501_SHEPD_HSM_24_SKYE-UIST-HARRIS

OUTER HEBRIDES - 2050 WHOLE SYSTEM PROPOSALS

ENGINEERING JUSTIFICATION PAPER

Scottish & Southern Electricity Networks

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CONTENTS

1 Executive Summary

The purpose of this Engineering Justification Paper (EJP) Re-Opener is to detail the long-term solution for the Western Isles network, to ensure it remains resilient and meets the projected demands of the island communities out to 2050. It is also for Scottish Hydro Electric Power Distribution (SHEPD) request for agreement on the need and technical solution to Ofgem for the first phase of this work. This is to replace the aging subsea electricity cable that connects mainland Scotland to the islands of South Uist and Benbecula.

SHEPD has identified Option 18[1] as the preferred long-term strategy for meeting the region's electricity demands whilst ensuring a resilient network, sufficient capacity, and low carbon footprint. This option involves replacing the existing Ardmore to Loch Carnan subsea cable with a larger one, installing a new cable between Harris and Clachan substations and laying a second subsea cable alongside the existing Ardmore to Harris route. Onshore connections to substations will support each route. This option has been chosen because it is:

1) The most cost-effective option with the highest Net Present Value (NPV).
2) Ensures future resilience on the Outer Hebrides.
3) Meets future demand and generation requirements.
4) Provides a credible route to facilitate decarbonisation of our embedded diesel generation fleet.

The investment timeline for this option spans 2025-2035, with the first circuit commissioning in 2027/28 and the last cable being completed in 2035, aligning with the forecasted Distribution Future Energy Scenarios (DFES) demand profile. The total capital cost of this option is [redacted], spread across the current and subsequent price control periods.

This paper outlines the intention to defer elements of the preferred solution until future price reviews, with the proposed new 33kV subsea cable from Dunvegan GSP on Skye to Loch Carnan 33kV Sw/STN on South Uist being taken forward for consideration in this Hebrides and Orkney Whole System (HOWSUM) reopener window.

The current 33kV cable running between Skye and South Uist has been in service for 31 years. The average End of Life (EoL) for this cable type is 30 years, therefore the cable has reached its EoL within the current price control period. The asset has been given a Health Index (HI) score 5/5 and a Criticality Index (CI) of 2/5, which means that it has a high probability of failure and needs to be replaced. The risk of asset failure will only increase as the asset is being used passed its EoL and the load on the cable continues to increase.

Although flexibility services were considered, they were discounted due to the large amount required (~30 MVA) and the lack of response from flexibility providers to SHEPD's global tender in 2023. As such, SHEPD recommends pursuing Option 18, ensuring a cost-effective engineering solution with the highest NPV.

This recommendation is based on a detailed analysis of 32 options (long list) of which 14 options (short list) were deemed to be technically feasible. The short-listed options underwent further Cost Benefit Analysis (CBA) to provide a commercial comparison. The analysis considered a whole system approach

1New Dunvegan – Loch Carnan subsea cable (plus supporting onshore), additional Harris – Clachan subsea cable (plus supporting onshore) and new secondary Ardmore – Harris subsea cable (plus supporting onshore)

as part of our options development. The detailed options analysis as mentioned above concluded that Option 18 was the most suitable option.

The project delivery strategy involves separating the submarine cable, overhead line/underground cable, and substation upgrades into three distinct packages to minimise contractual risks and effectively manage the project under CDM regulations. The supply chain has been tested through previous RIIO-RIIO-ED1 projects, and early market engagement has begun for submarine cable installation contractors to ensure availability of resources for RIIO-ED2. [redacted]

3 Investment Summary Table

Name of Scheme/Programme	Outer Hebrides Strategic Investment	
Primary Investment Driver	Asset replacement of Ardmore – Loch Carnan 33kV subsea cable Future resilience on the Outer Hebrides Future demand and generation requirements Decarbonisation of our diesel generation fleet.	
Scheme reference/ mechanism or category	501_SHEPD_HSM_24_SKYE-UIST-HARRIS	
Output reference/type	300mm^2 subsea cable Onshore 33kV Overhead Line cables Onshore substation upgrades	
Cost	[redacted]	
Delivery Year	Between 2025 and 2035	
Reporting Table(s)	R3 – Re-openers (subject to specific activities, costs may fall under other reporting tables)	
Outputs in RIIO ED2 Business Plan	HOWSUM development funding has been provided as part of SHEPD's RIIO-ED2 settlement for HOWSUM project development costs. For Skye-Uist, development costs in RIIO-ED2 are currently estimated at [redacted] (see also Hebrides and Orkney Whole System Core Narrative, Table 5). We have deducted development costs from the 'Cost' and 'Spend Apportionment' values in this table to take account of this funding. A refined view of costs will be provided as part of SHEPD's cost submission in summer 2024.	
Spend Apportionment	**RIIO-ED2**	**RIIO-ED3+**
	[redacted]	[redacted]
MVA released	30.9 MVA	

Table 1: Investment summary table

4 Introduction

This Engineering Justification Paper (EJP) sets out SHEPD's plan to replace the existing subsea electricity cable from Ardmore GSP on Skye to Loch Carnan 33kV Sw/STN on South Uist, to ensure that we continue providing a safe and reliable network and provide sufficient load capacity to enable 2045 net zero targets.

In the previous submission we developed two separate EJPs one for South (Loch Carnan) and one for North Uist (Clachan), however, in the interest of taking a Holistic Network Design (HND) approach we have combined the optioneering, to avoid the need for costly intervention at Harris. The options as outlined in Section 0, consider the need to intervene in Harris. The options either remove the need for intervention due to providing N-1 contingencies or require the combination of two options to provide N-1 contingency for Harris.

4.1 Geographical Context

As illustrated in Figure 1, the Western Isles are fed from a single radial transmission circuit from Fort Augustus Grid substation, which runs for approximately 165km from Fort Augustus[2] to Ardmore on the northwest coast of the island of Skye.

At Ardmore the network splits, with two 33kV subsea cables owned by SHEPD crossing the seabed to make landfall on the Western Isles.

The north cable is approximately 32km in length and makes landfall on the island of Harris, before continuing to Harris grid substation, where the circuit steps back up to a 132kV circuit owned by SSEN Transmission which heads north before terminating at Stornoway Grid substation, an additional 57km away.

The south cable from Ardmore is approximately 46km in length and makes landfall on South Uist at Loch Carnan substation, from where the network is distributed around the Uist islands.

There is no local interconnection between the Lewis/Harris distribution network and the Uist distribution network.

2 Fort Augustus is on mainland Scotland and thus not represented in Figure 1.

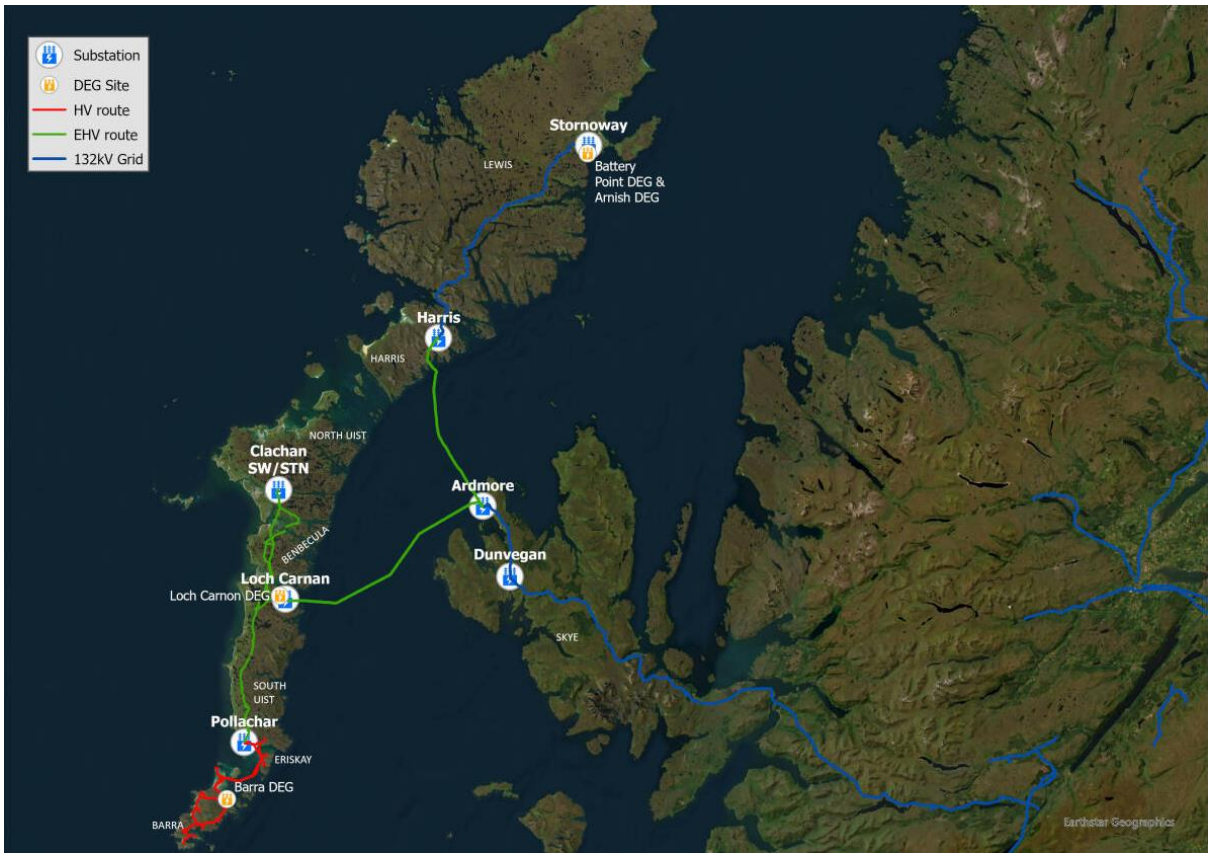

Figure 1: Existing cable route and proposed two new circuits to Uist in RIIO-ED2 submission

4.2 Uncertainty Mechanism

Due to uncertainties in respect of the development of demand, renewables generation, and the status of the High Voltage Direct Current (HVDC) Western Isles transmission link at the time of submission of RIIO-ED2 business plan, the HOWSUM bespoke re-opener was put in place. Re-openers are a type of RIIO uncertainty mechanism. Depending on their design, they allow Ofgem to adjust a licensee's allowances (in some cases up and in some cases down), outputs and delivery dates in response to changing circumstances during the price control period.

The re-opener application must include a clear statement as to the need for the proposed expenditure or the problem the licensee is trying to address in the context of its significance for consumers, network assets, and wider society. The application must include an explanation of how stakeholder engagement contributed to the identification and design of the preferred option and where there are opportunities to collaborate with other network companies on whole system issues, this must be reflected in the analysis and evidence provided. The Outer Hebridean Islands under consideration are Vatersay, Barra, Eriskay, South Uist, Benbecula, North Uist, Harris and Lewis. This EJP falls within the scope of the HOWSUM and as such will address the requirements listed in the re-opener guidance above.

4.3 Primary Investment Drivers

SHEPD's overarching strategy is "to decarbonise the Western Isles, meet security of supply standards, drive least worst regret investment to facilitate island net zero ambitions and deliver a coordinated approach that meets stakeholder, customer, and consumer needs".

Therefore, our three Primary Investment Drivers for this EJP are:

1) Future resilience on the Outer Hebrides. This can be considered through two elements:
    a. Asset Condition: Considering the age and condition of the existing subsea cable assets.
    b. Future impacts of diesel generation: Understanding how we can maintain resilience on the islands whilst reducing reliance on our aging diesel generation fleet.
2) Future demand and generation requirements. This can be further broken down into:
    a. Load Growth: Electrification of heat, transport, and industrial processes on the islands and their impact on future demand requirements.
    b. Generation Growth: The Hebrides, Orkney and surrounding waters have a significant potential for wind and tidal.
3) Decarbonisation of our diesel generation fleet.

Replacing the subsea cable aligns will all three of our primary drivers as it will reduce the risk of an asset failure, allow us to meet future demand and generation requirements by increasing the capacity, and decarbonise our network by reducing our reliability on diesel generators. Table 2 summarises the primary drivers mentioned above.

Driver	Primary	Description
Future resilience on the Outer Hebrides	Primary	Replacement of subsea cable will increase the reliability of the network by reducing the overall probability of failure.
Future demand and generation requirements	Primary	Increased capacity rating will accommodate future demand and generation growth.
Decarbonisation of our diesel generation fleet.	Primary	Reduce reliability on diesel generators.

Table 2: Primary investment drivers

4.5 Needs Case

The need to replace this cable is clear and there are a number of primary drivers that support intervention.

4.5.1 Subsea cable asset condition

A primary driver for our works is to replace end of life submarine cables. These cables exist in extreme conditions and failure of a cable can take many months to locate and repair or in worst case scenarios completely replace.

4.5.2 Future demand and generation requirements

Investment in new subsea assets is costly and we need to ensure we are developing a network that meet stakeholders' needs through to 2045. We have considered this through two elements:

1. Load growth -electrification of heat, transport and industrial processes on the islands and their impact on future demand requirements.
2. Generation growth - The Hebrides, Orkney and surrounding waters have significant potential for wind, and tidal.
3. Decarbonisation of our diesel generation fleet. - This is a significant source of carbon emissions for SHEPD when required to run for long periods of time. Emissions reached 2238.49tCO2-e in 2022/23 across the fleet, and we must reduce these to meet out 1.5-degree Science Based Target (SBT).
4. Continued island resilience*:* Resilience conditions for Scottish islands are unique given the geographies and potential lengthy system outages in the unlikely event of a subsea cable fault. We have developed a specific Net Zero policy for the treatment of these island groups recognising the impacts of decarbonisation on electrification of heat and transport. We are looking to achieve the resilience levels in our policy through staged interventions. This will be continually developed through our 2025 HOWSUM re-opener application, and subsequent submissions.

4.5.3 Summary

Intervention is, therefore, imperative to ensure that SHEPD continue to meet the needs of our customers. The following sections provide further evidence for the need of investment within this price control period.

5 Background Information

5.1 Intervention Priorities

This EJP aligns to Step 4 (Figure 2) of our Common Network Assets Indices Methodology (CNAIM), which states that the asset needs intervention. CNAIM was adopted in 2017 and is based on our initial Condition Based Risk Management (CBRM)[3] methodology developed in 2014.

The RIIO-ED2 Business Plan submission is 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.

Our proposed investment programme in RIIO-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 (CBA). We are proposing planned replacement of cables where the certainty of need is the highest, driven by high probability and impact of failure in RIIO-ED2. This ensures maximum cost efficiency (e.g. lowest impact to consumer bills) and network reliability.

SHEPD have adopted a four-step funnel approach, as shown in Figure 2, 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 in the Scottish Islands Strategy within our RIIO-ED2 Business Plan.[4]

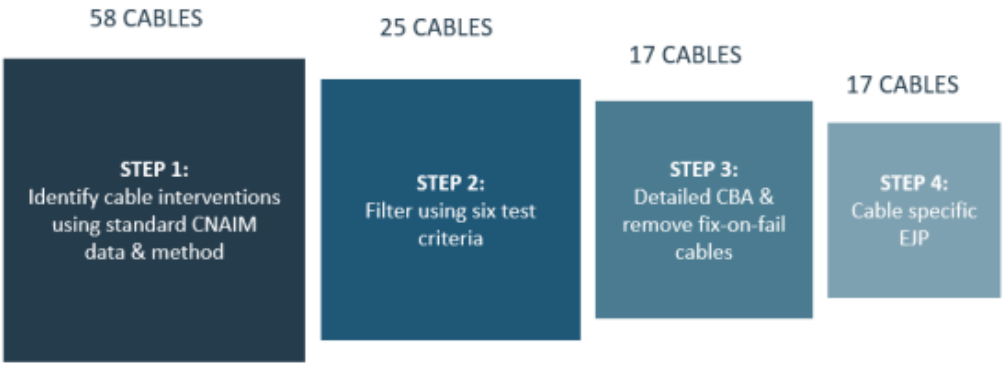

Figure 2: Cable filter selection process

Our aim is to maintain our assets appropriately, in an enduring, economic and efficient manner. The CNAIM methodology enables us to prioritise investment towards assets that have a high Health Index and high probability of failure.

3 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.

[4] A_8.1_ScottishIslands_CLEANFINAL_REDACTED.pdf (ssenfuture.co.uk)

5.2 Existing Asset Conditions

Utilising the information gathered on our assets and sites from inspections along with other key information collected during installation, commissioning, and configuration we utilise the industry standard approach of CNAIM system to prioritise our investment in assets.

The approach is based on a standard risk approach assessing the Probability of Failure (Health Index) and the Consequences of Failure (Criticality Index) to calculate an overall risk score (Monetised Risk) for each applicable asset type and this can provide a cumulative total figure for each of our license network areas (SHEPD and SEPD).

5.2.1 Health Index

The Health Index (HI) is a key output of the CNAIM and is a framework for collecting information relating to asset health and Probability of Failure. The HI provides a view on the condition of the asset relative to its normal expected EoL. The HI consists of five bandings, HI1 to HI5. The HI1 banding represents assets with the lowest Probability of Failure and HI5 the highest. Table 3 sets out the HI bandings.

Bandings	Definition	Range
Health Index 1	New or as New	• The subsea cable outer serving has no visible damage. • There is no exposed armour. • There is no exposed insulation.
Health Index 2	Good or Serviceable condition	• The subsea cable outer serving may have visible damage. • There are small number of sections with damaged armour. • There is no exposed insulation.
Health Index 3	Deterioration requires assessment and monitoring	• The subsea cable outer serving has areas of visible damage. • There are numerous sections of exposed armour. • There is no exposed insulation.
Health Index 4	Material deterioration, intervention requires consideration	• The subsea cable outer serving has visible damage and at points it is no longer present. • There are significant sections of exposed armour, with corroded armour visible. • There is no significant exposed insulation.
Health Index 5	End of serviceable life, intervention required.	• The subsea cable outer serving has visible damage and has little or none left.

Bandings	Definition	Range
		• There are significant sections of exposed armour, with major corrosion to the armour. • Armour is likely to have lost mechanical strength. • There is exposed insulation.

Table 3: HI bandings and definition

Our subsea cable team has carried out an inspection on around 30 subsea cables, including the asset in question. The current 33kV cable running between Skye and South Uist has been in service for 31 years. This cable has now reached the end of its serviceable life and is recorded as an HI5 cable. SSEN have concerns over the cables ability to continue to provide a reliable and secure connection to the islands and wish the replace the asset to alleviate the health concerns. Table 4 shows the HI score in RIIO-ED1 and the future band. The asset reached HI5 in 2023 and the risks will only compound in the upcoming regulatory period.

Circuit Name	Current HI Band (RIIO-ED1)	Future HI Band (RIIO-ED2)
South Uist	HI5	HI5
North Uist	HI1	HI1

Table 4: HI Banding in RIIO-ED1 and RIIO-ED2

5.2.2 Criticality Index

The Criticality Index (CI) is a framework for collecting information relating to Consequences of Failure. The CI consists of four bandings, C1 to C4. High criticality assets should be replaced ahead of low criticality assets to protect network customers. Assets are currently allocated to a CI Band according to the relative magnitude of the Consequences of Failure for the individual asset compared to the Average Overall Consequences of Failure for the relevant Health Index Asset Category. The C1 banding represents assets with lower-than-average consequences of failure, whereas the C4 banding is used for those with significantly higher than average consequences of failure. In CNAIM, Consequences of Failure are assessed by considering four separate consequence categories:

- Financial;
- Safety;
- Environmental; and
- Network Performance.

The HI and CI values are combined into a table to provide the inputs for the monetised risk assessment.

5.2.3 Monetised Risk Assessment

The output from CNAIM has been used to inform the intervention criteria utilising our internal Network Asset Indices Methodology (NAIM) on how the assets are selected for prioritised investment. This is based on the assets relative position in the standard CNAIM reporting Risk Index matrix as illustrated by two tables below, which shows the value of monetised risk attributed to each asset according to its attributed Health and Criticality within each cell, providing a reference risk value in £. The model evaluates the probability of failure, the cost of intervention and the impact cost, which is used to assess 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 Strategy within our RIIO-ED2 Business Plan.[5]

The specific Health Score Intervention Criteria we have established for this asset category has been developed within a number of internal workshops with our subject matter expert with the objective of finding the optimal balance of risk between proactive and reactive asset intervention. This approach has also been tested and ratified through targeted stakeholder engagement and intends to maximise both the reliability and importantly the affordability of the network for our customers.

The overall score was HI5 and C2 for Loch Carnan and HI1 and C2 for the Harris cable. Table 5 and Table 6 below show how the monetised risk value increases the higher the Health Index and the Criticality levels are.

		Health Index				
		HI1	HI2	HI3	HI4	HI5
Criticality	C1					
	C2					✕
	C3					
	C4					

Table 5: Health/ Criticality Risk Index Matrix (Existing Ardmore – Loch Carnan cable)

		Health Index				
		HI1	HI2	HI3	HI4	HI5
Criticality	C1					
	C2	✕				
	C3					
	C4					

Table 6: Health/ Criticality Risk Index Matrix (Existing Ardmore – Harris cable)

5 A_8.1_ScottishIslands_CLEANFINAL_REDACTED.pdf (ssenfuture.co.uk)

5.3 Existing Network Arrangements

4.3.1 Uist archipelago

The existing 33kV network configuration is shown in Figure 3 single-line diagram below. The Loch Carnan system is reliant on supply from Ardmore. The subsea cable is the single connecting component between the Ardmore substation and the Loch Carnan substation which supplies five primaries (Clachan, Aird, Drimore and Pollachar). Its performance is therefore critical to the performance of the entire Loch Carnan system.

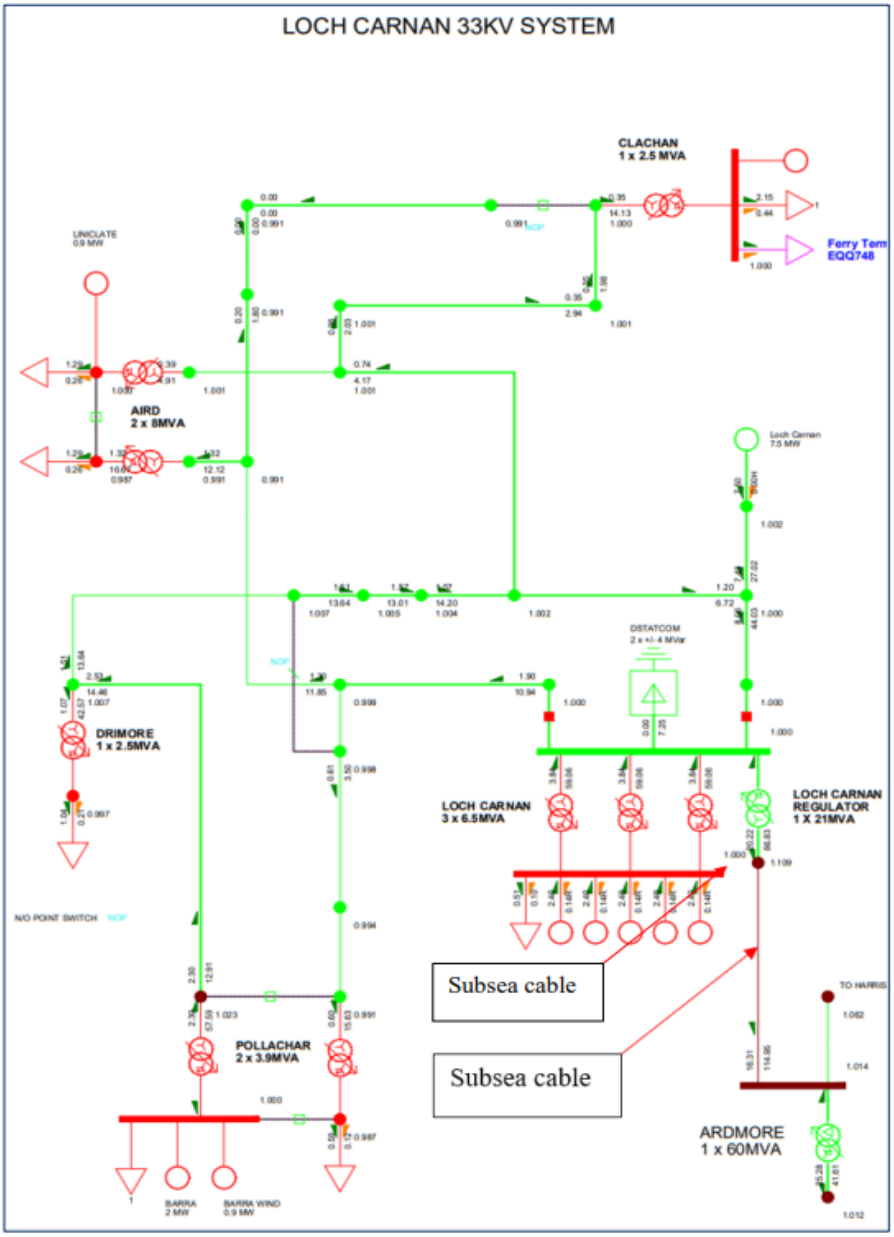

Figure 3: Existing circuit (Uist Archipelago)

5.3.1.1 Security of Supply (Uist Archipelago)

The current network is compliant with both network planning standard P2/8[6] and the Distribution Code[7] on security of supply for these islands[8], which means if the feed from Ardmore is lost,the supply is restored to the Uist Archipelago network using the local diesel generation at at Loch Carnan and Barra power stations. Contractor estimates suggest it would take up to 2 years until the cable can be fully restored in case of failure, which will have a significant impact on security of supply and impact to customers

5.3.2 Lewis and Harris

The existing 33kV network configuration is shown in the single-line diagram at Figure 4. The Isles of Lewis and Harris are currently supplied by SSEN Transmission's network via a single circuit fed from the 132kV busbar at Fort Augustus Grid Substation. The radial circuit comprises of mainly 132kV overhead line to Ardmore Grid Substation on the Isle of Skye. A 33kV section of overhead line, land and subsea cable (owned by SSEN Distribution) connects to Harris Grid Substation from Ardmore GSP 33kV busbar. This is then "Stepped up" to 132kV and an overhead line (owned and operated by SSEN Transmission) runs the length of the island to Stornoway Grid Substation. There are two Primaries on Harris (Stockinish and Tarbert) and eight Primaries on Lewis (Arnish, Barvas, Battery Point, Callanish, Coll, Gisla, Laxay and Maaruig). SSEN Distribution also operates two embedded Diesel Power Stations. Arnish and Battery Point on Lewis, which are used to meet island demands in the event of an outage to the 33kV subsea cable from Ardmore GSP.

6 ENA EREC P2 Issue 8 (dcode.org.uk)

7 Specifically PO-PS-037 in Distribution Code Annex 1; Microsoft Word - Section 11 Notice - Schedule 2 - POPS037.doc (ofgem.gov.uk)

8 For smaller parts of this network, exemptions are in place.

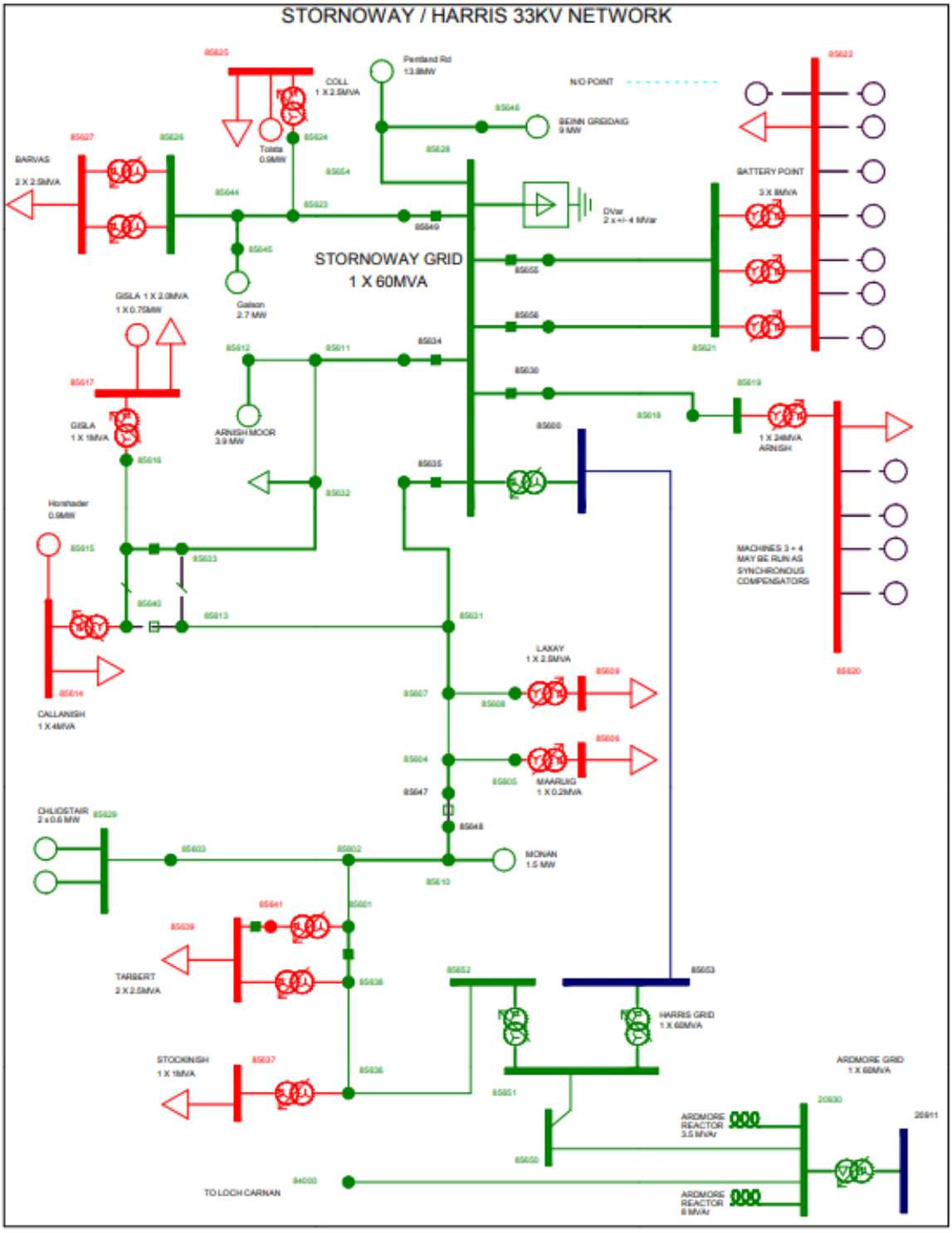

Figure 4: Existing network (Lewis and Harris)

4.3.2.1 Security of supply (Lewis and Harris)

The network on Lewis & Harris is not currently compliant with the network planning standard P2-8, however this piece of the SSEN network is exempt under PO-PS-037 Standards of Voltage and Security of Supply. In the event of an outage to the existing supply feed from Ardmore GSP on Skye, supplies on the island are restored via the two embedded generation stations on Lewis (Battery Point & Arnish DEG). Similarly, to the Uist network, it is estimated that in the event of a fault feeding the Lewis & Harris network, It would take approximately two years to reestablish the subsea cable to the islands.

5.4 Load Forecast

The Distributed Future Energy Scenario (DFES) process creates projections for the volumes and regional distribution of the uptake of demand (load) and generation (supply) customers across the four regions which make up our SHEPD licence area. This uses stakeholder-informed bottom-up analysis using a scenario framework consistent with the national industry-developed Future Energy Scenarios (FES).

Through our DFES work, a range of political and economic outlooks are considered to create the envelope of credible future network usage. We use this information internally to determine Strategic Investment Options. The DFES provided the load and generation forecast for North and South Uist.

As part of the analysis, we assess four different scenarios:

1) Consumer Transformation
2) Leading the Way
3) System Transformation
4) Falling Short

We consider all four scenarios from a system needs perspective but currently take ‘Consumer Transformation’ as a credible ‘best view’ of future requirements. The future demand and generation profiles are illustrated in Figure 5, Figure 6 and Figure 7.

The current subsea cable running from the Ardmore grid to the Loch Carnan primary station is a 95 mm² PILC 'HSL'DWA [redacted] cable, rated at 16 MVA (red line) (derated load is 14 MVA). Presently, the demand on the Ardmore to Loch Carnan cable stands at 8.43 MVA, which is equivalent to 60% of its rated capacity. The isles of Lewis and Harris are supplied via a single 500 mm² CU subsea cable from Ardmore GSP to Harris GSP rated at 35.5MVA. Presently the demand on the Ardmore to Harris cable stands at 20.96MVA. The load projections for the primary substations on North and South Uist, as well as Lewis and Harris, are depicted in Figure 5.

Figure 5: DFES 2050 - load growth

The load forecast was taken from the Consumer Transformation 2050 DFES. SHEPD has applied a modification to the DFES in relation to the demand at Clachan, where the original DFES contained an abnormally large demand forecast which we do not currently consider is realistically likely to materialise. A full summary is provided in Appendix 7 – Jacobs Phase 1: Optioneering Studies Report which has been submitted in tandem to this EJP.

The generation forecast for the Consumer Transformation scenario is depicted in Figure 6 and Figure 7 below.

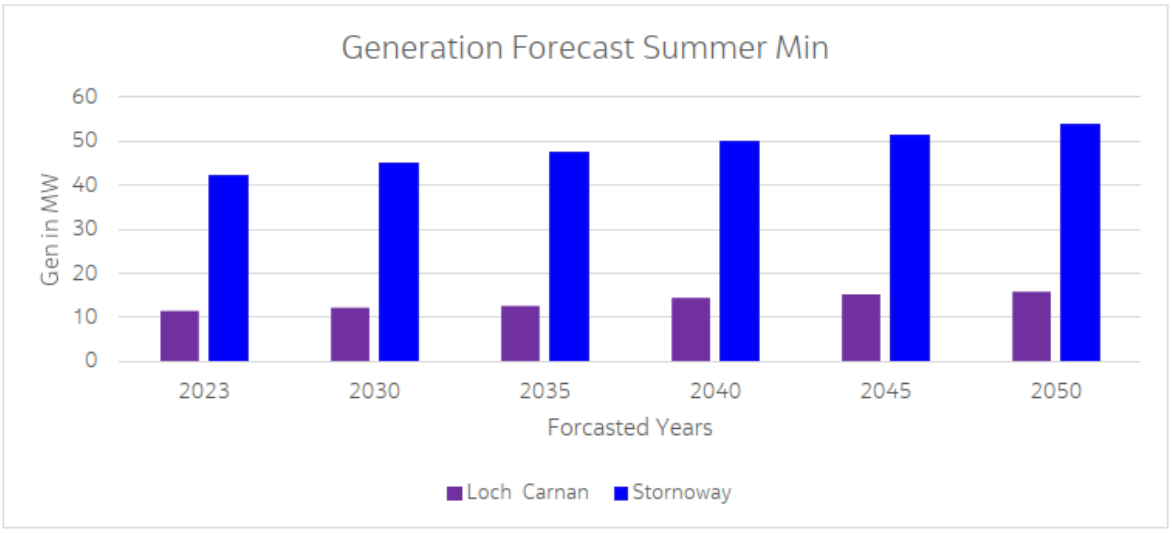

Figure 6: DFES 2050 - generation growth - summer

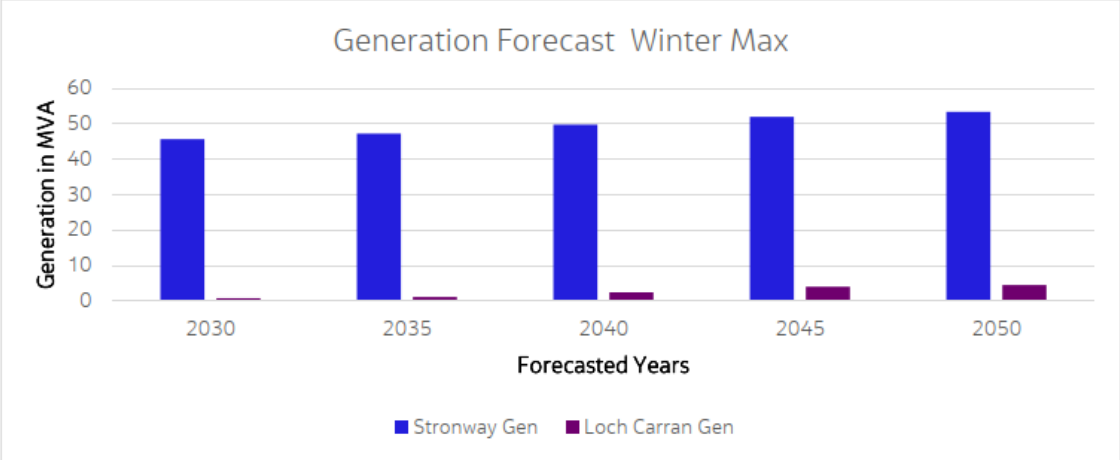

Figure 7: DFES 2050 - generation growth - winter

5.5 Regional Stakeholder Engagement and Whole Systems Analysis Summary

RIIO-ED2 engagement

Stakeholder engagement has been a core component of all aspects of our RIIO-ED2 Business Plan and has been instrumental in defining how we approach our proposed asset related investments. Therefore, in preparation for our RIIO-ED2 business plans stakeholder engagement exercises were undertaken to understand more clearly what is important to our network customers during RIIO-ED2 and to ensure the views of our stakeholders were reflected in the cost and volumes we proposed for each asset category in line with our Enhanced Engagement Strategy (Annex 3.1).[9] Figure 8 below illustrates the number of RIIO-ED2 engagement events we held, sources of insight we gathered, and stakeholders with whom we engaged.

Figure 8: RIIO-ED2 total engagement

9 A_3.1_Enhanced_Engagement_Strategy_Ofgem_CLEANFINAL_REDACTED.pdf (ssenfuture.co.uk)

The details from some of our critical stakeholder feedback on our Asset Management Strategy and their views on the importance of improving network reliability is presented in Figure 9:

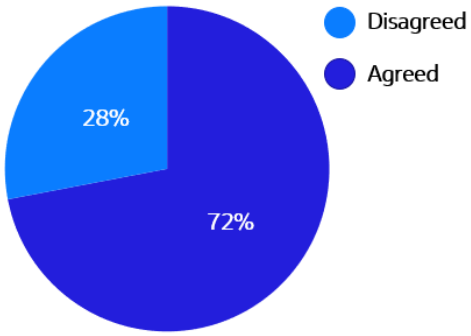

Figure 9: Stakeholder views on our asset management strategy

Figure 9 shows that 72% of our customers in SHEPD either “agreed” or “strongly agreed” with our asset management proposal to target assets with the highest probability of failure in RIIO-ED2.

Furthermore, 71% of consumers thought it was “very important” that SHEPD are committed to reliability, which was the second highest priority for our consumers after affordability.

Within reliability, our customers top priorities were:

- Restoring the electricity supply as quickly as possible in the event of a power cut. This was particularly pertinent for those age 65+ and our vulnerable customers.
- Keeping the power on with minimal power cuts.

5.5.1 Local Authority and Government

Our engagement with Local Authorities (LAs) and government brought to light that when maintaining a reliable network, they would like SHEPD to strike a balance between simply fixing older assets and replacing assets (at a higher cost) to ensure that the network is reliable for future use.

This is aligned with what we are requesting as part of this intervention, which is to increase reliability in the present and develop a network that is fit for future needs.

5.5.2 Community Energy Groups and interest groups

Community Energy Groups (CEGs) are an important contributor to the grid and thus are part of our whole system approach. As part of the consultation, we engaged with 8 CEGs within the region. The stakeholder consultation showed that CEGs and interest groups find important that we ensure the transition does not leave people behind, especially those off the mainland. Further, this stakeholder group asked to plan investment against current and future population projections to plan investments effectively.

DFES projections have been considered in the optioneering forecast which provides a direct proxy for current and future population growth as a demand of electricity. These projections allow us to plan capacity based on realistic local demand and supply scenarios.

HOWSUM engagement during RIIO-ED2

5.5.3 Whole system approach

Over the last few months, we have worked closely with local stakeholders, customers, market participants government bodies and our transmission company to build on our engagement prior to RIIO-ED2 and develop an enduring Whole System solution to meet the future energy needs of the Outer Hebrides and to enable the region to support the transition to net zero through its extensive natural resource potential.

A number of options have been considered, some based on specific feedback from island stakeholders. It should be noted that some of these elements are not sufficiently mature today, however, potentially form part of our longer-term strategic plans:

1. Traditional Distribution elements: We have considered how future network needs could be met with additional Distribution investment. It is generally recognised that all islands will need to remain connected to the mainland GB system so there is a definite need for continued Transmission and / or Distribution circuitry and capacity.
2. Traditional Transmission elements: We have worked closely with SSEN Transmission to understand their future requirements and considered the potential for a 132kV connection to the islands in the future.
3. Use of new technologies: We have discussed and will assess the use of new technologies such as hydrogen and other forms of storage to help resolve some of the drivers for change.
4. Use of flexibility: We see flexibility as potentially being required as part of all the developed options. For load related drivers, it can help optimise the timing of future investment needs.
5. Repowering of diesel generators: The potential to repower our diesel generators with green alternatives is being considered as an option to help decarbonise the Scottish islands.

We are assessing all the options above as part of our analysis for our January 2025 HOWSUM application.

5.5.4 Summary

As part of our engagement for RIIO-ED2, it was confirmed that a wide range of stakeholders, including the Transmission Operator (TO), strongly support our proposed approach of prioritising assets with a higher likelihood of failure as part of the asset management strategy. In addition, stakeholders also highlighted that network reliability was a high priority, greater than sustainability but below value for money. Stakeholders communicated that reliability is expected as they depend on electricity for so many things in everyday life. This dependence on a reliable network is increasing, for example, with more households working from home and the electrification of heating and transport. These expectations and views validate Ofgem's Interruptions Incentive Scheme (IIS) targets and Guaranteed Standards, so on this basis we have set our ambition to meet these levels of network performance. Building on this engagement as part of the HOWSUM re-opener, we have seen strong support for adopting a whole system strategy for the island networks, where the use of flexibility markets and emerging technologies is considered along with traditional asset investment to secure a reliable and fit for purpose network.

5.6 Flexible Market Viability

Through its innovative Constraint Managed Zone (CMZ) initiative in 2016, SSEN was the first UK DNO to introduce Flexibility Services and it continues to lead in the delivery of flexibility across the distribution networks. Since our first BAU contract in October 2019 and thanks to our ongoing commitment to 'flexibility first', our improved systems, supporting processes, and the evolving Local Energy Markets, we have grown our portfolio to 202 MW[10] of Flexible Service across SSEN in 2023. The procurement and use of Transmission and Distribution Flexibility Services to manage areas on our network that are subject to constraints, is a key tool to avoiding the need for expensive and time-consuming network reinforcement and promoting markets for service provision, which should drive more economic, efficient and smarter approaches.

To progress towards net zero and improve security of supply, we undertook the following analysis for this EJP. There are two potential use cases for flexibility in the Outer Hebrides. Firstly, as a tool to defer network investment to an optimum time. Secondly as a long-term option to provide resilience to the islands. We summarise our findings on both below.

5.6.1 Flexibility to defer investment needs

Flexibility as a potential substitute for reinforcement has been evaluated as part of our whole system approach and has been assessed as a deferral option within this EJP. The quantity of flexibility required to forestall reinforcement by 2050 is estimated to be between 3 and 30 MVA depending on the option. Our 2023 global call for flexibility opened has not highlighted significant volumes of flexibility on the islands today, however we will be considering the future potential in 2025 given its primary use cases are for the later phases of work.

5.6.2 Flexibility to provide long term resilience to the islands

Flexible generation and storage have the potential to support future resilience on the Outer Hebrides. The primary requirements are a need for certainty over capability, ability to operate in islanded mode, and ability to export sustained power over a long period of time. We have reviewed the current generation background on the island and have yet to identify existing generation that could provide this capability. However, we are aware that projects such as the RIPEET project's work on hydrogen storage may have this capability in the future.[11] We intend to engage further with stakeholders in 2024 to further understand the future capabilities on the islands for this service.

5.7 Confidence Table

Table 7 provides an indication of our confidence levels in each of the sections which have been analysed/utilised as part of the solution assessment.

10 https://utilityweek.co.uk/ssen-sees-140-increase-in-flexible-capacity/
11 Outer Hebrides | RIPEET Project

Confidence Factor	Certainty (High, Medium, Low)	Comments
Load Forecast	Medium	We are using the 2022 DFES data has been used for the purpose of this study and a predictor of load forecast. However, these are longer term proposals and as such we recognise the potential for variation during the period to 2050.
Existing Asset Condition	High	Offshore ROV inspections and identified HI 5 asset condition.
Existing Operational Issues	Medium	No operational issues have been encountered to date.
Connections Activity	Medium	Connections are regularly changing, and new applications can be received at any time. However, we had reasonable certainty based on DFES analysis that demand growth has been accurately captured in the DFES.
Regional Stakeholder engagement	High	Western isles whole system webinars have been held also with the offer of bilateral. Further engagement undertaken through DFES and wider community engagement sessions.
Flexible market Viability	Low	Flexibility as a viable alternative to reinforcement has been explored as part of the optioneering study. The amount of flexibility which would need to be procured to prevent reinforcement before 2050 is approximately between 3 to 30MVA on average for the options developed. Our 2023 global call for flexibility opened has not highlighted significant volumes of flexibility on the islands today, however we will be considering the future potential in 2025 given its primary use cases are for the later phases of work.
Funding Position	Medium	We have agreement to use the HOWSUM, and the outcome of the submission is subject to Ofgem's assessment. Based on our analysis of island needs we believe we have identified the correct solution for implementation at the correct time. We are undertaking a tendering exercise to ascertain cable installation costs before making a full regulatory submission.

Table 7: Confidence table

7 Optioneering

SSEN has a defined approach in the strategic development of its distribution networks to enable net zero at a local level. This approach is referred to as the Net Zero strategic planning process. The aim of the Net Zero strategic planning process is to provide the capacity on the network to deliver net zero by 2050 whilst retaining a clear focus on safety and reliability.

This approach extends to Scottish islands, and we have trialled this new approach in our development of proposals relating to relevant RIIO-ED2 uncertainty mechanisms including the Hebrides and Orkney Whole System Uncertainty Mechanism (HOWSUM). The approach is summarised in the process chart at Figure 10.

Figure 10: Summary of Net Zero Strategic Planning Process

The following section presents a long list and shortlist of options which were developed through the process. A full long list of all options examined can be found in Appendix B.

7.1 Long List of Options

SHEPD undertook a thorough optioneering study and identified a long list of 32 options that could provide a technical solution to the problem outlined in this EJP. This is explored further in the Outer Hebrides Whole System Assessment – Optioneering Study which accompanies this document.

The optioneering study considered scenarios for both summer and winter to ensure the varying demand and support from local generation[12] combinations were all accounted for. Contingency N-1 analysis was also undertaken.

The study concluded that 14 options[13] can meet these criteria and are thus technically feasible. These options were shortlisted as they are acceptable for both summer and winter conditions to 2050 under both normal and contingency arrangements. These options are summarised in Table 8.

12 Generation has been excluded from the winter contingency.

13 Excludes baseline option.

SI No.	Name	Summary
8	Replace Ardmore – Loch Carnan subsea cable with two larger cables & new Ardmore – Harris subsea cable	• Add new two Ardmore – Loch Carnan subsea cables. • Add new subsea cable/OHL from Admore to Harris.
9	Replace Ardmore – Loch Carnan subsea cable with two larger cables & new 132kV feeder from Ardmore – Harris subsea cable	• Add new two Ardmore – Loch Carnan subsea cables. • Add new 132kV subsea/OHL from Admore to Harris.
11	Replace Ardmore – Loch Carnan subsea cable with larger cable and add a new larger size cable / OHL Ardmore – Clachan & new Ardmore – Harris subsea cable	• Add new Ardmore – Loch Carnan subsea cable. • Add new subsea cable/OHL from Admore to Clachan. • Add new subsea cable/OHL from Admore to Harris
12	Replace Ardmore – Loch Carnan subsea cable with larger cable and add a new larger size cable / OHL Ardmore – Clachan & new 132kV feeder from Ardmore – Harris subsea cables	• Add new Ardmore – Loch Carnan subsea cable. • Add new subsea cable/OHL from Admore to Clachan. • Add new 132kV subsea/OHL from Admore to Harris.
14	Remove Ardmore – Loch Carnan subsea cable and replace with Dunvegan – Loch Carnan OHL/subsea cable and Ardmore – Clachan subsea cable / OHL & new Ardmore – Harris subsea cable	• Decommission the existing Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add Ardmore – Clachan OHL/subsea cable. • Add new subsea cable/OHL from Admore to Harris.
15	Remove Ardmore – Loch Carnan subsea cable and replace with Dunvegan – Loch Carnan OHL/subsea cable and Ardmore – Clachan subsea cable / OHL & new 132kV feeder from Ardmore – Harris subsea cable	• Decommission the existing Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add Ardmore – Clachan OHL/subsea cable. • Add new 132kV subsea/OHL from Ardmore to Harris
18	New Dunvegan – Loch Carnan subsea cable /OHL , additional Harris – Clachan subsea cable / OHL & new Ardmore – Harris subsea cable	• Decommission the existing Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add Harris – Lochmaddy subsea cable plus new OHL from Lochmaddy to Clachan. • Add new subsea cable/OHL from Admore to Harris.

19	New Dunvegan – Loch Carnan subsea cable and additional underground line onshore, additional Harris – Clachan subsea cable / OHL & new Ardmore – Harris subsea cable	• Decommission the existing Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add Harris – Lochmaddy subsea cable plus new OHL from Lochmaddy to Clachan. • Add new subsea cable/OHL from Admore to Harris
20	New Dunvegan – Loch Carnan subsea cable, additional Harris – Clachan subsea cable / OHL & new 132kV feeder from Ardmore – Harris subsea cable	• Decommission the existing Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add Harris – Lochmaddy subsea cable plus new OHL from Lochmaddy to Clachan. • Add new 132kV subsea/OHL from Admore to Harris.
23	New Ardmore – Loch Carnan subsea cable and additional Dunvegan – Loch Carnan OHL/subsea cable & new Ardmore – Harris subsea cable	• Add new Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add new subsea cable/OHL from Admore to Harris.
24	New Ardmore – Loch Carnan subsea cable and additional Dunvegan – Loch Carnan OHL/subsea cable & new 132kV feeder from Ardmore – Harris subsea cable	• Add new Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add new 132kV subsea/OHL from Admore to Harris.
26	New Ardmore – Loch Carnan subsea cable & new Ardmore – Harris subsea cable	• Add Ardmore – Loch Carnan subsea cable. • Add new subsea cable/OHL from Admore to Harris. • Add Harris – Lochmaddy subsea cable plus new OHL from Lochmaddy to Clachan.
28	New Ardmore – Loch Carnan subsea cable, additional Dunvegan – Loch Carnan OHL/subsea cable, additional Harris – Clachan subsea cable / OHL & new Ardmore – Harris subsea cable	• Add Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add Harris – Lochmaddy subsea cable plus new OHL from Lochmaddy to Clachan. • Add new subsea cable/OHL from Admore to Harris
29	New Ardmore – Loch Carnan subsea cable, additional Dunvegan – Loch Carnan OHL/subsea cable, additional Harris – Clachan subsea cable / OHL & new 132kV feeder from Ardmore – Harris subsea cable	• Add Ardmore – Loch Carnan subsea cable. • Add Dunvegan – Loch Carnan OHL/subsea cable. • Add Harris – Lochmaddy subsea cable plus new OHL from Lochmaddy to Clachan. • • Add new subsea cable/OHL from Admore to Harris

Table 8: Technically feasible options

The technically feasible options were further shortlisted based on their economic feasibility, to a set of 5[14] options (highlighted in green in the table above). The 5 options with the highest NPV were shortlisted for further optioneering.

These options have been assessed in more detail below including a sensitivity option.

7.2 Short List of Options

Our optioneering process fully adheres to the Ofgem Re-opener guidance and at a minimum includes the following options:

1) Do minimum (Baseline),
2) Option that delays capital expenditure (all options), and
3) Market based flexibility (Section 5.5.3).

The options analysis contains various solutions to secure both the Uist Archipelago network and the Lewis and Harris networks, be that as separate interventions or combined solutions for the whole of the Western Isles network. The options considered in the CBA consider the Western Isles as a whole and fully meet the requirements for securing the island networks out to 2050. The long list has been further refined, based on the results of the CBA, to the 5 lowest NVPs. These options are detailed in Table 9.

Option no.	Description
Baseline	Capital is allocated to ensure that emergency service repair can take place, in the event of failure occurring in RIIO-ED2.
11	Replace Ardmore – Loch Carnan subsea cable with larger cable and add a new larger size cable / OHL Ardmore – Clachan & new Ardmore – Harris subsea cables.
14	Remove Ardmore – Loch Carnan subsea cable and replace with Dunvegan – Loch Carnan OHL/subsea cable and Ardmore – Clachan subsea cable / OHL & new Ardmore – Harris subsea cables.
18	New Dunvegan – Loch Carnan subsea cable /OHL, additional Harris – Clachan subsea cable / OHL & new secondary Ardmore – Harris subsea cable.
19 **(Sensitivity of Option 18)**	New Dunvegan – Loch Carnan subsea cable and additional underground line onshore, additional Harris – Clachan subsea cable / OHL & new secondary Ardmore – Harris subsea cable. Difference to Option 18 is the undergrounding of 15kms of cable between Dunvegan and Loch Carnan.

14 Option 19 is a sensitivity analysis of Option 18, where SHEPD assessed the cost difference of undergrounding part of the cabling.

Option no.	Description
26	New Ardmore – Loch Carnan subsea cable & new Ardmore – Harris subsea cables.

Table 9: Options considered

8 Detailed Option Analysis

The options that have been shortlisted are those which were feasible in N-1 operating conditions in both summer and winter scenarios were considered as viable for the investment need.

8.1 Baseline: Do Minimum (Replace on Failure)

Option Description

In addition to the above 14 options consideration was also given to a 'do minimum' option.

Under this option, there would be no replacement of the existing subsea cable between Ardmore – Loch Carnan or any broader works,. Instead, we would allocate capital to ensure that in the event of a cable failure during RIIO-ED2, SHEPD will have the required financial resources to secure emergency service repair teams and the associated components needed for cable repairs. However, it's essential to note that this approach deviates from SSE's commitment to its maintenance strategy, which emphasises predictive maintenance to minimise ongoing costs for consumers, as opposed to resorting to reactive maintenance measures.

Opting for a reactive approach is inherently more expensive than proactively addressing the risk through asset replacement. In this scenario, SHEPD would need to swiftly secure an emergency repair team and procure necessary parts on the same day, without the ability to negotiate prices or leverage advantages from advance orders and bulk purchases. As well as driving up costs, this lack of a procurement plan is also expected to increase the project construction risk for both SHEPD and contractor staff.

The projected duration for repairing the asset is 2 years, signifying that both our private and industrial customers would face substantial disruptions due to the outage. During this downtime, it will also be necessary to run the Loch Carnan Distributed Embedded Generation (DEG) to continue meeting the islands demand, resulting in running costs of around £23 million and 39,000 tCO_2 per annum. The impact to customers, the downtime of the assets and the greenhouse gas emissions have all been accounted for as costs (Table 10: Baseline cost breakdown (2021 prices)).

Cost

The estimated total capital expenditure would amount to [redacted], which includes [redacted] for the replacement of the subsea cable. However, in addition to the capital costs we would also incur constrained generation and impact costs, which far exceed the capital expenditure costs (Table 10).

Line Items	Cost (£m)
Subsea Cable	[redacted]
Onshore - 33kV U/G Cable	[redacted]

Table 10: Baseline cost breakdown (2021 prices)

The costs have been calculated based on the actual cost of replacing the asset in the event of a failure. This cost estimate is derived from scenarios where replacement occurs under emergency conditions, without adequate time for efficient planning and procurement.

Limitations

This presents several significant limitations to broader decarbonisation on the Outer Hebrides. Firstly, it would not create the additional network capacity needed for the islands to decarbonise or additional generation to connect. Whilst this may be a credible option in the short term, it would not be viable as a strategic position for 2050.

Secondly it does not help SSEN decarbonise its diesel generation fleet by maintaining current reliance levels of our DEG.

Finaly, it poses a substantial risk to consumers in the event of a fault, as the downtime would result in severe disruptions to their power supply. Additionally, the approach is costly and inefficient, involving the expensive procurement of emergency services and replacement cables without the benefits of advanced planning and cost-effective purchasing. As a single-circuit solution, it maintains a dependency on a single cable, introducing vulnerabilities in the event of unforeseen failures or maintenance, which could impact the reliability of the power supply for consumers.

This option also presents significant limitations to the replacement of the Ardmore – Loch Carnan cable in the short term.

1. It poses a substantial risk to consumers in the event of a fault, as the downtime would result in severe disruptions to their power supply. As the outage is unplanned, the outage time could be increased by external factors such as adverse weather preventing repair or the availability of skilled personnel and specialised equipment (e.g. vessels) to repair and replace the subsea cable.
2. The approach is costly and inefficient, involving the expensive procurement of emergency services and replacement cables without the benefits of advanced planning and cost-effective purchasing. The cost of repairing a subsea cable can be significant as specialist vessels are needed to lay a non-standard cable, so the emergency nature of replacement is likely to further increase this expense.
3. The replacement cable lacks the capacity to accommodate future load growth, potentially necessitating further investments down the line. This provides a disbenefit as the replacement cable would need to be replaced before its manufactured EoL, thus providing poor Value for Money (VfM).
4. It does not account for the possibility of a more efficient route, which could optimise both operational and capital cost efficiency. Due to the nature of the emergency, the cable will need to be laid along the existing route removing any potential efficiencies captured via a whole system approach or a more efficient route.
5. As a single-circuit solution, it maintains a dependency on a single cable, introducing vulnerabilities in the event of unforeseen failures or maintenance, which could impact the reliability of the power supply for consumers. Both the current solution and provisional solution will not provide N-1 security.
6. Whilst the cable is disrupted, it will be necessary to run DEG. This is both operationally expensive and contrary to SHEPD's Net Zero ambitions. It is assumed that the DEG will need to run for up to 24 months to provide sufficient power to the island residents whilst the cable is replaced.

8.2 Option 11: Replace Ardmore – Loch Carnan Subsea cable with Larger Cable and Add New Larger Size Cable / OHL Ardmore – Clachan and New Ardmore – Harris Subsea Cables

Option 11 includes the removal of the existing Ardmore to Loch Carnan (South Uist) subsea cable (95mm^2) with a larger cable (300mm^2) using the existing route. It also involves a 33km new subsea cable (300mm^2) from Ardmore to Lochmaddy and a 16km overhead line between Lochmaddy and Clachan (North Uist). Furthermore, this option would retain the existing 32.3km (500mm^2) subsea cable between Ardmore and Harris and commission a second (500mm^2) subsea cable between Ardmore and Harris. The new circuits are 33 kV and are shown with a dashed green line. The green solid line is the existing subsea cable from Ardmore to Harris. Each route will be supported with onshore connections to the substations. The routes are further depicted in Figure 11. This will provide N-1 capacity and cater for demand growth until at least 2050.

Figure 11: Option 11 route map

Cost

The estimated capital cost components of this option are the three cable routes (subsea and onshore) and upgrades to the Ardmore, Harris and Clachan substations. This totals to [redacted]; which occurs through the current and subsequent price control periods. Table 11 provides a breakdown of cost.

Line Items	Route	Cost (£m)
Subsea cable (Ardmore - Loch Carnan)	(Ardmore - Loch Carnan)	[redacted]
Onshore - OHL	(Ardmore - Loch Carnan)	-
Onshore - Poles	(Ardmore - Loch Carnan)	-
Onshore - 33kV U/G Cable	(Ardmore - Loch Carnan)	[redacted]
Subsea cable (Ardmore - Lochmaddy)	(Ardmore - Clachan)	[redacted]
Onshore - OHL	(Ardmore - Clachan)	[redacted]
Onshore - Poles	(Ardmore - Clachan)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Clachan)	[redacted]
Subsea cable (Ardmore - Harris)	(Ardmore - Harris)	[redacted]
Onshore - OHL	(Ardmore - Harris)	[redacted]
Onshore - Poles	(Ardmore - Harris)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Harris)	[redacted]
Substation upgrade - Ardmore	[redacted]	[redacted]
Substation upgrade - Harris		[redacted]
Substation upgrade - Clachan		[redacted]

Table 11: Option 11 cost breakdown (2021 prices)

Benefits

Option 11 is the costliest option of the 5 that have been shortlisted, however it provides the benefit of following an existing route removing the need for a detailed site survey for the Ardmore to Loch Carnan route. This can improve timescales for delivery as it reduces some of the front-end design work required for the intervention. Moreover, our existing knowledge of the route removes an unforeseen uncertainty that could arise down the line therefore, de-risking this option in comparison to options that follow a new route.

Limitations

The biggest limitation of this option is the single point of failure risk by connecting all subsea cable circuits to Ardmore GSP. This risk is mitigated in other options however, ultimately Option 11 doesn't provide our consumers with optimum value for money.

8.3 Option 14: Remove Ardmore – Loch Carnan Subsea Cable and Replace with Dunvegan – Loch Carnan OHL/Subsea Cable and Ardmore – Clachan Subsea Cable / OHL and new Ardmore – Harris Subsea Cables

Option 14 includes the removal of the existing Ardmore to Loch Carnan (South Uist) subsea cable (95mm^2) with a 16.5km OHL between Dunvegan and Loch Pooltiel and a 38.5km larger subsea cable (300mm^2) between Loch Pooltiel and Loch Carnan (South Uist). Additionally, we would lay a 33km subsea cable between Ardmore and Lochmaddy and a 16km OHL between Lochmaddy and Clachan (North Uist). Furthermore, this option would retain the existing 32.3km (500mm^2) subsea cable between Ardmore and Harris and commission a second (500mm^2) subsea cable between Ardmore and Harris. The new circuits are 33 kV and are shown with a dashed green line. The green solid line is the existing subsea cable from Skye to Harris. Each route will be supported with onshore connections to the substations. The routes are further depicted in Figure 12. This will provide N-1 capacity and cater for demand growth until at least 2050.

Figure 12: Option 14 route map

Cost

The estimated capital cost components of this option are the three cable routes (subsea and onshore) and upgrades to the Ardmore, Harris and Clachan substations. This totals to [redacted]; which occurs through the current and subsequent price control periods. Table 12 provides a breakdown of cost.

Line Items	Route	Cost (£m)
Subsea cable (Dunvegan - Loch Carnan)	(Dunvegan - Loch Carnan)	[redacted]
Onshore - OHL	(Dunvegan - Loch Carnan)	[redacted]
Onshore - Poles	(Dunvegan - Loch Carnan)	[redacted]
Onshore - 33kV U/G Cable	(Dunvegan - Loch Carnan)	[redacted]

Line Items	Route	Cost (£m)
Subsea cable (Ardmore - Lochmaddy)	(Ardmore - Clachan)	[redacted]
Onshore - OHL	(Ardmore - Clachan)	[redacted]
Onshore - Poles	(Ardmore - Clachan)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Clachan)	[redacted]
Subsea cable (Ardmore - Harris)	(Ardmore - Harris)	[redacted]
Onshore - OHL	(Ardmore - Harris)	[redacted]
Onshore - Poles	(Ardmore - Harris)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Harris)	[redacted]
Substation upgrade - Ardmore		[redacted]
Substation upgrade - Harris		[redacted]
Substation upgrade - Clachan		[redacted]

Table 12: Option 14 cost breakdown (2021 prices)

Benefits

This option is similar to Option 11, however, it takes a slightly more ([redacted]) economical route (Dunvegan to Loch Carnan route), which reduces the overall cost of the option.

Limitations

Similarly, to Option 11, there is a single point of failure risk by connecting two of the three subsea cable circuits to Ardmore GSP, giving no means to backfeed the Lewis & Harris network should this occur. This risk is mitigated in other options however, ultimately Option 11 doesn't provide our consumers with optimum value for money.

Through the deliverability assessment of all the options considered, it has been identified that the proposed overhead line section from Dunvegan GSP to the subsea cable landing point at loch Pooltiel may be difficult to consent, possibly having an impact on the delivery of the solution.

This option is more costly than comparator options and exposes SHEPD to future uncertainty, with no financial trade-off for our consumers.

8.4 Option 18: New Dunvegan – Loch Carnan Subsea Cable (Plus Supporting Onshore), Additional Harris – Clachan Subsea Cable (Plus Supporting Onshore) and New Secondary Ardmore – Harris Subsea Cable (Plus Supporting Onshore)

Option 18 entails replacing the existing Ardmore to Loch Carnan subsea cable (95mm^2) with a larger cable (300mm^2) from Dunvegan to Loch Carnan. It also involves a new cable from the Harris to Clachan substations, via Lochmaddy, and a secondary subsea cable alongside the existing Ardmore to Harris route. Each route will be supported with onshore connections to the substations. The routes are further depicted in Figure 13. This will provide N-1 capacity and cater for demand growth until at least 2050.

Figure 13: Option 18 route map

Cost

The estimated capital cost components of this option are the three cable routes (subsea and onshore) and upgrades to the Dunvegan, Clachan and Harris substations. This totals to [redacted]; which occurs through the current and subsequent price control periods. Table 13 provides a breakdown of cost.

Line Items	Route	Cost (£m)
Subsea cable	(Dunvegan - Loch Carnan)	[redacted]
Onshore - OHL	(Dunvegan - Loch Carnan)	[redacted]
Onshore - Poles	(Dunvegan - Loch Carnan)	[redacted]
Onshore - 33kV U/G Cable	(Dunvegan - Loch Carnan)	[redacted]
Subsea cable	(Harris- Clachan)	[redacted]
Onshore - OHL	(Harris- Clachan)	[redacted]
Onshore - Poles	(Harris- Clachan)	[redacted]
Onshore - 33kV U/G Cable	(Harris- Clachan)	[redacted]
Subsea cable	(Ardmore - Harris)	[redacted]
Onshore - OHL	(Ardmore - Harris)	[redacted]
Onshore - Poles	(Ardmore - Harris)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Harris)	[redacted]
Substation upgrade - Dunvegan	[redacted]	[redacted]
Substation upgrade - Harris		[redacted]
Substation upgrade - Clachan		[redacted]

Table 13 - Option 18 cost breakdown (2021 prices)

Benefits

There are several benefits associated with this option.

- The primary benefit of Option 18 is that the Dunvegan to Loch Carnan route is shorter than the existing Ardmore to Loch Carnan route. This makes it the most cost-effective of all short-listed options. Lower total capex cost will have a lower impact on standing charges thus reducing future increase in charges to our customers.
- Moreover, laying a shorter cable has the benefit of having a lower impact on communities, natural capital, and the seabed. Providing social and environmental related benefits.
- Furthermore, a shorter cable will have a lower total equipment CO_2 footprint due to needing less material.

Limitations

There are some uncertainties with the viability of the route due to the absence of a detailed site survey. If it is selected as the preferred option, however, a detailed site survey will be conducted prior to any construction. Through the deliverability assessment of all the options considered, it has been identified that the proposed overhead line section from Dunvegan GSP to the subsea cable landing point at loch Pooltiel may be difficult to consent, possibly having an impact on the delivery of the solution.

8.5 Option 19: New Dunvegan – Loch Carnan subsea cable (plus supporting underground onshore), additional Harris – Clachan subsea cable (plus supporting onshore) & new secondary Ardmore – Harris subsea cable (plus supporting onshore)

Option 19 is sensitivity analysis of Option 18, in which the 16.5km Dunvegan to Loch Caran onshore cable is all underground. The subsea section of the Dunvegan to Loch Carnan route is the same, as is the entirety of the Harris to Clachan and Ardmore to Harris routes. The routes are further depicted in Figure 14. This will provide N-1 capacity and cater for demand growth until at least 2050.

Figure 14: Option 19 route map

Cost

The estimated capital cost components of this option are the three cable routes (subsea and onshore) and upgrades to the Dunvegan, Clachan and Harris substations. This totals to [redacted]; which occurs through the current and subsequent price control periods. Table 14 provides a breakdown of cost.

Line Items	Route	Cost (£m)
Subsea cable	(Dunvegan - Loch Carnan)	[redacted]
Onshore - 33kV U/G Cable	(Dunvegan - Loch Carnan)	[redacted]
Subsea cable	(Harris- Clachan)	[redacted]
Onshore - OHL	(Harris- Clachan)	[redacted]
Onshore - Poles	(Harris- Clachan)	[redacted]
Onshore - 33kV U/G Cable	(Harris- Clachan)	[redacted]
Subsea cable	(Ardmore - Harris)	[redacted]
Onshore - OHL	(Ardmore - Harris)	[redacted]
Onshore - Poles	(Ardmore - Harris)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Harris)	[redacted]
Substation upgrade - Dunvegan	[redacted]	[redacted]
Substation upgrade - Harris		[redacted]
Substation upgrade - Clachan		[redacted]

Table 14: Option 19 cost breakdown (2021 prices)

Benefits

The benefit of this option compared to Option 18 is the underground section of the Dunvegan to Loch Carnan route. Much of the Isle of Skye, where the underground cable will exist, is a protected Special Area of Conservation, so installing the cable underground rather than on overhead lines will protect the visual amenity of the area.

Limitations

The limitation of the underground cable is that the construction costs are more than the overhead line alternative. The underground cable connection is expected to cost around [redacted] in capital expenditure, compared to [redacted] for the overhead alternative. SHEPD are committed to preserving the natural capital of Scotland, however, the associated ~6-fold cost increase does not provide good value for money for our consumers.

Furthermore, the undergrounding of cabling is a more time-consuming process, which may result in delays and extended timescales.

8.6 Option 26: Replace Ardmore – Loch Carnan Subsea Cable (Plus Supporting Onshore), Additional Harris – Clachan Subsea Cable (Plus Supporting Onshore) and New Secondary Ardmore – Harris Subsea Cable (Plus Supporting Onshore)

This option is similar to Option 18. It takes the same Harris to Clachan and Ardmore to Harris routes as in Option 18, however the existing Ardmore to Loch Carnan cable (which has reached EoL) is replaced in this option with a new Ardmore – Loch Carnan cable. Each route will contain a combination of subsea and onshore cables and it will also be necessary to undertake upgrades to the Ardmore, Harris and Clachan substations. The routes are further depicted in Figure 15. This will provide N-1 capacity and cater for demand growth until at least 2050.

Figure 15: Option 26 route map

Cost

The estimated capital costs of this option are the three routes of cables, subsea and onshore, plus upgrades to substations. The total of this is [redacted] which will be spent through RIIO-ED2 and RIIO-ED3. Table 15 provides a breakdown of cost.

Line Items	Route	Cost (£m)
Subsea cable	(Ardmore - Loch Carnan)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Loch Carnan)	[redacted]
Subsea cable	(Harris- Clachan)	[redacted]
Onshore - OHL	(Harris- Clachan)	[redacted]
Onshore - Poles	(Harris- Clachan)	[redacted]
Onshore - 33kV U/G Cable	(Harris- Clachan)	[redacted]
Subsea cable	(Ardmore - Harris)	[redacted]
Onshore - OHL	(Ardmore - Harris)	[redacted]
Onshore - Poles	(Ardmore - Harris)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Harris)	[redacted]
Substation upgrade - Ardmore	[redacted]	[redacted]
Substation upgrade - Harris		[redacted]
Substation upgrade - Clachan		[redacted]

Table 15: Option 26 cost breakdown (2021 prices)

Benefits

The primary benefit of this option is that there is a high level of confidence with the feasibility of the Ardmore to Loch Carnan route as a cable already exists along this route. This option also eliminates the necessity for a detailed site survey, which improves the timescales for completion. This is important as the current cable has reached its end of life therefore expediting replacement of the cable is key to ensure that customers won't be impacted by future outages.

Limitations

Option 26's drawback is that the Ardmore to Loch Carnan route is longer than the alternative Dunvegan to Loch Carnan route (as in Option 18). This raises its comparative capital and operational costs, without providing any real additional benefits other than removing the need for a detailed site survey.

The longer route makes the option more costly, therefore negating any cost savings associated with removing the need for a detailed site survey.

Therefore, this option doesn't provide a cost-effective solution to our consumers.

9 Optioneering Summary Table

We have undertaken a front-end optioneering style approach based on high quality data, expert informed judgement and financially robust costing appraisals using optioneering. This structured approach to identifying schemes is built on the knowledge gained from various areas of the business and the different licence areas we operate.

Table 16 provides an overall summary of the options considered or shortlisted for financial and CBA appraisal and includes options discounted.

Option	Driver		Risk			Decision	
	Contributes to Primary Driver	Contributes to SSE Commitment	Technically Feasible	Cost Effective	Confident in Outcome	Delivery Risk	Take Option Forward to CBA
Baseline	No	No	No	No	No	High	No
Option 11	Yes	Yes	Yes	Medium	Yes	Low	Yes
Option 14	Yes	Yes	Yes	Medium	Yes	Medium	Yes
Option 18	Yes	Yes	Yes	Yes	Yes	Medium	Yes
Option 19	Yes	Yes	Yes	Medium	Yes	Medium	Yes
Option 26	Yes	Yes	Yes	Medium	Yes	Medium	Yes

Table 16: Summary of optioneering

10 Cost Benefit Analysis

This section will outline the process undertaken and the output of the Cost Benefit Analysis (CBA). We have conducted a full CBA for each option that was technically feasible. From this list, we have then considered the options with the highest NPVs. Therefore, this EJP considers options 11, 14, 18, 19 and 26.

The approach that we have taken to conduct the CBA is strictly aligned to the guidance given by Ofgem utilising the latest guidance document and CBA model.

- RIIO-ED2 Engineering Justification Paper Guidance
- Re-opener Guidance and Application Requirements Document
- RIIO-ED2 Cost Benefit Analysis (CBA) Guidance
- RIIO-ED2 Data Templates and Associated Instructions and Guidance | Ofgem

The capital costs, operating costs and assumptions have been carefully costed, are based on historical costs and have been verified by subject matter experts. These are set out in Table 17.

10.1 CBA of Investment Options

Displayed in Table 17 is the expenditure components, split by Capex and Opex, for the next three price control periods. The vast majority of costs is made up of capital costs, with operating costs accounting for a smaller fraction of total expenditure. The bulk of the operating expenditure for the short-listed options is a consequence of operating the DEG on standby, which is treated as an operating cost in this table.

	RIIO-ED2			RIIO-ED3			RIIO-ED4		
Option	**Capex**	**Opex**	**Totex**	**Capex**	**Opex**	**Totex**	**Capex**	**Opex**	**Totex**
Baseline	[redacted]	[redacted]	[redacted]	-	[redacted]	[redacted]	-	[redacted]	[redacted]
Option 11	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 14	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 18	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 19	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 26	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 17 - Cost summary - 2021 Prices (£m)

The cost summary in Table 17 shows that Option 18 is the least costly of all the options which meet the investment needs. The reasoning for this is discussed in detail in Section 68.2 The most expensive option is Option 26.

The three forthcoming price control periods are the only ones displayed here, as all capital expenditure (outside of asset renewals at EoL) is concluded in 2034 (RIIO-ED4) for all options.

10.2 CBA Results

The output of the CBA is displayed below in Table 18.

Option	10 years	20 years	30 years	45 years	Whole life (55 years)
Option 11	5.73	-27.73	-47.01	-62.45	**-71.77**
Option 14	10.91	-18.37	-35.14	-48.36	**-56.36**
Option 18	10.77	-16.22	-31.44	-43.21	**-50.43**
Option 19	9.05	-19.00	-34.83	-47.07	**-54.75**
Option 26	5.70	-25.84	-43.80	-57.97	**-65.22**

Table 18 - Net Present Value at different intervals (£m, 2021 prices)

The NPV is heavily driven by capital expenditure, which therefore logically leads to Option 18 producing the most positive result and Option 11 displaying the least positive NPV.

Table 19 and Table 20 display the whole life cost and benefit of each option. As we have used a 55-year appraisal period (as per Ofgem's CBA guidance), this does include a portion of renewals, as the asset life of a subsea cable is modelled at 45 years. Note also that these costs are not discounted to present values. The societal benefits are net negative due to the increased cable volume and associated losses.

Option	Capex	Opex	DEG	Totex
Option 11	[redacted]	[redacted]	[redacted]	[redacted]
Option 14	[redacted]	[redacted]	[redacted]	[redacted]
Option 18	[redacted]	[redacted]	[redacted]	[redacted]
Option 19	[redacted]	[redacted]	[redacted]	[redacted]

Option	Capex	Opex	DEG	Totex
Option 26	[redacted]	[redacted]	[redacted]	[redacted]

Table 19: Option whole life costs (£m, 2021 prices)

As in Table 19, Option 18 also has the lowest expected capital costs over the whole life of the assessment period (55 years). Option 11 is the costliest option.

Option	Total Societal Net Benefits	Avoided Baseline Costs	Total Benefits
Option 11	-102.90	180.28	**77.38**
Option 14	-82.50	180.28	**97.78**
Option 18	-68.91	180.28	**111.37**
Option 19	-68.91	180.28	**111.37**
Option 26	-89.31	180.28	**90.97**

Table 20: Option whole life benefits (£m, 2021 prices)

Option 11's Societal Benefits are the most negative of all options considered. This is driven by the relative increase in losses of the Ardmore to Loch Carnan subsea cable, compared to the shorter Dunvegan to Loch Carnan route. The benefits for Options 18 and 19 are modelled as identical, as they share the same cable routes.

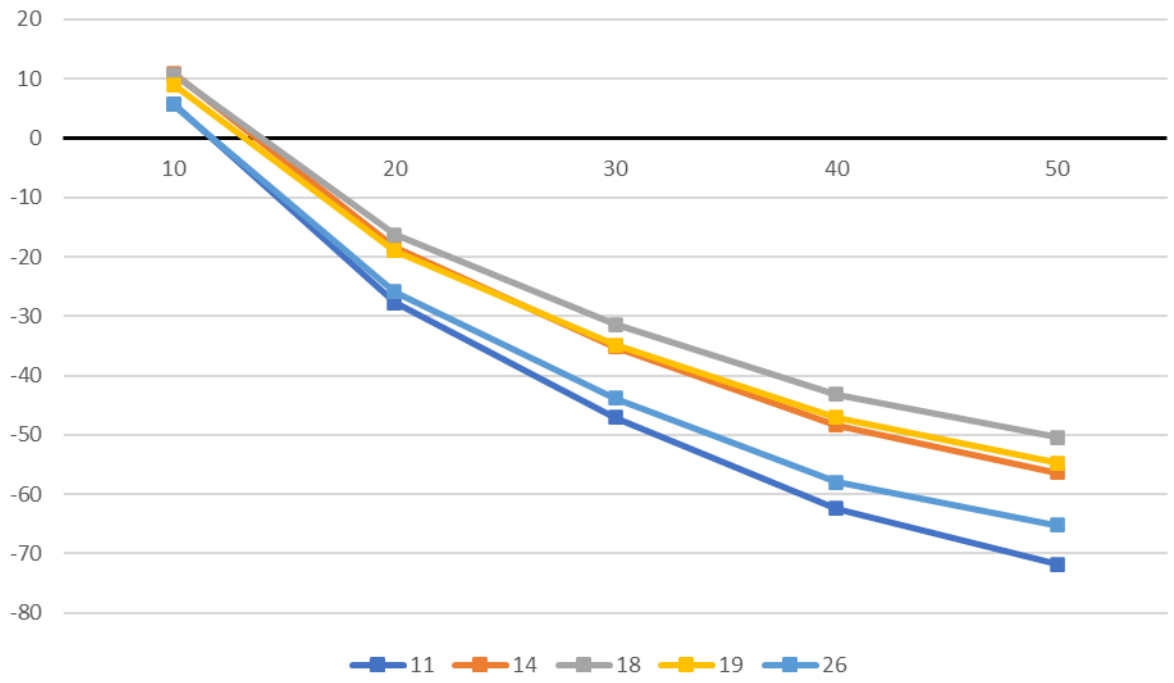

Table 21: Option whole life benefits (£m, 2021 prices)

11 Preferred Option

The preferred option for this EJP is Option 18. This option is successful in providing a solution to the needs case, delivers the best value to customers and is the economical of all the short-listed options. Taken forward, we are confident that it will put SHEPD in the best place to achieve targets and contribute towards providing a resilient network for current and future customers.

11.1 Phasing of Preferred Option

The options considered in the above sections outline our enduring solution for the Western Isles networks. As part of our analysis of the island needs, we have investigated the phasing of the different elements of the proposal based on the projected demand growth on the islands out to 2050. Our analysis of the projected demands indicates that deferral of some of the elements contained in the preferred option is prudent to ensure efficient delivery and adequate scope to monitor our preferred option against the latest demand projections and technological advancements.

We have considered the future demand needs at Harris and Stornoway grid over the medium-term, and the consequential requirements for reinforcement of the network between Skye and Harris. Our analysis, shown in Figure 16, suggests that demand would exceed the rating of the existing 33kV 500sqmm cable by 2032. We believe that flexibility could play a role in deferring this reinforcement to the optimal time, and as such are not progressing this element of the preferred solution at this time.

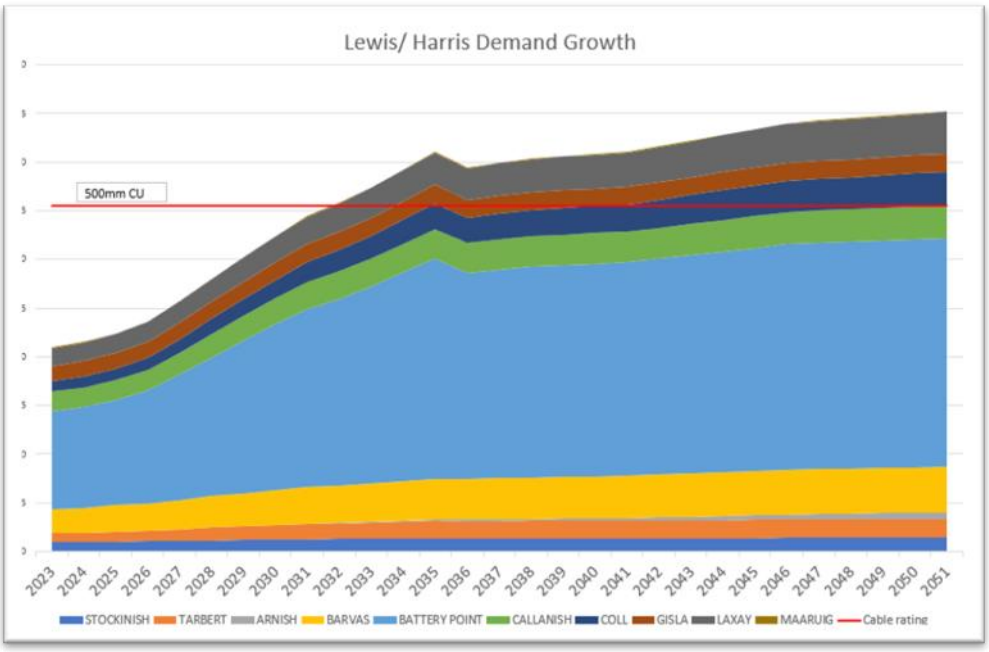

Figure 16: Lewis and Harris 2050 demand (2022 DFES)

Similarly, we have considered future demand requirements for the Uist archipelago. DFES projections have shown a significant demand increase due to a potential spaceport in the area. This would have driven a need for cable uprating in 2029 to meet the revised demand. However, we have examined the potential demand for this development in more detail considering demand requirements for other similar developments. In response we have reduced our demand forecasts considerably such that the load driver for the Uist archipelago does not become active until the 2040s. In both cases the projected demands would be adequately supported by the proposed 300sqmm subsea cable (required on an asset condition basis) and the need for flexibility services is unlikely.

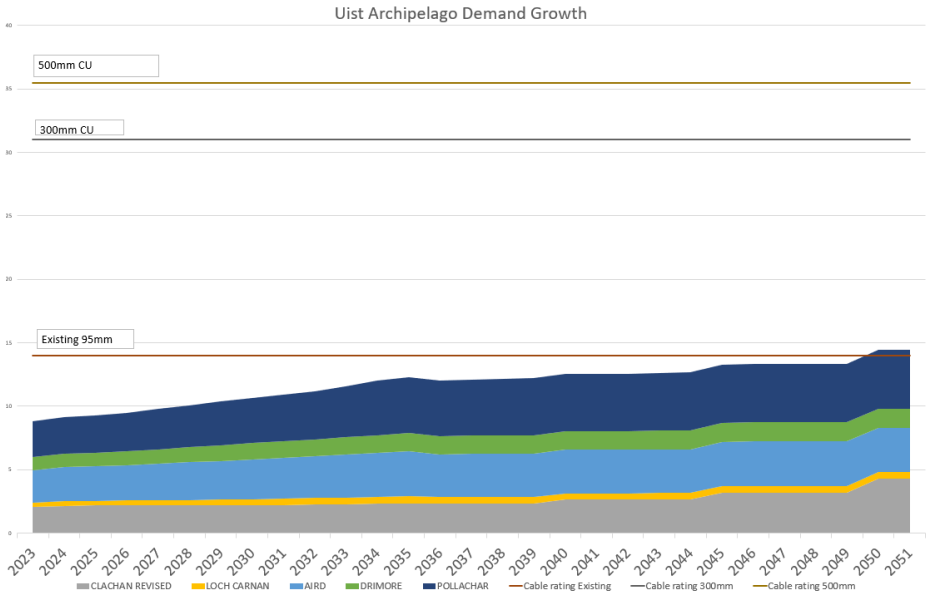

Figure 17: Uist archipelago 2050 demand (2022 DFES)

Finally, we have considered the future resilience of the islands. The networks are currently supported by four embedded Diesel Power Stations on the Western Isles. These are Arnish and Battery Point on Lewis, Loch Carnan on South Uist and Barra Power Station on Barra. Our optioneering analysis provides a credible route to facilitate decarbonisation of our embedded diesel generation fleet by installing the proposed subsea cable link between Clachan 33kV Sw/Stn on Uist and Harris GSP on Harris. This is one of a number of options that we will consider further in 2024.

A summary of the elements to be taken forward for implementation in this re-opener window are shown in Table 22:

Element	Description	Progressed at this submission
Skye - Uist	Removing the existing Ardmore to Loch Carnan subsea cable (95mm2) with a larger cable (300mm2) from Dunvegan to Loch Carnan.	Yes
Skye - Harris	Augmentation of existing Ardmore to Harris 500mm 33kV subsea cable with additional 500mm 33kV subsea cable	No
Harris - Uist	Installation of a new 33kV 300mm Subsea cable between Harris GSP and Clachan 33kV Sw/STN	No

Table 22: Phasing of Investments

The Skye – Harris and Harris – Uist elements will be kept under review ahead of the January 2025 HOWSUM submission window.

12 Deliverability and Risk

This section will document the approach to delivery, list any potential deliverability constraints and any necessary mitigation strategies that will need to be undertaken to minimise the risk.

The output of this EJP is to replace the existing subsea cables with new and higher load cables that appropriately reflect the demand and supply of the region.

12.1 Delivery Strategy

The delivery strategy for the overall project is to [redacted].

The supply chain required to deliver the project has been tested through delivery of RIIO-ED1 projects. This has shown that the supply chain is able to provide the capacity and skills required to deliver these projects. As we move into RIIO-ED2 with the increased amount of CAPEX delivery required it is important for us to ensure that the supply chain can continue to deliver. In response to this we have commenced early market engagement with subsea cable installation contractors to ensure that the capacity and skills to deliver this project are available.

To deliver the subsea cable package we will [redacted]. The marine route surveys will be progressed with a separate contractor to make use of the advanced development funding from Ofgem and inform the detailed design.

12.1.1 Project plan

The submarine cable programme is to survey the proposed marine routes in 2024 and complete the design and engineering following this in the same year. On completion of the design, all consent applications will be prepared and applied for in 2025. Procurement of the submarine cable is planned to commence mid to end of 2025 enabling installation in 2026. In Figure 18 we set out the project plan for the delivery of this project.

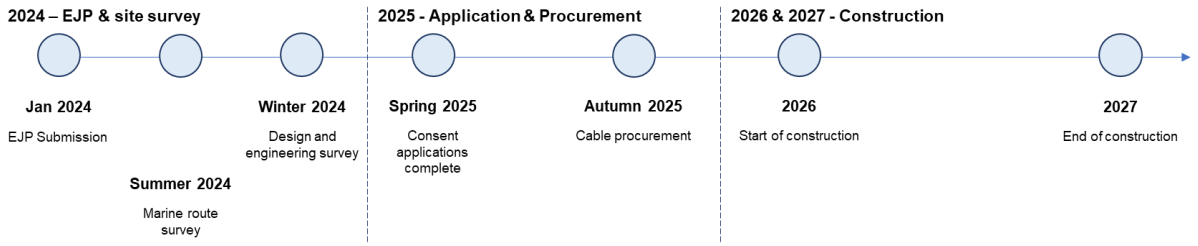

Figure 18: Project Plan timeline

12.2 Procurement and Contracting Strategy

This section details the procurement and contracting strategy for the Skye-Uist cable replacement, setting out the completed, ongoing, and planned procurement activities, and summarising and explaining the proposed contracting strategy for each.

Several factors are considered in determining an approach that will deliver and achieve the optimum outcome. [redacted].

There are several complexities associated with the Skye – Uist cable replacement project which require consideration in context of the procurement strategy and process:

1) [redacted].
2) Despite the development funding in place, the nature of the uncertainty mechanism makes it challenging to schedule the project.

A Request for Information (RFI) was issued to the market in August 2023 to gauge interest in the project, confirm vessel availability and manufacturing capacity. Suppliers were identified via Achilles System, which was also used for issue of the RFI. [redacted]. In due course and when the preferred technical solution is confirmed - a formal competitive Invitation to Tender (ITTs) shall be issued via SHEPD procurement portal - Jaggaer.

A full list of procurement activities completed and outstanding can be found in Appendix C.

The section highlights the contracting approach undertaken by SHEPD for the Skye to Uist subsea cable replacement. It highlights the key activities, completed to date and key activities to be progressed.

It should be noted that SHEPD is required to comply with the Utilities Contract (Scotland) Regulations 2016 and as such a regulated tender process for the Skye-Uist subsea cable replacement shall be followed.

[redacted].

In the meantime, and to progress the project, it is proposed to issue a standalone contract for the offshore route surveys. The ITT for this was issued in November 2023. This information shall be used to confirm the suitability of individual and routes and shall eventually be passed onto installation contractor for them to complete the route design. [redacted].

[redacted]

[redacted]:

- [redacted].
- [redacted].
- [redacted].

[redacted].

12.2.1 Work undertaken in RIIO-ED1 and RIIO-ED2

The purpose of the marine engineering desktop studies is to progress early engineering of the potential subsea cable routes. These have been completed and the studies have identified potential routes which can now be surveyed.

The marine survey [redacted] has now been issued out to tender with the intention to progress marine surveys when the weather allows in spring 2024.

Other ongoing works as part of the development funding include environmental onshore and offshore desktop studies to understand the environmental constraints associated with the project.

12.2.2 Managing and monitoring delivery

The project will be managed under SSE's Large Capital Project governance framework. This framework ensures that all large capital investment projects for the SSE Group are governed, developed, approved, and executed in a safe, consistent, sustainable and effective manner.

Delivery of the project will be led by the Project Manager who will manage a project team made up of key disciplines such as Engineering, Consents, Procurement & Commercial, Safety, Environmental and Planning. This project team will be supported by other disciplines such as Quality, Operational Personnel, Risk Management, and others as required.

The dedicated Project Manager will set the project baseline programme at the beginning of the project and monitor progress throughout. Progress will be informed by the project team and by contractors who will submit their programmes to the project planner regularly identifying any delays and changes.

The Project Manager will utilise the following Key Performance Indicators (KPIs) to monitor the status of the project, cost, and outcomes:

1. **Cost Performance Index (CPI):** Compares the actual cost of work performed to the budgeted cost, indicating cost efficiency.
2. **Schedule Performance Index (SPI):** Measures the efficiency of schedule performance by comparing actual progress to planned progress.

3. **Quality Performance:** Tracks adherence to quality standards and identifies defects or rework needed.
4. **Safety Incident Rate:** Measures the frequency of safety incidents or accidents on the construction site.
5. **Resource Utilisation:** Evaluates how effectively labour, equipment, and materials are used.
6. **Customer Satisfaction:** Assesses client satisfaction through feedback and project outcomes.
7. **Change Order Rate:** Tracks the frequency of changes requested during the project and their impact on cost and schedule.
8. **Earned Value (EV):** Compares the value of work completed against the planned value, providing insight into project progress.

12.3 Estimated Cost of Preferred Option

To manage cost there will be procurement, insurance and legal reviews held at each key stage of the project. This will define the contract strategy and ensure that SHEPD agree well defined contracts that both protect SHEPD and manage risks appropriately. Costs will be estimated at each stage of the project and will include tendered costs to achieve accurate estimates. Regular review of expenditure and forecast will be done throughout the project to monitor this and deliver the project within budget.

At this stage, without a full tender process being completed, we are limited to the use of estimated costs to advise the CBA and give a breakdown of the preferred solution. The full tender costs for the Dunvegan – Loch Carnan element of the preferred option will be provided on completion of route surveys and full market tender for the works.

Table 23 provides a breakdown of the costs for the preferred option. The estimated to cost [redacted] in capex.

Line Items	Route	Cost (£m)
Subsea cable	(Dunvegan - Loch Carnan)	[redacted]
Onshore - OHL	(Dunvegan - Loch Carnan)	[redacted]
Onshore - Poles	(Dunvegan - Loch Carnan)	[redacted]
Onshore - 33kV U/G Cable	(Dunvegan - Loch Carnan)	[redacted]
Subsea cable	(Harris- Clachan)	[redacted]
Onshore - OHL	(Harris- Clachan)	[redacted]
Onshore - Poles	(Harris- Clachan)	[redacted]
Onshore - 33kV U/G Cable	(Harris- Clachan)	[redacted]
Subsea cable	(Ardmore - Harris)	[redacted]
Onshore - OHL	(Ardmore - Harris)	[redacted]
Onshore - Poles	(Ardmore - Harris)	[redacted]
Onshore - 33kV U/G Cable	(Ardmore - Harris)	[redacted]
Substation upgrade - Dunvegan	[redacted]	[redacted]
Substation upgrade - Harris		[redacted]
Substation upgrade - Clachan		[redacted]

Table 23: Cost breakdown

12.3.1 Regional variations in cost

The implementation of subsea cables in the Outer Hebrides presents unique challenges and cost considerations compared to onshore or underground installations. The inherent difficulty in installing subsea cables significantly amplifies project expenses, attributing to increased complexity and labour-intensive processes. Importantly, the logistical challenge of transporting equipment onto the islands escalates costs considerably when compared to similar mainland operations.

12.3.2 Ensuring cost robustness of preferred option

Furthermore, SHEPD has undertaken a comprehensive cost assurance process to ensure the robustness of estimated costs for this EJP. This approach involves various stages of cost validation. Firstly, certain costs have been solidified through established framework contracts with suppliers, ensuring that prices are transparent and competitive. Secondly, internal quantity surveyors costed the interventions based on known industry cost benchmarking employing lessons learned from past projects providing an additional layer of scrutiny and credibility. Lastly, a collaborative effort with suppliers has been crucial, where costs have been verified and mutually agreed upon, ensuring alignment and accuracy in the project budget. Through these procedures, SHEPD has developed a robust cost estimate for this EJP.

12.4 Risks and Mitigations

Risk will be managed in accordance with the Large Capital Governance framework to ensure risks are identified, assessed, mitigated and monitored. This is done using a risk management system that the project team uses to capture this process and to review the risks regularly. The risk cost will be determined using Quantitative Cost Risk Analysis to provide a realistic appraisal of the potential value.

12.4.1 Specific Risks and mitigations

A list of the risks and mitigations are provided below.

1) **Delivery:** The challenges for delivery of the subsea cable include limited vessel availability suitable to install the lengths of submarine cable proposed. [redacted].
    a. **Mitigations:** This can be managed through early engagement and commitment to Contractors to secure the equipment availability required. In order to achieve this [redacted].
2) **Remote location:** The Scottish Outer Hebrides has various logistical challenges due to its remote location including but not limited to accessibility, small local supply chain, marine/environmental/ecological challenges, variable and uncertain weather conditions due to proximity to the Atlantic.
    a. **Mitigations:** Utilise suppliers that are experienced with operations in the area.
3) [redacted].
    a. [redacted].
4) [redacted].
    a. [redacted].

5) **Capacity of cable manufacturers:** Cable must have SHEPD Design Authority approval and no factory joints.
    a. **Mitigations:** Ensure that before procurement we engage with supplier to receive sign-off that the cable meets our requirements.
6) **Consenting risk on Skye:** Through the deliverability assessment of all the options considered, it has been identified that the proposed overhead line section from Dunvegan GSP to the subsea cable landing point at loch Pooltiel may be difficult to consent, possibly having an impact on the delivery of the solution.
    a. **Mitigations:** A contingency route to Ardmore GSP is being assessed alongside the preferred solution. This will allow SHEPD to progress with the contingency in the event of a cable failure or lack of progress with the wayleaves to allow construction of the overhead line.
7) **Failure of Skye – Uist cable during works:** There is a risk that the existing subsea cable between Skye and Uist fails during the project works. This would leave island supplies fed from the DEG at Loch Carnan and Barra substations.
    a. **Mitigations:** Surveying a subsea cable route between Ardmore – Loch Pooltiel would enable a subsea connection to be made via Loch Pooltiel. Depending on the project maturity, this could accelerate restoration significantly.

Our rigorous risk assessment process, comprehensive mitigation planning, and strategic allocation of risks enable us to proactively manage potential threats to our delivery.

13 Conclusion and Recommendation

The preferred option is Option 18, which is to remove the existing Ardmore to Loch Carnan subsea cable (95mm^2) with a larger cable (300mm^2) from Dunvegan to Loch Carnan. It also involves a new cable (33kV OHL) from the Harris to Clachan substations, via Lochmaddy, and a secondary subsea cable (33kV OHL) alongside the existing Ardmore to Harris route. Each route will be supported with onshore connections to substations.

Option 18 meets all our primary drivers, is the most cost-effective option and provides the region with N-1 capacity in addition to providing sufficient capacity for demand growth until at least 2050 according to our DFES projections.

The timeline for investment for the 3 cables begins with the building of the first cable in 2025 (RIIO-ED2) and with the completion of the last cable in 2035 (ED4). The cables are rolled out in line with the forecasted DFES demand profile. This option considers flexibility; however, flexibility services have been discounted due to the large amount (~5 MVA) required and the fact that no flexibility providers responded to SHEPD's tender in 2023.

This timeline and the solution will be kept under review through 2024, Any changes will be highlighted in the January 2025 HOWSUM submission.

Therefore, in conclusion, SHEPD concluded to pursue Option 18 ensuring that we continue to provide a resilient network, with sufficient capacity, and lower carbon footprint all whilst ensuring a cost-effective engineering solution (option had highest NPV).

14 References

The documents detailed in Table 24, Table 25, and Table 26, should be used in conjunction with this document.

Table 24: Scottish and Southern Electricity Networks Document

Reference	Title
N/A	Hebrides and Orkney Whole System UM Core Narrative

Table 25: External Documents

Reference	Title
B2413737-JAC-10-XX-ST-E-0001_Rev2	Appendix 7 – Jacobs Phase 1: Optioneering Studies Report

Table 26: Miscellaneous Documents

Title
* (Arial - 9) *
* Text *

15 Revision History

No	Overview of Amendments	Previous Document	Revision	Authorisation
01	Re-submission	* Text *	* Text *	* Text *
02				

Appendix A Definitions and Abbreviations

Acronym	Definition
BAU	Business As Usual
CBA	Cost Benefit Analysis
CBRM	Condition Based Risk Management
CDM	Construction Design Management
CEM	Common Evaluation Methodology
CEGS	Community Energy Groups
CI	Criticality Index
CMZ	Constrained Management Zone
CNAIM	Common Network Assets Indices Methodology
CPI	Cost Performance Index
CT	Consumer Transformation
DEG	Distributed Embedded Generation
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
DTS	Desk Top Survey
EJP	Engineering Justification Paper
EoL	End of Life
EPCI	Engineering, Procurement, Construction, and Installation contract
EV	Earned Value
FES	Future Energy Scenarios
GB	Great Britain
GSP	Grid Supply Point
HI	Health Index
HND	Holistic Network Design
HOWSUM	Hebrides and Orkney Whole System Uncertainty Mechanism
HVDC	High Voltage Direct Current
IIS	Interruptions Incentive Scheme
LA	Local Authority
LW	Leading the Way
MVA	Mega Volt Ampere
MW	Megawatt
NPV	Net Present Value
OHL	Overhead Line

Acronym	Definition
PO	Purchase Order
PFE	Pentland Firth East
RFI	Request for Information
RIIO-ED1/2	RIIO Electricity Distribution Price Control periods 1 and 2
ROV	Remotely Operated Vehicle
SBT	Science Based Target
SHEPD	Scottish Hydro Electric Power Distribution
SEPD	Southern Energy Power Distribution
SPI	Schedule Performance Index
SSEN	Scottish and Southern Electricity Network
SW/STN	Switching Station
TO	Transmission Operator
UM	Uncertainty Mechanism
VfM	Value for Money

Appendix B Long-list of Options

Option	Description
Option 1	Is the retention of the existing 47 km, 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) to either repair or replace it on failure.
Option 2	The decommission of the existing 47km, 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A new 95mm2 (capacity: -16MVA) subsea cable using a similar route between Ardmore and LochCarnan (South Uist)
Option 3	The decommission of the existing 47km, 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A larger 185mm2 (capacity:-21.94MVA as per SSEN) subsea cable using a similar route between Ardmore and Loch Carnan (South Uist)
Option 4	The retention of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) and the addition of: • A 47km, 95mm2 subsea cable on a similar route between Ardmore and Loch Carnan (South Uist)
Option 5	The retention of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) and the addition of: • A 47km,185mm2 subsea cable on the same route between Ardmore and Loch Carnan (South Uist)
Option 6	The retention of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) and the addition of: • A 33km,185mm2 subsea cable between Ardmore and Lochmaddy and a 16km overhead line between Lochmaddy and Clachan (North Uist).
Option 7	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • Two 47km, 300mm2 subsea cables between Ardmore and Loch Carnan (South Uist

Option	Description
Option 8	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • Two 47km, 300mm2 subsea cables between Ardmore and Loch Carnan (South Uist). • Retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris.
Option 9	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • Two 47km, 300mm2 subsea cables between Ardmore and Loch Carnan (South Uist) • Retention of the existing 500 mm, 33 kV subsea cable between Ardmore and Harris and the addition of a 132 kV feeder comprising 33 km and 5.6 km of subsea cable and OHL between Ardmore and Harris
Option 10	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km,300mm2 subsea cable between Ardmore and Loch Carnan (South Uist) • A 33km, 300mm2 subsea cable between Ardmore and Lochmaddy and a 16km overhead line between Lochmaddy and Clachan (North Uist)
Option 11	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km,300mm2 subsea cable between Ardmore and Loch Carnan (South Uist) • A 33km, 300mm2 subsea cable between Ardmore and Lochmaddy and a 16km overhead line between Lochmaddy and Clachan (North Uist) • Retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris
Option 12	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km,300mm2 subsea cable between Ardmore and Loch Carnan (South Uist) • A 33km, 300mm2 subsea cable between Ardmore and Lochmaddy and a 16km overhead line between Lochmaddy and Clachan (North Uist)

Option	Description
	• Retention of the existing 500 mm2, 33 kV subsea cable between Ardmore and Harris and the addition of a 132 kV feeder comprising 33 km and 5.6 km of subsea cable and OHL between Ardmore and Harris
Option 13	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 16.5 km OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 33km subsea cable between Ardmore and Lochmaddy and a 16 km OHL between Lochmaddy and Clachan (North Uist)
Option 14	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 16.5 km OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 33km subsea cable between Ardmore and Lochmaddy and a 16 km OHL between Lochmaddy and Clachan (North Uist) • Retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris
Option 15	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 16.5 km OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 33km subsea cable between Ardmore and Lochmaddy and a 16 km OHL between Lochmaddy and Clachan (North Uist) • Retention of the existing 500 mm2, 33 kV subsea cable between Ardmore and Harris and the addition of a 132 kV feeder comprising 33 km and 5.6 km of subsea cable and OHL between Ardmore and Harris
Option 16	New Ardmore – Loch Carnan subsea cable, additional Dunvegan – Loch Carnan OHL/subsea cable and additional Harris – Clachan subsea cable / OHL.
Option 17	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with:

Option	Description
	• Two 33km,300mm2 subsea cables between Ardmore and Lochmaddy (North Uist) and two 16 km OHL between Lochmaddy and Clachan.
Option 18	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 16.5 km OHL between Dunvegan and Loch Pooltiel and 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 16 km OHL and 25 km subsea cable between Harris and Lochmaddy and 16 km OHL between Lochmaddy and Clachan (North Uist) • Retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris
Option 19	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 16.5 km cable between Dunvegan and Loch Pooltiel and 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 16 km OHL and 25 km subsea cable between Harris and Lochmaddy and 16 km OHL between Lochmaddy and Clachan (North Uist) • Retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris
Option 20	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 16.5 km OHL between Dunvegan and Loch Pooltiel and 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 16 km OHL and 25 km subsea cable between Harris and Lochmaddy and 16 km OHL between Lochmaddy and Clachan (North Uist) • Retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris
Option 21	The retention of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) and the addition of: • A16.5km, OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 185mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist)

Option	Description
Option 22	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km, 300mm2 cable between Ardmore and Loch Carnan (South Uist) • A16.5km, OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist)
Option 23	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km, 300mm2 cable between Ardmore and Loch Carnan (South Uist) • A16.5km, OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • Retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris
Option 24	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km, 300mm2 cable between Ardmore and Loch Carnan (South Uist) • A16.5km, OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • Retention of the existing 500 mm2, 33 kV subsea cable between Ardmore and Harris and the addition of a 132 kV feeder comprising 33 km and 5.6 km of subsea cable and OHL between Ardmore and Harris
Option 25	The retention of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) and the addition of: • A 16 km OHL and 25 km OHL and subsea cable between Harris and Lochmaddy and 16 km OHL between Lochmaddy and Clachan (North Uist)
Option 26	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47 km, 300mm2 cable between Ardmore and Loch Carnan (South Uist) • A 16 km OHL and 25 km OHL and subsea cable between Harris and Lochmaddy and 16 km OHL between Lochmaddy and Clachan (North Uist) • Retention of the existing 32.3 km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris.

Option	Description
Option 27	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km, 300mm2 cable between Ardmore and Loch Carnan (South Uist) • A 16.5km, OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 16 km OHL and a 25 km subsea cable between Harris and Lochmaddy and 16 km OHL between Lochmaddy and Clachan (North Uist)
Option 28	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km, 300mm2 cable between Ardmore and Loch Carnan (South Uist) • A 16.5km, OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 16 km OHL and a 25 km subsea cable between Harris and Lochmaddy and 16 km OHL between Lochmaddy and Clachan (North Uist) • Retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris.
Option 29	The decommission of the existing 95mm2 subsea cable between Ardmore and Loch Carnan (South Uist) with: • A 47km, 300mm2 cable between Ardmore and Loch Carnan (South Uist) • A 16.5km, OHL between Dunvegan and Loch Pooltiel and a 38.5 km, 300mm2 subsea cable between Loch Pooltiel and Loch Carnan (South Uist) • A 16 km OHL and a 25 km subsea cable between Harris and Lochmaddy and 16 km OHL between Lochmaddy and Clachan (North Uist) • Retention of the existing 500 mm2, 33 kV subsea cable between Ardmore and Harris and the addition of a 132 kV feeder comprising 33 km and 5.6 km of subsea cable and OHL between Ardmore and Harris.
Option 30	The option considers the retention of the existing 32.3 km, 500 mm2 subsea cable between Ardmore and Harris. • A larger 185mm2 (capacity: -21.94MVA as per SSEN) subsea cable using a similar route between Ardmore and Loch Carnan (South Uist).
Option 31	The retention of the existing 32.3km, 500 mm2 subsea cable between Ardmore and Harris and the addition of a second 500 mm2 subsea cable between Ardmore and Harris.

Option	Description
Option 32	Considers the retention of the existing 500 mm2, 33 kV subsea cable between Ardmore and Harris and the addition of a 132 kV feeder comprising 33 km and 5.6 km of subsea cable and OHL between Ardmore and Harris. If this option is taken forward the operating arrangement of the 132 kV and 33 kV system would need to be finalised (effects of paralleling).

Appendix C Procurement Activities

Package	Package Description	Procurement Strategy	Comments	Required Completion/Delivery Date
1	Skye to Uist Route Desktop Study (DTS)	[redacted]	[redacted]	[redacted]
2	Fisheries Liaison and Scouting Surveys	[redacted]	[redacted]	[redacted]
3	Offshore Route Surveys	[redacted]	[redacted]	[redacted]

Package	Package Description	Procurement Strategy	Comments	Required Completion/Delivery Date
1	EPCI Contract for Skye to Uist 2 Cable Submarine Cable, Design, Manufacture, Survey & Installation.	[redacted]	[redacted]	[redacted]
2	Shunt Reactor – Plant	[redacted]	[redacted]	[redacted]
3	Shunt Reactor – Civils, M&E and Commissioning	[redacted]	[redacted]	[redacted]

Package	Package Description	Procurement Strategy	Comments	Required Completion/Delivery Date
4	Surplus cable load in to storage	[redacted]		[redacted]
5	Professional Services – Cable design Assurance	[redacted]	[redacted]	[redacted]
6	Marine Warranty Surveyor	[redacted]	[redacted]	[redacted]
7	Goods and Equipment Importation	[redacted]	[redacted]	[redacted]
8	Onshore Modification – OHL Works	[redacted]	[redacted]	[redacted]
9	Onshore Environmental Surveys	[redacted]	[redacted]	[redacted]
10	Ground Condition Surveys/Trial Pits	[redacted]	[redacted]	[redacted]
11	Commissioning	[redacted]	[redacted]	[redacted]