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ORKNEY ISLANDS 2050 WHOLE SYSTEMS

ENGINEERING JUSTIFICATION PAPER

Scottish & Southern Electricity Networks

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Technical Recommendation	
Regulatory review	
Recommended by	
Approved by	

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1 Executive Summary

1.1 Summary

The purpose of this Engineering Justification Paper (EJP) is to detail the long-term solution for the network connecting the Orkney islands to the GB mainland system, 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) to lay out the need and technical solution to Ofgem for the first phase of this work. This is to upgrade the existing submarine electricity cables and install new submarine electricity cables that connect mainland Scotland to the islands of Orkney.

SHEPD has identified that there are two diverging pathways (Option 7A and Option 2) as potential preferred options for meeting the region's electricity demands whilst ensuring a resilient network, sufficient capacity, and low carbon footprint. Both pathways commence with the installation of a new 66kV submarine cable (running at 33kV) between Thurso South and South Ronaldsay substation starting in RIIO-ED2. Two pathways then develop during the RIIO-ED3 period: 1) Pathway 1 – a pathway based on demand resilience where 66kV submarine links are installed to the Orkney islands (Option 7A); 2) Pathway 2 - a pathway based on generation export where an additional transmission circuit is supported by 33kV reinforcement (Option 2). Onshore connections to substations will support each route.

The current optimum pathway is Pathway 1 (Option 7A), but this will be reviewed in preparation for RIIO-ED3. This option has been chosen because it is:

1) The most cost-effective option with the highest Net Present Value (NPV).Option 7A has slightly worse NPV than Option 7.
2) Ensures future resilience for the Orkney islands.
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 2025-2050, with the first new cable (66kV running at 33kV) being delivered in 2028/29 and the second cable reinforcements being completed in 2033, aligning with the forecasted Distribution Future Energy Scenarios (DFES) demand profile.[1] The total capital cost of this option is [redacted], spread across the current and subsequent price control periods.

This recommendation is based on a detailed analysis of 11 options (long list) of which 5 options (short list) fulfilled our stringent criteria. The shortlist of options is shown in Table 1 alongside the 'do nothing' and 'flexible solution' options. A fifth option was subsequently added; Option 7A, to recognise the opportunity to manage future pathways through 66kV construction.

The short-listed options underwent Cost Benefit Analysis (CBA) to provide a commercial comparison. The analysis considered a whole system approach as part of our options development and therefore each option includes the scope of works outlined to support 2050 needs. The detailed options analysis as mentioned above concluded that Option 7A was the most suitable option at RIIO-ED2. However, if transmission works are needed to connect further generation, and a second transmission link is necessitated, then Option 2 would become the most efficient solution.

Due to the uncertainty in future demand and generation growth scenarios in the region, we are proposing to take a staged approach for the initial works in RIIO-ED2. This will involve the delivery of a Thurso South – South Ronaldsay 66kV circuit, operated at 33kV. This staged approach will allow us to keep both potential pathways available as we plan for RIIO-ED3 and beyond to net zero.

[redacted]

[1] DFES include the predicted growth of demand, storage and distributed generation, and low carbon technologies such as electric vehicles and heat pumps. There are four different scenarios: Falling Short (FS), System Transformation (ST), Consumer Transformation (CT) and Leading the Way (LW).

[redacted]. The supply chain has been tested through previous RIIO-ED1 projects, [redacted]

Table 1 - Overview of Considered Options.

Option	Description	Cost (C0a, £M)	NPV (£M)	CBA Consideration and Result
Do nothing.	Leave the network in its current state.	[redacted]	[redacted]	[redacted] Disregarded as an option.
Option 7A (Preferred Option) with Use of Flexible Solution in RIIO-ED2	Defer the RIIO-ED2 Capex by 1 year under the CT, ST and FS scenarios. No deferral under the LW scenario.			The Common Evaluation Methodology (CEM) tool indicates the potential deferral under all scenarios, but there was not sufficient market viability.
Option 2	Install three new 33kV circuits between 2025 and 2050, and a second transmission link by 2040.	[redacted]	[redacted]	The least cost 33kV option but requires installation of three new 33kV circuits and also a 2nd Finstown town T-Link by 2040.
Option 3	Install four new 33kV circuits between 2025 and 2050 and a second transmission link by 2050.	[redacted]	[redacted]	More expensive 33kV option and requires installation of four new 33kV circuits and also a 2nd Finstown town T-Link by 2050.
Option 7	Install a new 66kV submarine route to South Ronaldsay in RIIO-ED2 and upgrade Pentland Firth East (PFE) and Pentland Firth West (PFW) running at 66kV in RIIO-ED3.	[redacted]	[redacted]	The least cost option. It does not require a 2nd Finstown town T-Link.
Option 8	Install a new 66kV submarine route to South Ronaldsay and upgrade PFE and PFW running at 66kV.	[redacted]	[redacted]	The PFE and PFW 66kV circuits are installed during the RIIO-ED2 period and Option 8 is not economic to reinforce PFE again following the recent completion of 33kV PFE 3 reinforcement works.
Option 7A	Install a new 66kV submarine route to South Ronaldsay running at 33kV in RIIO-ED2 and upgrade Pentland Firth East (PFE) and Pentland Firth West (PFW) running at 66kV in RIIO-ED3.	[redacted]	[redacted]	It is beneficial to develop into the corresponding pathway depending on the growth of the generation and demand by the end of RIIO-ED2. If the demand grows fast, this option will develop into pathway 1 with 66kV development as described in Option 7. If the generation development triggers the requirement of the 2nd Finstown infeed, this option will develop into pathway 2 to install additional 33kV submarine routes to Orkney Islands (Option 2).

2 Investment Summary Table

Table 2 – Investment Summary Table

Name of Scheme/Programme	Orkney islands 2050 Whole Systems Engineering Justification Paper	
Primary Investment Driver	Future resilience on the Orkney islands Future demand and generation requirements Decarbonisation of our diesel generation fleet.	
Scheme reference/ mechanism or category	EJP/SHEPD/SUBSEA/Thurso South	
Output reference/type	33kV or 66kV 500mm^2 submarine cable Onshore 33kV or 66kV overhead Line and cables Onshore 33kV or 66kV substation upgrades	
Cost	[redacted]	
Delivery Year	The works are between 2025 and 2050. Install a new 66kV submarine route to South Ronaldsay running at 33kV in RIIO-ED2.	
Reporting Table(s)	R3 – Re-openers (subject to specific activities, costs will be included under other reporting tables)	
Outputs in RIIO-ED2 Business Plan C0(a)	HOWSUM development funding has been provided as part of SHEPD's RIIO-ED2 settlement for HOWSUM project development costs. For Orkney, development costs in RIIO-ED2 are currently estimated at [redacted].	
Spend Apportionment	**RIIO-ED2**	**RIIO-ED3+**
	[redacted]	[redacted]
MVA released	220 (Finstown GSP)	94

3 Appendices Summary

Table 3 - Summary of Appendices

1.	**Definitions and Abbreviations**

4 Introduction

This Engineering Justification Paper (EJP) outlines reinforcement of the Orkney islands network to the Thurso South network. Growth in generation and demand in the region combined with plans to decarbonise flexibility solutions is leading to a need to upgrade assets in the Orkney region. Orkney is currently supplied by two submarine cables from Thurso South GSP to Scorradale which have a combined capacity of 64.3 MVA. The works outlined in this EJP provide a long-term solution for import and export capacity for the Orkney islands looking out to 2050. The proposed solution involves installation of a 66kV submarine cable from Thurso South to South Ronaldsay within RIIO-ED2 with further works required from RIIO-ED3 onwards. There are two alternative pathways to achieve this from RIIO-ED3 and our proposals maintain this optionality in the wake of uncertainty in the region.

The specific geographic area of Thurso South GSP is shown in Figure 1 below. This area covers the local authorities of the Highland Council and Orkney Islands Council.

Section 5 outlines the existing network arrangements, the load growth forecast based on the DFES data and network analysis, justifying the requirement of reinforcement.

An overview and a comparison of the considered options are given in Section 6, with a detailed option analysis being provided in Section 7, where the reasons for the options that are deemed unviable, and thus not taken forward to the CBA, are presented. Details and the results of the CBA can be found in Section 8. The preferred option is shown in Section 9 followed by the deliverability and possible risks of the proposed option in Section 10. Section 11 presents the strategic planning of investment to operate a congestion-free grid up to at least 2050. Finally, Section 12 concludes this EJP, providing main conclusions and recommendations contained within this document.

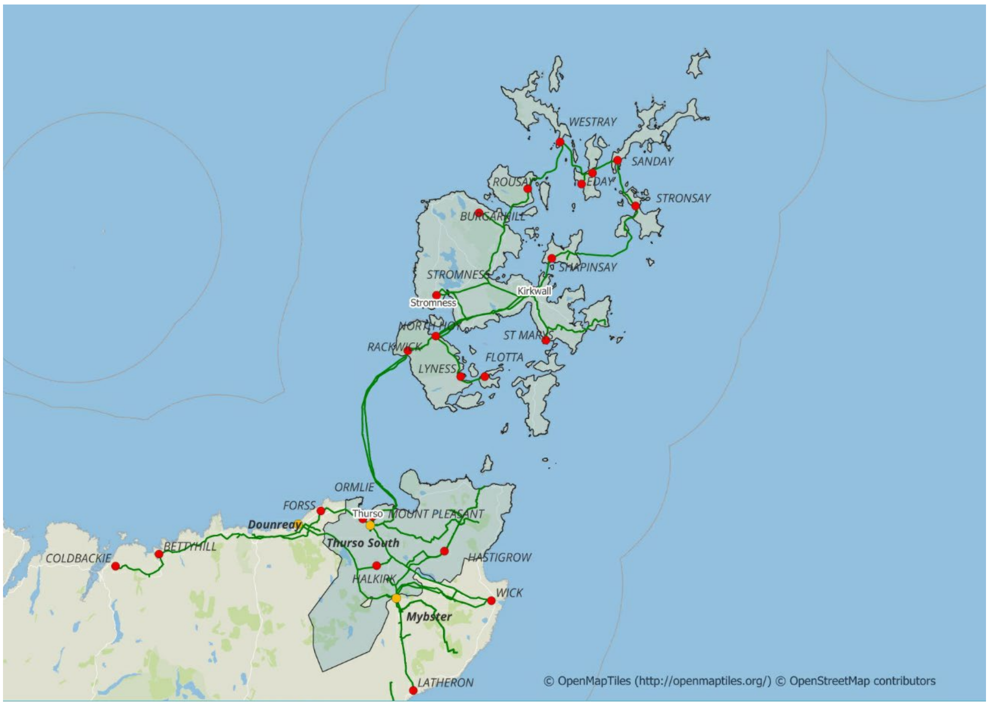

Figure 1 - Thurso South GSP Supply Area and Local Authority Boundaries.

4.1 Uncertainty Mechanism

The Hebrides and Orkney Whole Systems Uncertainty Mechanism was put in place following the submission of the RIIO-ED2 business plan. A number of drivers are relevant under the scope of this regulatory mechanism, including demand and generation forecasts, continued resilience of island groups, the need to reduce Distributed Embedded Generation (DEG) emissions and meet net zero targets, and the replacement of life expired assets.

The content of this EJP focuses on the Orkney islands which is one of the island groups being considered under the January 2025 submission.

4.2 Primary Investment Drivers

SHEPD's overarching strategy is to decarbonise the Orkney islands, 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 Orkney islands. This can be considered through two elements:
    a. Asset Condition: Considering the age and condition of the existing submarine cable assets.
    b. Future impacts of diesel generation: Understanding how we can maintain resilience on the islands whilst removing 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 Orkney islands and surrounding waters have a significant potential for wind and tidal.
3. Decarbonisation of our diesel generation fleet.

The proposed pathway with 66kV submarine links running at 33kV in RIIO-ED2 (Option 7A) aligns with all three of our primary drivers as it [redacted], allows us to meet future demand and generation requirements by increasing the circuit capacity, and decarbonise our network by removing reliance on diesel generators. Table 4 below summarises the primary drivers mentioned above.

Table 4 - Summary of the primary drivers

Driver	Primary	Description
Future resilience on Orkney	Primary	Additional circuits to Orkney islands will reduce dependency on existing cables and provide greater support [redacted].
Future demand and generation requirements	Primary	Increased capacity rating will accommodate future demand and generation growth.
Decarbonisation of our diesel generation fleet	Primary	Remove reliance on diesel generation.

4.3 Needs Case

There is a clear need to change the current network arrangements in Orkney islands based on current load forecasts which are discussed further in Section 5.4.

4.3.1 Future demand and generation requirements

Investment in new submarine assets is costly and we need to ensure we are developing a network that meets stakeholders' needs through to 2050.

We have considered this through four 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 Orkney islands 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 when required to run for long periods of time. Emissions reached [redacted] tCO2-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 submarine cable fault. We have developed a specific Islands Resilience 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.

4.3.2 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 Existing Network Arrangements

The Orkney islands are supplied from Thurso South GSP via two 33kV submarine cables via Scorradale substation. There are fourteen 33/11kV primary substations at Orkney, as shown in Table 5, supplying approximately 14,058 customers.

Diesel generators at Kirkwall provide back-up power supplies to the islands in the event of an interruption to the submarine cable supplies.

Two submarine cables connect Thurso South substation with Scorradale substation. There are four 33kV circuits which supply the rest of the Orkney demand from Scorradale substation.

The existing 33kV network topology is shown in Figure 2 and Figure 3.

Table 5 - Customer number breakdown and substation peak demand readings (2024)

Substation Name	Site Type	Number of Customers Served	Transformer number / MVA rating	2024 Substation Maximum MVA (Season)
Orkney Islands Area				
BURGARHILL	Primary Substation	898	Single 4/8MVA transformer	1.79
EDAY	Primary Substation	126	Single 1MVA transformer	0.83

Substation Name	Site Type	Number of Customers Served	Transformer number / MVA rating	2024 Substation Maximum MVA (Season)
Orkney Islands Area				
EDAY TIDAL	Primary Substation	2	Single 8MVA transformer	0.18
FLOTTA	Primary Substation	78	Single 2.5MVA transformer	0.12
KIRKWALL	Primary Substation	6,637	Double 12/24MVA transformers	16.02
LYNESS	Primary Substation	286	Single 1MVA transformer	0.9
NORTH HOY	Primary Substation	39	Single 0.2MVA transformer	0.06
ROUSAY	Primary Substation	230	Single 2.5MVA transformer	1.44
SANDAY	Primary Substation	430	Single 1MVA transformer	0.755
SHAPINSAY	Primary Substation	207	Single 2.5MVA transformer	0.29
ST MARYS	Primary Substation	1,602	Single 4MVA transformer	2.96
STROMNESS	Primary Substation	2,833	Double 7.5/15MVA transformers	5.4
STRONSAY	Primary Substation	222	Single 2.5MVA transformer	0.33
WESTRAY	Primary Substation	479	Single 4MVA transformer	1.85
Thurso South Area				
HALKIRK	Primary Substation	1,145	Single 2.5MVA transformer	1.99
HASTIGROW	Primary Substation	1,867	Single 5MVA transformer	2.48
MOUNT PLEASANT	Primary Substation	1,594	Double 7.5/15MVA transformers	3.81
ORMLIE	Primary Substation	4,057	Double 7.5/15MVA transformers	4.11

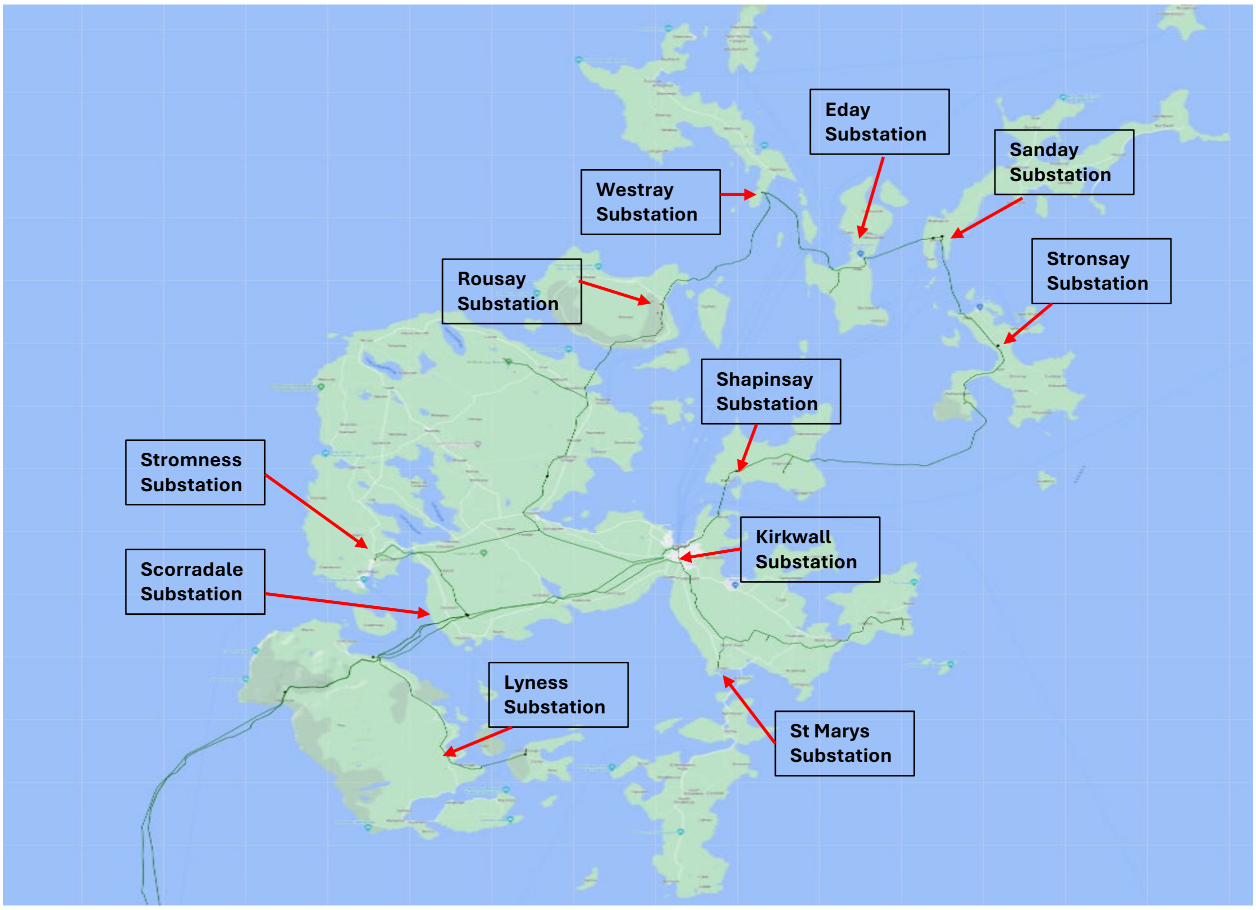

Figure 2 - The Existing Orkney Islands Network Topology

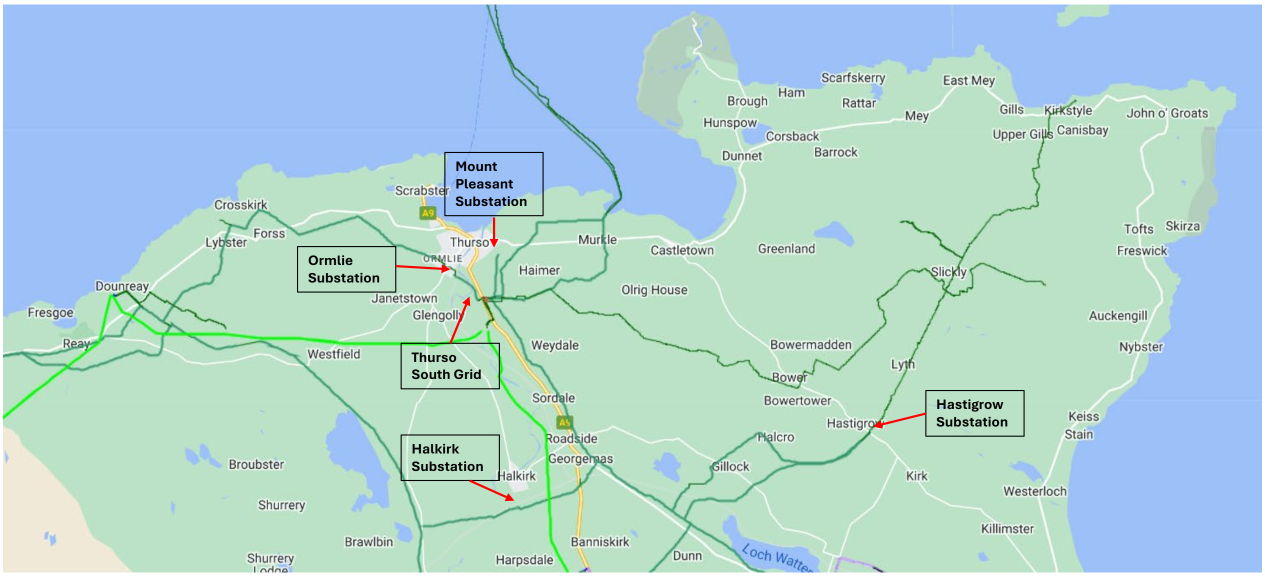

Figure 3 - The Existing Thurso South Mainland Network Topology

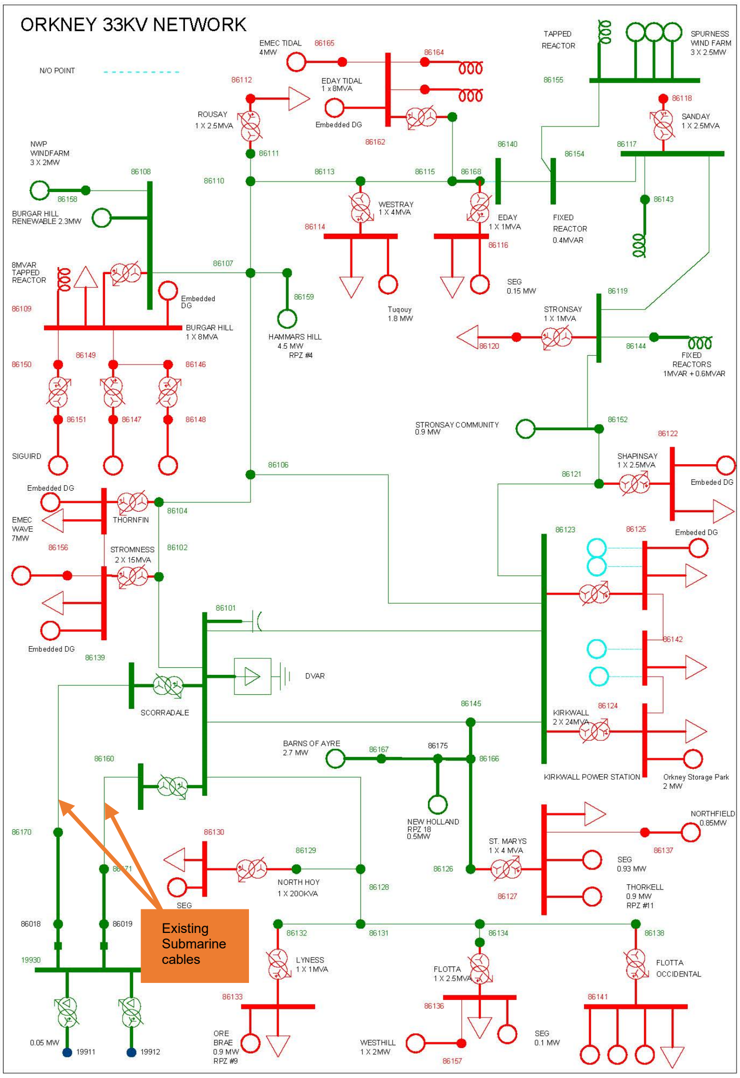

Figure 4 - Existing Orkney Islands Network Topology

5.2 Projects in Progress

Within Thurso South GSP several works are underway to meet demand requirements in the Orkney islands. The proposed works are summarised in Table 6 below.

Table 6 - Works already triggered through customer connections and the DNOA process

Substation	Description	Driver	Forecast completion 2	Fully resolves future strategic needs to 2050?
Orkney Islands Area				
Finstown GSP and associated 33kV reinforcements	New GSP	Transmission and DNOA process	2028	✗
Burgar Hill	Resilience (WSC Scheme)	Resilience (WSC Scheme)	2027	✗
Sanday	Transformer Replacement to 2.5MVA	Asset Condition	2027	✓
Lyness	Transformer Replacement to 2.5MVA	Asset Condition	2028	✓
Eday	Transformer Replacement to 2.5MVA	Asset Condition	2025	✓
Kirkwall Transformer or new Kirkwall Primary	Replace T1/T2 transformers or install a third transformer or install a new primary near Kirkwall	DNOA process	2030	✓
St Mary P2 Compliance and new primary at Ronaldsay	33kV second infeed and 11kV P2 reinforcement works	DNOA process	2028	✓
Thurso South Mainland				
Ormlie and Mount Pleasant	Install the second transformer at both primaries	Green Recovery Scheme	2025	✓
Halkirk	Transformer Replacement to two 6.3MVA	DNOA process	2030	✓

Alongside these asset solutions being deployed, flexibility solutions are also being used to release additional capacity.

5.3 Network Schematic (following completion of above works)

The network considered for long-term modelling is shown in Figure 5.

[2] These dates are best view at the time of publication and subject to change during the delivery process.

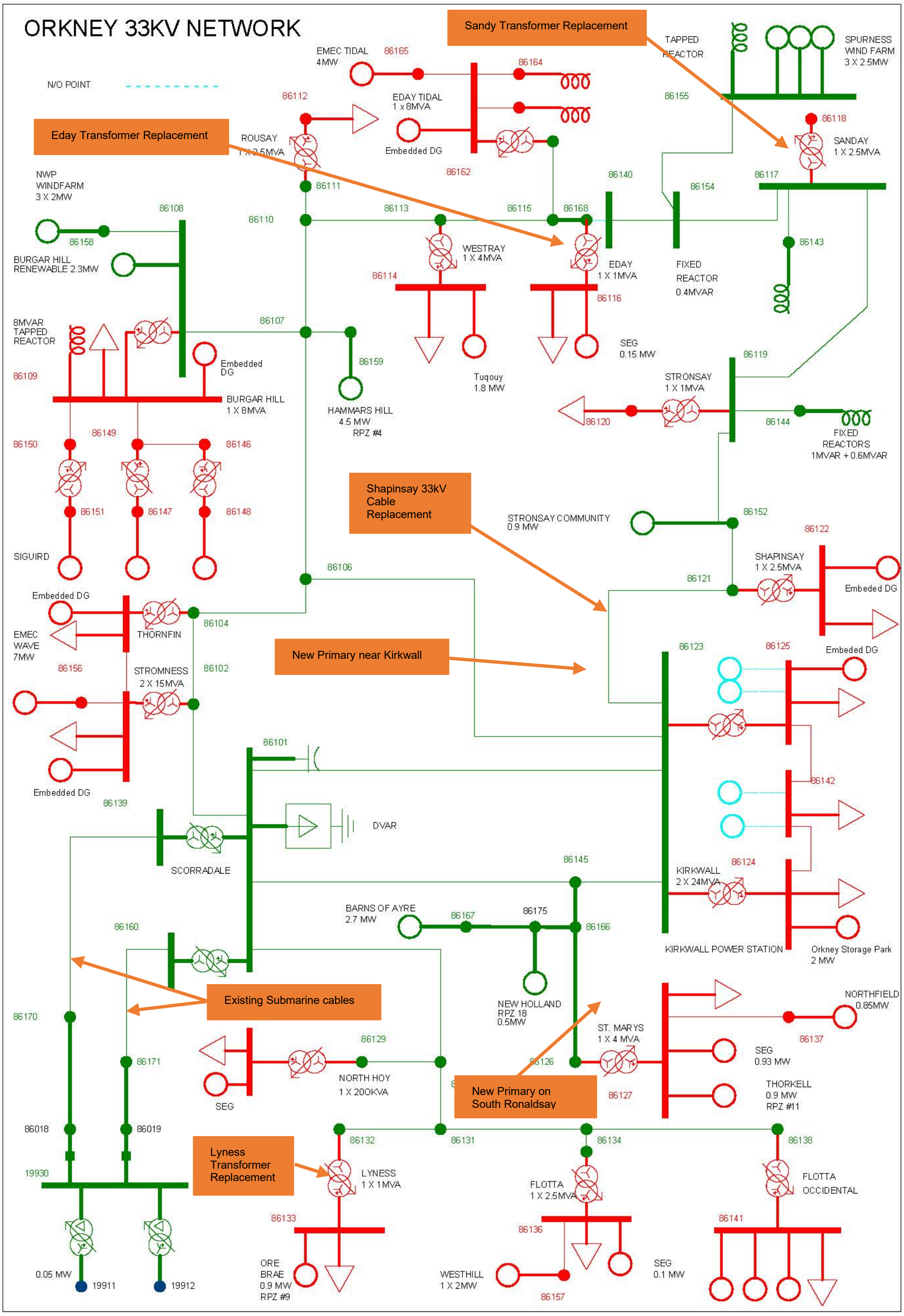

Figure 5 Schematic network with works in progress on the Orkney islands

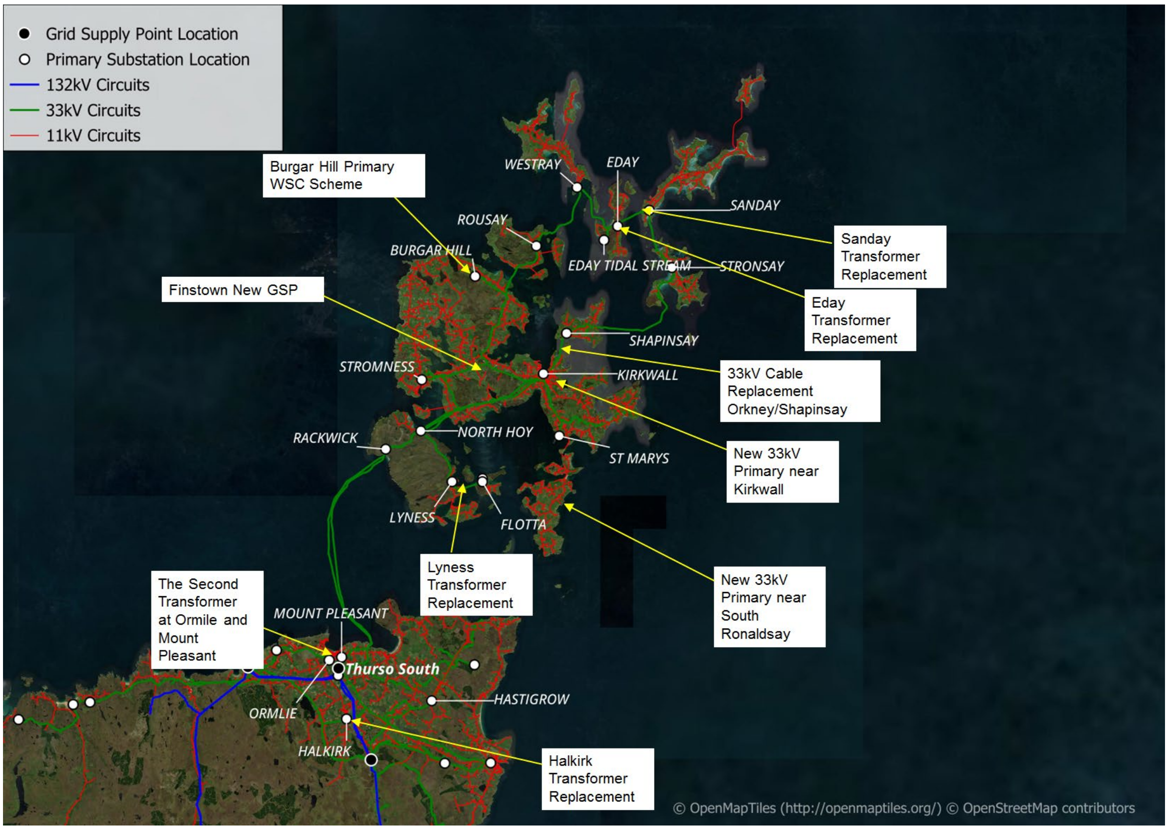

Figure 6 GIS view of network with works in progress and system needs annotated

5.4 Load Forecast for the Orkney Islands

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 our four regions. 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. As part of the scenario, we assess four different scenarios:

1) Customer Transformation (CT)

2) Leading the Way (LW)

3) System Transformation (ST)

4) Falling Short (FS)

Based on stakeholder feedback Customer Transformation has been selected as the baseline scenario for investment. The LW scenario in 2050 has also been checked as the sensitive scenario as the demand under the LW scenario is heavier than the CT scenario. The winter-peak maximum demand and the summer minimum demand with the maximum generations are presented in this paper, as this corresponds to the worst-case demand in winter and the worst-case generation in summer scenarios. The study results have confirmed that the options for the CT scenario are also applicable for the LW scenario.

5.4.1 Generation Capacity Projections and Demand Forecast Summary

The generation capacity projections and demand forecasts are summarised in Table 7 and Table 8. From these projections and forecasts, our network requires the reinforcement works to meet future demand per DFES.

Table 7 - Cumulative generation capacity projections from today to 2050 for Orkney Islands.

Substation	CT Scenario (in MW)					LW Scenario (in MW)				
	2024	2028	2033	2040	2050	2024	2028	2033	2040	2050
Orkney	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Substation	ST Scenario (in MW)					FS Scenario (in MW)				
	2024	2028	2033	2040	2050	2024	2028	2033	2040	2050
Orkney	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 8 - Orkney Islands Group Demand Forecast to 2050 - Source: SSEN DFES 2023 (PowerBI)

Substation	CT Scenario (in MW)					LW Scenario (in MW)				
Areas	2024	2028	2033	2040	2050	2024	2028	2033	2040	2050
Orkney DFES demand	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Contracted Demand	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Additional [redacted] Demand	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
TOTAL (MW)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Substation	ST Scenario (in MW)					FS Scenario (in MW)				
Areas	2024	2028	2033	2040	2050	2024	2028	2033	2040	2050
Orkney	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Figure 7 - Demand Forecast for Orkney – Breakdown by Primaries – CT. Source: SSEN DFES 2023

[redacted]

Figure 8 - Demand Forecast by Technology for Orkney – LW. Source: SSEN DFES 2023

5.4.2 Diesel Embedded Generation (DEG) Decarbonisation

SSEN has developed a 2050 strategy for the decarbonisation of its Diesel Embedded Generation (DEG) fleet. This will contribute to SSEN achieving the aim under our Science Based Targets (SBTs) to reduce GHG emissions by 55% by 2033, as outlined in the RIIO-ED2 business Plan. Further details can be found in our Sustainability Strategy.[3]

The application of this strategy will be tailored to each island group, recognising both the needs of the island communities and also the status of the existing DEG infrastructure.

5.5 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 Common Network Asset Indices Methodology (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).

Table 9 - HI bandings and definition

Bandings	Definition	Range
Health Index 1	New or as New	• The submarine 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 submarine 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 submarine 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 submarine 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.

[3] Sustainability - SSEN

Bandings	Definition	Range
		• There is no significant exposed insulation.
Health Index 5	End of serviceable life, intervention required	• The submarine cable outer serving has visible damage and has little or none left. • 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.

5.5.1 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.

Our submarine cable team has carried out an inspection on around 30 submarine cables, including the assets in question. The condition of the existing submarine cables from Thurso South to Mainland Orkney has been considered below in Table 10. The current 33kV cable running Pentland Firth west circuit has been in service for 25 years and the asset has a HI score of [redacted] The current 33kV cable running Pentland Firth East circuit was installed recently and it has a HI score of [redacted]

Table 10 - HI banding and criticality index.

Asset	Criticality Index 2024	Health Index 2024	Health Index 2028	Health Index 2033
Pentland Firth West (PFW)	C2	[redacted]	[redacted]	[redacted]
Pentland Firth East 3 (PFE)	C2	[redacted]	[redacted]	[redacted]

5.5.2 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 the table 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.

The specific Health Score Intervention Criteria we have established for this asset category has been developed within several 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 for one of the cables from Mainland Orkney to Hoy South is shown Table 11. The table shows how monetised risk value increase the higher the Health Index and the Criticality levels are.

Table 11 - Health/Criticality Risk Index Matrix (Existing Mainland Orkney PFW cable)

Asset		Health Index				
		HI1	HI2	HI3	HI4	HI5
Criticality	C1	[redacted]				
	C2					
	C3					
	C4					

5.6 Existing Operational Issues

Regional stakeholder engagement was carried out, including representatives from regional and large capital design, delivery, consenting, protection, and asset management.

The current network is [redacted] with the support of Kirkwall DEG during the winter [redacted]. The demand in winter is managed by Active Network Management (ANM) with support from the local diesel generation at Kirkwall power plant [redacted].

Previous efforts to release generation capacity on the islands have been successful with ANM and the Distributed Generation Automatic Disconnection (DGAD) schemes having enabled more generation to connect to the distribution network. However, the ANM scheme is now at capacity. As a result, further network and non-network options will be required to relieve generation constraints on Orkney.

5.7 Network Analysis Summary

Network analysis studies have been carried out using the 2023 release of the DFES data for the CT scenarios analysing the network for 2028, 2033, 2040 and 2050. The studies have assumed completion of the previously mentioned works outlined in Section 5.2.

The studies were based on the assumptions outlined in Table 12.

Table 12 - Study assumptions

Assumption	Type
Voltage limits: Normal Running Arrangements: [redacted] All unknown cables assumed to be equal to lowest rated cable in RSN.	Technical threshold for study Winter Demand Network modelled as wholly intact with maximum winter loads applied at each Primary Substation. Zero Generation (including embedded 11kV) operating on GSP. Summer Generation Network modelled as wholly intact with minimum summer loads applied at each Primary Substation. Full Generation (including embedded 11kV) operating on GSP.

Following completion of network analysis the following constraints/conclusions have been identified under the CT scenario in Table 13. These results are also applicable for the LW scenario.

Table 13 - Study Summary

Options	Summary
Do Nothing (Demand)	**2028** Studies show that there are [redacted]. 2033 Studies show that there are [redacted].
Option 7 (Demand)	**2028** Studies show that there are [redacted] following the proposed new South Ronaldsay 66kV circuit for 2029. **2033** Studies show that there are [redacted] following the proposed the proposed 66kV PFE and PFW reinforcement for 2033. **2040** Studies show that there are [redacted] following the proposed reinforcement for 2033. **2050** Studies show that there are [redacted] following the proposed reinforcement for 2033.
Option 7 (Generation)	**2028**

	Studies show that there are [redacted] on Orkney inland network (non-HOWSUM related) following the proposed new South Ronaldsay 66kV circuit for 2029. **2033** Studies show that there are [redacted] on Orkney 33kV northern ring network (non-HOWSUM related) following the proposed 66kV PFE and PFW reinforcement for 2033. **2040** Studies show that there are [redacted] for Orkney inland 33kV circuits following the proposed reinforcement for 2040. **2050** Studies show that there are [redacted] for inland 33kV circuits following the proposed reinforcement for 2050.
Option 8 (Demand)	**2028** Studies show that there are [redacted] following the proposed 66kV PFE and PFW reinforcement for 2029. **2033** Studies show that there are [redacted] following the proposed the proposed new 66kV South Ronaldsay circuit for 2033. **2040** Studies show that there are [redacted] following the proposed reinforcement for 2033. **2050** Studies show that there are [redacted] following the proposed reinforcement for 2050.
Option 8(Generation)	**2028** Studies show that there are [redacted] on Orkney inland network (non-HOWSUM related) following the proposed 66kV PFE and PFW reinforcement for 2029. **2033** Studies show that there are [redacted] on Orkney 33kV northern ring network (non-HOWSUM related) following the proposed new 66kV South Ronaldsay circuit for 2033. **2040** Studies show that there are [redacted] for Orkney inland 33kV circuits following the proposed reinforcement for 2040. **2050** Studies show that there are [redacted] for inland 33kV circuits following the proposed reinforcement for 2050.
Option 2 (Demand)	**2028** Studies show that there are [redacted] following the proposed new Thurso South - South Ronaldsay 33kV circuit for 2029.

	2033 Studies show that the new Thurso South - Scorradale 33kV is required by 2033 [redacted]. Kirkwall DEG needs re-powering with a zero emission alternative by 2033 [redacted] between 2034 and 2040. **2040** Finstown 2nd T-Link is required by 2040 [redacted]. **2050** A new 33kV Thurso South - South Ronaldsay via (Hoy) is required [redacted].
Option 3 (Demand)	**2028** Studies show that there are [redacted] following the proposed new Thurso South - South Ronaldsay 33kV circuit for 2029. **2033** Studies show that the new Thurso South - Scorradale 33kV is required by 2033 [redacted]. Kirkwall DEG needs re-powering as a zero emission alternative by 2033 [redacted] between 2034 and 2040. **2040** A new 33kV Thurso South - South Ronaldsay via (Hoy) is required by 2040 [redacted]. **2050** A new 33kV Thurso South - Scorradale is required [redacted].
Option 2&3 (Generation)	**2028** Studies show that there are [redacted] on Orkney 33kV northern ring network (non-HOWSUM related) following the proposed new South Ronaldsay 33kV circuit for 2029. **2033** Studies show that there are [redacted] on Orkney 33kV northern ring network (non-HOWSUM related) following the proposed the proposed new 33kV Thurso South – Scorradale circuit for 2033. **2040** Studies show that there are [redacted] for Orkney 33kV northern ring circuits following the proposed reinforcement for 2040. **2050** Studies show that there are [redacted] for Orkney 33kV northern ring circuits following the proposed reinforcement for 2050.

5.8 Regional Stakeholder Engagement and Whole Systems Analysis Summary

Thurso South GSP supplies the Orkney Islands Council area.

SSEN has active working relationships with the local authority and other key stakeholders in the Orkney Islands. We have engaged with Orkney Islands Council through their attendance at our local authority roadshow events as well as seeking their input into our plans for the Hebrides and Orkney Whole System Uncertainty Mechanism, through which we are building a whole system plan for the network in the Orkney islands out to 2050.

We also have regular engagement with EMEC, and Highlands and Islands Enterprise's Net Zero Transition and Carbon Neutral Islands teams, through which we maintain a 2-way flow of information on respective plans for the area. Ongoing engagement with the Islands Centre for Net Zero provides us with further insight on Orkney's energy landscape.

This engagement, along with engagement with local businesses and groups, has helped SSEN stay informed about planning and development in the region that will impact local communities' use of the network.

5.8.1 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.

5.8.2 Community Energy Groups and Interest Groups

There are several active community energy groups and community generators in the Orkney islands area. SSEN are aware of the appetite for exploration of further community energy initiatives in this area and are continuing to engage with local stakeholders to ensure our network plans are fit for purpose.

5.8.3 Whole System Approach

Over the last few years, we have worked closely with local stakeholders, customers, market participants government bodies and our transmission company to develop an enduring Whole System solution to meet the future energy needs of the Orkney islands 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 second transmission link 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 considered as an option to help decarbonise the Scottish islands.

5.8.4 Network resilience for island groups connected by submarine cables

SSEN own and operate 446.55km of Distribution (33kV & 11kV) Submarine Cables, across 60 islands within Scottish Hydro Electric Power Distribution (SHEPD) licence area covering the north of Scotland. To maintain this network of submarine cables SSEN's Islands Resilience policy was developed to provide increased resilience in areas connected via submarine cables where faults can take significant periods of time to repair. Based on the level of resilience required for each of the island groups fed from sub-sea cables the standard summarised in Table 14 was developed.

Table 14 - SSEN Group Demand sizes for Island Groups fed via submarine cables

Forecasted 2050 group demand (CT)*	Relevant 2050 P2-8 Category	Islands Resilience Policy for Island groups fed via subsea cables
Over 60MW and up to 300MW	D	Group demand secured for sustained long duration N-2 condition through a combination of network assets and local generation (including third party).
Over 4MW And up to 60MW	C	
Over 1MW And up to 4MW	B	Group demand secured for sustained long duration N-1 condition through a combination of network assets and local generation (including third party). N-2 condition managed through use of portable generation or use of existing generation on island if available.
<1MW	A	

5.8.5 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.

5.9 Flexible Market Viability

SSEN uses flexibility services to create capacity in areas of constrained network. Flexibility Services is a key tool in the design and operation of the network and is used to support our network investment programme by enabling outages to go ahead; optimising the build programme and deferring reinforcement where economical to do so.

SSEN procures flexibility services from owners, operators, or aggregators of Distributed Energy Resources (DERs), which can be generators, storage, or demand assets. Services are typically needed at specific locations and times of day where high power flows are expected to occur.

The estimation of available flexibility in this area is particularly difficult due to the need to make assumptions about domestic and commercial flexibility participation rates and capacity in the Orkney Islands. Current flexibility services in this part of Scotland have been primarily achieved through MD (Maximum Demand) contracted Customers and Distributed Generation in the form of complex ANM systems.

In August 2024, we launched a Request for Information[5] (RFI) to identify new Flexibility Service Participants in a selection of island communities and establish routes to market in this geographical location. For the Orkney islands the consultation revealed one potential provider willing to provide generator turn up service subject to ANM.

The RFI has not identified a single area where Flexibility Services can be currently used to remove the reliance on diesel generators totally. It may be possible to reduce their use in some areas with Flexibility Services. In other areas long term market stimulation may eventually allow a combined solution.

In summary, the RFI has successfully highlighted that there is keen interest in Flexibility Services in the Island communities from both commercial assets and community led schemes. However, there are clear complexities and barriers for participation, particularly around ANM and Grid Access. Flexibility solutions will likely require strong financial incentives and support on infrastructure investments to overcome these challenges and expand renewable integration across the islands. We will continue to communicate with providers and monitor progress in the market.

5.10 Confidence Table

The Table 15 is filled in with either High, Medium or Low to summarise our confidence in the justification for the evidence which has identified the constraint.

Table 15 - Confidence Table

Confidence Factor	Certainty (High, Medium, Low)	Comments
Load Forecast	Medium	We are using the 2023 DFES data 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. This risk is mitigated to an extent through to use of multiple scenarios.
Existing Asset Condition	Medium	Offshore ROV inspections [redacted].
Existing Operational Issues	High	The network is managed by ANM scheme.

[5] REQUEST FOR INFORMATION: FLEXIBILITY SERVICES IN SCOTLAND'S ISLANDS

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	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. However, the amount of flexibility which would need to be procured to prevent reinforcement before 2050 is approximately between [redacted] on average for the options developed. Procuring between [redacted] worth of flexibility is not currently achievable and thus flexibility has been discounted as a viable alternative. However, it is possible that smaller amounts of flexibility could be procured to defer reinforcement by a few years. This will continue to be assessed.
Funding Position	Medium	HOWSUM development funding has been provided as part of SHEPD's RIIO-ED2 settlement for HOWSUM project development costs. Based on our analysis of island needs we believe we have identified the correct solution for implementation at the correct time. [redacted], and we will undertake further engagement with the market to ascertain cable installation costs to inform our RIIO-ED3 business plan.

6 Summary of options considered

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 strategic development process. The aim of the strategic development 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 used 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 Figure 9.

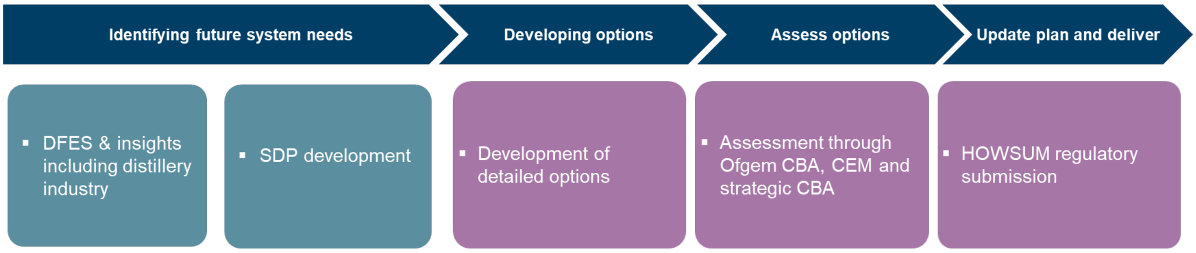

Figure 9 - Summary of Strategic Development Process.

6.1 Long list of Options

Our optioneering approach used to identify and evaluate schemes is built on the knowledge gained from various areas of the business while operating as a DNO. Based on the technical feasibility, a long list of options were considered (shown in Table 16). Then the shortlist of options were derived as the list of technically feasible solutions to the investment need. For clarity the full scope of works out to 2050 is included for each option to show the whole systems approach that was taken to consider the options.

Table 16 - Longlist of options

Name	Summary
1. Do nothing	No compliant with future demand and generation developments.
2. 33kV reinforcement of existing PFE and PFW with three new submarine cables, a second transmission link and flexibility procurement.	The reinforcement of the existing Pentland Firth West circuit and Pentland Firth East circuit. • The west circuit (PFW) submarine cable is replaced with 33kV 500mm² (35.5MVA) submarine cable (Thurso South - Hoy and Hoy - Scorradale) using a similar route between Thurso South and Scorradale in 2045 • The 20MVA regulator on the east circuit (PFE) is replaced with a 35MVA unit between 2024 and 2028 The addition of: • A 57km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and South Ronaldsay via John O'Groats between 2024-2029

	• A 60km, 33kV 500mm^2 submarine cable and onshore OHL between Thurso South and Scorradale between 2029-2033 • A 54km, 33kV 500mm^2 submarine cable and onshore OHL between Thurso South and South Ronaldsay via Hoy between 2040-2050 • Flexible solution from 2033 to 2040 to allow removal of reliance on Kirkwall DEG • The second transmission link by 2040
3. 33kV reinforcement of existing PFE and PFW with four new submarine cables, a second transmission link and flexibility procurement.	The reinforcement of the existing Pentland Firth West circuit and Pentland Firth East circuit • The west circuit (PFW) is replaced with a new 33kV 500mm^2 (capacity: -35.5MVA) submarine cable (Thurso South - Hoy and Hoy - Scorradale) using a similar route between Thurso South and Scorradale in 2045 • The 20MVA regulator on the east circuit (PFE) is replaced with a 35MVA unit between 2024 and 2028 The addition of: • A 63km, 33kV 500mm^2 submarine cable and onshore OHL between Thurso South and South Ronaldsay via John O'Groats between 2024-2029 • A 60km, 33kV 500mm^2 submarine cable and onshore OHL between Thurso South and Scorradale between 2029-2033 • A 60km, 33kV 500mm2 submarine cable and onshore OHL between Thurso South and South Ronaldsay via Hoy between 2029 and 2040 • A 60km, 33kV 500mm2 submarine cable and onshore OHL between Thurso South and Scorradale between 2041 and 2050 • Flexible solution from 2033 to 2040 to allow removal of reliance on Kirkwall DEG • The second transmission link by 2050
4. 33kV reinforcement of existing Pentland Firth East and West circuit with addition of three submarine cable routes, a second transmission link and flexibility procurement.	The reinforcement of the existing Pentland Firth West circuit and Pentland Firth East circuit • The west circuit (PFW) is replaced with a new 33kV 500mm^2 (capacity: -35.5MVA) submarine cable (Thurso South - Hoy and Hoy - Scorradale) using a similar route between Thurso South and Scorradale in 2045 • The 20MVA regulator on the east circuit (PFE) is replaced with a 35MVA unit between 2024 and 2028 The addition of: • A 63km, 33kV 500mm^2 submarine cable and onshore OHL between Thurso South and South Ronaldsay via Hoy between 2024-2029 • A 60km, 33kV 500mm^2 submarine cable and onshore OHL between Thurso South and Scorradale between 2029-2033 • A 57km, 33kV 500mm^2 submarine cable and onshore OHL between Thurso South and South Ronaldsay (via John O'Groats) between 2040-2050 • Flexible solution from 2033 to 2040 to allow removal of reliance on Kirkwall DEG

	• The second transmission link by 2040
5. 33kV reinforcement of existing Pentland Firth East and West circuit with addition of three submarine cable routes, the second transmission link and flexibility procurement.	The reinforcement of the existing Pentland Firth West circuit and Pentland Firth East circuit • The west circuit (PFW) is replaced with a new 33kV 500mm² (capacity: -35.5MVA) submarine cable (Thurso South - Hoy and Hoy - Scorradale) using a similar route between Thurso South and Scorradale in 2045 • The 20MVA regulator on the east circuit (PFE) is replaced with a 35MVA unit between 2024 and 2028 The addition of: • A 57km, 33kV 500mm² submarine cable and onshore UG cable between Thurso South and South Ronaldsay via John O'Groats between 2024-2029 • A 63km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and South Ronaldsay via Hoy between 2029-2033 • A 60km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and Scorradale between 2040-2050 • Flexible solution from 2033 to 2040 to allow removal of reliance on Kirkwall DEG • The second transmission link by 2040
6. 33kV reinforcement of existing Pentland Firth East and West circuit with addition of three submarine cable routes, a second transmission link and flexibility procurement.	The reinforcement of the existing Pentland Firth West circuit and Pentland Firth East circuit • A new 33kV 500mm² (35.5MVA) submarine cable (Thurso South - Hoy and Hoy - Scorradale) on the west circuit using a similar route between Thurso South and Scorradale in 2045 • The 20MVA regulator on the east circuit (PFE) is replaced with a 35MVA unit between 2024 and 2028 The addition of: • A 63km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and South Ronaldsay via Hoy between 2024-2029 • A 57km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and South Ronaldsay via John O'Groats between 2029-2033 (Using onshore big cable section) • A 60km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and Scorradale between 2040-2050 • Flexible solution from 2033 to 2040 to allow removal of reliance on Kirkwall DEG • The second transmission link by 2040

7. 66 kV upgrade of PFW and PFE with additional 66kV cable.	• Install 57km 66kV Thurso South - South Ronaldsay via John O'Groats between 2024-2029 • Upgrade PFW and PFE circuits to be running at 66kV between 2029-2033
8. 66kV upgrade of PFW and PFE followed by additional 66kB cable.	The decommissioning of the existing Pentland Firth West circuit and Pentland Firth East circuit with: • Two 66kV submarine circuits on the same route between 2024 and 2029 • Install 57km 66kV Thurso South - South Ronaldsay via John O'Groats between 2025-2033
9. Install 66kV link from Thurso South to South Ronaldsay and upgrade PFW to 66kV	• Install 66kV Thurso South - South Ronaldsay between 2024-2029 • Upgrade PFW circuit to be running at 66kV between 2029-2032 • The second transmission link by 2040
10. A reinforcement of PFE and two 66kV cables.	• Install 63km 66kV Thurso South - South Ronaldsay via Hoy between 2024-2029 • Upgrade PFW and PFE circuits to be running at 66kV between 2029-2032
11. Upgrading of PFE and PFW with one 66kV cables.	The reinforcement of the existing Pentland Firth West circuit and Pentland Firth East circuit • The onshore OHL on the east circuit is reinforced to be 35.4MW and the 20MVA regulator is replaced with a 35MVA unit between 2024 and 2028 The decommissioning of the existing Pentland Firth West circuit with: • One 66kV submarine circuit on the same route between 2024 and 2029 The addition of: • A 57km, 66kV submarine cable and onshore OHL between Thurso South and South Ronaldsay via John O'Groats between 2029 and 2032. • The second transmission link by 2040

6.2 Short List of Options

The shortlist of options considers the feasible options from the longlist of options, identified as a result of testing the technical feasibility of the options.

Table 17 - Shortlist of options

Name	Summary
1. Do nothing	No compliant with future demand and generation developments.
2. 33kV reinforcement of existing PFE and PFW with three new submarine cables, a second transmission link and flexibility procurement.	The reinforcement of the existing Pentland Firth West circuit and Pentland Firth East circuit. • The west circuit (PFW) submarine cable is replaced 33kV 500mm² (35.5MVA) submarine cable (Thurso South - Hoy and Hoy - Scorradale) using a similar route between Thurso South and Scorradale in 2045 • The 20MVA regulator on the east circuit (PFE) is replaced with a 35MVA unit between 2024 and 2028 The addition of: • A 57km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and South Ronaldsay via John O'Groats between 2024-2029 • A 60km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and Scorradale between 2029-2033 • A 54km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and South Ronaldsay via Hoy between 2040-2050 • Flexible solution from 2033 to 2040 to allow removal of reliance on Kirkwall DEG • The second transmission link by 2040
3. 33kV reinforcement of existing PFE and PFW with four new submarine cables, the second transmission link and repowering Kirkwall generation.	The reinforcement of the existing Pentland Firth West circuit and Pentland Firth East circuit • The west circuit (PFW) is replaced with a new 33kV 500mm² (35.5MVA) submarine cable (Thurso South - Hoy and Hoy - Scorradale) using a similar route between Thurso South and Scorradale in 2045 • The 20MVA regulator on the east circuit (PFE) is replaced with a 35MVA unit between 2024 and 2028 The addition of: • A 63km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and South Ronaldsay via Hoy between 2024-2029 • A 60km, 33kV 500mm² submarine cable and onshore OHL between Thurso South and Scorradale between 2029-2033 • A 60km, 33kV 500mm2 submarine cable and onshore OHL between Thurso South and Scorradale between 2029 and 2040

	• A 60km, 33kV 500mm2 submarine cable and onshore OHL between Thurso South and South Ronaldsay via Hoy between 2041 and 2050 • Flexible solution from 2033 to 2040 to allow removal of reliance on Kirkwall DEG • The second transmission link by 2050
7. 66 kV upgrade of PFW and PFE with additional 66kV cable.	• Install 57km 66kV Thurso South - South Ronaldsay via John O'Groats between 2024-2029 • Upgrade PFW and PFE circuits to be running at 66kV between 2029-2033
8. 66kV upgrade of PFW and PFE followed by additional 66kB cable.	The decommission of the existing Pentland Firth West circuit and Pentland Firth East circuit with: • Two 66kV submarine circuits on the same route between 2024 and 2029. • Install 57km 66kV Thurso South - South Ronaldsay via John O'Groats between 2025-2033
9. Proposed Option 7A	• Install 57km 66kV Thurso South - South Ronaldsay via John O'Groats (running at 33kV) between 2024-2029 • Upgrade PFW and PFE circuits to be running at 66kV between 2029-2033

7 Detailed option analysis

7.1 Option 1: Do Nothing

Doing nothing would lead to a breach of SSEN's Islands Resilience policy for island groups connected by submarine cables. This is due to generic growth in demand throughout the island group as well as many anticipated connections.

Limitations

This option presents several significant limitations.

1. It cannot meet the compliance requirements for the demand growth and no activities are taken to meet the zero carbon targets.
2. 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 sub-sea cable.
3. The approach is costly and inefficient, involving the expensive procurement of emergency services and replacement cables under the failure of the existing Scorradale submarine circuits without the benefits of advanced planning and cost-effective purchasing. The cost of repairing

a sub-sea 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.

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. If the Finstown GSP is lost and demand cannot be met after RIIO-ED2, it will be necessary to run a DEG. This is both operationally expensive and contrary to SHEPD's net zero ambitions. [redacted]

7.2 Option 2: 33kV reinforcement of existing PFE and PFW with three new 33kV submarine cables, the second transmission link and flexibility procurement.

Option 2 involves the reinforcement by 2028 of the 20 MVA regulator increased to 35 MVA. Additionally, a submarine cable (57km) from Thurso South to South Ronaldsay via John O'Groats will be delivered by 2029. The circuit includes a new 33kV OHL (30km) of 150mm^2 Cu OHL from Thurso South to the landing point of the submarine Cable (near John O'Groats) and establish a new 15km of 500mm^2 Cu 33kV submarine cable between John O'Groats and Burwick. Approx 10km of 150mm^2 Cu OHL and 1.5km of 800mm^2 onshore cable are installed between Burwick and South Ronaldsay. This work would come under the RIIO-ED2 price control.

Following completion of these works a new circuit from Thurso South to Scorradale via Hoy would be delivered in 2033. A flexible solution is needed to support the demand between 2034 and 2040 before the second transmission link to Finstown is installed by 2040. A further two circuits will be delivered by 2045 - one from Thurso South to South Ronaldsay via Hoy and Flotta and one on the PFW route replacing the existing submarine cable. This solution would create a total of five distribution links from the mainland to Orkney. This option is contingent on a 2nd 132kV transmission infeed installed at Finstown GSP by 2040 as shown by the blue dashed line in Figure 10.

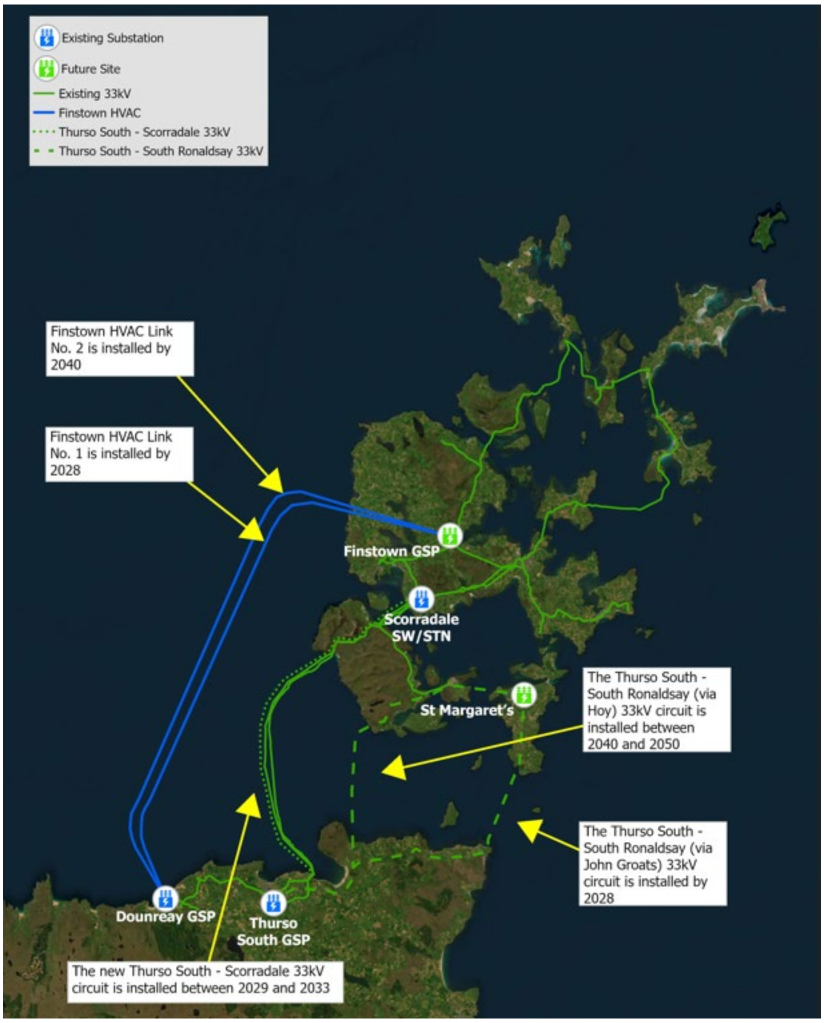

Figure 10 - Option 2 route map.

Cost

The capital cost components of this option are the three new cable routes (submarine and onshore) and upgrades of the existing PFW and PFE circuits to the Scorradale and South Ronaldsay substations. This totals to [redacted]; which occurs through the current and subsequent price control periods. Table 18 provides a breakdown of cost.

Table 18 - Option 2 cost breakdown (2021 prices)

Line Items	Route	Cost (£m)
PFE Onshore Reinforcement Works	PFE Regulator Replacement Works	[redacted]
EHV Sub Cable	Thurso South - South Ronaldsay via John O'Groats	[redacted]

Line Items	Route	Cost (£m)
33kV OHL (Pole Line) Conductor	Thurso South - South Ronaldsay via John O'Groats	[redacted]
33kV Pole	Thurso South - South Ronaldsay via John O'Groats	[redacted]
33kV UG Cable (Non Pressurised)	Thurso South - South Ronaldsay via John O'Groats	[redacted]
Thurso South Substation Costs	Thurso South - South Ronaldsay via John O'Groats	[redacted]
South Ronaldsay Substation Costs	Thurso South - South Ronaldsay via John O'Groats	[redacted]
EHV Sub Cable	Thurso South - South Ronaldsay via Hoy	[redacted]
33kV OHL (Pole Line) Conductor	Thurso South - South Ronaldsay via Hoy	[redacted]
33kV Pole	Thurso South - South Ronaldsay via Hoy	[redacted]
33kV UG Cable (Non Pressurised)	Thurso South - South Ronaldsay via Hoy	[redacted]
Thurso South Substation Costs	Thurso South - South Ronaldsay via Hoy	[redacted]
South Ronaldsay Substation Costs	Thurso South - South Ronaldsay via Hoy	[redacted]
EHV Sub Cable	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV OHL (Pole Line) Conductor	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV Pole	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV UG Cable (Non Pressurised)	Thurso South - Scorradale New 33kV Circuit	[redacted]
Thurso South Substation Costs	Thurso South - Scorradale New 33kV Circuit	[redacted]
Scorradale Substation Costs	Thurso South - Scorradale New 33kV Circuit	[redacted]

Line Items	Route	Cost (£m)
EHV Sub Cable	PFW Replacement	[redacted]
33kV OHL (Pole Line) Conductor	PFW Replacement	[redacted]
33kV Pole	PFW Replacement	[redacted]
33kV UG Cable (Non Pressurised)	PFW Replacement	[redacted]
132kV Sub Cable	Finstown Second 132kV Infeed	[redacted]
132kV UG Cable (Non Pressurised)	Finstown Second 132kV Infeed	[redacted]
Dounreay Substation Costs	Finstown Second 132kV Infeed	[redacted]
Finstown Substation Costs	Finstown Second 132kV Infeed	[redacted]
Third Party Flexible Solution Cost	Flexible Capacity between 2033 and 2040 for N-2	[redacted]
Sum		[redacted]

Benefits

Option 2 is the least cost option of the 33kV options that have been shortlisted, and it provides the benefit of following two new 33kV routes to South Ronaldsay and install a new 33kV route to Scorradale. This can significantly improve the supply resilience for the Orkney islands. If transmission works are needed to connect further generation, and a second transmission link is necessitated, then Option 2 would become the most efficient solution overall.

Limitations

The biggest limitation of this option is subject to the installation of the 2nd Finstown transmission infeed by 2040. [redacted] However, ultimately Option 2 provides our customers with good value for money during RIIO-ED2.

7.3 Option 3: 33kV reinforcement of existing PFE and PFW with four new submarine cables, the second transmission link and flexibility procurement.

Option 3 follows all works within Option two with the addition of another 33kV cable from Thurso South to Scorradale between 2041 and 2050. A flexible solution is needed to support the demand between 2034 and 2040 before the second transmission link to Finstown is installed by 2040. This option is contingent on a 2nd 132kV transmission infeed installed at Finstown GSP by 2050 as shown by the blue dashed line in Figure 11.

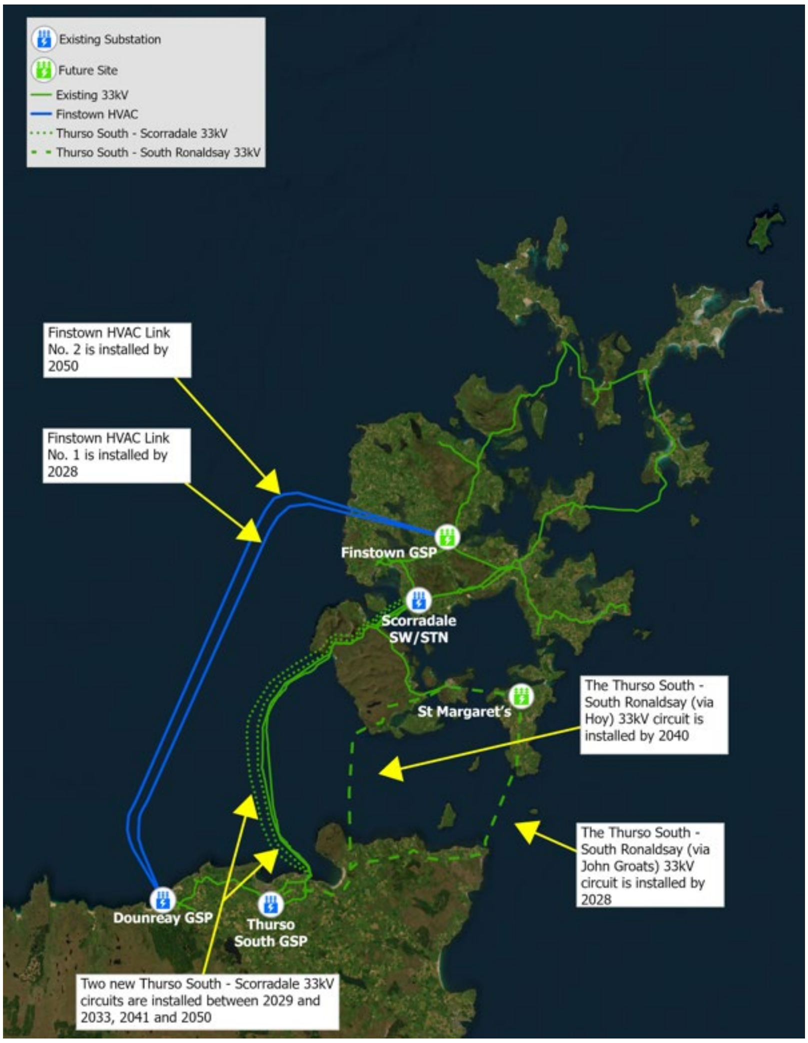

Figure 11 - Option 3 route map

Cost

The capital cost components of this option are the four new cable routes (submarine and onshore) and upgrades of the existing PFW and PFE circuits to the Scorradale and South Ronaldsay substations. This totals to [redacted]; which occurs through the current and subsequent price control periods. Table 19 provides a breakdown of cost.

Table 19 - Option 3 cost breakdown (2021 prices)

Line Items	Route	Cost (£m)
PFE Onshore Reinforcement Works	PFE Regulator Replacement Works	[redacted]
EHV Sub Cable	Thurso South - South Ronaldsay via John O'Groats	[redacted]
33kV OHL (Pole Line) Conductor	Thurso South - South Ronaldsay via John O'Groats	[redacted]

Line Items	Route	Cost (£m)
33kV Pole	Thurso South - South Ronaldsay via John O'Groats	[redacted]
33kV UG Cable (Non Pressurised)	Thurso South - South Ronaldsay via John O'Groats	[redacted]
Thurso South Substation Costs	Thurso South - South Ronaldsay via John O'Groats	[redacted]
South Ronaldsay Substation Costs	Thurso South - South Ronaldsay via John O'Groats	[redacted]
EHV Sub Cable	Thurso South - South Ronaldsay via Hoy	[redacted]
33kV OHL (Pole Line) Conductor	Thurso South - South Ronaldsay via Hoy	[redacted]
33kV Pole	Thurso South - South Ronaldsay via Hoy	[redacted]
33kV UG Cable (Non Pressurised)	Thurso South - South Ronaldsay via Hoy	[redacted]
Thurso South Substation Costs	Thurso South - South Ronaldsay via Hoy	[redacted]
South Ronaldsay Substation Costs	Thurso South - South Ronaldsay via Hoy	[redacted]
EHV Sub Cable	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV OHL (Pole Line) Conductor	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV Pole	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV UG Cable (Non Pressurised)	Thurso South - Scorradale New 33kV Circuit	[redacted]
Thurso South Substation Costs	Thurso South - Scorradale New 33kV Circuit	[redacted]
Scorradale Substation Costs	Thurso South - Scorradale New 33kV Circuit	[redacted]
EHV Sub Cable	PFW Replacement	[redacted]

Line Items	Route	Cost (£m)
33kV OHL (Pole Line) Conductor	PFW Replacement	[redacted]
33kV Pole	PFW Replacement	[redacted]
33kV UG Cable (Non Pressurised)	PFW Replacement	[redacted]
132kV Sub Cable	Finstown Second 132kV Infeed	[redacted]
132kV UG Cable (Non Pressurised)	Finstown Second 132kV Infeed	[redacted]
Dounreay Substation Costs	Finstown Second 132kV Infeed	[redacted]
Finstown Substation Costs	Finstown Second 132kV Infeed	[redacted]
EHV Sub Cable	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV OHL (Pole Line) Conductor	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV Pole	Thurso South - Scorradale New 33kV Circuit	[redacted]
33kV UG Cable (Non Pressurised)	Thurso South - Scorradale New 33kV Circuit	[redacted]
Thurso South Substation Costs	Thurso South - Scorradale New 33kV Circuit	[redacted]
Scorradale Substation Costs	Thurso South - Scorradale New 33kV Circuit	[redacted]
Third Party Flexible Solution Cost	Flexible Capacity between 2033 and 2040 for N-2	[redacted]
Sum		[redacted]

Benefits

With two new 33kV routes to South Ronaldsay and two new 33kV routes to Scorradale this option can significantly improve the supply resilience for the Orkney Islands.

Limitations

The biggest limitation of this option is the need for an additional 33kV subsea route by 2040 when compared with Option 2. Overall, Option 3 costs more money to install an extra 33kV subsea route. Option 3 is also subject to the installation of the 2nd Finstown transmission infeed by 2050.

7.4 Option 7: Additional 66kV cable followed by 66 kV upgrade of PFW and PFE.

Option 7 involves a new 57km 66kV circuit from Thurso South to South Ronaldsay via John O'Groats installed by 2029 as shown in Figure 12. The circuit includes a new 66kV OHL (30km) from Thurso South to the landing point of the submarine Cable (near John O'Groats) and a new 15km of 66kV submarine cable between John O'Groats and Burwick. Approx 10km of OHL and 1.5km of 66kV onshore cable are installed between Burwick and South Ronaldsay. Additionally, one 132/66 kV and another 66/33kV transformers with associated CBs are required at both Thurso South and South Ronaldsay. This work is within the RIIO-ED2 price control.

Further works are required to upgrade the PFW and PFE circuits to be running at 66kV between 2029 and 2032. This option is not reliant on another 132kV transmission infeed to Finstown GSP.

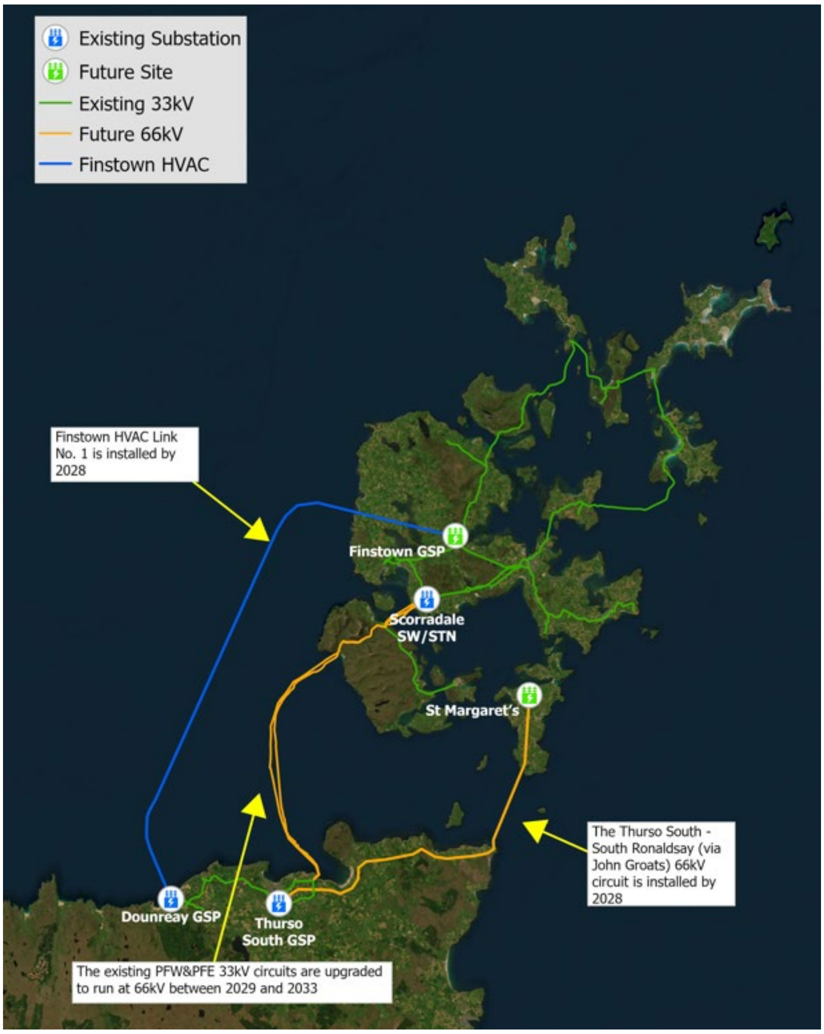

Figure 12 - Option 7 route map

Cost

The capital cost components of this option are a new 66kV cable route (subsea and onshore) and upgrades of the existing PFW and PFE circuits 66kV. This totals to [redacted]; which occurs through the current and subsequent price control periods. Table 19 provides a breakdown of cost.

Table 20 - Option 7 cost breakdown (2021 prices)

Line Items	Route	Cost (£m)
66kV Sub Cable	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV OHL (Pole Line) Conductor	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV Pole	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV UG Cable (Non Pressurised)	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
Thurso South Substation	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
South Ronaldsay Substation	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV Sub Cable	66kV PFW	[redacted]
66kV OHL (Pole Line) Conductor	66kV PFW	[redacted]
66kV Pole	66kV PFW	[redacted]
66kV UG Cable (Non Pressurised)	66kV PFW	[redacted]
Thurso South Substation	66kV PFW	[redacted]
Scorradale Substation	66kV PFW	[redacted]
66kV Sub Cable	66kV PFE	[redacted]
66kV OHL (Pole Line) Conductor	66kV PFE	[redacted]
66kV Pole	66kV PFE	[redacted]
66kV UG Cable (Non Pressurised)	66kV PFE	[redacted]
Thurso South Substation	66kV PFE	[redacted]
Scorradale Substation	66kV PFE	[redacted]
Sum		[redacted]

Benefits

Option 7 is not subject to requirement for the installation of the 2nd Finstown transmission infeed. It provides the best cost benefit solution for the strategy of one new 66kV route to South Ronaldsay and upgrading PFW and PFE circuits to 66kV. This can significantly improve the supply resilience for the Orkney islands.

Limitations

The biggest limitation of this option is that it may prove to not be the optimum solution if a second transmission link is later triggered due to generation connections.

7.5 Option 8: 66kV upgrade of PFW and PFE followed by additional 66kV cable.

Option 8 includes the upgrade of PFW and PFE circuits to run at 66kV by 2029. This option also requires installation of a 57km 66kV cable from Thurso South - South Ronaldsay via John O'Groats between 2025-2033.

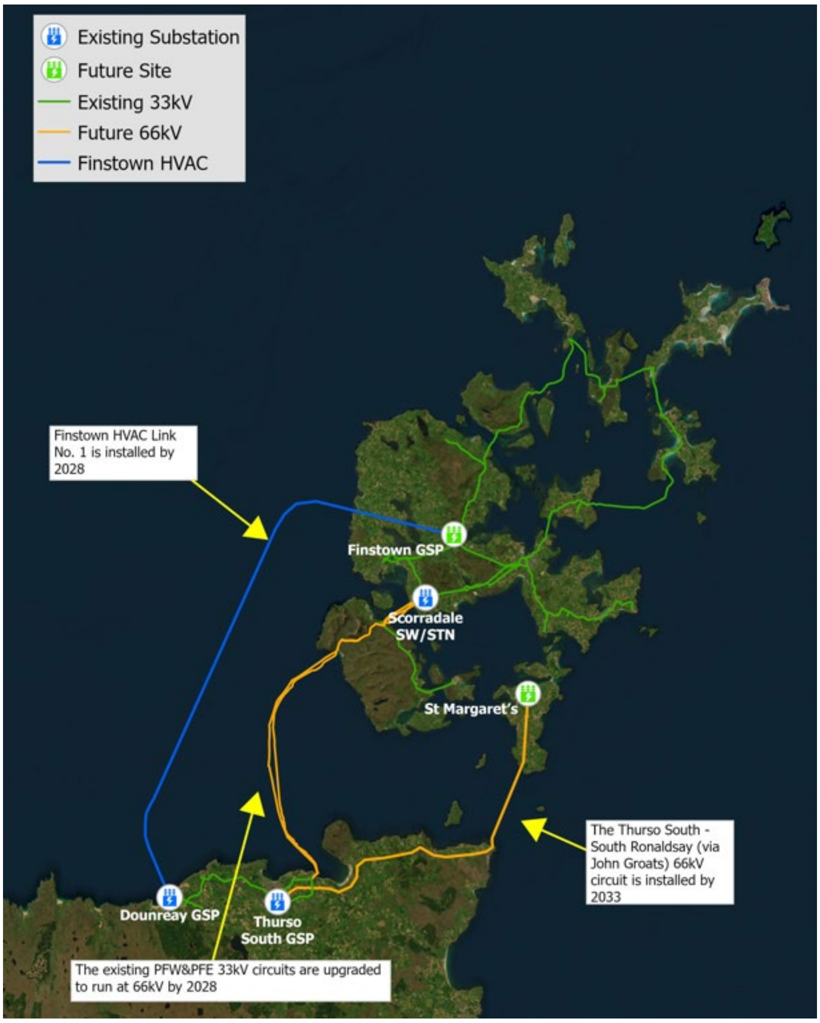

Figure 13 - Option 8 route map

Cost

The capital cost components of this option are the same as the total cost of Option 7. This totals to [redacted]; which occurs through the current and subsequent price control periods.

Table 21 - Option 8 cost breakdown (2021 prices)

Line Items	Route	Cost (£m)
66kV Sub Cable	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV OHL (Pole Line) Conductor	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV Pole	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV UG Cable (Non Pressurised)	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
Thurso South Substation	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
South Ronaldsay Substation	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV Sub Cable	66kV PFW	[redacted]
66kV OHL (Pole Line) Conductor	66kV PFW	[redacted]
66kV Pole	66kV PFW	[redacted]
66kV UG Cable (Non Pressurised)	66kV PFW	[redacted]
Thurso South Substation	66kV PFW	[redacted]
Scorradale Substation	66kV PFW	[redacted]
66kV Sub Cable	66kV PFE	[redacted]
66kV OHL (Pole Line) Conductor	66kV PFE	[redacted]
66kV Pole	66kV PFE	[redacted]
66kV UG Cable (Non Pressurised)	66kV PFE	[redacted]
Thurso South Substation	66kV PFE	[redacted]
Scorradale Substation	66kV PFE	[redacted]

Line Items	Route	Cost (£m)
Sum		[redacted]

Benefits

Option 8 is to upgrade the PFE and PFW circuits to 66kV during the RIIO-ED2 period. [redacted]

Limitations

The biggest limitation of this option is that it sets a direction in RIIO-ED2 which may later prove to be less efficient if a second transmission link is installed. It also replaces the existing 33kV submarine cables earlier in their asset life than Option 7.

7.6 Option 7A: Additional 66kV cable (running at 33kV) during the RIIO-ED2 followed by 66 kV upgrade of PFW and PFE.

This proposed option builds on the outline of Option 7 but recommends that infrastructure constructed at 66kV is initially operated at 33kV to maintain optionality. Specifically, the proposed option involves a new 57km 66kV circuit from Thurso South to South Ronaldsay via John O'Groats installed by 2029 and running it at 33kV during RIIO-ED2. The circuit includes a new 66kV OHL (30km) from Thurso South to the landing point of the submarine cable (near John O'Groats) and the establishment of a new 15km of 66kV submarine cable between John O'Groats and Burwick. Approx 10km of OHL and 1.5km of 66kV onshore cable are installed between Burwick and South Ronaldsay. Additionally, two 33kV CBs are required at both Thurso South and South Ronaldsay. This work is within the RIIO-ED2 price control. Further works are required to upgrade the PFW and PFE circuits to be running at 66kV between 2029 and 2033. This option is not reliant on another 132kV transmission infeed to Finstown GSP.

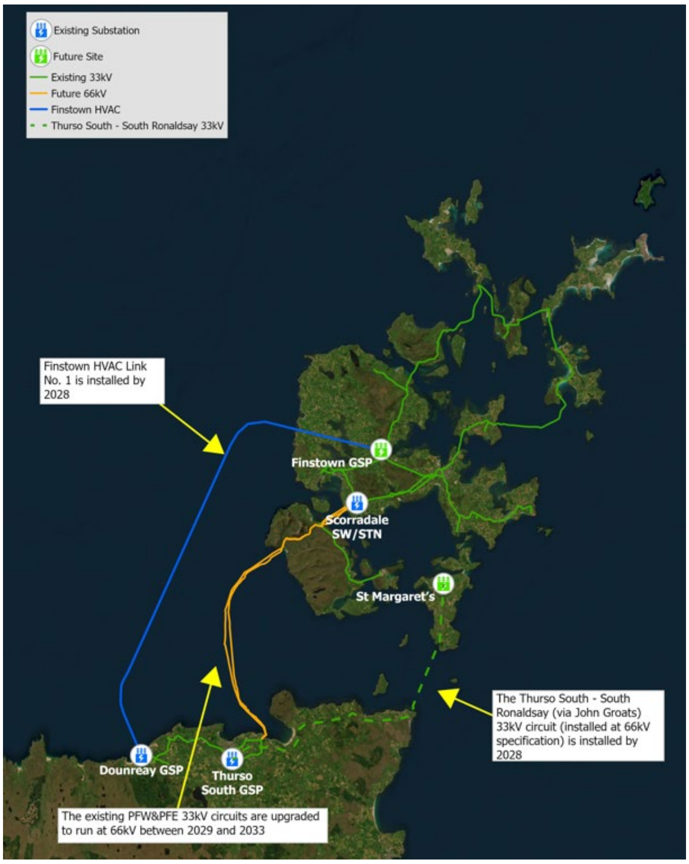

Figure 144 - Option 7A route map

Cost

The capital cost of this option is [redacted]; which occurs through the current and subsequent price control periods.

Table 22 – Proposed Option cost breakdown (2021 prices)

Line Items	Route	Cost (£m)
66kV Sub Cable	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV OHL (Pole Line) Conductor	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV Pole	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV UG Cable (Non Pressurised)	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
Thurso South Substation	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]

Line Items	Route	Cost (£m)
South Ronaldsay Substation	66kV Thurso South - Ronaldsay via John O'Groats	[redacted]
66kV Sub Cable	66kV PFW	[redacted]
66kV OHL (Pole Line) Conductor	66kV PFW	[redacted]
66kV Pole	66kV PFW	[redacted]
66kV UG Cable (Non Pressurised)	66kV PFW	[redacted]
Thurso South Substation	66kV PFW	[redacted]
Scorradale Substation	66kV PFW	[redacted]
66kV Sub Cable	66kV PFE	[redacted]
66kV OHL (Pole Line) Conductor	66kV PFE	[redacted]
66kV Pole	66kV PFE	[redacted]
66kV UG Cable (Non Pressurised)	66kV PFE	[redacted]
Thurso South Substation	66kV PFE	[redacted]
Scorradale Substation	66kV PFE	[redacted]
33kV PFE Regulator	33kV PFE Regulator Replacement works	[redacted]
33kV Thurso South Substation during RIIO-ED2	66kV Thurso South - Ronaldsay via John O'Groats Running at 33kV	[redacted]
33kV South Ronaldsay Substation during RIIO-ED2	66kV Thurso South - Ronaldsay via John O'Groats Running at 33kV	[redacted]
Sum		[redacted]

Benefits

The proposed option is to construct the proposed Thurso South - Ronaldsay circuit as 66kV but to operate the circuit at 33kV during the RIIO-ED2 period.. If the demand grows as forecast, this option will develop into Pathway 1 with 66kV development as described in Option 7. If generation development triggers the requirement of the 2nd Finstown infeed, this option will develop into Pathway 2 to install additional 33kV subsea routes to Orkney islands, as described in Option 2.

Limitations

This option will require an amount of 33kV equipment during RIIO-ED2 when the 66kV Thurso South - Ronaldsay circuit is running at 33kV. This option therefore costs incrementally more than Option 7.

7.7 Use of flexibility

We issued a Request for Information (RFI) for island flexibility services in August 2024. This has enabled us to understand the potential number or type of services that could be provided for use in Scottish islands. This exercise has not identified one specific location with significant volumes of flexibility resource that could be used to avoid the complete use of diesel generation or deferral of investment in RIIO-ED2 timescales. However, it has confirmed there is significant interest in participating in Flexibility Services in the islands, but investment would be required by individual parties which is difficult to justify without certainty of use and therefore income streams.

7.7.1 Flexibility Option During RIIO-ED2

The CEM assessment applying [redacted] availability/utilisation prices shows (in Figure 15) expenditure on the initial 66kV cable can be deferred for one year under the CT, FS and ST scenario. There is no deferral under the LW scenario. The cumulative NPV in Figure 16 also shows the impacts under different scenarios. As there was insufficient flexibility identified under the RFI, we do not recommend deferring Option 7A during RIIO-ED2. We will continue to support the development of flexibility resource that could provide flexibility services for use on Scottish islands in RIIO-ED3.

		Overall NPV of deferral	Optimal length of baseline deferral (years)	NPV of optimal deferral
Config	1	Flexibility under Consumer Transformation	1	[redacted]
Config	2	Flexibility under Falling Short	1	[redacted]
Config	3	Flexibility under Leading the Way	Baseline	£0
Config	4	Flexibility under System Transformation	1	[redacted]

Figure 15 – Optimal Length of Baseline Deferral for RIIO-ED2 Expenditure

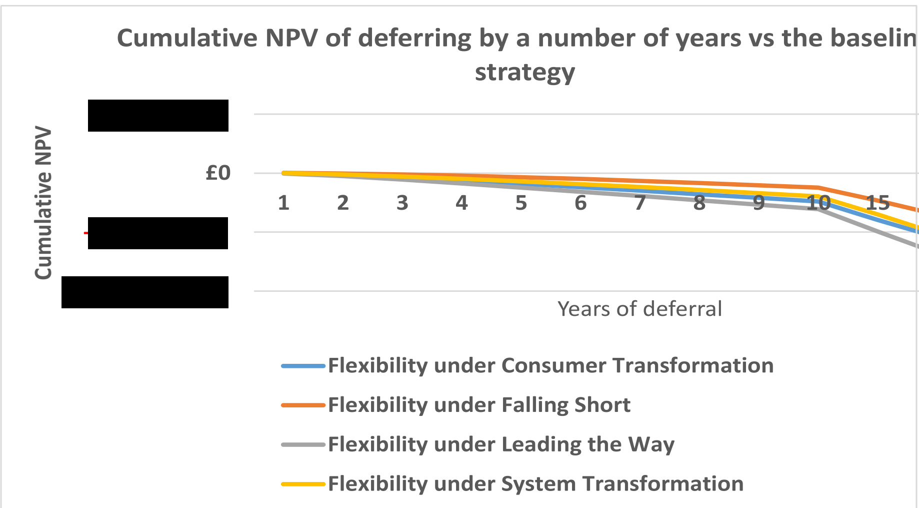

Figure 16 – Cumulative NPV of Deferring Investment in RIIO-ED2 66kV Works

7.7.2 Flexibility Option for the Second Transmission Link

There is a need to provide additional resilience through a second transmission link to Finstown from 2033 in the generation export pathway (Option 2) to allow removal of reliance from DEG. Figure 17 shows the peak load in Orkney islands against the N-2 network capacity from 2033 to 2050.

We used the CEM tool to investigate how flexibility can be used to provide support from 2032 in lieu of a second transmission link to Finstown.

The CEM assessment with [redacted] availability/utilisation prices shows (in Figure 18) that the second transmission link expenditure can be deferred for fifteen years under the CT scenario. There is deferral of seven years under the LW scenario. The cumulative NPV in Figure 19 also shows the impacts under different scenarios. As there is uncertainty on the commissioned year for the second transmission link given this is dependent on generation applications in the Orkney islands, we will still propose to install the second transmission link by 2040, and use flexibility services for Option 2 and Option 3 to provide N-2 resilience between 2033 and 2040. We will review this requirement of flexibility services in preparation for RIIO-ED3.

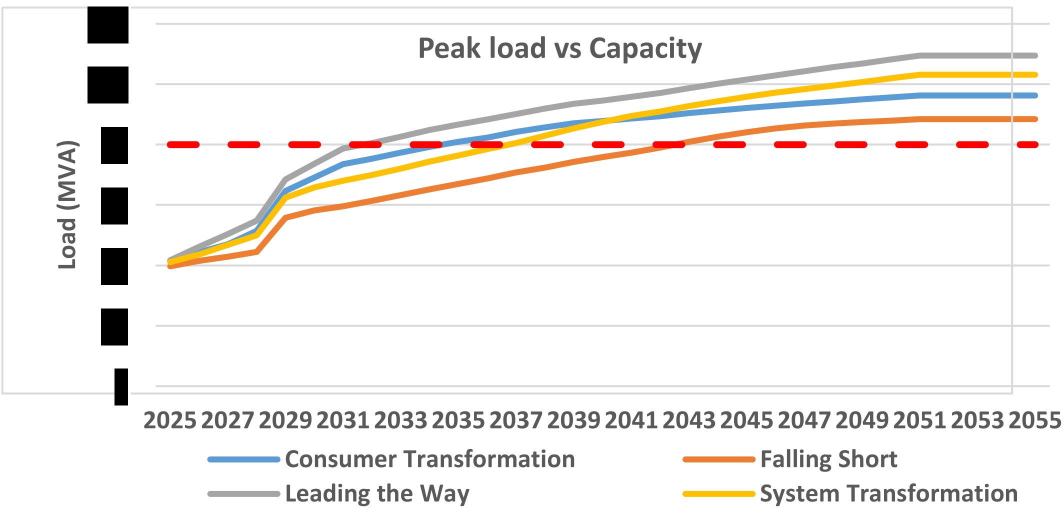

Figure 17 - Peak Load vs Network Capacity in 2032 (N-2)

	Overall NPV of deferral	**Optimal length of baseline deferral (years)**	**NPV of optimal deferral**
Config 1	Flexibility under Consumer Transformation	15	[redacted]
Config 2	Flexibility under Falling Short	45	
Config 3	Flexibility under Leading the Way	7	
Config 4	Flexibility under System Transformation	10	

Figure 18 – Optimal Length of Baseline Deferral for the Second Transmission Link to Finstown

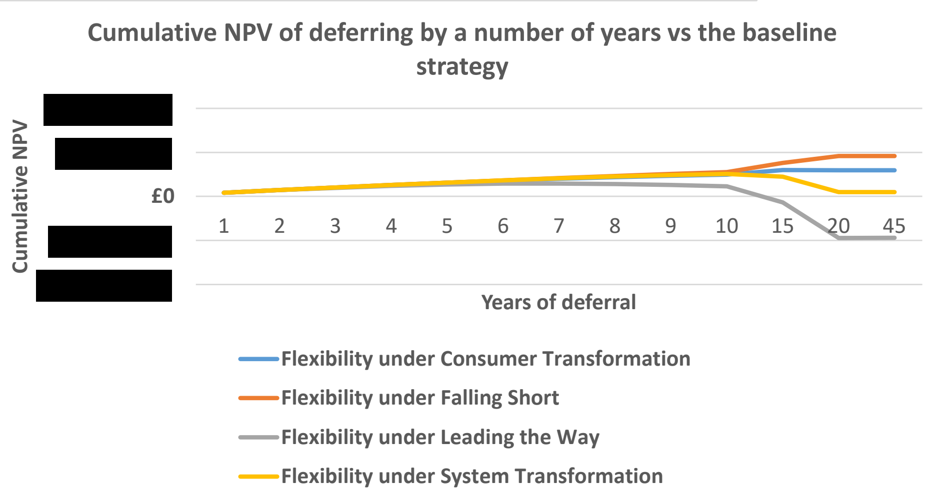

Figure 19 – Cumulative NPV of Deferring Investment in Second Transmission Link

7.8 Option Summary

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 in which we operate.

The table below provides an overall summary of the options considered or shortlisted for financial and CBA appraisal and includes options discounted.

Table 23 - Option Summary Table

Options	Contributes to Primary Driver	Contributes to SSEN Net Zero/SBT Commitment	Technically Feasible	Cost Effective	Confident in Outcome	Delivery Risk	Take Option Forward to CBA
Baseline – Do nothing	No	No	Yes	No	No	[redacted]	No
Option 2	Yes	Yes	Yes	No	Yes		Yes
Option 3	Yes	Yes	Yes	No	Yes		Yes
Option 7	Yes	Yes	Yes	Yes	Yes		Yes
Option 8	Yes	Yes	Yes	Yes	Yes		Yes
Option 7A	Yes	Yes	Yes	Yes	Yes		Yes

8 Cost Benefit Analysis (CBA)

This section outlines the process undertaken and the output of the Cost Benefit Analysis (CBA). We have conducted a full CBA for each option on the shortlist that was technically feasible.

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 23.

8.1 CBA of investment options

The expenditure components, split by capital expenditure (Capex) and operational expenditure (Opex), for the next three price control periods are displayed in Table 24. The vast majority of these costs are made up of capital costs, with operating costs accounting for a smaller fraction of total expenditure. [redacted]

Table 24 - Cost Summary - 2021 Prices (£m)

	RIIO-ED2			RIIO-ED3			RIIO-ED4		
Options	Capex	Opex	Totex	Capex	Opex	Totex	Capex	Opex	Totex
Option 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 7	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 8	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 7A	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

The cost summary in Table 23 shows that Option 2 is the least costly of all the options in RIIO-ED2 which meet the investment needs. The most expensive options are Option 7, 7A and 8.

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 2050 for all options.

8.2 CBA Results

The output of the CBA is displayed below in Table 25.

Table 25 - Net Present Value at different intervals (-£m, 2021 prices)

Options	10 years	20 years	30 years	45 years	Whole life (55 years)
Option 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 7	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option 8	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option7A	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

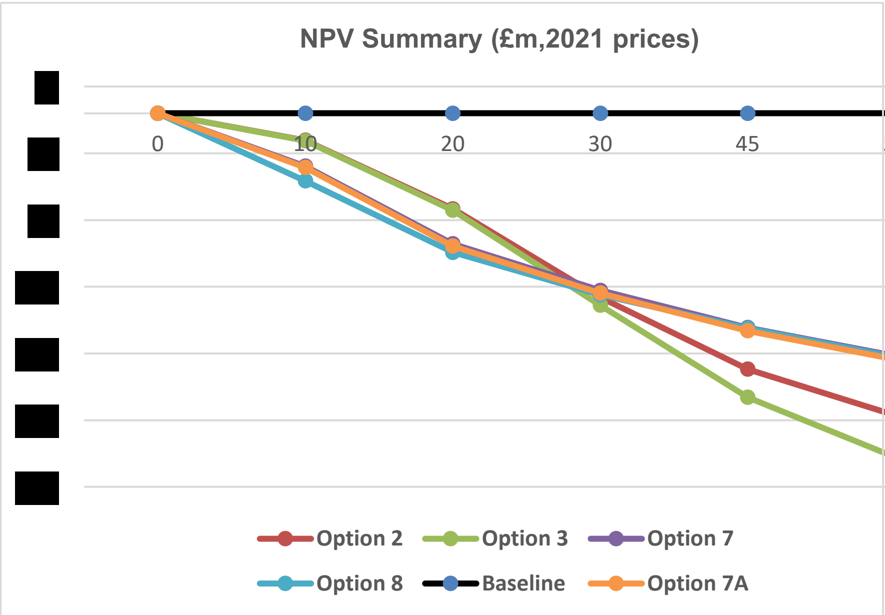

Figure 2021 - NPV Summary for Options

The NPV is heavily driven by capital expenditure, which therefore logically leads to Option 3 producing the least positive result and Option 7 displaying the most positive NPV.

The output tables below 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 submarine 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.

Table 26 Option Whole Life Costs (£m, 2021 prices)

Options	Capex	Opex	DEG	Totex
Option 2	[redacted]	[redacted]	[redacted]	[redacted]
Option 3	[redacted]	[redacted]	[redacted]	[redacted]
Option 7	[redacted]	[redacted]	[redacted]	[redacted]
Option 8	[redacted]	[redacted]	[redacted]	[redacted]
Option 7A	[redacted]	[redacted]	[redacted]	[redacted]

As in Table 26 Options 7 and 8 also have the lowest expected capital and operating costs over the whole life of the assessment period (55 years). Option 3 is the costliest option.

Table 27 Option Whole Life Benefits (£m, 2021 prices)

Options	Total Societal Net Benefits	Total DNO Net Benefits
Option 2	[redacted]	[redacted]
Option 3	[redacted]	[redacted]
Option 7	[redacted]	[redacted]
Option 8	[redacted]	[redacted]
Option 7A	[redacted]	[redacted]

Option 8's Societal Benefits are the most positive of all options considered. This is driven by the relative reduction in losses of the upgraded PFW and PFE 66kV submarine cable to achieve greater societal benefits than Option 7/7A. The DNO net benefits for Options 7, 7A and 8 also have more positive benefits than those of Option 2 and 3.

9 Preferred option

SHEPD has identified that there are two diverging pathways (Option 7/7A and Option 2) as potential preferred options for meeting the region's electricity demands whilst ensuring a resilient network, sufficient capacity, and low carbon footprint. The detailed options analysis as mentioned above concluded that Option 7 (Pathway 1) was the most suitable option at this time in providing a solution to the needs case. This is because it is the most economical of all the short-listed options, alongside Option 8, and delivers the best long term value to customers. However, if transmission works are needed to connect further generation, and a second transmission link is necessitated, then Option 2 (Pathway 2) would become the most efficient solution. In this scenario, RIIO-ED2 works proposed under Options 7 (construction and operation of new cable at 66kV) or 8 (early intervention on PFE and PFW) would no longer be optimum.

We therefore identified the additional Option 7A under which we would progress the interventions recommended in Option 7 but operate new 66kV assets at 33kV within RIIO-ED2. We believe that the small increased cost would mitigate regretted investment in other options in the context of uncertainty on future demand and generation growth scenarios, by enabling future optionality to follow either Pathway 1 (Option 7) or Pathway 2 (Option 2) from RIIO-ED3.

Both pathways commence with the installation of a new 66kV submarine cable (running at 33kV) between Thurso South and South Ronaldsay substation during RIIO-ED2. Two pathways then develop during the RIIO-ED3: 1) Pathway 1 - upgrading the existing 33kV Pentland Firth East (PFE) and Pentland Firth West (PFW) circuit to run at 66kV; 2) Pathway 2 - installing a new 33kV subsea route to Scorradale. Onshore connections to substations will support each route.

The current optimum pathway is therefore Option 7A that is refined from Option 7, but this will be reviewed in preparation for RIIO-ED3.

10 Deliverability and Risk

This section documents the approach to delivery, list any potential deliverability constraints and any necessary mitigation strategies that will need to be undertaken to minimise the risk of delivery of the first stage of the project in RIIO-ED2.

10.1 Delivery Strategy

[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. [redacted]

To deliver the sub-sea cable package [redacted]

10.1.1 Project Plan

The submarine cable programme is to survey the proposed marine routes in 2026 and complete the detailed design and engineering following this in the following year. On completion of the design, all consent applications will be prepared and applied for in 2026. Procurement of the submarine cable is planned to commence mid to end of 2027 enabling installation in 2028. Below we set out the project plan for the delivery of this project.

10.2 Procurement and Contracting Strategy

This section details the procurement and contracting strategy for the Thurso South – South Ronaldsay elements, 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]

[redacted]

The section highlights the contracting approach undertaken by SHEPD for the Thurso South – South Ronaldsay sub-sea 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 submarine 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 [redacted]

As referenced above, the proposed contracting structure for the Thurso South – South Ronaldsay submarine cable replacement project [redacted]

- [redacted]
- [redacted]

[redacted]

10.2.1 Work undertaken in RIIO-ED1 & ED2

The purpose of the marine engineering desktop studies is to progress early engineering of the potential sub-sea cable routes. We have completed initial desktop route analysis and the studies have identified potential routes which can now be progressed to full desktop study and survey.

10.2.2 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.

10.3 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.

10.3.1 Regional variations in cost

The implementation of sub-sea cables in the Thurso South presents unique challenges and cost considerations compared to onshore or underground installations. [redacted]

10.3.2 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. [redacted] Through these procedures, SHEPD has developed a robust cost estimate for this EJP.

10.4 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.

10.4.1 Risk and Mitigations

A list of the risks and mitigations are provided below.

1) **Delivery:** [redacted]
   a. **Mitigations:** [redacted]
2) **Remote location:** The Orkney Islands have 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:** [redacted]
3) **Unprecedented cost increase:** Resource constraints have driven up labour costs, while the Ukraine Conflict has disrupted the global supply chain, causing price hikes and material scarcity. [redacted]
   a. **Mitigations:** [redacted]
4) **Challenging insurance market:** [redacted]
   a. **Mitigations:** [redacted]
5) **Capacity of cable manufacturers:** Cable must have SHEPD Design Authority approval and no factory joints.

a. **Mitigations:** [redacted]

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

11 Outlook to 2050 (Uncertainty)

The nature of the Orkney islands network leads to a need for whole systems thinking ensuring coordination between transmission and distribution to find the optimal solution. In this instance a proposed 2nd 132kV link to Orkney has been assessed against, and in conjunction with distribution solutions at 33kV and 66kV. The proposed solution involves installation in RIIO-ED2 of a 66kV submarine cable from Thurso South to South Ronaldsay and the operating of this circuit at 33kV in order to maintain optionality in the wake of uncertainty in the region. This solution will not meet needs in 2050 based on current estimates however by choosing a pathway solution with commonality across the options it enables better use of current assets and delays decision points until increased certainty of growth in the region. This strategy will allow SSEN to make the most optimal decision and provide maximum value to customers.

12 Conclusion and Recommendation

SHEPD has identified that there are two diverging pathways (Option 7/7A and Option 2) as potential preferred options for meeting the region's electricity demands whilst ensuring a resilient network, sufficient capacity, and low carbon footprint.

Both pathways commence with the installation of a new 66kV submarine cable (running at 33kV as proposed under Option 7A) between Thurso South GSP and South Ronaldsay substation during the RIIO-ED2. Two pathways then develop during RIIO-ED3: 1) Pathway 1 – a pathway based on demand resilience where 66kV submarine links are installed to the Orkney Islands (Option 7); 2) Pathway 2 - a pathway based on generation export where an additional transmission circuit is supported by 33kV reinforcement (Option 2).

The current optimum pathway is Pathway 1 (Option 7/7A), but this will be reviewed in preparation for RIIO-ED3.

Pathway 1 (Option 7/7A) meets all our primary drivers, is the most cost-effective option and provides the region with [redacted] capacity in addition to providing sufficient capacity for demand growth until at least 2050 according to our DFES projections. However, if transmission works are needed to connect further generation, and a second transmission link is necessitated, then pathway 2 (Option 2) would become the most efficient solution. To combine the benefits of Option 7 and Option 2, Option 7A is refined to be the preferred option to pursue two diverging pathways (Option 7 and Option 2). Option 7A costs [redacted] during RIIO-ED2 and the new cable (66kV running at 33kV) will be delivered in 2028/2029.

Therefore, in conclusion, SHEPD concluded to pursue Option 7A ensuring that we continue to provide a resilient network, with sufficient capacity, and lower carbon footprint all whilst ensuring a cost-effective engineering solution. We believe that the retained pathway optionality benefits outweigh the additional lifetime costs of less than [redacted].

13 References

The documents detailed in Table 28 - Scottish and Southern Electricity Networks Documents, Table 28 – External Documents, and Table 12.3 – Miscellaneous Documents, should be used in conjunction with this document.

Table 28 - Scottish and Southern Electricity Networks Documents

Reference	Title
	HOWSUM-Core Re-opener Narrative

Table 29 – External Documents

Reference	Title
	Technical Report of Orkney Network Analysis

14 Subsequent Sections

15 Revision History

No	Overview of Amendments	Previous Document	Revision	Authorisation
01				
02				

Appendix A Definitions and Abbreviations

Table 0.1 – Definitions and Abbreviations

Acronym	Definition
AIS	Air-insulated Switchgear
ASCR	Aluminium Conductor Steel Reinforced
BSP	Bulk Supply Point
Capex	Capital Expenditure
CBA	Cost Benefit Analysis
CBRM	Condition Based Risk Management
CEM	Common Evaluation Methodology
CI	Customer Interruptions
CML	Customer Minutes Lost
CNAIM	Common Network Asset Indices Methodology
CT	Consumer Transformation
DEG	Distributed Embedded Generation
DFES	Distribution Future Energy Scenarios
DGAD	Distributed Generation Automatic Disconnection
DNO	Distribution Network Operator
EJP	Engineering Justification Paper
EoL	End of Life
ESA	Electricity Supply Area
EV	Electric Vehicle
FCO	First Circuit Outage
FES	Future Energy Scenarios
GIS	Geographic Information System
GM	Ground Mounted
GSP	Grid Supply Point
HI	Health Index
HOWSUM	Hebrides and Orkney Whole System Uncertainty Mechanism
IDP	Investment Decision Pack
IIS	Interruptions Incentive Scheme
LA	Local Authority
LCT	Low Carbon Technology
LEP	Local Enterprise Partnership
LI	Load Index
LRE	Load Related Expenditure

LW	Leading the Way
MD	Maximum Demand
NPV	Net Present Value
OHL	Overhead Line
Opex	Operational Expenditure
PFE	Pentland Firth East
PFW	Pentland Firth West
PM	Pole Mounted
PV	Photovoltaics
RIIO-ED2	The Current Electricity Distribution Price Control
RIIO-ED3	The next Electricity Distribution Price Control
RIIO-ED3+	Future Electricity Distribution Price Controls
RFI	Request for Information
RSN	Relevant Section of Network
SBT	Science Based Targets
SCO	Second Circuit Outage
SHEPD	Scottish Hydro Electric Power Distribution
SSEN	Scottish and Southern Electricity Network
SP	Steady Progression
ST	System Transformation
VfM	Value for Money
TO	Transmission Operator
XLPE	Cross-linked Polyethylene