SHETLAND FUTURE DEVELOPMENTS

BEYOND 10 YEAR PLAN

Scottish & Southern Electricity Networks

CONTENTS

1 Executive Summary

The Shetland Islands sit over 100 miles off the coast of north-east Scotland as the most northerly outpost of Great Britain (GB). It comprises a vibrant Island community which is dependent on a reliable power source to support its key industries of fishing, oil and gas exploration, agriculture and tourism which provide the mainstay of employment opportunities on the Islands. For decades, the reliable power supply has been provided by Lerwick Power Station (LPS) – a diesel based power station commissioned back in the 1950s. In recent years this has been supplemented by Sullom Voe Terminal (SVT) and other Distributed Generation (DG), mainly onshore wind generation.

The emergence of onshore wind farms (particularly Viking Energy Wind Farm) has enabled Shetland to be connected to the GB Electricity System via a HVDC Transmission link due to be energised in April 2024 with the Gremista GSP energised in November 2025 to connect to the existing SHEPD network. The continued drive to net zero creates further opportunities for renewable generation in the form of additional onshore as well as offshore wind, alongside tidal power and new demand[1] over the next 20-30 years. Table 1-1 below summarises some of the potential developments around Shetland and current level of confidence in those developments firming up:

Table 1-1: Shetland Demand/Generation Developments

Scenario	New Transmission Connected Generation	New Transmission Connected Demand
High Certainty	2,985 MW	400 MW
Mid Certainty	3,485 MW	1,422 MW
Low Certainty	3,635 MW	3,420 MW

In this context – and including our Distribution Future Energy Scenarios (DFES) for Distribution Demand and Generation – we have considered what the longer-term security of supply pathways for Shetland look like out to 2050 and beyond. Group Demand on Shetland is currently 44MW (Distribution) and there is no interruption to the entire Group Demand for a First Circuit Outage (FCO) as it is secured immediately by generation at LPS, supported by SVT and DG. By 2050 it is forecast that Group Demand on Shetland could be 3,514MW (94MW Distribution) meaning that the entire Group Demand will need to be secured immediately for a FCO and in addition the majority of the demand will need to be secured for Second Circuit Outages (SCO). This means that by 2050 we will need at least two and quite likely three routes of supply for Shetland[2]. The pathways to provide these routes are as follows (and summarised in Figure 1):

- **Pathway 1**: A single Transmission link supported by a battery and fault ride-through service. The battery and fault ride-through are required in the event of fault on the Transmission link to keep the lights on until LPS can get up to full capacity. We would need to seek a new service or battery at the end of the asset life (10-15years) and also invest in LPS to ensure that it is capable of running beyond the mid-2030s while also meeting environmental legislation.
- **Pathway 2**: This starts with the same solution as in Pathway 1 but sees a second Transmission link installed in the mid-2030s. Given lead times this is realistically the earliest point at which a second link could be operational. The second link would likely be in place of any investment in new battery asset or service at the end of the current service contract and would also likely reduce the investment required at LPS as less back-up capacity would be required.
- **Pathway 3**: This is the same as Pathway 2 but sees a third Transmission link installed (either at the same time as the second link or more likely later in the 2040s. A third link would likely remove the need for LPS or reliance on a battery service/other flexibility solutions.

Figure 1 below provides a summary of the pathways and key decision points.

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[1] Including hydrogen electrolysis, oil & gas platform electrification, carbon capture platforms.

[2] Customer engagement would be required to determine if two circuits is acceptable along with some form of Active Network Management to constrain demand/generation within the limits of two circuits.

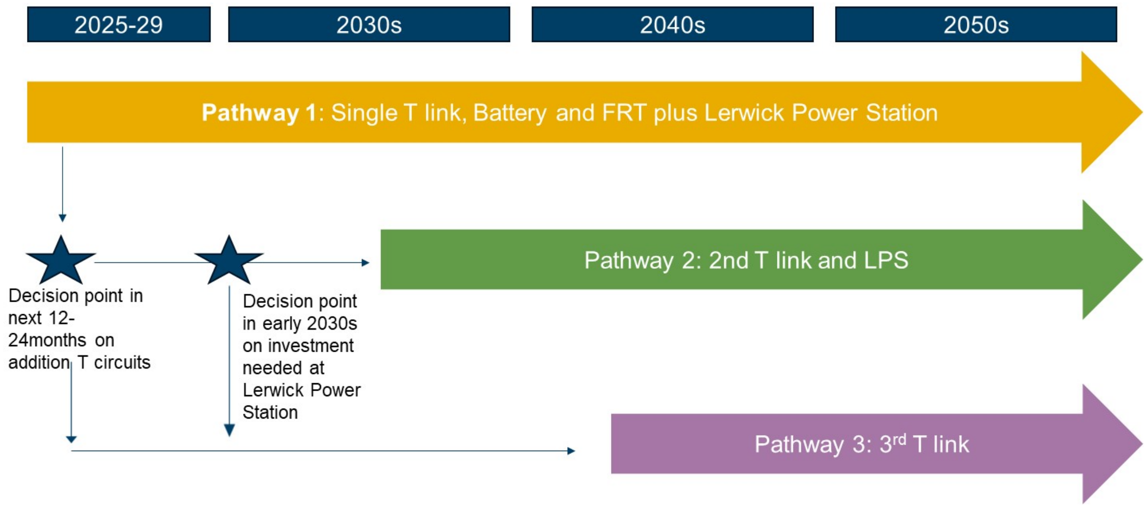

Figure 1 – Shetland Pathways and Key Decisions

We have assessed these pathways within a CBA to provide insights into the key trade-offs across these pathways. This analysis leads to some important conclusions which place our proposed investment for the Shetland Standby Solution in a longer term context. Firstly, a second Transmission link cannot be justified as a standalone Distribution solution – it is lower whole life cost to pay for a number of separate Standby Services over a 40-year period and invest in expanded capacity and new (more efficient) engines at LPS, than invest in a second transmission circuit. Consequently, the whole system solution will be driven by whether there is sufficient demand for further Transmission capacity by the new developments around Shetland. As outlined in Table 1 current engagement suggests that this is possible but this needs to be firmed up.

The CBA analysis also shows that depending on that needs case, there will be a decision to be made on whether it is efficient to install a third Transmission link at the same time as the second one, or wait. If the decision is made to wait, it will necessitate investment at LPS. The CBA currently shows that given the cost of a third Transmission link, this investment at LPS may be justified even if it simply defers the date at which investment is made in the third Transmission link by 4-5 years. There could be significant option value in such a deferral as it seems likely that following a second link, the volume of flexible resources available to manage security of supply would increase significantly (as well as diversity of these resources). This could negate the need for the third Transmission link even if there was additional need for capacity.

This assessment provides confidence that the investment in the Shetland Standby Solution is no regret – it is the most economic and efficient solution which can work alongside the new (single) Transmission link and LPS to secure supplies on Shetland. While a second Transmission link means reduced/avoided need for a Standby Service, there is currently no approved needs case and the timeline to get that in place within the asset life of the battery being used for the Standby Service (10 years).

Working closely with SHE Transmission, we will continue to engage with stakeholders to further refine the picture of emerging needs for capacity in and around Shetland. This will feed into the two key decision points in the next five years around the scale of Transmission investment needed and any requirement to also invest in upgrading LPS so that it can operate beyond the mid-2030s.

2 Introduction

2.1.1 There are a number of existing projects planned for Shetland which will see SHET establish a HVDC link and establish the Gremista GSP to connect and supply Shetland customers with electricity directly from the GB Mainland for the first time. At this point SHEPD has a project to secure the Shetland Standby Solution by converting LPS to become Standby Generation and procure a Standby Service; this will secure the supply to Shetland demand for faults/outages of the HVDC link.

2.1.2 As part of the Shetland Standby Solution the major benefit of the recommended solution is the flexibility it provides both to SHEPD and the Whole System with regards to optionality.

2.1.3 The rational for having the Medium Term period was to defer the replacement of LPS, allowing for the maturity of low carbon alternatives to replace Standby Generation (LPS) and the uncertainty around future wind farms and connections to oil and gas demand to become clearer.

2.1.4 At present the requirements for Shetland and the proposed solution can be split into distinct periods:

- Short Term (Existing): Present day to November 2024.
- Short Term (+1 Year): November 2024 to November 2025.
- Medium Term (10 Years): November 2025 to November 2035.
- Long Term (10 Years +): November 2035 Onwards.

2.1.5 This paper looks to document the Long Term strategy for Shetland and how the present solution and recommended Medium Term solution can be adapted to best suit the future customer requirements and network arrangements that may be required. To best consider the possible future scenarios, the Ofgem Cost Benefit Analysis (CBA) template has been used to provide Net Present Value (NPV) costs for the possible Long Term options.

2.1.6 It should be noted that the CBA and the NPV costs are used to provide a least regret basis for the recommended Medium Term solution and they do not seek to justify or seek a decision on which of the Long Term options should be progressed. This least regret analysis shall be considered by SHET as they progress with the wider Whole System solutions to meet customers' needs on Shetland and the surrounding area, including customers on the SHEPD network.

3 Background

3.1 Present:

3.1.1 At present the demand on Shetland is supplied by the SHEPD distribution network and is islanded from the GB Transmission System. The energy to supply Shetland demand is provided by generation at LPS, a Power Purchase Agreement (PPA) with SVT and DG.

3.1.2 LPS is reaching the end of its ability to operate as a full duty power station, but it can be retained as Standby Generation for a period of up to 10 years, subject to HVDC link reliability.

3.1.3 SHET is installing a single circuit 600MW HVDC link from the GB Mainland to Shetland and will install two 132kV circuits from Kergord to Gremista where the Gremista GSP will be established.

3.1.4 SHET will connect and supply the SHEPD demand through the Gremista GSP. In addition, they will connect 685MW of Wind Generation to their new Shetland Transmission network.

3.1.5 With the possibility that the mismatch between generation to demand on Shetland could be as high as 600MW if the single link to the GB Mainland was to fault, there is a need for Distribution Fault Ride Through (D-FRT) capability to absorb this excess during these faults and allow the SHEPD network to disconnect from the SHET network and avoid a blackout of Shetland[3].

3.1.6 SHEPD is recommending securing a Standby Solution for Shetland by retaining LPS as Standby Generation for 10 years and securing a Standby Service to provide D-FRT and energy storage until Standby Generation at LPS can be started.

3.1.7 Additional Standby Generation and Standby Service will be required if high demand growth occurs. Demand forecasts, considering DFES and large new connections, show the Shetland peak demand will not exceed 73MW within RIIO-ED2, but modular augmentation will likely be required in RIIO-ED3 for most DFES scenarios.

3.1.8 NGESO/SHET have informed SHEPD that the energisation date for the Gremista GSP will now be November 2025. SHEPD is awaiting the formal update of the contractual documents from NGESO.

3.2 Future - SHEPD

3.2.1 Based on the present new connections and DFES-CT the Shetland demand is not forecast to significantly change or exceed the capability of the 600MW HVDC link or the Gremista GSP. Demand is forecast to grow from the existing 44MW up to 94MW by 2050.

3.2.2 There are several large generator connections coming forward that will exceed the N-1 capability of the Gremista GSP and therefore constrained/flexible connections will be required unless Gremista GSP and the 132kV circuits are reinforced by SHET. Generation is forecast to grow from the existing 13MW up to 51MW[4] by 2050, 171MW including BESS.

3.2.3 New large demand would trigger the Shetland Direction and pay their share towards the Standby Generation and Standby Service to be augmented.

3.2.4 Future network reinforcement will consider a Whole System approach, including reinforcement of the Gremista GSP, the need for future GSPs on or additional links to Shetland and the co-ordination of SHEPD and SHET cable and overhead line routes.

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[3] Existing supply is secure for N-1 events. Shetland is forecast in 2025/26 to be Class of Supply D for ENA EREC P2/8 which requires for First Circuit Outage: >60MW immediate GD-20MW.

[4] Excluding Standby Generation/Service & other BESS.

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3.3 Future - SHET:

3.3.1 There is a need for further development of the transmission network following completion of the first Shetland HVDC link and its connection to Gremista GSP. This is to enable the connection of transmission contracted generation and demand comprising of three consented windfarms with a total capacity of 240MW, two of which have a route to market (CfDs), and [redacted] of hydrogen electrolysis demand by 2028. There are further demand applications of about [redacted] that are currently being assessed for connection, with potential for more identified through stakeholder engagement.

3.3.2 The requirement to reduce carbon emissions from the Oil and Gas (O&G) industry by 50% by 2030 is driving the industry to electrify their assets. [redacted] SHET engagement with [redacted] has identified approximately [redacted] of further O&G platform electrification demand [redacted] of Shetland. Additionally, the [redacted] has also highlighted potential further electrification demand for carbon capture storage as they are licensing storage sites in the North Sea. They are starting work in 2024 to estimate the potential size and timing of this demand.

[redacted]

3.3.4 Against this background, working with SHEPD, the Shetland Island Council and other key stakeholders, SHET is taking a whole system strategic long-term approach to plan the development of the transmission system. Responses to developer webinars and questionnaire in 2023 have revealed significant interests in Hydrogen [redacted] confirmed offshore generation, oil and gas platform electrification around Shetland over a range of technologies including storage and flexibility services. Indicative timescales show that most of these ambitions are around the period 2028 to the mid-2030s.

3.3.5 Given the level of uncertainty over the timing of the hydrogen technology and infrastructure development, the approach to the long-term strategy is to identify a no regret short to mid-term development pathway which enables a plausible range of potential future pathways to net zero, depending on the speed and direction of technology development. The transmission strategy work is underway and scheduled to conclude in Q1 2024.

4 Long Term Plan

4.1 Pathways

Three possible future Long Term options have been identified for Shetland when considering the significant variation that could be possible.

4.1.1 Single Link to GB Mainland.

This option represents the existing situation remaining as it is with security of supply unchanged by large new demand and generation connections to the SHET network. SHET and SHEPD would again consider a Whole System approach to the D-FRT and SHEPD would secure the distribution connected demand as part of the future replacement of Standby Generation at LPS.

4.1.2 Dual Link to GB Mainland.

In this option a second link is established, SHEPD would still need to consider the significant mean time to repair for faults on the links and outages for maintenance/upgrade. SHEPD would reduce the requirements for the Standby Service and the integration of some elements into the replacement Standby Generation, which would be retained in some form. The D-FRT capability would now require SHET to resolve, due to significant changes in the possible size of demand/generation mismatch. This will consider two possibilities:

a) An additional 1800MW link, most likely triggered by [redacted] generation connecting to the SHET network.
b) An additional 600MW link, to demonstrate a lower cost for a link to Shetland, most likely triggered by demand connecting to the SHET network which requires a firm[5] connection.

4.1.3 Triple Link to GB Mainland.

In this option a third link is established, depending on the reliability of the HVDC links, the maintenance/repair times should no longer impact SHEPD and it would be possible to remove the need for the Standby Service and Standby Generation. Connection points would be established for emergency generation to be connected, if required for contingency plans. SHET would provide the D-FRT capability.

4.2 Option 1 - Single Link to GB Mainland

4.2.1 GB Mainland Links:

For this scenario the single circuit 600MW HVDC link which is under construction[6] will be the only link between GB Mainland and Shetland, due to be energised in April 2024. The Gremista GSP will be available in November 2025 with interconnection to the existing SHEPD network in the following months.

4.2.2 Standby Generation:

With only a single circuit to the GB Mainland SHEPD would retain Standby Generation on Shetland. This is available today and sufficient for the present demand providing that the forecast HVDC link availability is achieved. Reinforcement of LPS would be required for:

- Delays resulting in LPS operating at full duty beyond November 2025.
- HVDC Link unavailability above [redacted]%.
- DFES load increases beyond RIIO-ED2.
- New large demand connections[7].

Based on the 2022 DFES-CT scenario the Shetland demand connected to the SHEPD network is forecast to reach 71MW at the end of RIIO-ED2 which is forecast to be met by the existing

[5] Secured for N-1 faults/outages, but not be secured for N-2. Requires agreement/derogation from P2 & SQSS.
[6] Justified with Ofgem approval on condition of financial close of Viking wind farm and SHEPD contribution.
[7] 2MVA Rule applies to Shetland; demand above this funds reinforcement of Standby Generation and Standby Service.

Standby Generation at LPS with the addition of two new engines in 2025 which have been triggered by the connection of a large new demand connection.

A replacement will be required for the Standby Generation (presently LPS) by 2035. This could be done as a complete replacement or through partial replacement over time. It is more likely that demand growth will occur, as per the 2022 DFES-CT scenario, therefore partial replacement would be achieved as the new capacity is added. There will still be a need for a larger capital expenditure closer to 2035 for the replacement of the remaining older engines.

Future additional capacity, partial and full replacement of Standby Generation shall consider the long term strategy, low carbon alternatives and if it is possible to provide additional elements such as contribution to the D-FRT or reduce the need to continue to reserve capacity or carry out future augmentation of the energy storage.

4.2.3 Standby Service:

It will be necessary to maintain the D-FRT and increase the size of the energy storage beyond the initial 10 year period as there will be only one link and the demand is forecast to continue growing. Large demand connections in this period would also trigger a need for more capacity.

[redacted]

A new procurement exercise would consider:

- Whole System approach and consider if SHEPD is still best placed to provide D-FRT.
- The ability to combine elements of the Standby Service with the Standby Generation.
- Extension of the existing service contract.
- Flexibility services from other demand and generation customers (partial or full).
- Asset purchase if the market is unable to provide the required services.

4.2.4 Cost: This option has an NPV of £396m over 10 years and £1,070m over 45 years.

4.2.5 Discussion – Option 1:

This is the default position based on SHEPD Shetland UM being approved and no justification for additional links to the GB Mainland in the future.

4.3 Option 2 - Dual Link to GB Mainland

4.3.1 GB Mainland Links:

For this scenario there would be two HVDC links between the GB Mainland and Shetland. The first being the single circuit 600MW HVDC link which is under construction[6] and the second being either a larger 1800MW HVDC link or the same size as the first single circuit (600MW). The first circuit will be supplying SHEPD by November 2025 and second by November 2035.

4.3.2 Standby Generation:

Due to there being only two links, the risk remains that during maintenance or pro-longed outages of one of the links[8] the Shetland demand would be vulnerable to fault on the second one. As the distribution connected demand is forecast to remain below 100MW there is not a need for SHEPD to secure the demand immediately for N-2 events, but it is not acceptable to leave Shetland without power for these extended repair times. It is therefore proposed that Standby Generation would be retained on Shetland, and follow the same process as detailed in Section 4.2.2.

[8] Subsea cable faults could result in 65-120 days for the mean time to repair.

4.3.3 Standby Service:

The D-FRT and energy storage would be maintained for the 10 year period proposed, as per Section 4.2.3. Large demand connections in this period would also trigger a need for more capacity.

Once the second link is established the energy mismatch and therefore the D-FRT requirement would be much greater, it is assumed SHET would resolve this and no longer require SHEPD to support this through their Standby Service[9]. There is still a requirement for an immediate supply to secure the demand for N-1 events, providing the two links are operated normally in parallel and SHET maintain the D-FRT function this would be achieved[10].

There is not a requirement for N-2 events for the SHEPD demand[11] (P2 or SQSS) and therefore it is possible to remove the requirement for the Standby Service if the economics no longer support it. If some or all of the Standby Service is required beyond the 10 year period then SHEPD would follow the same process as details in Section 4.2.3.

4.3.4 Cost:

Large Link:	10 Year NPV of £920m and 45 Year NPV of £3,244m.
Large Link (2yrs Early):	10 Year NPV of £1,032m and 45 Year NPV of £3,289m.
Large Link (2yrs Late):	10 Year NPV of £644m and 45 Year NPV of £3,070m.
Small Link (Reduced Gen):	10 Year NPV of £436m and 45 Year NPV of £1,336m.

4.3.5 Discussion – Option 2:

When comparing Options 1 and 2 the cost of having two links to the GB Mainland (Option 2) is not preferred when compared to the cost of a single link and SHEPD providing the Standby Service and Standby Generation (Option 1).

The sensitivities have shown that bringing the second link forward by two years is not preferred either, it actually shows that deferring the costs (two years late) for the 2nd link is preferred even if you were able to make savings by reducing the Standby Service contract down to eight years. This is because the value of the deferred CAPEX for the links is considerably more than the cost of the Standby Service for a year. Even if a smaller capacity link is considered (the same size as the first 600MW HVDC link) along with not replacing the Standby Generation (which is not considered suitable for Shetland) the cost of Option 1 is still much more efficient.

[9] If analysis shows that a Whole System solution required SHEPD to continue with the Standby Service then this would be shown in the justification for the second link.

[10] An auto-changeover could be considered if quick enough to maintain existing quality and security of supply.

[11] There may be a wider need when considering SHET connected demand which SHET are considering.

4.4 Option 3 – Triple Link to GB Mainland

4.4.1 GB Mainland Links:

For this scenario there would be three HVDC links between the GB Mainland and Shetland. The first being the single circuit 600MW HVDC link which is under construction[6], the second being a larger 1800MW HVDC link and the third also being an 1800MW HVDC link. The first circuit will be supplying SHEPD by November 2025, the second by 2035 and the third by 2045.

4.4.2 Standby Generation:

With three links the risk of pro-longed outages is significantly reduced. It is therefore proposed that permanent Standby Generation would no longer be required on Shetland. Space will be secured, with consents, at key sites with connection infrastructure established to facilitate the connection of emergency generation as a contingency.

4.4.3 Standby Service:

The D-FRT and energy storage would be maintained for the 10 year period proposed, as per Section 4.2.3. Large demand connections in this period would also trigger a need for more capacity.

Once the second and third links are established the energy mismatch and therefore the D-FRT requirement would be much greater, it is assumed SHET would resolve this and no longer require SHEPD to support this through their Standby Service[9]. There is still a requirement for an immediate supply to secure the demand for N-1 events, but providing that two of the three links are operated normally in parallel and SHET maintain the D-FRT function this would be achieved[10].

For N-2 events, although not a requirement for the SHEPD demand[11] (P2 or SQSS), it will be secured either automatically if all three links are operated normally in parallel, or the SHEPD Shetland demand could be secured within switching time onto the third circuit.

Providing two of the links are operated in parallel and SHET maintain the D-FRT requirement then the Standby Service would not be required after the initial 10 year period.

4.4.4 Cost:

Third Link (2nd by 2035, 3rd by 2045): 10 Year NPV of £920m and 45 Year NPV of £4,589m.

Third Link (2nd & 3rd both by 2033): 10 Year NPV of £1,594m and 45 Year NPV of £5,335m.

4.4.5 Discussion – Option 3:

When comparing Options 1 and 3 the cost of having three links to the GB Mainland (Option 3) is not preferred when compared to the cost of a single link and SHEPD providing the Standby Service and Standby Generation (Option 1).

The sensitivities have shown that bringing the three links forward to 2033 is not preferred either, it shows that deferring the costs for the second and third links is preferred even if you were able to make saving by reducing the Standby Service contract down to eight years. This is because the value of the deferred CAPEX for the links is considerably more than the cost of the Standby Service for a year.

4.5 Summary of Options

4.5.1 Table 4-1 presents the summary of the CBA analysis for the three pathways based on the options described in this section:

Table 4-1: Shetland Demand/Generation Developments

Option	Sensitivity	10 Year NPV	45 Year NPV
Option 1 - Single Link to GB Mainland	None	£396m	£1,070m
Option 2 - Dual Link to GB Mainland	None	£920m	£3,244m
	Small Link Capacity and Reduced Standby Generation	£436m	£1,336m
Option 3 - Triple Link to GB Mainland	None	£920m	£4,589m

4.5.2 It can be seen that the preferred option on both a 10 year and 45 year NPV is Option 1.

4.5.3 A second, or third, link cannot be justified by SHEPD alone and would require a Whole System approach with SHET and other large customer connections.

4.5.4 If a second, or third, link are justified then Option 1 provides a no regret option allowing time for the development and construction of the future links in time for when they are needed, without incurring any higher costs.

4.5.5 This analysis shows that if Pathway 1 (single link) is progressed then there are two important decision points when moving to the other pathways (for a 2nd or 3rd link) to feed into the future needs for the Shetland Standby Generation and Standby Service. The first decision point is in the next 12-24 months such that SHEPD can determine their investment needs and strategy for augmenting and replacing Standby Generation in RIIO-ED3. The second decision point is in the early 2030s such that SHEPD can determine the ongoing need for Standby Generation and Standby Service in RIIO-ED4 and beyond. This is captured in Figure 2.

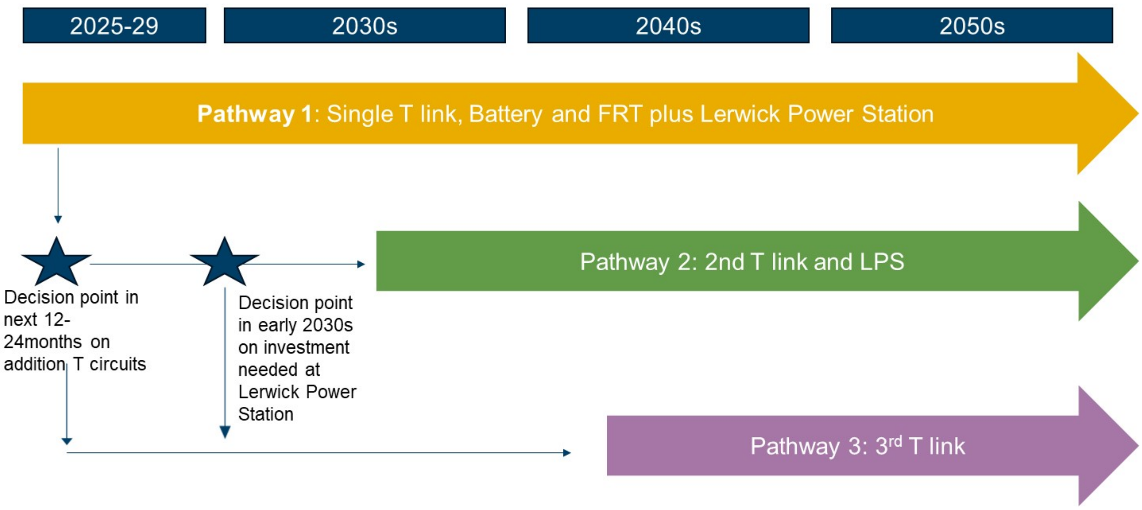

Figure 2 – Shetland Pathways and Key Decisions

5 Conclusion

5.1.1 The present solution (Option 1) offers the least regret overall when compared to the other options as well as being the most economical solution when only considering the SHEPD Shetland demand and generation.

5.1.2 If a second or third link is not justified, then Option 1 still provides the previously highlighted flexibility to flex to a low carbon solution for the replacement of the Standby Generation.

5.1.3 As additional Standby Generation capacity is required on Shetland the new capacity shall be provided from modern engines with lower emissions and consider the long term replacement of the Standby Service if technical studies allow.

5.1.4 Due to the high costs for links between the GB Mainland and Shetland, without further large demand and generation connections, SHEPD is unable to justify the cost for:

- The second or third link over the cost of Option 1.
- The cost associated with bringing forward the connection of a second or third link.

5.1.5 It is not possible to deliver a second or third link in the next few years, especially considering the time taken to consent and deliver the one which is already in construction. The present indication is a second link could be ready for 2035. SHEPD will need to provide an interim solution regardless of if a second link is approved and progressed to construction. Even considering an early installation of a second link the least cost and preferred solution is still not to bring forward the work.

5.1.6 If a future link is justified by future large demand and generation connections, then Option 1 provides a least regret option as it is cheaper compared to the alternatives and, providing a decision is known on if a second or third link is required prior to the replacement of the Standby Service and Standby Generation, it allows the flexibility to change and avoid stranded assets if decisions are made at the relevant decision points to feed into future investment decisions.

Appendix A Cost Benefit Analysis (CBA)

Attachment 3 – Long Term Options CBA.xlsx