possible 11kV land based cable connection can be established, as an aleternative to a subsea cable installation, utilising the A87 road bridge crossing Loch Long in Dornie.
- Initial investigations highlight a number of possible challeges associated with delivering a successful land connection and therefore a subsea solution will be progressed at this stage. Due to the anticipated challenges, and low deliverability confidence at this stage, the proposed solution is the installation of a higher rated 11kV subsea cable replacement.

The estimated cost to deliver the proposed subsea cable solution is anticipated to be around £[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 2023/24 in this EJP and this will be refined as our programme develops.

This scheme delivers the following outputs and benefits:

- Improves network resilience by replacing a poor conditioned, ageing subsea cable with a new cable.
- Removes a bottleneck within the existing network capacity.
- Reduces the risk of incurring impact costs, constrained generation, temporary generation and CO_2 impacts.
- Reduces the monetised risk on the Loch Long (Dornie) subsea cable, forecast to be £123,280 by the end of ED2 with no intervention, to £12,614.

While a land based solution provides the best long term value for customers and is the favoured solution, if the technical challenges can be overcome within the detailed design stage, this EJP is written to support a replacement subsea cable as the preferred 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

Table1 below provides a high-level summary of the key information relevant to this Engineering Justification Paper (EJP).

Table 1: Investment Summary

<table>
<tr><td>Name of Programme</td><td colspan="3">Loch Long (Dornie) Asset Replacement</td></tr>
<tr><td>Primary Investment Driver</td><td colspan="3">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.</td></tr>
<tr><td>Investment reference/mechanism or category</td><td colspan="3">Cost Benefit Analysis reference:
335_SHEPD_SUBSEA_LOCH_LONG</td></tr>
<tr><td>Output reference/type</td><td colspan="3">As above</td></tr>
<tr><td>Cost (£m)</td><td colspan="3">£[redacted]</td></tr>
<tr><td>Delivery year</td><td colspan="3">ED2 (2023/24)</td></tr>
<tr><td>Reporting Table</td><td colspan="3">CV7: Asset Replacement</td></tr>
<tr><td>Outputs included in RIIO ED1 Business Plan</td><td colspan="3">No</td></tr>
<tr><td rowspan="2">CV7 Asset Replacement RIIO ED2 Spend (£m)</td><td>Asset Category</td><td>ED2 (£m)</td><td>Total (£m)</td></tr>
<tr><td>HV Subsea Cable</td><td>[redacted]</td><td>[redacted]</td></tr>
</table>

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 Long (Dornie) subsea cable which is fed from Nostie Bridge 33/11 kV Primary Substation and provides supplies to Dornie and the area around Loch Duich. The existing 35 mm² PILC 11 kV cable is 0.362 km long and provides a connection across Loch Long to Dornie.

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).

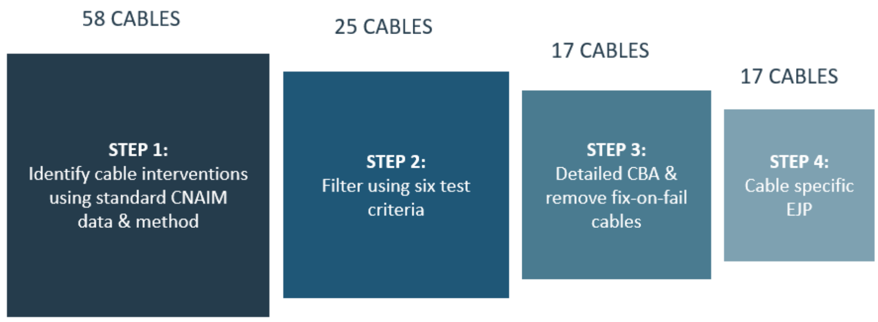
The RIIO-ED2 Business Plan submission has been based on the latest version of the industry standard CNAIM v2.1 which was approved for use in RIIO-ED2 by Ofgem in April 2021. The supporting data used in the modelling of this submission is based on the reported position of our asset condition for RIIO-ED1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

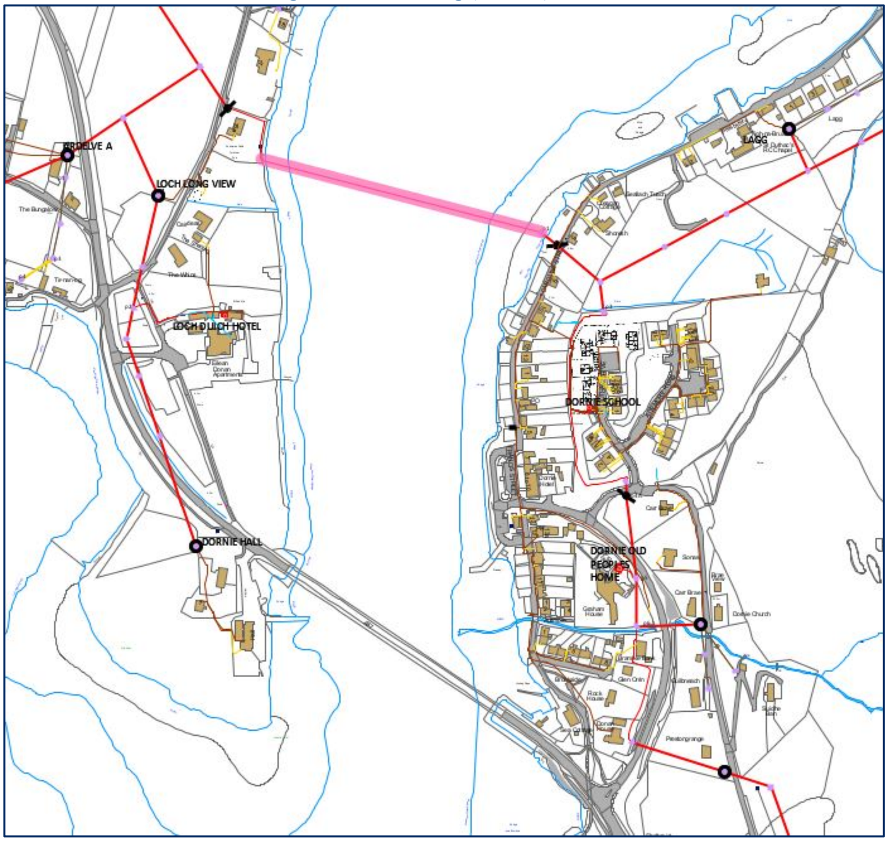
This EJP covers Step 4 for the Loch Long (Dornie) subsea cable which has qualified as requiring intervention. We set out here our approach to clearly justify why the circuit design approach is being proposed and associated costs are the most economic and efficient and what work would be required to deliver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



4.2 Demand Forecast

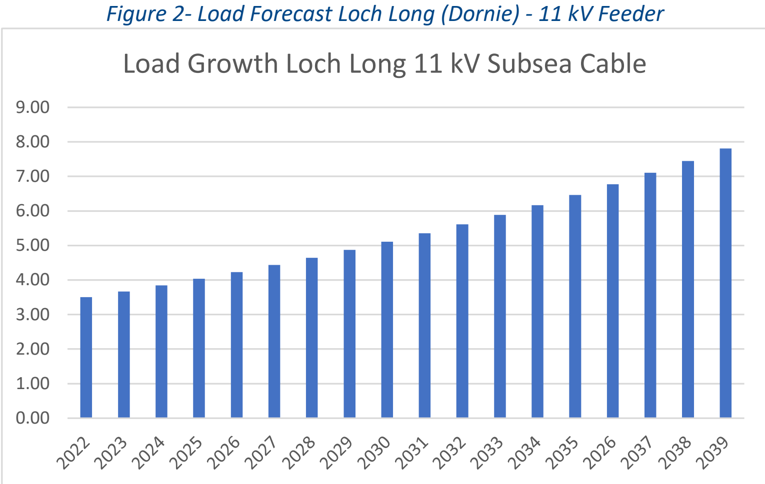
The Loch Long (Dornie) subsea cable which is fed from Nostie Bridge 33/11 kV Primary S/S, provides supplies to 395 customers in Dornie and the area around Loch Duich. The existing cable is a 35 mm² PILC 11 kV cable and is 0.362 km long, as shown in Figure 1 below.

Figure 1 - Loch Long (Dornie) Route



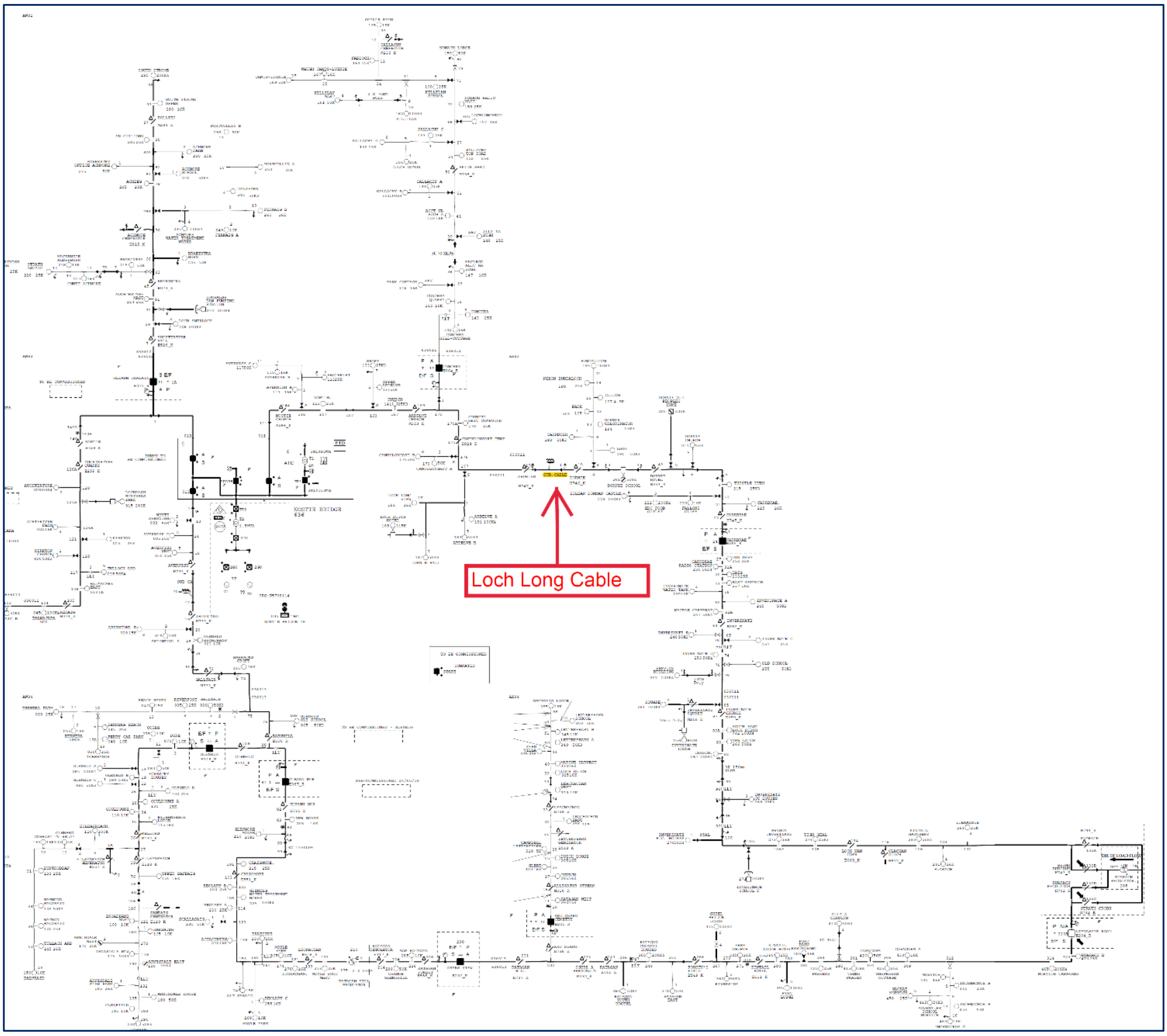
The 11 kV Loch Long (Dornie) subsea cable is rated at 2.9 MVA. The current maximum demand on the Loch Long (Dornie) cable is 3.3 MVA (115% of the cable rating). The average Consumer Transformation (CT) DFES forecast growth for the area, is 4.083%, and forecast demand at the end of ED2 is expected to be 4.47 MVA (159% of the cable rating). The demand projection is shown in Figure 2 below.

Figure 2- Load Forecast Loch Long (Dornie) - 11 kV Feeder



4.3 Existing Network Arrangement

The subsea cable across Loch Long to Dornie forms part of a large 11 kV network feeding from Nostie Bridge 33/11 kV Primary.



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 Loch Long (Dornie) subsea cable was installed in 1981 and has been in service for 40 years it currently has a Heath Index HI5 and Criticality Index of CI1.

5 Options Considered

This section of the report sets out the investment options that have been considered when determining the appropriate intervention required to resolve the existing risk/impact issues 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

Table 2 below provides a summary of the six (6) 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 with a higher rated cable	Low initial cost	Availability of material and resource when required. High cost of repair where practical with unknown resolution of the fault. Does not resolve the immediate issue demand exceeding the rating of the cable.	Rejected
2. Replace	Replace the cable with a higher rated cable along the same route	Improves HI. Provides new life cycle and allows greater protection of cable. Increases capacity, resolving current limitation and provides for future load growth.	Initial cost. Remains single circuit security.	Proposed option
3. Augmentation	Install a higher rated cable on a similar route whilst also maintain the existing cable in service.	Similar cost to replacement Provides N-1 for the remainder of the existing cable life Increases capacity for resolving current limitation and for future load growth.	Increased inspection and maintenance costs.	Rejected
4. Replacement using HDD	Directional drilling and installation of new cable in duct	Provides new life cycle and allows greater protection of cable.	High cost. Remains single circuit security.	Rejected

Option	Description	Advantages	Disadvantages	Results
		Removes dependence on a subsea cable. Increases capacity for resolving current limitation and for future load growth.	Requires feasibility study to confirm the practicality and cost HDD. Would require longer cable route. Require upgrades to onshore network.	
5. Reinforcement with two cables using HDD	Similar to option 4 but installation of two cables.	Removes dependence on a subsea cable. Provides N-1 security option. Increases capacity for resolving current limitation and for future load growth.	Most expensive option	Rejected
6 Replacement with underground cable via land route	Installation of new connection following a land route crossing the Loch via a road bridge	Least cost Removes dependence on a subsea cable. Increases capacity for resolving current limitation and for future load growth.	Access for installation of cable on bridge crossing are unknown, requires a survey to assess feasibility of solution. OHL tie ins are challenging	Preferred Option (Subject to further engineering)

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. Since the maximum demand has already exceeded the rating of the cable it would be proposed to install a suitably rated cable to meet the forecast increased demand.

In the event of a cable failure, supplies to 395 customers would be interrupted and 0.1 MW of generation would be constrained off. To supply the demand requires the deployment of mobile generators for the duration of the outage. The generic model has assumed this will be for a period of six months to allow the mobilisation of resources to replace the cable.

The CI/CML, temporary generation costs, CO_2 costs and constrained generation costs during the outage are estimated at £3,436 k.

The emergency replacement of 362m of subsea cable following a similar route to the existing cable, as shown in Figure 1 above, have been estimated based on the planned replacement costs uplifted by [redacted] % for an emergency replacement to £[redacted] k.

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 -£3,390 k

This option was rejected as it does not address the immediate issue of the maximum demand exceeding the cable rating. Furthermore, it would incur impact cost, constrained generation cost and reputational damage.

6.2 Option 2: Planned replacement during ED2

Planned replacement of the cable with a new suitably rated subsea cable to meet the forecast increased demand prior to failure. The replacement of the 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 will avoid the costs incurred in the event of a failure.

The replacement 363m of subsea cable would follow a similar route to the existing cable as shown in Figure 1 above has been estimated at a cost of £[redacted] k.

The Probability of Failure of the existing cable will increase from 0.015 to 0.036 in ED2 without intervention, but will be reduced to 0.004 with replacement. This drives the NPV benefits calculation which in this case is -£57 k.

This is the proposed option at this stage as it will reduce the overall risk of cable failure and provides the best NPV of all options, excluding option 6 which has not been determined to be feasible at this stage.

6.3 Option 3: Augmentation of the existing route with a second higher rated cable

This option is similar to option 2, laying a new suitably rated subsea cable to increase the potential capacity of the circuit, but retaining the existing cable in service until it fails. This option would incur additional costs over option 2 due to the requirements for a new connection into the 11 kV network at either end of the cable.

This option would provide enhanced security against a single cable failure with two circuits in operation 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 -£342 k.

This option was rejected as it does not provide the best NPV.

6.4 Option 4: Planned replacement using HDD

Replacing the existing subsea cable with a new, suitably rated, underground cable installed by horizontal directional drilling (HDD). The HDD would require to follow a longer route than the existing cable due to the availability of potential drilling compounds and pop out locations. The new route would require to be approximately [redacted] m long, subject to HDD feasibility. The new cable will be connected to the existing network with some sections of existing OHL requiring upgrading from 2 wire to 3 wire. The old subsea cable would then be disconnected.

The replacing of the subsea cable with an underground cable will impact the Health Index and Probability of Failure resulting in a change to the characteristics set by the age and condition. This option is the planned replacement of the cable during ED2 with a new cable to increase the potential capacity of the circuit and improve cable health condition. This will avoid the costs incurred in the event of a failure.

The cost of this option is estimated at £[redacted] k including £[redacted] k for a feasibility study.

As in Option 2, the reduction the in Probability of Failure drives the NPV calculation which in the case is -£836 k.

This option was rejected as it does not provide the best NPV.

6.5 Option 5: Planned replacement with two cables using HDD

This option is similar to Option 4, replacing the existing subsea cable with two new underground cables, installed by HDD following a similar route to the existing subsea cable.

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

This option provides N-1 security against a fault in this section of the network, this drives the NPV calculation which in this case is £2,400 k

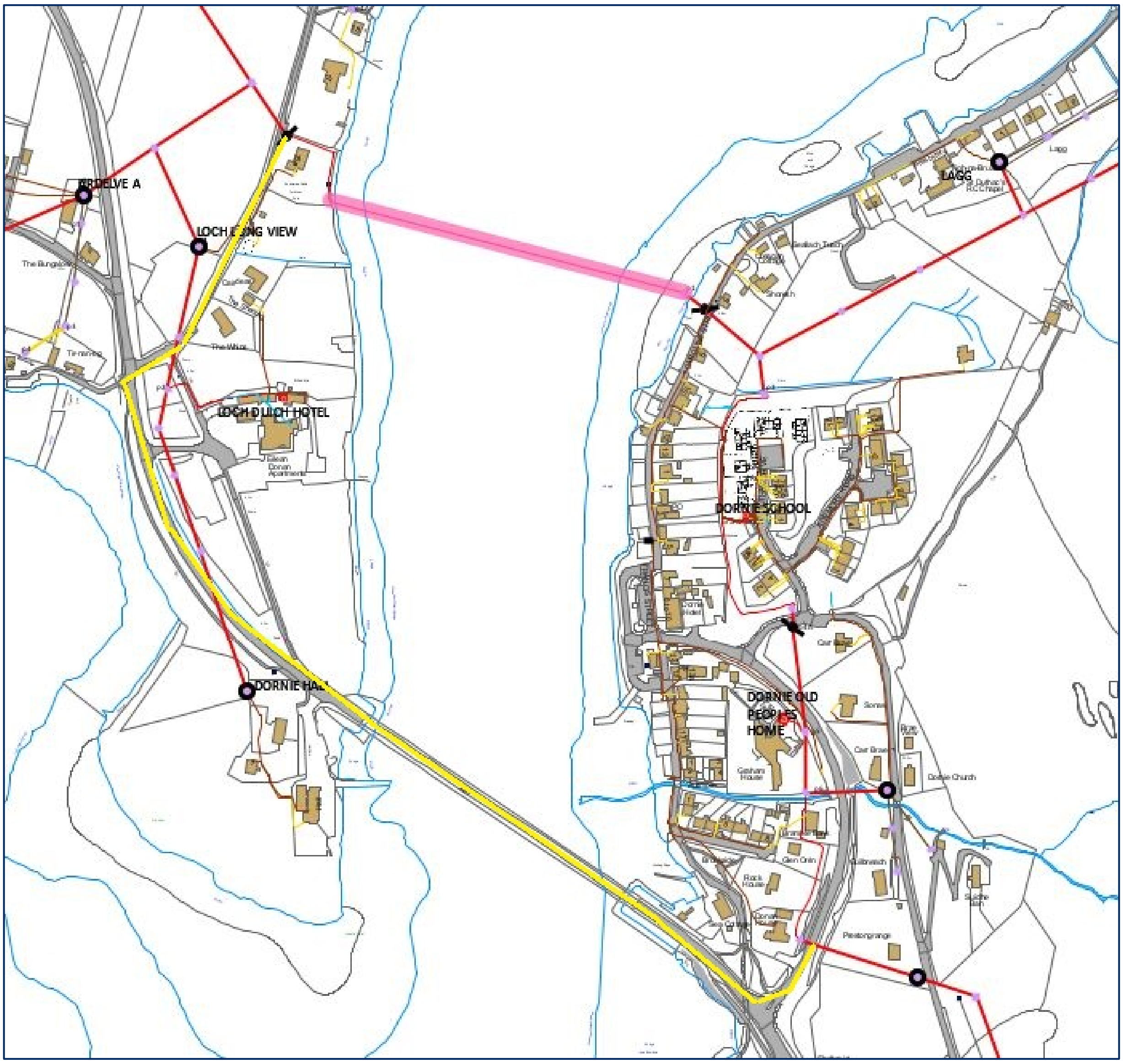
This option offers additional benefits over other options; however, it is the most expensive and the benefits delivered do not justify the additional investment.

6.6 Option 6: Planned replacement with larger cable via an alternative land route.

Option 6 proposes a new underground cable connection to the 11 kV Dornie network crossing Loch Long on the A87 road bridge. The new cable route is estimated to require [redacted] km of new 11kV U/G cable and some

OHL modifications, mainly upgrading some two-wire network to three-wire. The estimated onshore route is highlighted in yellow in Figure 3 below.

Figure 3 - Proposed Option 6 Underground Cable Route



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 £2,097 k.

This is the preferred option for this circuit as it addresses the existing circuit rating issue, is most cost effective, offers the best NPV and removes the reliance on a subsea cable. However, this option requires a full cable route survey to determine if the bridge crossing is feasible before the option can be progressed.

7 Summary of Cost Benefit Analysis (CBA)

This section of the report provides an overview of 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 Cost Benefit Analysis

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 with larger cable	£m	[redacted]	-	-	-	-	[redacted]
3. Augmentation larger cable	£m	[redacted]	-	-	-	-	[redacted]
4. Replacement using HDD	£m	[redacted]	-	-	-	-	[redacted]
5. Reinforcement with two cables using HDD	£m	[redacted]	-	-	-	-	[redacted]
6 Replacement with UGC via land route	£m	[redacted] **	-	-	-	-	[redacted]

** Requires a full cable route survey to determine if the bridge crossing is feasible before the option can be progressed.

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 would increase if the existing circuit remained in service beyond 2028.

A comparison of the whole life NPV values for each option is shown in Table 4 below. This shows option 6 to be the preferred option. As explained previously, option 6 has yet to be confirmed as feasible and there appears to be a number of challenges which could prevent this options implementation. Therefore, option 2 is currently being progressed as the required solution, which is feasible to install at this time. This option has the second best NPV of all options.

Table 4 – Summary of NPV

Options	NPV After 45 Years (£m)
1. Do Minimum	-3.45
2. Replace with larger cable	-0.06
3. Augmentation larger cable	-0.35
4. Replacement using HDD	-0.84
5. Reinforcement with two cables using HDD	-2.41
6 Replacement with UGC via land route	£2.14

7.3 Volume on Progressed Option

The option selected requires a new cable to be laid along the existing cable route and connected into the current 11 kV network.

Table 5 – Volume for Preferred Option

Asset Category	Unit	2023/24	2024/25	2025/26	2026/27	2027/28	Total
HV subsea Cable	km	[redacted]	0	0	0	0	[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 across Loch Long to Dornie.

Due to the number of subsea cable faults in 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.

This EJP covers the Loch Long (Dornie) subsea cable for which the monetised risk value was evaluated as £50,831 at the start of ED2 and, without intervention, will increase to £123,280 at the end of ED2. With the intervention proposed in this EJP the value of monetised risk will reduce to £12,614. The PoF will increase significantly over ED2 and the consequences of failure are £5.64 million including £2.30 million to replace the cable on failure.

Option 2 has been selected as the adopted option of intervention for the existing cable at a cost of £[redacted] m. However, investigations, site surveys and further engineering will be conducted to confirm if a land route, utilising the existing bridge crossing, is feasible. At present it is believed option 6 will have significant challenges in being achieved.

CV Table	Asset Category	RIIO ED2 Spend £m
CV7 Asset Replacement	HV Subsea Cable	[redacted]