EJP/SEPD/NURS/SAMP/001

SOUTHAMPTON BSP RESERVE BUSBAR AND 33KV NETWORK ENGINEERING JUSTIFICATION PAPER

CONTENTS

1 Executive Summary

1.1 Summary

The proposed investment at the Southampton BSP reserve busbar and the downstream 33kV network [redacted]

The primary investment drivers for this scheme are load related P2/8 compliance issues. The projected demand growth, as forecasted in the Distribution Future Energy Scenarios (DFES), has been used to identify specific problems within the network and to determine the necessary reinforcement works to accommodate this growth. Specifically, this EJP addresses future thermal overloading issues for the 60MVA 132/33kV Southampton BSP transformers, the 6.6kV switchgear and upstream 33kV circuit at Chapel Primary, as well as the 33kV circuits between Southampton–Central Bridge and Central Bridge–Old Docks. In addition, technical solutions also reflected upon the 132kV network connectivity of Southampton BSP to propose a futureproof design and ensure the network's capacity for long term expansion.

Two reinforcement options are proposed in this EJP to create the thermal capacity for the forecasted demand growth, namely the construction of a new BSP with a dedicated dual 132kV supply from Nursling GSP + reinforcement of the 33kV network (Option 2), as well as deferral of reinforcement proposed in Option 2 with flexibility (Option 3). High level descriptions of these options are summarised in Table 1, alongside the status quo option of Do Nothing (Option 1).

Table 1: Overview of options considered

	Option	Description	CBA Consideration and Result
1	Do nothing	[redacted]	[redacted] **Not progressed to CBA**
2	Construction of a new BSP + reinforcement of the 33kV network	This solution involves constructing a new BSP within the existing Southampton BSP compound to support the growing demand in the Southampton urban area, including the significant requirements of the Port of Southampton. To accommodate the assets of the new BSP, it is necessary to move the existing Southampton BSP 33kV switchboard indoors. The new assets will include an indoor 33kV switchboard, three 90MVA 132/33kV transformers, and a new 132kV indoor switchboard. Additionally, a dual 132kV underground circuit from Nursling GSP to the new BSP is proposed to enhance the network's capacity and reliability. Reinforcement of the 33kV network currently supplied via the Southampton BSP reserve busbar is also proposed. This involves the reinforcement of the 6.6kV switchboard at Chapel, an overlay of the Central Bridge – Old Docks and Central Bridge – Chapel circuit, alongside the installation of three new underground circuits from Central Bridge to the new BSP.	This is a viable solution and will therefore be **progressed to CBA**
3	Option 2 with the use of flexibility	Introduces flexibility into option 2. Defers multiple sets of reinforcement, namely the upgrade of the 6.6kV switchboard at Chapel Primary, as well as the upstream 33kV Central Bridge – Chapel circuit.	This is a viable solution and will therefore be **progressed to CBA**

		Other sets of reinforcement were deemed economically not beneficial.	

The preferred option of this scheme is Option 3, with the cost breakdown shown in Table 2.

[redacted]

The total reinforcement costs in RIIO ED2, ED3 and beyond [redacted] are planned for investment starting from 2025 with phased development, and flexibility is applied to defer the reinforcement where economic viability of using flexibility is proved. All price bases are 20/21, and the discount rate for the Net Present Value (NPV) is 3%. [redacted]

The scheme delivers the following outputs and benefits:

- The uplift in network capacity by 180MVA via the construction of a new BSP, necessary to meet the needs of our customers.
- Uplift in network capacity of 41.9MVA, 18.2MVA, 8.7MVA and 8.6MVA for the new BSP – Central Bridge circuit, Central Bridge – Old Docks circuit, Central Bridge – Chapel circuit and Chapel 6.6kV switchboard respectively.
- Facilitates the efficient, economic, and co-ordinated development of our Distribution Network for Net Zero.

2 Investment Summary Table

Table 3 provides a high-level summary of the key information relevant to this Engineering Justification Paper (EJP) which discusses the investment proposals for the Southampton BSP reserve busbar and 33kV network.

Table 3 Investment Summary Table

Name of Scheme/Programme	Southampton BSP reserve busbar and 33kV network	
Primary Investment Driver	Load related	
Scheme reference/ mechanism or category	**EJP/SEPD/NURS/SAMP/001**	
Output reference/type	***Construction of new BSP*** 33kV CB (Gas Insulated Busbars) (ID) (GM) Building cost for 33kV indoor switch room for Southampton and new BSP 33kV UG Cable (Non Pressurised) 132kV - TRAFO - 90MVA 132/33kV transformer 132kV CB (Gas Insulated Busbars) (ID) (GM) Building cost for 132kV indoor switch room for new BSP 132kV UG Cable (Non Pressurised) ***33kV network reinforcement*** 6.611kV CB (GM) Primary 33kV UG Cable (Non Pressurised) Flexibility procurement	
Cost	[redacted]	
Delivery Year	2025-2034	
Reporting Table(s)	CV1 – Primary reinforcement	
Outputs in RIIO ED2 Business Plan?	No	
Spend Apportionment	**ED2**	**ED3+**
	[redacted]	[redacted]
MVA released	No reinforcement to be completed by end of ED2	Construction of a new BSP: **180MVA** New BSP – Central Bridge circuit: **41.9MVA** Central Bridge – Old Docks circuit: **18.2MVA** Central Bridge – Chapel circuit: **8.7MVA** Chapel 6.6kV switchboard: **8.6MVA**

3 Appendices Summary

This EJP contains detailed information that is gathered throughout the analyses and assessments. For better readability, the detailed information is included as appendices. The Table below depicts an overview of the appendices of this EJP**.**

Table 4: List of appendices

Appendices	Description
Appendix A – Definitions and Abbreviations	Appendix A contains an overview of all used abbreviations and their definitions.
Appendix B – Network Assessments	Technical assessment of the existing/new network
Appendix C – Flexibility viability assessment	Contains the flexibility viability forms for all flexible solutions proposed

4 Introduction

This Engineering Justification Paper (EJP) for the Southampton BSP reserve busbar and 33kV network [redacted]

These issues are caused by a combination of contracted new customer connections under the respective substations, and an increase in peak demand growth forecasted by the Distribution Future Energy Scenarios (DFES). This EJP proposes technical options to address these issues and compares the associated cost of the solutions.

While the primary focus of this paper is on addressing the thermal overloading of the Southampton BSP reserve busbar transformers and the downstream 33kV supply, it is essential to consider the surrounding network to achieve the optimal overall solution. Equally important is the need to design proposed options with futureproofing in mind, ensuring the network's capacity for long-term expansion. Therefore, the technical options proposed in this paper will incorporate these considerations to ensure the network’s sustainable growth and streamline the process of accommodating additional customer connections.

The breakdown of each report section is given below:

Section 5 of this EJP describes our proposed load related investment plan for the reinforcement of the Southampton BSP reserve busbar and its downstream 33kV network. The primary driver considered within this paper is load-related, specifically the thermal overloading triggered by the demand forecasts.

This EJP provides high-level background information for this proposed scheme explaining the existing network arrangements, the load growth forecasts through the Distribution Future Energy Scenarios (DFES) and setting out the need for the upgrades. This section of the EJP additionally describes the network studies undertaken, detailing the results which further justify the need of the proposed investment.

Section 6 provides an overview of the considered options and identifies the most appropriate option as the proposed solution to address the network issues. This section includes a Table that summarises the net present value of all the options included in the Cost Benefit Analysis, the year in which each cost is incurred and the year in which each option would need to be triggered. Section 6 therefore summarises the results detailed in section 7 on the optioneering process and section 8 on the cost-benefit analysis of each option.

Section 7 provides an exhaustive list of the options considered through the optioneering process to establish the most economic and efficient solution. Each option is described in detail, with the EJP setting out the justification for the viable options taken forward to the Cost Benefit Analysis.

Section 8, Cost Benefit Analysis (CBA) Summary, provides the comparative results of all the options considered within the CBA and sets out the rationale and justification for the preferred solution. This section also describes how we have established the cost efficiency of the plan with reference to the unit costs that have been chosen.

Section 9 describes the deliverability of the plan for RIIO-ED2 and ED3+ and this proposed investment. It also addresses possible risks based on the required works, the proposed assets, and other surrounding factors, such as the procurement of additional construction space.

Section 10 addresses the strategic aspect of the investments and further needed actions to operating a congestion free grid until at least 2050.

Section 11 concludes the EJP and provides a summary of main conclusions and recommendations contained within this document. This includes the recommended preferred option, a summary of the costs and timeline of this option, a reasoning on the use of flexibility as well as key risk and delivering options.

5 Background Information

5.1 Existing Network Arrangements

Southampton BSP

Southampton (SAMP) BSP is located within the Nursling GSP region of the Southern Electric Power Distribution (SEPD) license area. Figures 1 and 2 illustrate its current configuration, consisting of Main 1 and Main 2 sections, each with a single 90MVA 132/33kV transformer, alongside a reserve bus section supplied by two 60MVA 132/33kV transformers. The complete network layout for both busbars is also presented as a single line diagram, seen in figure 3. Although this EJP focuses primarily on the Southampton BSP reserve busbar section and the downstream network, the full schematic of the entire BSP is necessary to understand its impact on the upstream 132kV feeders.

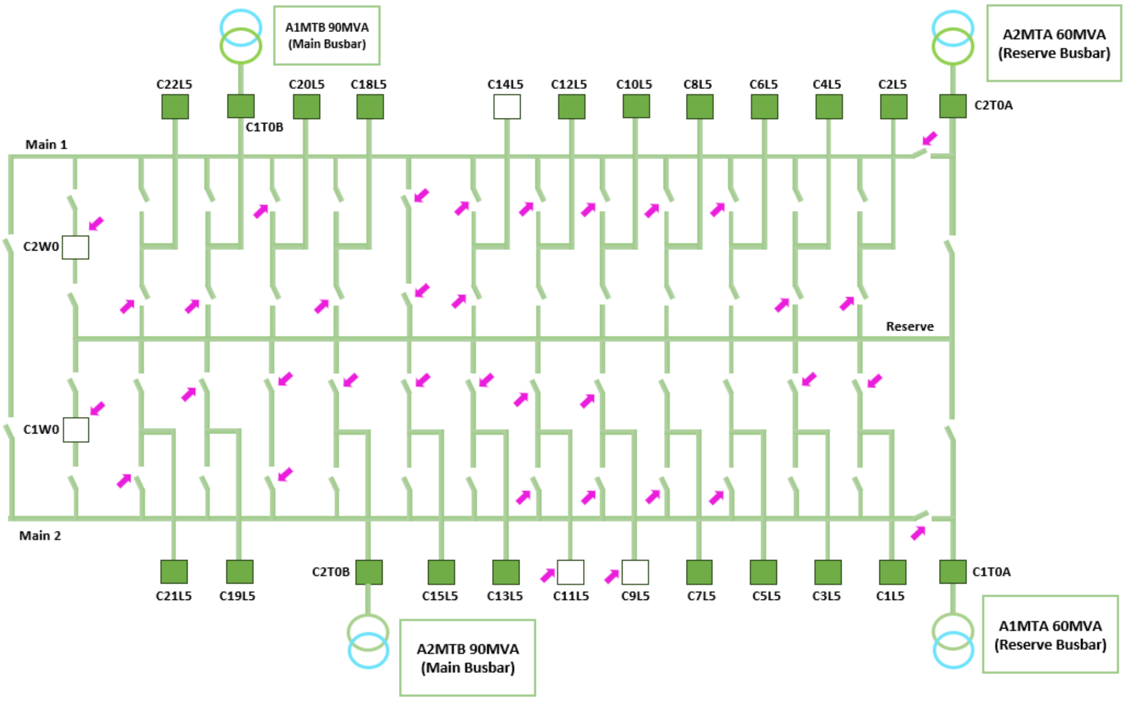

Figure 1: Southampton BSP busbar configuration SLD

Figure 2: Southampton BSP aerial view

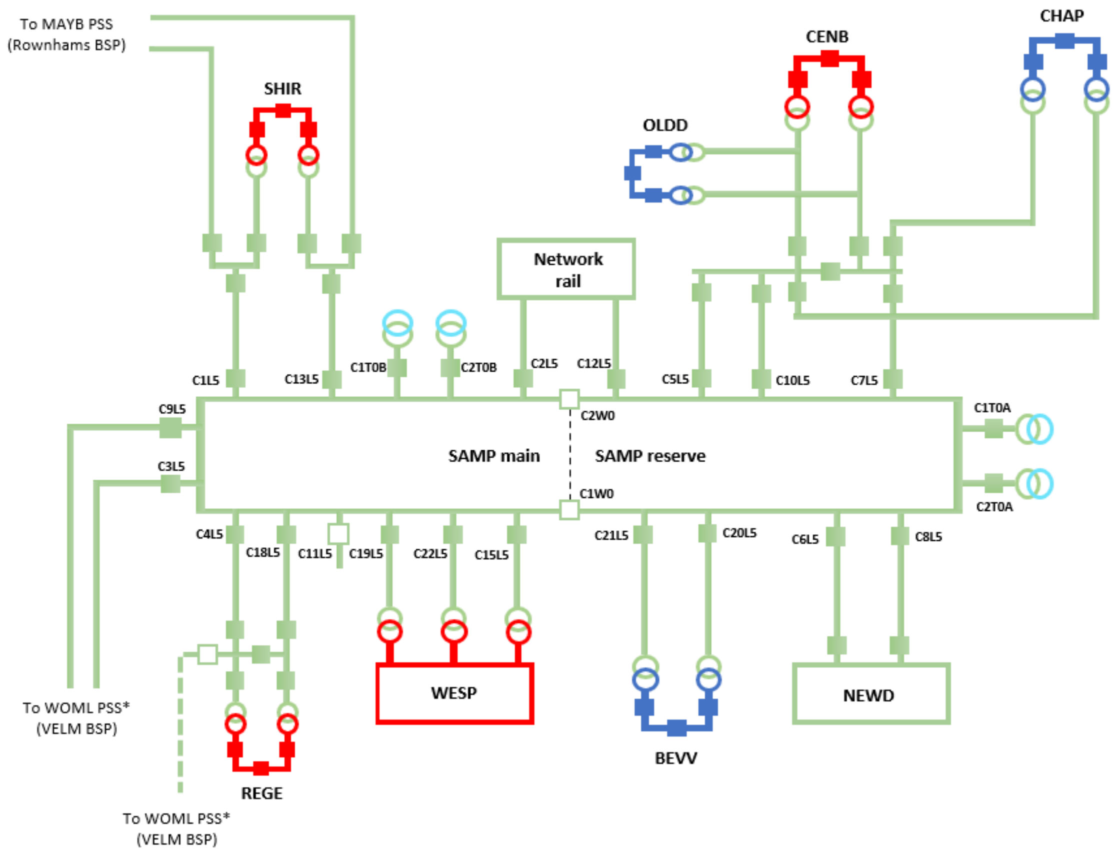

Figure 3: Southampton BSP - existing network arrangement single line diagram

*It is worth noting that capital scheme PS004477 will make the following alterations to the existing network:

- Reinforcement of all existing SAMP-BEVV circuits
- Reinforcement of all existing SAMP-WESP circuits
- Reinforcement of the existing SAMP-WOML circuit
- Addition of a new SAMP-WOML circuit
- Decommissioning of existing REGE-WOML circuit

Southampton BSP reserve busbar

The reserve busbar fully supplies SSEN-owned Bevois Valley (BEVV), Chapel (CHAP), and Central Bridge (CENB) primaries, as well as privately owned New and Old Docks (NEWD and OLDD) primaries, which in turn feed power to the Port of Southampton. Additionally, it partially supplies Network Rail, in conjunction with the Main busbar.

Bevois Valley, New Docks, and Network Rail receive direct power from the reserve busbar, whilst the remaining sites initially receive supply through a 33kV switchboard at Central Bridge. This switchboard is linked to the Southampton reserve busbar via three direct feeds, two of which are primarily oil filled.

The complete layout of the relevant network presented as a single line diagram (SLD) is shown in figure 4. Additionally, the relevant circuit data, such as circuit lengths and ratings, is displayed in Table 5.

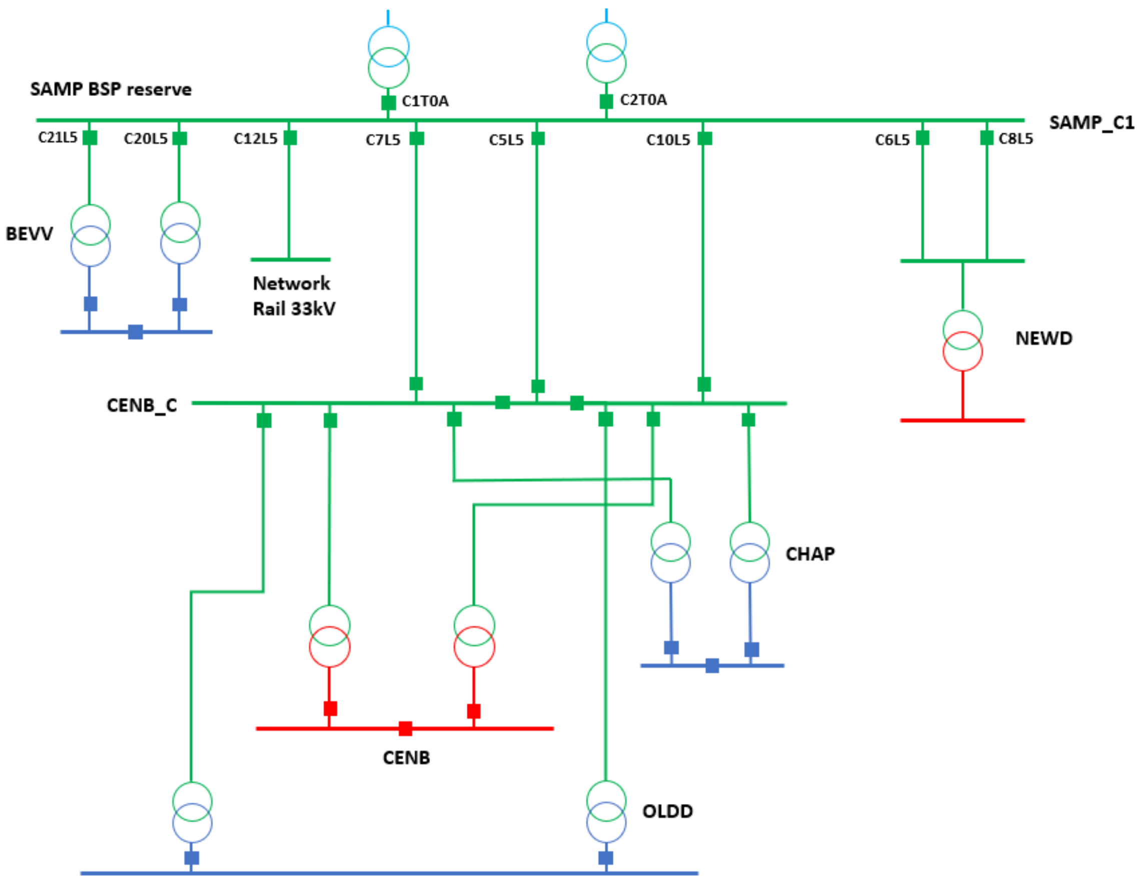

Figure 4*: Southampton BSP reserve busbar SLD layout (post PS001996)

**Please note that this is the network configuration post completion of ongoing capital schemes PS001996, detailed below.*

Table 5: Cable specifications

Circuit name	Circuit type	Length (km)	Rating (MVA)		
			Winter rating	Spr/Aut rating	Summer rating
Southampton – Bevois Valley 1	400AL Oil filled	2.50	27.2	24.1	24.1
Southampton – Bevois Valley 2	400AL Oil filled	2.50	27.2	24.1	24.1
Southampton – Central Bridge 1	240CU XLPE	0.20	30.6	27.1	27.1
	0.15CU	1.80	17.4	15.4	15.4
Southampton – Central Bridge 2	240CU XLPE	0.40	30.6	27.1	27.1
	400AL Oil filled	1.42	28.7	25.4	25.4
Southampton – Central Bridge 3	400AL Oil filled	1.42	28.7	25.4	25.4

	240CU XLPE	0.40	30.6	27.1	27.1
Southampton – New Docks 1	0.25CU Oil filled	1.20	27.2	24.1	24.1
Southampton – New Docks 2	0.25CU Oil filled	1.20	27.2	24.1	24.1
Central Bridge – Old Docks 1	0.1CU HSL	0.57	14.3	12.7	12.7
Central Bridge – Old Docks 2	0.1CU HSL	0.57	14.3	12.7	12.7
Central Bridge – Chapel 1	0.15CU HSL	0.41	17.4	15.4	15.4
	0.4CU Oil Filled	0.51	35.9	31.8	31.8
Central Bridge – Chapel 2	0.25CU Oil Filled	0.90	27.2	24.1	24.1

It is worth noting that some ongoing capital works, listed below will slightly alter the asset capabilities of this network.

- PS006666 - proposes the uprating of existing 33/6.6kV transformers at Chapel Primary.
- PS001996 – proposes the indoor conversion with reconfiguration (to take Old Docks off the current teed off connection as shown in Figure 4 and reconnect to the new indoor switchboard via 2 dedicated CBs) of the 33kV switchboard at Central Bridge Primary.

Southampton BSP 132kV network

Southampton BSP is currently supplied by two feeders from Nursling GSP via the Millbrook (MILL) switching station, with each feeder supplying a transformer on both the main and reserve busbars. Additionally, two 33kV dual circuit interconnections from the main busbar, one to Rownhams BSP and one to Velmore BSP, link Southampton with the surrounding network. The network layout presented as a simplified single line diagram can be seen in figure 5.

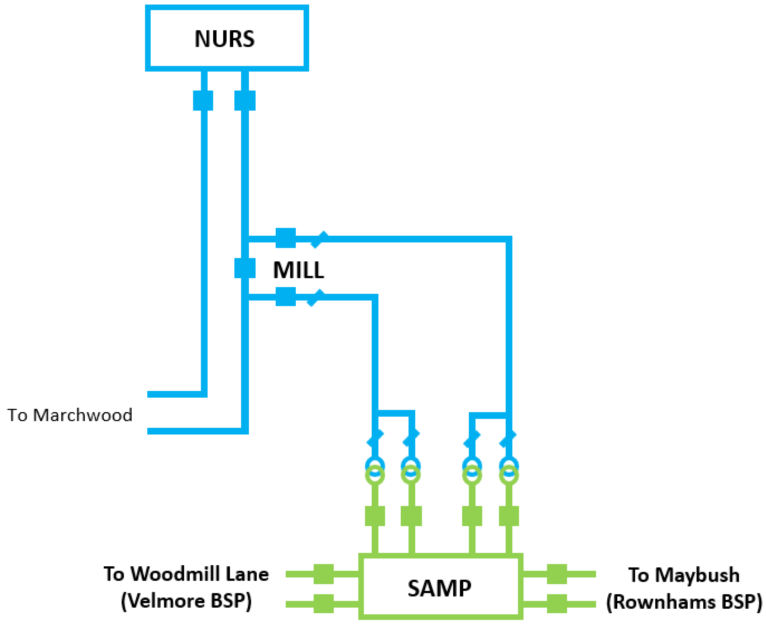

Figure 5: Southampton BSP 132kV network SLD layout

5.2 Load Forecast for Southampton BSP

To understand the future growth of demand and generation at the Southampton BSP reserve busbar and its downstream 33kV network, extensive scenario studies have been carried out, aptly named the Distribution Future Energy Scenarios (DFES). The basis for this work is National Grid's Future Energy Scenarios (FES) 2023. This framework comprises four potential pathways for the future of energy based on how much energy may be needed and the location of consumption. The variables for the four scenarios are driven by government policy, economics and consumer attitudes related to the speed of decarbonisation and the level of decentralisation of the energy industry. Based on the enhanced stakeholder engagement feedback, we have chosen Consumer Transformation (CT) as the baseline scenario for our investment because Consumer Transformation is the most realistic scenario which lies between the ambitious Leading the Way and the Falling Short scenario.

Newly accepted customer connections will further contribute to the total load on the network and therefore have also been considered in the expected peak demand growth. The aggregated demand from recently accepted schemes has been integrated within the DFES data to form a complete demand growth profile within the area, with the list of jobs and their respective capacities listed in Table 6.

[redacted]

Similarly, owing to development works taking place at the Port of Southampton, the demand requirements at this location are projected to significantly increase in the coming years as shown in figure 6 below.

[redacted]

Out of the required 80.49 MVA, 21.5 MVA is currently being supplied by Southampton BSP. The additional forecasted customer demand growth of 59.5MW presents significant but discrete loads and it is not appropriate to assume significant diversity at this stage. Consequently, the remaining 59.5 MVA has been equally incorporated into the DFES demand growth profile for assessing its impact on the relevant network.

Southampton BSP reserve busbar

Figure 7 shows the finalised peak demand growth profile at the Southampton BSP reserve busbar for winter, summer, and spring/autumn in the CT scenario. As the 132/33kV transformers pose the thermal limitation at the compound, the inclusion of their First Circuit Outage (FCO) ratings will pinpoint the specific years when their thermal capacity would be breached. [redacted]

[redacted]

Chapel Primary

Figure 8 illustrates the completed demand profile at Chapel Primary across all seasons in the CT scenario. In this case, the thermally limiting asset is the 6.6kV switchgear, followed by the upstream 33kV circuit during the spring/autumn season. The FCO ratings for both assets are provided in the diagram for reference. As mentioned in Section 5.1, the 33/11kV transformers at this primary will be replaced as part of PS006666, negating concerns for their thermal capabilities.

[redacted] Similarly, the projected demand growth during the spring/autumn season is set to exceed the upstream 33kV circuit capacity from 2034 onwards.

[redacted]

<u>Southampton – Central Bridge 33kV circuit</u>

Another thermal constraint on the examined network is the Southampton – Central Bridge 33kV triple circuit, which serves Central Bridge, Chapel, and Old Docks primaries. Figure 9 displays the aggregated demand profile for these sites throughout all seasons in the CT scenario, along with the winter FCO capacity of this circuit. Given the unbalanced loads passing through each cable during N-1 fault conditions, the FCO rating was established at 39.6MVA. [redacted]

[redacted]

Finally, no reinforcement works are required within the ED2 or ED3 periods for Central Bridge or Bevois Valley primaries when studying their respective DFES demand growth. Consequently, these profiles will not be included in this EJP.

5.3 Existing Asset Conditions

Network reinforcements and network expansion do not always have to be triggered by load changes but can also be caused by aging processes of existing network elements. Accordingly, it is also part of this EJP to examine the condition of existing assets. The methodology of assessing the Health Index (HI) scoring has been considered for all relevant components on the network, where a higher health index correlates to poorer asset health. As part of setting the methodology, it has been agreed that the study will extend beyond the ED2 period. As such, the target network and its network elements will be studied until 2050.

Table 7 provides an overview of the Health Index (HI) for assets under the Southampton BSP reserve busbar and the relevant downstream network. Alongside the current health index, values for 2028 (end of RIIO – ED2), 2035 and 2050 are also presented. [redacted]

[redacted]

5.4 Existing Operational Issues

Since a new Southampton BSP is proposed in this EJP, the arrangement of the associated 33kV switchboard is discussed in this section. With its dedicated 132kV dual circuits from Nursling GSP, the new BSP is electrically separated from the existing Southampton Main/Reserve BSP, though it is proposed to be constructed on the same site. The 33kV switchboards for both the new BSP and the existing Southampton Main/Reserve are proposed to be build indoor due to space limitation.

The operational arrangement of these two switchboards, as illustrated in Figure 11 and detailed in Section 7.2, is discussed as follows:

<u>33kV indoor board for the new BSP:</u>

The 33kV indoor board for the new BSP will be supplied by three new 90MVA 132/33kV transformers and supply feeders that are currently under the Southampton BSP reserve busbar. A double busbar arrangement with two sections and a solid operational arrangement is proposed. The three 90MVA 132/33kV transformers will be connected to three quadrants and the primary substation feeder arrangement is split as much as possible.

This arrangement avoids losing two transformers or two feeders to the same primary substation in the worst-case scenario of a busbar fault, which is the result of a malfunctioned CB tripping (fault negative) followed by busbar protection action.

<u>33kV indoor board for the existing Southampton BSP:</u>

The 33kV indoor board for the existing BSP will be supplied by the existing four 90MVA/60MVA 132/33kV transformers and supply the feeders that are currently under the main busbar. A double busbar arrangement with 3 bus sections and a split operational arrangement is proposed. Being split at the bus coupler CB, the two 90MVA and two 60MVA transformers are connected to each side of the couplers, replicating the existing wrapped round arrangement of these four BSP transformers.

A split operational arrangement is proposed to prevent unbalanced power flow due to differing transformer sizes, as well as fault level issues at the 33kV BSP busbar and 11kV primary substation when running four transformers in parallel. This split arrangement also necessitates a 3rd bus section, as Western Esplanade primary is fed by 3 feeders from the two 90MVA BSP transformers, meaning any 2 feeders allocated to the same bus section will be off under a credible busbar outage. [redacted]

<u>33kV interconnection</u>

To enhance the network security of supply, two 33kV interconnectors are proposed to link different sections between the new and existing BSP boards. Both links are normally open under normal operational arrangement and will be closed to back feed one another under relevant outage scenarios.

5.5 Network Analysis Summary

Thermal Constraints:

The following thermal issues were identified by modelling the existing network with the forecasted demand for 2050 for Southampton reserve BSP Substations, as well as the downstream 33kV networks that feed Central Bridge, Chapel, and Old Docks. The results are discussed as follows:

- 6.6kV switchgear:

The Chapel Primary transformer will be upgraded to firm capacity of 30MVA by a SSEN driven non-load capital scheme, with an estimated completion time of 2026. [redacted] Chapel switchgear therefore needs upgrading to utilise the whole capacity of an upgraded transformer.

- 33kV network:

The Central Bridge – Old Docks dual circuit is driven by the development plan on the Port of Southampton. The existing network capacity is just sufficient to cover their contracted demand and hence the reinforcement work needs to start now to avoid hindering the connection of planned growth.

Only one of the dual Central Bridge – Chapel circuit will be exceeded by the forecasted load from 2034 and, hence requiring to be upgraded to suit the demand growth.

The Southampton – Central Bridge circuit group consists of 3 circuits, only 2 of which are of the same rating. As such, the firm capacity of this circuit group is less than the sum of the two lowest circuit ratings due to asymmetrical loading. This firm capacity has been used in the associated DFES presentation in Section 5.2, with reinforcement identified immediately to provide the required capacity to the forecasted growth. Since all three existing Southampton – Central Bridge circuits consist largely of oil-filled sections and have been reported with frequent leakage, the reinforcement proposal also brings additional environmental benefits.

- Southampton Main and Reserve BSP:

As seen in Figure 7, the total demand under the Southampton BSP reserve busbar forecasted for 2050 is 180MVA for summer, which is the firm capacity achieved by three 90MVA transformers. As illustrated in Appendix B, the projected demand growth towards 2050 under the Southampton BSP main busbar is 170MVA, which would also require the firm capacity from three 90MVA transformers. If we were to rearrange the main busbar transformers as such to meet the demand growth, then either a large 132kV indoor switchboard would have been required to accommodate the six 90MVA BSP transformers, or two separate 132kV indoor switchboards would have been needed for each group of the three 90MVA transformers. Moreover, an additional 90MVA transformer would have also been needed on the main BSP side, as the existing assets only have two 90MVA transformers.

In comparison, the combination of the existing two 90MVA and two 60MVA transformers could sustain the demand growth forecasted under the main busbar until 2048. This could also remove the necessity of a 132kV switchboard as existing upstream network arrangement at Southampton BSP could be retained. As such, this EJP proposes a new BSP to take over the demand under the existing reserve busbar (with the associated 132kV switchboard and upstream 132kV supply from Nursling GSP) and leave the demand under main busbar to the existing 90/60MVA transformers.

[redacted]

Voltage Constraints:

No voltage issues were found on the scenarios used to assess P2/8 compliance.

Fault Level Constraints:

As identified in Appendix B, this EJP needs to depend on the capital scheme PS001996 for the 33kV switchboard refurbishment at Central Bridge. No other fault level issues are identified for the post reinforcement networks.

5.6 Regional Stakeholder Engagement and Whole systems analysis Summary

Southampton Bulk Supply Point supplies Southampton and, to a lesser extent, Test Valley and New Forest.

SSEN has strong working relationships with local authorities and other key stakeholders in the region. We have met with Southampton City, Test Valley Borough, and Hampshire County Councils to discuss local area energy planning, tools for efficient data exchange, and the potential for collaboration on projects in the near future. We have engaged with Community Energy South, who have partnered with Hampshire County Council to advance local renewable energy projects throughout the region. SSEN led the Solent Achieving Value from Efficiency (SAVE) Project from 2014 to 2019 in collaboration with the University of Southampton and other regional partners to trial energy efficiency measures that can help manage peak load. We also engage with the South West Net Zero Hub, of which the Solent Local Enterprise Partnership is a member, and have met with the Partnership for South Hampshire to discuss network constraints in the area. This engagement has helped SSEN to stay informed about planning and development that will impact local communities' use of the network.

Southampton City Council aims for the city to be net zero by 2035, as detailed in their Net Zero Strategy. New developments will be required to generate a certain fraction of their energy demand from on-site renewable generation (these measures reduce demand requirements but do not lead to significant reverse power flow considerations). The Council has also initiated several projects to expand electric vehicle infrastructure in support of this target, including an electric vehicle trial for private hire cars and taxis; ongoing rollout of electric vehicle charge points across the city; electrification of the council's vehicle fleet; and a commitment to zero emissions from public transit by 2030 as detailed in their Green City Plan 2030. They have also installed solar panels on the Sea City Museum as part of the Council's Corporate Assets Decarbonisation Scheme.

In its Carbon Mitigation Action Plan, Hampshire County Council details numerous steps it has planned to electrify various sectors of the local economy, including electric vehicle charge point trials, rollout of electric vehicles within its fleet, and installation of solar PV on depot buildings. The Council also organised a solar PV and battery storage group buying scheme for homeowners through Solar Together.

Test Valley Borough Council was recently awarded funds through the UK Shared Prosperity Fund to support decarbonisation projects in partnership with Community Energy South. Additionally, the Council has secured funding through the Public Sector Decarbonisation Scheme to decarbonise heating in council-owned buildings. New Forest District Council also has partnered with Community Energy South for a two-year initiative starting in 2023 to deliver community-owned renewable energy. Their Greener Housing Strategy lays out various means by which they are decarbonising their housing stock, including through the provision of solar PV and heat pumps.

5.7 Flexible Market Viability

To efficiently integrate new customers into the grid while accommodating anticipated load growth, flexibility can offer a cost-effective solution to defer or even avoid grid reinforcements. As multiple assets under the Southampton BSP reserve busbar and downstream 33kV network face a future capacity challenge, exploring the deferral of reinforcement through flexibility is necessary. This EJP outlines options to achieve this and assesses their economic viability using the Common Evaluation Method (CEM) tool.

As will be established in Section 7.3, deferring reinforcement was only economically beneficial for the assets associated with the Chapel 6.6kV switchboard replacement and the upstream 33kV Central Bridge–Chapel circuit. However, crucial for the postponement of investment is that sufficient flexibility is available on the market. Therefore, the availability of flexibility to cover the expected demand that would otherwise exceed the network capacity was assessed for Chapel primary for the relevant years.

The optimal deferral period for the Chapel 6.6kV switchboard reinforcement, evaluated using the CEM tool, leverages flexibility between 2029-2032. A similar study was performed on the Central Bridge – Chapel 33kV circuit, where flexibility utilisation is recommended in 2034. The flexibility requirement was compared to the flexibility availability within these years, as shown in Table 8. The results suggest that sufficient flexibility is available and reinforcement deferral is feasible.

[redacted]

The detailed results of the feasibility assessment are shown in Appendix C

5.8 Confidence Table

The confidence we have in the assumptions and input data for this EJP are described in Table 9.

Table 9: Confidence Table

Confidence Factor	Certainty	Comments
Load Forecast	High	DFES data used has been adjusted to include the projected demand increase from customers such as the Port of Southampton and other customer connection requests.
Existing Asset Condition	High	Existing assets under the Southampton BSP reserve busbar are relatively healthy, [redacted].
Existing Operational Issues	High	As this work proposes a new BSP, the arrangement of the newly proposed 33kV switchboard has been discussed. The proposed 33kV double busbar arrangement for both the new and existing BSP would give sufficient flexibility of control and operation.
Connections Activity	High	Works on the Port of Southampton will form the majority of the load growth within coming years.
Regional Stakeholder engagement	High	The local authorities have committed to achieve their own net zero targets. They have set out goals and funding to reach these goals in the next years, which is incorporated in the forecast of the local DFES.
Flexible market Viability	High	Flexibility was assessed for the majority of reinforcement proposed within this EJP, however was only deemed economically viable for reinforcement related to Chapel Primary. There is ample flexibility available under Chapel primary to defer both sets of reinforcement.
Funding Position	High/Medium	The majority of reinforcement proposed within this paper is required to commence within ED2 and extends into ED3. These proposals were driven due to peak demand growth under the Southampton urban area, with significant contribution from works under the Port of Southampton.

6 Summary of options considered.

6.1 Summary of Options

Table 10 presents a summary of all investment options considered, alongside their respective advantages, disadvantages and whether it is progressed to CBA. More detailed option descriptions and analysis are provided in Section 7.

Table 10: Options Overview

	Option	Description	Advantages	Disadvantages	CBA Consideration and Result
1	**Do nothing**	[redacted]	No new assets needed and therefore no investment required.	This option does not address any of the raised issues and will not allow for new customer connections and put existing customers at risk.	[redacted] **Not progressed to CBA**
2	**Construction of a new BSP + reinforcement of the 33kV network**	This solution involves constructing a new BSP within the existing Southampton BSP compound to support the growing demand in the Southampton urban area, including the significant requirements of the Port of Southampton. To accommodate the assets of the new BSP, it is necessary to move the existing Southampton BSP 33kV switchboard indoors. The new assets will include an indoor 33kV switchboard, three 90MVA 132/33kV transformers, and a new 132kV indoor switchboard. Additionally, a dual underground circuit from Nursling GSP to the new BSP is proposed to enhance the network's capacity and reliability. Some reinforcement of the 33kV network currently supplied via the Southampton BSP reserve busbar is also proposed. This involves the reinforcement of the 6.6kV switchboard at Chapel, an overlay of the Central Bridge – Old Docks and Central Bridge – Chapel circuit, alongside the installation of three new	• [redacted] Beyond this, sufficient capacity is created until 2047. • Future-proof solution, creating space within the existing compound for future reinforcement. • Mitigates potential SCO issues with growth of group demand. • Introducing 33kV double busbars to both the new and existing switchboards, which add	• Considerable design and construction time • High associated capital costs	This is a viable solution and will therefore be **progressed to CBA**

		underground circuits from Central Bridge to the new BSP.	operational and control flexibility.		
3	**Option 2 with the use of flexibility**	Introduces flexibility into option 2. Defers multiple sets of reinforcement, namely the upgrade of the 6.6kV switchboard at Chapel Primary, as well as the upstream 33kV Central Bridge – Chapel circuit. Other sets of reinforcement were deemed economically not beneficial.	Flexibility provides a way to defer the network expansion and is quick to implement	It is not a long-term solution, and the asset reinforcement is still required	This is a viable solution and will therefore be **progressed to CBA**

6.2 Options comparison Table

Table 11 provides the yearly cost distribution for all options that were considered within this EJP. Table 12 then focuses on the C0a costs for the recommended solution, providing a more detailed breakdown with respect to the possible investment drivers, all in the 20/21 Price Base.

[redacted]

[redacted]

7 Detailed option analysis

This section presents the possible options to solve the load-related issues identified in this paper, explaining the importance and rationale behind each decision. Technically viable solutions will outline the necessary reinforcement works to resolve each issue, which then undergo thorough consideration and analysis using the Cost Benefit Analysis (CBA) tool, to facilitate informed decision-making.

7.1 Option 1: Do Nothing

As demonstrated in Section 5.2, the peak demand growth is set to exceed the FCO capacity of the current network arrangement primarily within the RIIO ED2 period, mostly due to the predicted load increase and accepted customer schemes. [redacted]

The thermal overloading risk on the relevant transformers and circuits leads to an increased risk of outages, which translates into more customer minutes lost and subsequent customer interruption costs. This also leads to an economic value loss of load, no capacity for new connections and a potential reputational loss for SSEN.

As this option does not solve the issue raised within this EJP, it is rejected and will not be progressed to the CBA.

7.2 Option 2: Construction of a new BSP + reinforcement of the 33kV network

[redacted]

This option addresses the thermal overload of existing assets via the following reinforcement:

Construction of a new BSP

As outlined in Section 5.1, Southampton BSP is currently supplied by two 132kV feeders from Nursling GSP via Millbrook, each feeding a transformer on both the main and reserve busbars. To accommodate the projected load growth on the reserve busbar, including the significant demand from the Port of Southampton developments, the replacement of the existing 132/33kV transformers and the addition of a 3rd asset is required by 2026. Additionally, addressing the demand growth on the Southampton BSP main busbar in ED3+ will require similar measures, ultimately bringing the total transformer count for the site to six. This network configuration is not feasible, thus alternative options must be explored.

This solution therefore proposes the construction of a new BSP with two dedicated feeders from Nursling GSP to support the significant load growth in the Southampton area. The strategy ensures the network is well prepared for long-term expansion, supporting the transition towards a net-zero future. Given the size and spatial potential of the Southampton BSP compound, alongside the spatial constrains of the urban residential area, it is proposed to construct the new BSP within the existing SSEN owned site.

To implement this solution, the following works must be completed:

Indooring of the existing Southampton BSP busbar + construction of 33kV busbar for new BSP

The assets required for constructing a new BSP demand a large amount of free space within the compound. However, the existing spatial constraints at Southampton BSP and the impracticality of extending the site due to its central location present a significant challenge.

Therefore, this solution proposes to convert the existing Southampton BSP main and reserve busbars to an indoor construction, with the relocation of the indoor switch room to the site's perimeter. This action releases a significant portion of space within the existing compound, facilitating the construction of the proposed new BSP. To optimise spatial efficiency, the indoor 33kV busbar of the new BSP can be built within the same location.

Other locations for the proposed indoor construction works have also been considered and discarded. For example, the nearby WESP PSS site has been considered but discarded due to insufficient space for the new assets proposed. In addition, thermal borehole next to site has been identified which could add thermal stress to the 132kV/BSP assets. Other sites such as Millbrook has also been considered: although this could have saved some 132kV cable distance from Nursling GSP, but this also involves moving 9x 33kV feeders over a long distance through Southampton city centre, which is logistically and cost wise less optimal.

An aerial view of Southampton BSP is presented in figure 10, with an indicative location of the new 33kV indoor switch room and a depiction of space released as part of the 33kV main and reserve busbar indooring.

Figure 10: Aerial view of Southampton BSP, with the location of the new 33kV indoor switch room and subsequent space released

A three-section indoor double busbar configuration is recommended for Southampton BSP, with the solution requiring the installation of 23 x 33kV gas insulated indoor circuit breakers (4x transformer, 4x bus section, 2x bus coupler, 13x feeder) and the construction of a new indoor switch room. As mentioned previously, by switching to an indoor arrangement the existing air insulated outdoor switchboard is to be dismantled, where the released space will be repurposed for constructing the new BSP.

Similarly, a two-section double busbar arrangement is recommended for the new BSP, with the solution requiring the installation of 16 x 33kV gas insulated indoor circuit breakers (3x transformer, 2x bus section, 2x bus coupler, 9x feeder) and the construction of a new indoor switch room. To alleviate load requirements from Southampton, it is proposed to transfer the following feeders to the new BSP:

- Southampton – Central Bridge (Load from Central Bridge, Chapel and Old Docks primaries)
- Southampton – Bevois Valley (Load from Bevois Valley Primary)
- Southampton – New Docks (Load from New Docks Primary)

Finally, a dual circuit interconnector is proposed between the existing and new BSP. This helps both sites support each other during Second Circuit Outage (SCO) scenarios, in the loss of both upstream 132kV circuits.

The future indoor 33kV busbar arrangements for both the existing Southampton BSP and the new BSP, depicted as a single-line diagram, is seen in figure 11. It is worth noting that feeder positioning and distribution between sections is purely indicative and should be finalised during detailed design.

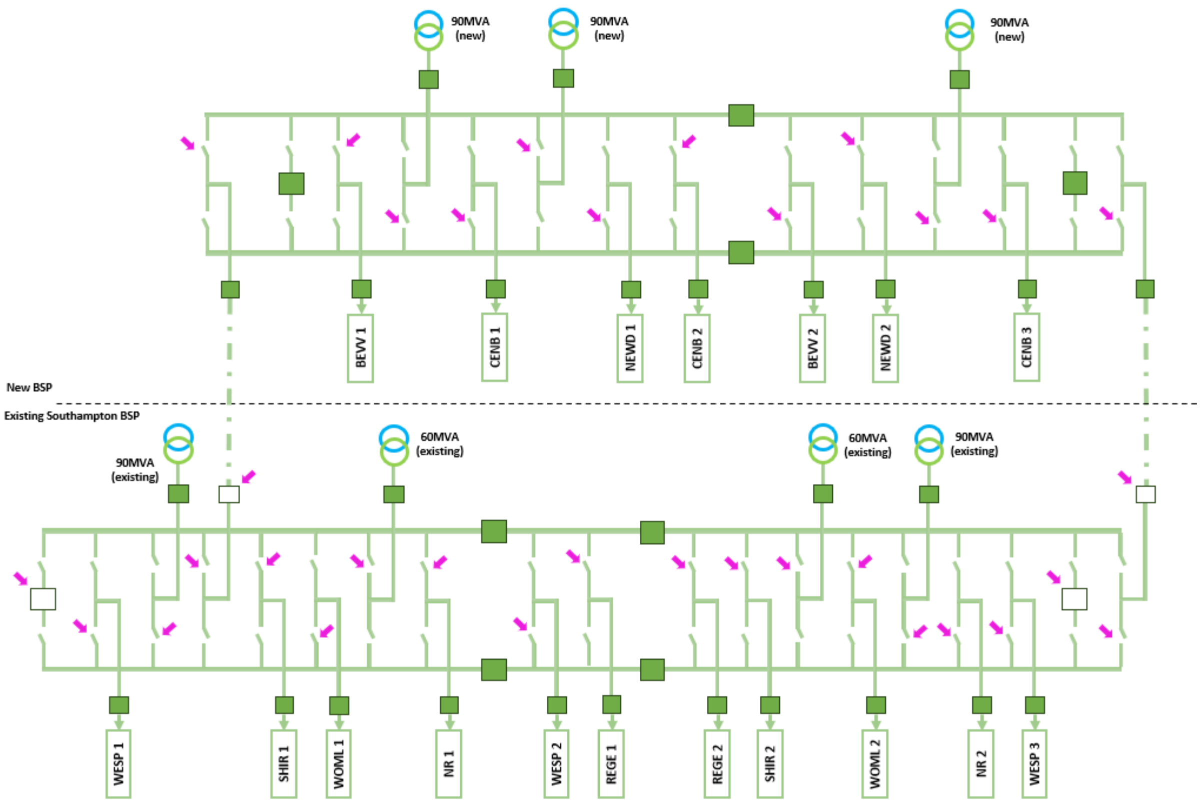

Figure 11: Proposed indoor 33kV busbar arrangements for both the existing Southampton BSP and the new BSP

<u>Installation of three 90MVA 132/33kV transformers and a 132kV indoor switchboard at the new BSP</u>

To accommodate the projected load growth of the substations being transferred to the new BSP, three 132/33kV 90MVA transformers must be installed. This ensures the network can operate without constraints until 2050, facilitating further customer connections and supporting the network's transition towards a net-zero future.

The requirements for three 132/33kV transformers and two dedicated 132kV feeders from Nursling GSP drive the necessity for an indoor 132kV switchboard to be installed at the new BSP. A three-section single busbar is proposed, with the solution requiring the installation of 7 x 132kV indoor circuit breakers (3x transformer, 2x section, 2x feeder) and the construction of a new indoor switch room.

It is worth noting that construction of the 132/33kV transformers and the 132kV indoor switch room cannot commence until the process of indooring the existing 33kV busbar is complete. As such, the location of these assets is to be determined post completion of the indooring works.

The proposed new BSP configuration, depicted as a single-line diagram, is seen in figure 12.

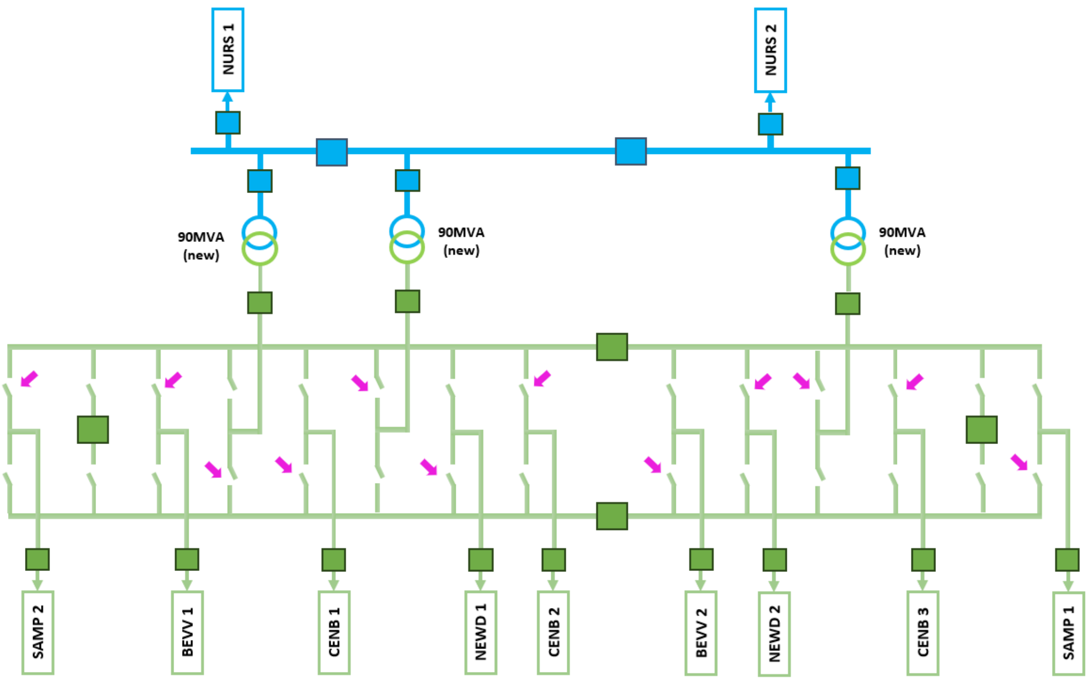

Figure 12: Proposed arrangement of the new BSP

Installation of a dual underground Nursling GSP - new BSP 132kV circuit

Power at the new BSP will be supplied via the installation of two new 132kV circuits from Nursling GSP. This solution involves approximately 9.8km of dual underground cable, alongside two new indoor CBs at Nursling GSP for cable termination. It should be highlighted that another project, proposing to indoor the existing 132kV busbar at Nursling GSP, will be running parallel to this scheme. Without its completion, the installed cable cannot be terminated at the GSP, hence a dependency must be established between the two projects.

The proposed cable route is illustrated in figure 13, with the final route to be determined under detailed design.

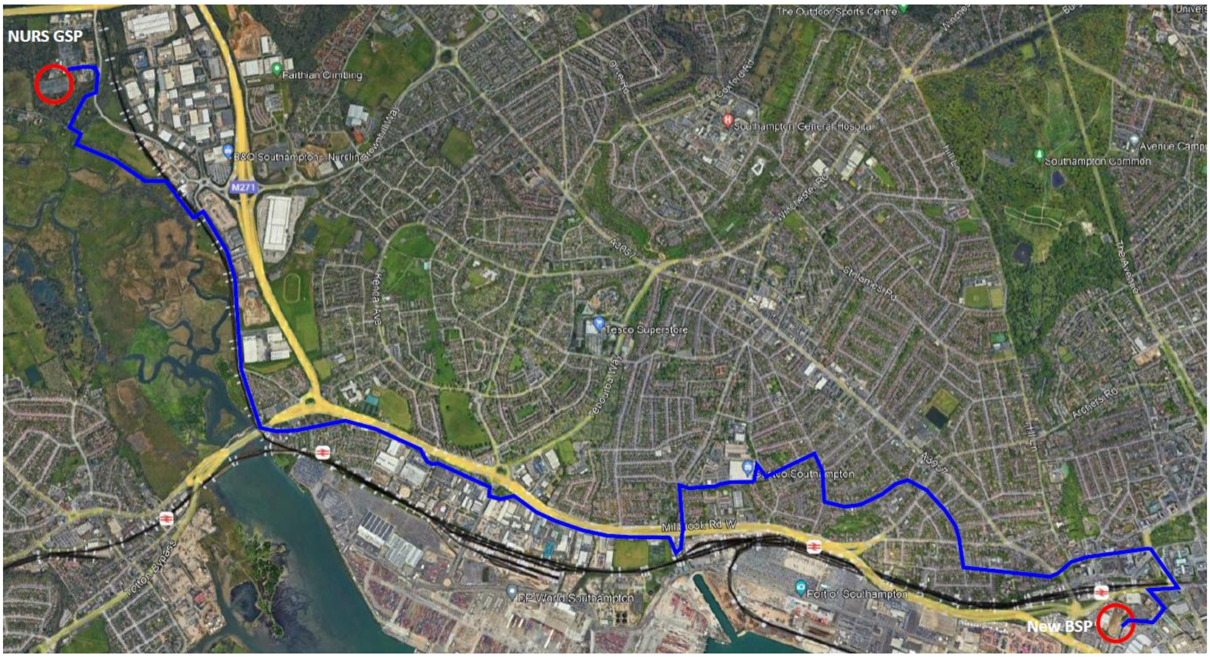

Figure 13: Indicative cable route for the new Nursling GSP - new BSP 132kV underground circuits

The subsequent 132kV network configuration for Southampton and the newly proposed BSP is illustrated in Figure 14. This solution secures the Southampton urban area by accommodating projected demand growth and prepares the network for long-term expansion by freeing up space in the existing compound.

Moreover, this configuration addresses potential SCO issues associated with the network's increasing group demand in future years. With each BSP receiving a direct supply from Nursling GSP and a dual 33kV interconnection between them, SCO concerns are effectively mitigated.

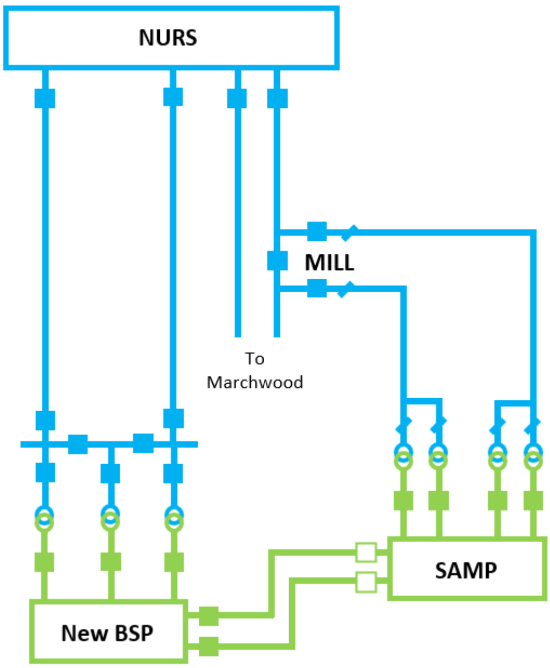

Figure 14: Proposed 132kV network configuration for Southampton and new BSP

Reinforcement of the 33kV network

<u>Chapel 6.6kV switchboard and upstream Central Bridge – Chapel 1 33kV circuit</u>

[redacted]

[redacted]. Note that only a 0.41km section of 0.15CU HSL must be reinforced, rather than the entire circuit.

<u>Southampton – Central Bridge and Central Bridge – Old Docks 33kV circuits</u>

To support the work at the Port of Southampton and the subsequent load increase at Old Docks Primary, it is proposed to overlay the entire Central Bridge – Old Docks 33kV circuit to match the contracted load.

As load from Old Docks Primary is supplied via the Central Bridge 33kV switchboard, the upstream Southampton BSP – Central Bridge 33kV circuits will equally be affected. To combat this, it is proposed to install 3 new circuits from the existing 33kV switchboard straight to the newly proposed BSP. Due to substantial load growth on the primaries carried by this circuit, this solution is only sufficient until 2047, hence a 4th circuit following the same route may be required in the future. An indicative route is shown in figure 15.

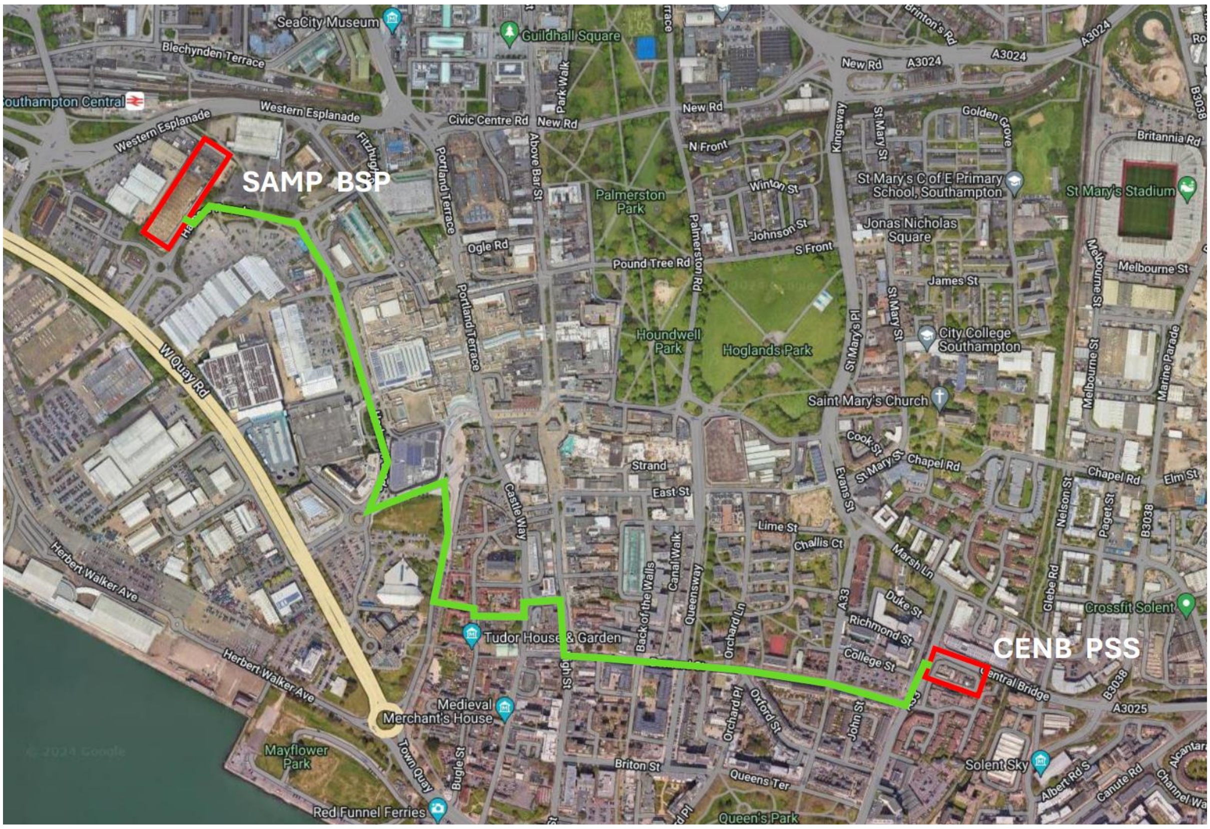

Figure 15: Indicative cable route for the new BSP - Central Bridge underground 33kV circuits

Combined solution

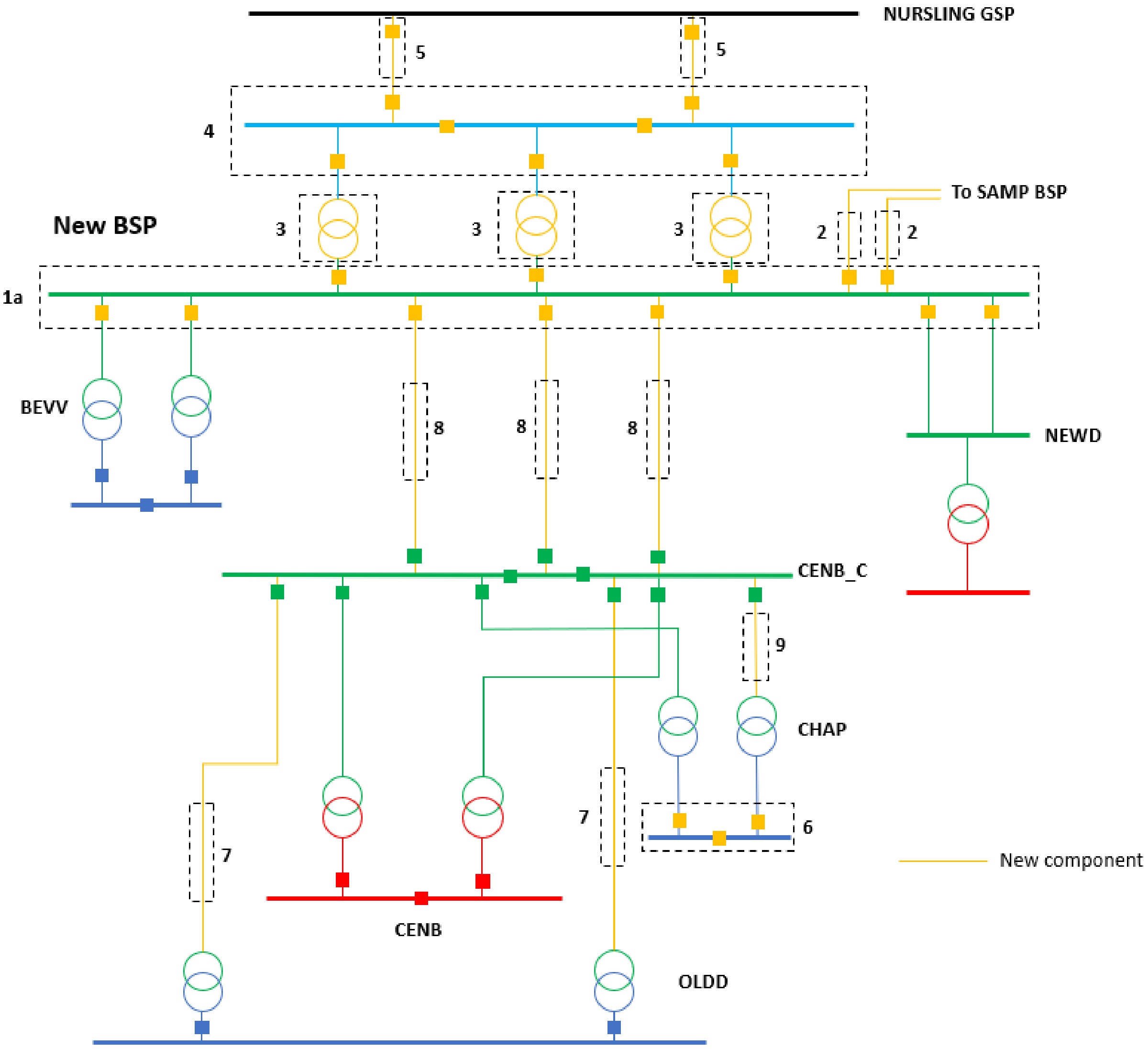

Figure 16: Combined solution, highlighting the required reinforcement works

Construction of a new BSP

- **Works 1a:** Install a 33kV indoor switchboard at new BSP with 16 x 33kV gas insulated indoor CBs.
- **Works 1b (not depicted within diagram)**: Install 33kV indoor switchboard for Southampton BSP with 23 x 33kV gas insulated indoor CBs. The existing air insulated outdoor switchboard is to be dismantled, where the released space will be repurposed for constructing the new BSP.
- **Works 2**: Install 33kV dual interconnection between Southampton and new BSP.
- **Works 3**: Install 3 x new 90MVA 132/33kV transformers at the new BSP.
- **Works 4**: Install a 132kV indoor switchboard at new BSP with 7 x 33kV gas insulated indoor CBs.
- **Works 5**: Install approximately 9.76km of new 132kV dual underground cable between Nursling GSP and the new BSP. Additionally, this will require the installation of 2 x new gas insulated indoor CBs at Nursling GSP

33kV network reinforcement

- **Works 6**: Upgrade the existing 6.6kV switchboard at Chapel Primary, consisting of 10x 6.6kV indoor CBs.
- **Works 7**: Overlay the existing Central Bridge – Old Docks circuit with approximately 0.54km dual underground 33kV cable.
- **Works 8**: Install approximately 1.93km of new 33kV triple underground cable between Central Bridge Primary and the new BSP.
- **Works 9**: Reinforce a portion of the existing Central Bridge – Chapel 1 circuit with approximately 0.54km of single underground 33kV cable.

As this delivers a P2/8 compliant solution and is in line with the overall SSE strategy, this option is progressed to the Ofgem CBA.

7.3 Option 3: Flexible solution

[redacted]

When flexibility is not utilised, Option 2 provides the only feasible network configuration. However, this section explores the possibility to defer or avoid investing in certain assets by using flexibility. This evaluation is performed following the Common Evaluation Methodology (CEM).

To defer the asset investment of Option 2, four sets of investments were identified and evaluated. These are the reinforcements associated with the construction of a new BSP, the installation of the new BSP – Central Bridge circuits, alongside the Chapel 6.6kV switchboard and the upstream Central Bridge – Chapel 33kV circuit upgrade.

The remaining sets of reinforcement proposed within Option 2 could not be delayed with the use of flexibility. The privately owned Old Docks Primary supplies a singular customer and is vital to the expansion works on the Port of Southampton, thus deferral of overlaying the Central Bridge – Old Docks circuits was deemed infeasible. Similarly, indooring works of the existing Southampton BSP 33kV switchboard are crucial to release space for assets of the newly proposed BSP, with any delays postponing the start of construction.

7.3.1 Construction of a new BSP

The CEM tool was used to determine whether the use of flexibility is viable in deferring the construction of the new BSP, namely the installation of the three 90MVA transformers, the 132kV switchboard, the two Nursling GSP – new BSP 132kV underground circuits and two associated indoor 132kV CBs at Nursling GSP. As described in section 7.2, these works are necessary to mitigate the thermal overloading of the 132/33kV transformers on the Southampton BSP reserve busbar, with the level capacity is exceeded per year shown in Table 13.

[redacted]

[redacted]

[redacted] However, as these works are not yet contracted, there is no risk of network overloading before reinforcement is finished.

The benefit of adopting flexibility for reinforcement deferral is shown in Table 14. Given the significant demand growth on the Southampton BSP reserve busbar, it is not cost effective to use flexibility for deferring the construction of a new BSP under both CT and LW scenarios. As the scope of work in this EJP was proposed based on CT scenario, the flexibility was not pursued as such.

[redacted]

7.3.2 Installation of three circuits for Central Bridge to the new BSP

The CEM tool was used to determine whether the use of flexibility is viable in deferring the installation of three new BSP – Central Bridge circuits. As described in section 7.2, these works are required to mitigate the thermal overloading of the existing Southampton BSP – Central Bridge circuits, with the level capacity is exceeded per year shown in Table 15.

[redacted]

[redacted] As with the construction of a new BSP, there is no risk of network overload before completion of this reinforcement since these works are not yet contracted.

The benefit of adopting flexibility for reinforcement deferral is shown in Table 16. Again, given the significant demand growth on sites supplied by these feeders, it is not cost effective to defer the installation of circuits from Central Bridge to the new BSP under all scenarios.

[redacted]

7.3.3 Chapel 6.6kV switchboard and Central Bridge – Chapel 33kV circuit upgrade

Lastly, the CEM tool was used to determine whether the use of flexibility is viable in deferring the reinforcement works associated with the Chapel 6.6kV switchboard and the Central Bridge – Chapel 33kV circuit upgrade. Although separate studies were conducted for each set of reinforcement, they will be presented together since both are triggered by the demand growth within Chapel Primary.

[redacted]

Table 18 summarises how many days of flexibility are required per year on the network to manage network capacity.

[redacted]

The possible hours per day of flexibility required can be shown in Table 19.

[redacted]

[redacted]

The benefit of adopting flexibility to defer the reinforcement of the Chapel 6.6kV switchboard is presented in Table 20.

[redacted]

Adopting flexibility together with option 2 is an economically viable investment to defer the replacement of the Chapel 6.6kV switchboard. [redacted]

Similarly, the benefit of adopting flexibility to defer the reinforcement of the Central Bridge – Chapel 33kV circuit is presented in Table 21.

[redacted]

Adopting flexibility together with option 2 is an economically viable investment to defer overlaying a portion of the Central Bridge – Chapel 33kV circuit. [redacted]

8 Cost Benefit Analysis (CBA)

This section provides an overview of the results from the Cost Benefit Analysis (CBA). This detailed exercise has been undertaken to support the investment strategies discussed within this EJP.

8.1 CBA of investment options

Only Option 2 outlined within Section 7 was deemed a viable non-flexible solution for addressing the thermal issues on the Southampton 33kV reserve busbar. Consequently, this was the only option advanced to the CBA stage, with its total cost displayed in Table 22 (in C0(a) and price base 2020/2021).

Additionally, flexibility was considered to expand on Option 2 and defer some of the reinforcement works proposed, as outlined in section 7.3. The cost breakdown for this option is seen in Table 23.

Table 22: Asset cost breakdown of Option 2

Assets	Unit cost	Volume	Reinforcement period	Cost
Construction of a new BSP				
33kV CB (Gas Insulated Busbars) (ID) (GM)	[redacted]			
Building cost for 33kV indoor switch room for Southampton and new BSP				
33kV UG Cable (Non Pressurised)				
132kV - TRAFO - 90MVA 132/33kV transformer				
132kV CB (Gas Insulated Busbars) (ID) (GM)				
Building cost for 132kV indoor switch room for new BSP				
132kV UG Cable (Non Pressurised)				
132kV CB (Gas Insulated Busbars) (ID) (GM)				
Reinforcement of the 33kV network				
6.611kV CB (GM) Primary	[redacted]			
33kV UG Cable (Non Pressurised)				
33kV UG Cable (Non Pressurised)				
33kV UG Cable (Non Pressurised)				

Table 23: Asset cost breakdown of Option 3

Assets	Unit cost	Volume	Reinforcement period	Cost
Construction of a new BSP				
33kV CB (Gas Insulated Busbars) (ID) (GM)	[redacted]			
Building cost for 33kV indoor switch room for Southampton and new BSP				
33kV UG Cable (Non Pressurised)				

132kV - TRAFO - 90MVA 132/33kV transformer	[redacted]
132kV CB (Gas Insulated Busbars) (ID) (GM)	
Building cost for 132kV indoor switch room for new BSP	
132kV UG Cable (Non Pressurised)	
132kV CB (Gas Insulated Busbars) (ID) (GM)	
Reinforcement of the 33kV network	
6.611kV CB (GM) Primary	[redacted]
33kV UG Cable (Non Pressurised)	
33kV UG Cable (Non Pressurised)	
33kV UG Cable (Non Pressurised)	
Flexibility procurement	

8.2 CBA Results

The table below gives an overview of the whole life Net Present Value (NPV) and total investment for each option considered:

Table 24: Whole life NPV and investment values for all options considered

Options	Whole life NPV	Investment
Option 2: Construction of a new BSP + reinforcement of the 33kV network	[redacted]	[redacted]
Option 3: Option 2 with the use of flexibility **Preferred solution**	[redacted]	[redacted]

Option 2 is the only viable non-flexible solution for addressing the thermal issues at the Southampton BSP 33kV reserve busbar. Moreover, the ability to defer certain investment in assets using flexibility further improves the Whole life NPV of this option. As such, **Option 3 is the preferred solution and will be taken forward**.

The preferred solution, subdivided into works associated with the construction of a new BSP and the reinforcement of the 33kV network, is to be rolled out in the following phases:

Construction of a new BSP

Phase 1 (2025-2028): Works associated with the indoor construction of the existing 33kV busbar in Southampton BSP, alongside the installation of the 33kV switchboard of the new BSP, must start immediately with a desired completion date by the end of 2028. As mentioned in section 7.2, this work is crucial to release space for assets of the new BSP.

Phase 2 (2026-2030): Reinforcement related to the new BSP within the existing compound, including the installation of new 132/33kV transformers and a 132kV switchboard, must begin in 2026 and be completed by the end of 2030. While construction cannot commence until Phase 1 is completed in 2028, design work and the ordering of long-lead items can start beforehand.

Phase 3 (2025-2030): Reinforcement involving the installation of the dual underground 132kV circuit from Nursling GSP can start immediately, with a target completion date by the end of 2030. While design and construction work can begin now, the project cannot be finalised until the completion of Phase 2, specifically the construction of the 132kV switchboard. Similarly, as mentioned in section 7.2, this work also depends on the completion of indooring works at Nursling GSP, proposed under another EJP.

Reinforcement of the 33kV network

Phase 1 (2025-2028): Work on reinforcing the Central Bridge - Old Docks 33kV circuit and installing three 33kV circuits from the new BSP to Central Bridge must begin immediately, with a target completion date by the end of 2028. It is important to note that the new BSP–Central Bridge circuit cannot be completed until the indooring of the existing 33kV Southampton BSP (Phase 1 of constructing the new BSP) is finished.

Phase 2 (2030-2032): Reinforcement associated with the 6.6kV switchgear at Chapel Primary has been deferred from 2029 by 4 years using flexibility. Therefore, the predicted completion date for this reinforcement is 2033, with flexibility being used from 2029-2032.

Phase 3 (2031-2034): Reinforcement associated with the upgrade of the Central Bridge Chapel circuit has been deferred from 2034 by 1 year using flexibility. Therefore, the predicted completion date for this reinforcement is 2035, with flexibility leveraged in 2034.

9 Deliverability and Risk

Medium/High risks have been identified on the 132kV Nursling – new Southampton BSP cable route:

- Potential flooding risks applies to the first leg cable route from Nursling GSP near the marsh land due to river Test.
- Railway crossing is identified on the cable route near Test Way, which requires a directional drill. Suitable location of thrust bore needs to be identified to not affect parking lot entry.
- Proposed route crosses Dock gate 20, which is the busiest entry to the Port of Southampton. There is risk in the associated road closures etc.
- Although the proposed route attempted to avoid all major roads in the Southampton city area, there are still large sections that cross residential areas and require permission from the local council. Earlier conversation with the council is suggested due to the associated risks and difficulty for the route permissions.

- Following the previous point, since the strategic investment scope of works incorporate the Port development, conversation with Port of Southampton should also be made to identify the opportunities to run the 132kV cable through the site of Port, where suitable. This will divert a large section of the 132kV cable from laying through the city centre road and hence alleviating the pressure of route permission application from the local council.

Medium/High risks have been identified on the 33kV indoor switch room works:

- Site visit is required to identify the availability and sufficiency of the location on site to accommodate the 33kV indoor switch room, which consists of the 33kV board for both existing BSP and the new BSP.
- The 33kV indoor switch room construction work is the enabler of the new Southampton BSP and 132kV Nursling – New BSP circuit works, as well as the 33kV circuit works. It is important to deliver the 33kV indoor work on time to avoid any cascaded delay of the subsequent works. This is vital to enable continued compliance of the relevant networks under reinforcement.

In addition, coordination of delivery with PS001996 (indoor conversion with reconfiguration of the 33kV switchboard at Central Bridge substation) is required to ensure sufficient room is reserved during the switch room construction. This is needed for the potential 4th Southampton to Central Bridge 33kV circuit by 2047.

10 Outlook to 2050

The proposed solution facilitates the provision of anticipated peak demand growth and accommodates additional customers in the Southampton area. According to the DFES estimates outlined in section 5.2, the newly introduced assets are anticipated to operate without congestion until at least 2044, when the condition of the Chapel 6.6kV switchboard must be reassessed. Beyond that point, by 2047, there may be a need to install a fourth circuit from Central Bridge to the new BSP or shift some load away from the relevant primaries at 11kV level. Additionally, future restrictions remain on the existing 60MVA transformers at Southampton BSP, projected to have thermal and asset health issues past 2048.

11 Conclusion and Recommendation

This Engineering Justification Paper (EJP) provides the relevant information in relation to the load related investment of the Southampton BSP reserve busbar and the downstream 33kV network.

Specifically, this EJP targets the future thermal overloading issues for the 60MVA 132/33kV transformers, the 6.6kV switchgear and upstream 33kV circuit at Chapel Primary as well as the 33kV Southampton – Central bridge and Central bridge – Old Docks circuits. These concerns are arising due to the already accepted new customer connections, the projected surge in peak demand growth forecasted in the Distribution Future Energy Scenarios (DFES), alongside the significant future demand requirements at the Port of Southampton.

Although the main focus of this paper is the thermal overloading of the Southampton BSP reserve busbar transformers and the downstream 33kV supply, the surrounding network was also considered to achieve the optimal overall solution. The technical option reflected upon the 132kV network connectivity of Southampton BSP, alongside its potential future needs to propose a futureproof design and ensure the network's capacity for long-term expansion and sustainable growth.

The sole non-flexible option proposed addresses the thermal overloading issue of the Southampton BSP 60MVA 132/33kV transformers by constructing a new BSP. This substation will feature three 90MVA 132/33kV transformers, along with 33kV and 132kV indoor switchboards, and will be supplied via two direct feeds from Nursling GSP. Due to the spatial potential of the Southampton BSP compound and the spatial constraints of the surrounding urban residential area, it is proposed to construct the new BSP within the SSEN-owned site. Consequently, the existing Southampton BSP 33kV switchboard must be moved indoors to release space.

This solution also addresses the thermal overloading of the Central Bridge – Old Docks and Southampton – Central Bridge 33kV circuits via the installation of higher rated underground cable between the sites. Similarly, the thermal overloading of the 6.6kV switchboard at Chapel Primary and a portion of the Central Bridge – Chapel circuit is tackled via reinforcement and uprating of the relevant assets.

Flexibility has proven to be an economically viable approach for deferring the reinforcement of the Chapel 6.6kV switchboard and the upstream Central Bridge–Chapel 33kV circuit by 4 years and 1 year respectively. However, due to the anticipated peak demand growth on the Southampton BSP reserve busbar in the coming years, deferring reinforcement associated with the construction of a new BSP or the installation of circuits leading to Central Bridge was not economically feasible.

Therefore, **Option 3 (Option 2 with the use of flexibility) was deemed the preferred overall choice in this EJP**, [redacted]. Whilst the cost saved by flexibility might seem marginal in this case, it will be pursued as part of our Flexibility First commitment and to ensure maximum optionality in the future and overall efficient investment.

12 References

The documents detailed in Table 12.1 - Scottish and Southern Electricity Networks Documents, Table 12.2 – External Documents, and Table 12.3 – Miscellaneous Documents, should be used in conjunction with this document.

Table 12.1 - Scottish and Southern Electricity Networks Documents

Reference	Title
* (Arial - 9) *	* (Arial - 9) *
* Text *	* Text *

Table 12.2 – External Documents

Reference	Title
* (Arial - 9) *	* (Arial - 9) *
* Text *	* Text *

Table 12.3 – Miscellaneous Documents

Title
* (Arial - 9) *
* Text *

13 Subsequent Sections

<Text>

14 Revision History

No	Overview of Amendments	Previous Document	Revision	Authorisation
01	* (Arial - 9) *	* Text *	* Text *	* Text *
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
CB	Circuit Beaker
CBA	Cost Benefit Analysis
CBRM	Condition Based Risk Management
CEM	Common Evaluation Methodology
CI	Criticality Index
CML	Customer Minutes Lost
CT	Consumer Transformation
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
EJP	Engineering Justification Paper
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
IDP	Investment Decision Pack
LCT	Low Carbon Technology
LEP	Local Enterprise Partnership
LI	Load Index
LRE	Load Related Expenditure
LW	Leading the Way
NPV	Net Present Value
OHL	Overhead Line
PM	Pole Mounted
PV	Photovoltaics
RSN	Relevant Section of Network
SCO	Second Circuit Outage

SSEN	Scottish and Southern Electricity Network
SP	Steady Progression
ST	System Transformation
XLPE	Cross-linked Polyethylene

Appendix B Network Assessment

This section presents the necessary network assessment data for this EJP work. In particular, fault level results that lead to the dependency of the capital scheme PS001996 is presented and discussed here. In addition, DFES for Southampton Main BSP (Figure B-1) is presented here as part of the justification of the proposed new Southampton BSP, although it is not the focus of this EJP work.

As can be seen from Figure B-1 that the thermal capacity of the Southampton Main BSP transformer will be exceeded at year 2035. In addition, the load growth towards 2050 for existing Southampton main busbar is 170MVA, which could be sustained by the combination of both status quo main and reserve BSP transformers until 2048.

[redacted]

Figure B-2 shows the three-phase fault level results on the 33kV and 11kV network downstream of the proposed new BSP. Fault level issue can be seen at Central Bridge 33kV as the existing constrained CB rating is 13.1kA/33.4kA break/make. The ongoing capital scheme PS001996 proposes to indoor the Central Bridge 33V swich room with CB rating of 25kA/62.5kA break/make, which is fault level proof to the post reinforcement network as of this present EJP work. As such, the scheme PS001996 is a precursor dependency of this EJP work.

Bus Name	Nominal V	Pre-fault V	X/R ratio	Ik''-Initial S	Ik''-Angle	Ip-Peak Ma	RMS Sym.	Angle Sym	DC Comp	RMS Asym
				(0ms)	(0ms)	(10ms)	(50ms)	(50ms)	(50ms)	(50ms)
	(kV)	(pu)		(kA)	(degrees)	(kA)	(kA)	(degrees)	(kA)	(kA)
SAMP-ANEW	132.	1.044	13.2	22.56	-85.42	57.75	21.49	-86.33	13.29	25.27
SAMP-CNEW	33.	1.031	15.3	17.46	-86.01	45.50	16.17	-87.74	14.09	21.45
CENB-C	33.	1.027	11.2	16.61	-84.73	41.99	15.35	-86.46	9.27	17.93
BEVV-F1	6.6	1.026	12.4	9.19	-85.36	23.48	8.72	-86.54	5.03	10.07
CENB-E	11.	1.025	7.1	13.45	-81.83	32.21	11.46	-85.09	4.55	12.33
CHAP-F	6.6	1.026	11.0	17.39	-84.69	44.12	15.70	-87.00	10.65	18.97
NEWD-C	33.	1.030	7.3	16.65	-82.23	39.91	15.49	-84.12	4.92	16.25
OLDD-F	6.6	1.026	21.5	12.01	-87.21	32.22	11.18	-88.96	12.91	17.08

Figure B-2: Post reinforcement three phase fault level for the new BSP

Appendix C Flexibility Viability Results

[redacted]

[redacted]

Appendix D Sensitivity Analysis

For each investment proposed in this EJP, we have reviewed the annual max demand figures under all DFES scenarios out to 2050. Based on this assessment, we will place this investment into one of the categories from Table D-1.

Table D-1: Description of each sensitivity analysis category

Category	Description	Applies to this EJP?
A	Schemes where the chosen investment size is large enough to meet peak demand/generation under all net zero compliant scenarios to 2050	✓
B	Schemes where we would require further future reinforcement of the particular asset(s) being proposed under a more aggressive scenario to 2050	
C	Schemes where the proposed investment is not required under any scenario to 2050 (if any)	
D	Schemes where investment can be deferred until a later date under some scenarios i.e. ST scenario indicates no investment needed until 2030	

Justification for categorisation:

The Southampton BSP reserve busbar and 33kV network EJP considers several complex solutions, including the construction of a new BSP, to resolve network issues occurring across multiple voltage levels. As such, careful consideration has been taken when carrying out the sensitivity analysis for this work, to ultimately classify this EJP as a category A project.

The sensitivity analysis for all constraints will be split and presented in individual sections, similar to those outlined in Section 5.2. Each section will display a graph highlighting the load growth of the network from the four different Distribution Future Energy Scenarios, alongside the pre and post reinforcement constraint point of the relevant assets. This allows us to understand whether the proposed solution is compatible with the present/future network under any scenario. For reference, the four scenarios studied are Customer Transformation (CT), Leading the Way (LW), Falling Short (FS) and System Transformation (ST).

A summary of the network constrains, their categorisation and the relevant justification can be seen in Table D-2.

Table D-2: Justification of categorisation for each constraint

Constraint	Category	Justification
Southampton BSP reserve busbar	A	[redacted]. Proposed solution meets forecasted demand for all scenarios out to 2050 except FS (until 2048), however foundations are laid for further future reinforcement if required
Southampton – Central Bridge 33kV circuit	A	[redacted] Solution does not meet forecasted demand out to 2050 for all scenarios, however does facilitate further future reinforcement if necessary.

Chapel Primary switchboard replacement	A	[redacted] Solution does not meet forecasted demand out to 2050 for all scenarios, however interim solution proposed until voltage rationalisation is required
Central Bridge – Chapel 33kV circuit	A	Constrained in 2034 under both LW and CT scenarios. Solution does not meet forecasted demand out to 2050 for all scenarios, but does provide a suitable platform to enable intervention later.

<u>Southampton BSP reserve busbar:</u>

[redacted]. Whilst the proposal of constructing a new BSP facilitates sufficient capacity out to 2050 for all DFES scenarios bar Falling Short (until 2048), this solution lays the foundation for further reinforcement if it is needed in the future.

[redacted]

<u>Southampton – Central Bridge 33kV circuit:</u>

[redacted]. The focus on winter reflects the anticipated sharp demand increase in the coming years. However, nearing 2050, summer demand growth is projected to surpass that of other seasons. Consequently, Figure D-3 highlights the summer peak demand growth to evaluate whether the proposed solution remains adequate through 2050. As shown, the installation of three new circuits between the new BSP and Central Bridge is only sufficient until 2045 for the FS scenario, 2047 for CT and 2048 for LW. Regardless of scenario, this solution builds the foundation for further future reinforcement, such as the installation of a fourth circuit, as mentioned in Section 10 of this report.

[redacted]

Chapel Primary switchboard replacement

[redacted]. The use of flexibility defers the reinforcement by until 2031 and 2032 for LW and CT respectively, meaning no ED2 funding for reinforcement was requested under this EJP, for either scenario.

Similar to the previous example, the projected summer demand exceeds other seasons nearing 2050, hence outlined in Figure D-5 to study whether the proposed solution is sufficient. As shown, the thermal capacity is exceeded in 2042 under FS, 2044 under CT and 2045 under ST. The installation of a new switchboard provides a cheaper interim solution before voltage rationalisation is required, also allowing for the utilisation of recently installed transformers at the primary under PS006666. Ultimately, the same solution would be proposed in this EJP regardless of the DFES scenario considered.

[redacted]

[redacted]

Central Bridge – Chapel 33kV circuit

Figure D-6 presents the peak Spring/Autumn demand growth at Chapel PSS, projected to exceed capacity of a portion of the Central Bridge – Chapel 33kV circuit by 2034 under both CT and LW scenarios. Regardless of scenario, reinforcement works would have been proposed at the same year.

Again, the summer demand growth exceeds that of other seasons in the future, hence Figure D-7 is used to determine whether the proposed solution is sufficient until 2050. The thermal capacity of the post reinforcement 33kV line will be exceeded in 2043 under the FS scenario, 2045 under CT and 2046 under ST. As in previous cases, the same reinforcement would have been proposed regardless of scenario, as further reinforcement of the existing line will be necessary under future price control periods.

[redacted]

[redacted]