PS008853

UXBRIDGE PRIMARY SUBSTATION ENGINEERING JUSTIFICATION PAPER

Scottish & Southern Electricity Networks

CONTENTS

1 Executive Summary

The purpose of this document is to provide justification for a load related investment and act as decision support tool, in conjunction with other appropriate means of justification for investment at **UXBRIDGE Primary Substation**, located at 1 Dukes Way, Uxbridge, UB8 2RN.

The Consumer Transformation Distribution Future Energy Scenarios for this group demand predict an increase in load totalling approximately 58MVA by the end of RIIO-ED2 price control period and approximately 88MVA by 2050. Technologies with major contribution for this increase are data centre, air conditioning and heat pumps. Firm-capacity for this group demand is currently 56MVA with 13,354 customers connected.

This project will specifically provide for the upgrade of the existing three 28MVA 66/11kV transformers with 40MVA units, [redacted]. This will increase the firm capacity at this substation to 76.2MVA, which is sufficient headroom for the forecasted increase in load until 2036. Anything further will require significant reinforcement works within a very limited compound area. Therefore, the outstanding capacity from 2036 should be covered by establishing a new substation elsewhere.

Classed as a strategic investment, this project shall start immediately with estimated completion by the end of RIIO-ED2 price control period and shall be funded under the Uncertainty Mechanism.

[redacted]

2 Summary Table

Name of Scheme/Programme	UXBRIDGE Primary Substation – Strategic Investment	
Primary Investment Driver	Load Related	
Scheme reference/ mechanism or category	PS008853 Uncertainty Mechanism	
Output reference/type	66kV - TRAFO - 40MVA 66/11kV transformer	
Cost	[redacted]	
Delivery Year	2028	
Reporting Table(s)	CV1 – Primary Reinforcement	
Outputs in RIIO ED2 Business Plan	No	
Spend Apportionment	**ED2**	**ED3+**
	[redacted]	
MVA released	20.2MVA (11kV)	

Table 2 – Summary Table

3 Introduction

This paper outlines the need for the upgrade of existing transformers at UXBRIDGE primary Substation.

Our **Load Related Plan Build and Strategy (Annex 10.1)** sets out our methodology for assessing load-related expenditure and describes how we use the Distribution Future Energy Scenarios (DFES) 2022 as the basis for our proposals. We have established a baseline view of demand which provides a credible forward projection of load-related expenditure for the ED2 price control period and reflects strongly evidenced support from our stakeholders. Our ex-ante baseline funding request is based on the minimum investment required under all credible scenarios. Our plan will create smart, flexible, local energy networks that accelerate progress towards net zero – with an increased focus on collaboration and whole-systems approaches.

This investment is a component of our strategic goal of 'Accelerating progress towards a net zero world'.

Section 4 of this Engineering Justification Paper (EJP) describes our proposed load related investment plan during RIIO-ED2. It provides high-level background information for this proposed scheme explaining the existing network arrangement, the load growth forecasts through the Distribution Future Energy Scenarios (DFES) and setting out the need for this project.

Section 5 provides an overview of the considered options and identifies the most appropriate option as proposed solution to address the network constraints. 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 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 those options which are deemed unviable solutions, and therefore not taken forward to the Cost Benefit Analysis.

Section 7 details the Cost Benefit Analysis (CBA) and provides comparative results of all the options considered within the CBA. It 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 8 describes the deliverability of the plan for RIIO-ED2, and this proposed investment. It also describes possible risks based on the required works, the proposed assets, and other surrounding factors, such as the procurement of additional construction space.

Section 9 addresses the strategic aspect of the investment and highlights the long-term aspects of operating a constrain-free grid until at least 2050.

Section 10 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.

4 Background Information

4.1 Existing Network Arrangements

Uxbridge Primary Substation is connected to IVER 66kV GSP through three 66kV radial circuits and circuit breakers named B1L5, B4L5 and B10L5 as illustrated in Figure 1.

[redacted]

The Uxbridge primary substation consists of 3x28MVA 66/11KV transformer connected to a 11kV switchboard (Figure 2).

[redacted]

The geographical distribution of Uxbridge PSS can be found in Figure 3. The compound has very limited space for upgrading and the 11kV switch house is also with limited space for new circuit breakers with all installed elevated from the ground as a flood mitigation measure as the substation is adjacent to a water canal. Table 3 illustrates the total number of customers connected to this substation.

Substation	Customers
UXBR PSS	13,354

Table 3 – Number of Customers

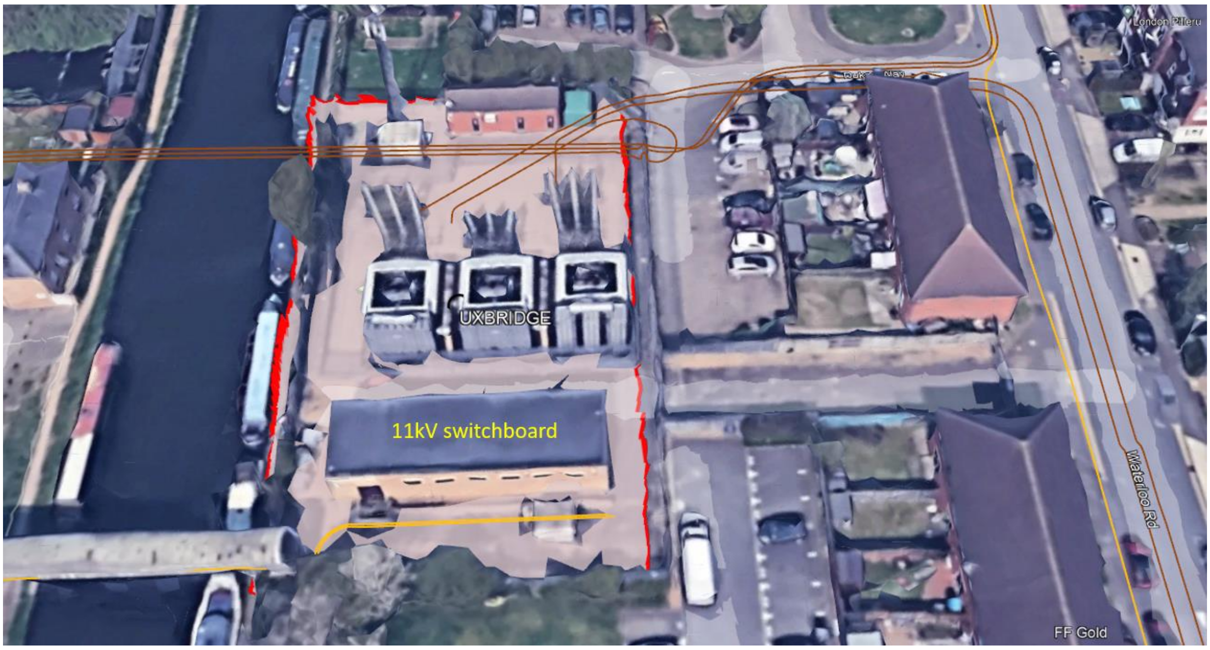

Figure 3 – UXBRIDGE Primary Substation Geographical Area

4.2 Load Forecast for Uxbridge Primary Substation

To understand the future pathways for demand and generation at this group demand, SSEN has carried out extensive scenario studies – the Distribution Future Energy Scenarios (DFES). This framework comprises four potential pathways for the future of energy based on how much energy may be needed and where it might come from. 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. We have worked closely with our partner Regen to develop the forecasts between 2022 and 2050 through enhanced engagement with the local authorities, local enterprise partnerships (LEPs), devolved governments, community energy groups and other stakeholders. Based on the enhanced stakeholder engagement feedback, we have chosen Consumer Transformation as the baseline scenario for our investment.

[redacted]

The firm capacity of this group demand is 56MVA, limited by the 28MVA transformers. [redacted] The capacity of the circuits upstream is greater than 64.4MVA and therefore, not considered as a limiting factor. Thus, no flexibility is deemed necessary to be procured until the proposed reinforcement works are completed. Refer to Figure 4 for details.

4.3 Existing Asset Conditions

Table 4 gives an overview of the Health Index (HI) for relevant assets considered at Uxbridge Primary Substation. Alongside the current health index, values for 2028 (end of RIIO – ED2), 2035 and 2044 are also presented. [redacted]

[redacted]

[redacted]

4.4 Existing Operational Issues

No operational issues reported. Flooding mitigation in place for the 11kV switchboard as the substation is located adjacent to the water canal.

4.5 Network Analysis Summary

Following the completion of the network analysis, constraints have been identified when modelling the forecasted demands shown in Section 4.2.

Thermal Constraints:

The firm capacity at Uxbridge PSS is 56MVA, limited by the rating of the transformers. The next limiting factor is the 66kV circuits to Iver 66kV GSP busbar, or 200MVA (Summer Cyclic Season). The 66kV circuit breakers at this GSP substation are rated 285MVA.[redacted]. The main driver for this increase in load is a mix of data centre increase in load, air conditioning and heat pumps. However, the transformers are allowed to overload up to 115% according to the type of load (Summer Cyclic), increasing the total capacity of the group demand to 64.4MVA.

Voltage Constraints:

[redacted].

Fault Level Constraints:

[redacted] Following the proposed networks upgrade, no fault level issues have been reported.

4.6 Regional Stakeholder Engagement and Whole systems analysis Summary

Uxbridge Primary Substation supplies Hillingdon and Buckinghamshire.

SSEN has strong working relationships with local authorities and other key stakeholders in the region. We have met with the Greater London Authority and Buckinghamshire Council to discuss development plans and local area energy planning. We also engage with the Greater Southeast Net Zero Hub, of which the GLA and Buckinghamshire Local Enterprise Partnership are members. This engagement has helped SSEN stay informed about planning and development that will impact local communities' use of the network. Hillingdon Council's operations will be carbon neutral by 2030, and they aim to roll out 300 electric vehicle charging points across the borough by 2030. As detailed in its Climate Change and Air Quality Strategy and on its website, Buckinghamshire Council plans to reduce council emissions 75% by 2030 and to meet the national target of net zero by 2050. The council has:

· Established a £5 million Climate Change Fund, used in part to increase renewable generation capacity.

· Organised a group purchasing scheme with Solar Together in 2022, which delivered over a thousand solar PV, electric vehicle charger, and home battery installations across the council area.

· Planned to install more than 1000 electric vehicle charge points by 2027.

· Begun to electrify its vehicle fleet, including waste collection services; and

· Installed heat pumps and solar panels on council-owned properties.

4.7 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 reinforcements.

For Uxbridge PSS group demand, CEM tool indicates no cumulative benefit of deferral the preferred option works proposed under this paper (Figure 5). Therefore, no further study has been carried out to assess the potential flexibility market availability in this area of the networks.

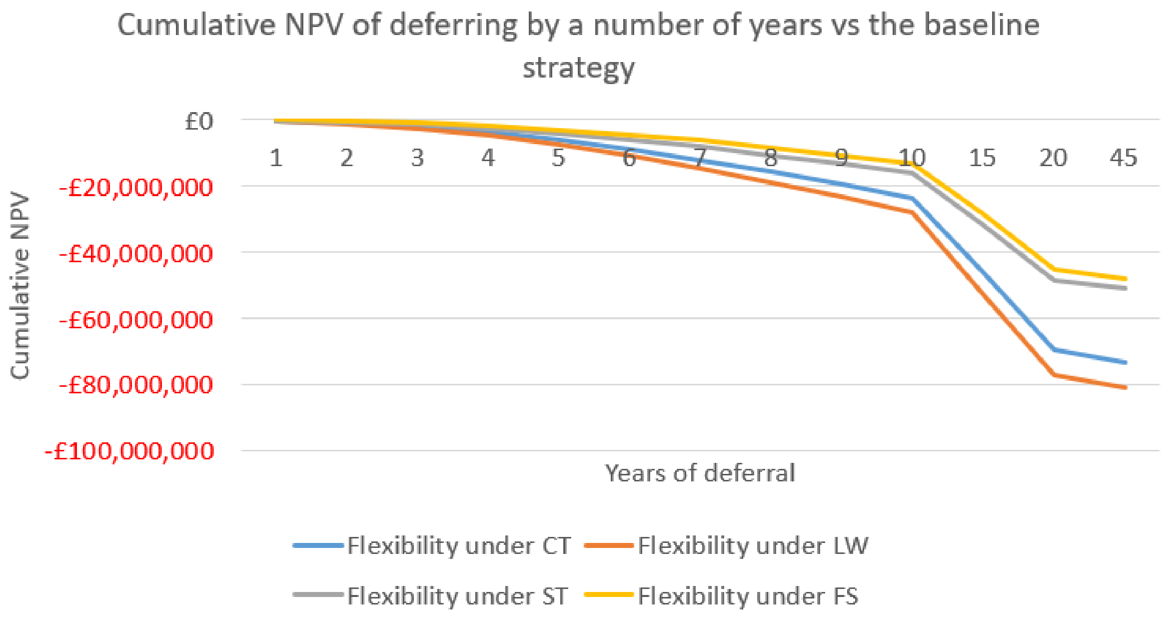

Figure 5 – Preferred Option Cumulative NPV

4.8 Confidence Table

The confidence in the assumptions and input data in this paper are described in Table 5.

Confidence Factor	Certainty (High, Medium, Low)	Comments
Load Forecast	Medium	There is always uncertainty on predicting load increase in a large area of the networks. However, we have strong relation with local authorities and key stakeholders with reliable information regarding future scenarios for load increase.
Existing Asset Condition	High	Based in our asset life cycle assessment tool.
Existing Operational Issues	High	No operational issues reported.
Connections Activity	High	Connection activity is well documented and captured by our systems and they are all included in our models to determine the reinforcement works required.
Regional Stakeholder engagement	High	The local authorities have recently updated their commitment to achieve their net zero carbon emission plan.
Flexible market Viability	N/A	Based on the results obtained using CEM tool flexibility is not cost effective.
Funding Position	Medium	Project to be fully funded by the Uncertainty Mechanism to be delivered by the end of ED2, looking to achieve the load forecast required by 2050.

Table 5 – Confidence Table

5 Optioneering

Summary of Options

The table below (Table 6) provides a summary of the investment options under consideration along with the advantages and disadvantages associated with each one. A more detailed description of each option is then provided in Section 6.

Option	Description	Advantages	Disadvantages	CBA consideration and results
1. Do Nothing	No action taken as the networks remain untouched.	No works required with no expenditure.	[redacted]	Customers at high risk. Not progressed to CBA.
2. Flexible Solution	Using flexibility to either defer or avoid reinforcement works.	Provides some network security until the triggered works are completed.	Short-term solution.	According to CEM results, the use of flexibility is not economically viable. Not Progressed to CBA.
3. Reinforcement by replacing existing assets with 2 new higher capacity transformers	Replacing the existing transformers with 2x80MVA transformers	Facilitate further works to upgrade the networks to meet the forecasted demand by 2036. One 66kV circuit from IVER 66kV would be made spare.	Space constraints.	Not Progressed to CBA.
4. Reinforcement by replacing existing assets with 3 new higher capacity transformers	Replacing the existing transformers with 3x40MVA transformers	Facilitate further works to upgrade the networks to meet the forecasted demand by 2036. Even though not mandatory, SCO scenario is covered under this option.	-	The only technically and economically viable long-term solution. **Preferred Option.** **Progressed to CBA.**

Table 6 – Summary of Options

5.1 Cost Comparison Table

Table 7 – Cost Comparison Table

compares the costs for the options considered.

Option		Whole Life NPV (£m)	C0a costs (£m)				
			2023/24	2024/25	2025/26	2026/27	2027/28
1	Do nothing	[redacted]					
2	Flexible Solution						
3	Reinforcement by replacing assets to the networks with 2 new transformers						
4	Reinforcement by replacing assets to the networks with 3 transformers						

Table 7 – Cost Comparison Table

6 Detailed option analysis

Option 1: Do Nothing

The option of doing nothing is high risk given that the confidence in the load growth (shown in Section 4.2) is high. Therefore, the following are the likely consequences of doing nothing based on existing network constraints and those forecasted.

- Equipment will be overloaded and, therefore, its life span will be shorter.
- Planned outages will become increasingly risky and so there is potential for an event where a significant number of customers will be left off for a long period of time.
- Load shedding would likely need to be implemented for second circuit outages to avoid thermal overload of assets.
- Load growth will see the network non-compliant with EREC P2.
- New connections will see long wait times to connect to the grid and, therefore, cause a bottleneck to known local developments and ambitions to meeting 2050 Net-Zero targets.

Therefore, this option is rejected and will not progress to the cost-benefit analysis.

Option 2: Flexible Solution or Curtailment

The outputs from CEM tool suggests that flexibility is not viable for the preferred option of this project (Figure 5). The cumulative benefit of deferral shows greater cost compared the cost of this scheme (Figure 6).

[redacted]

Therefore, this option is rejected and will not progress to the cost-benefit analysis.

Option 3: Reinforcement by replacing existing assets with two new higher capacity transformers.

This option provides for the replacement of the existing assets at UXBRIDGE PSS with new transformer units as per Figure 7. Due to the new configuration of the proposed transformers, the 11kV switchboard should be replaced as well. As only two transformers as suggested, one of the 66kV circuits from IVER 66kV switchboard should be made available. The cable should then be pot-ended and the circuit breaker at IVER 66kV GSP isolated and retained for future use. However, the site has very limited space and it is deemed 80MVA transformer units would not fit in it. Furthermore, the new 11kV switchboard will demand a building extension to accommodate additional circuit-breakers and again, space is a major issue.

Therefore, this option is rejected and will not progress to the cost-benefit analysis.

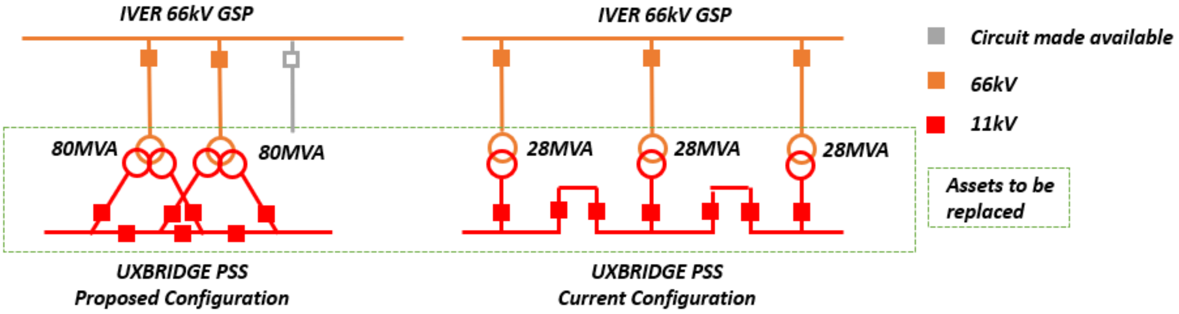

Figure 7 – Option 3 Proposed Works

Assets	Volume	Cost £m (2020/21 Baseline)
Transformer 66/11 kV 80 MVA	2	£3.8m
6.6/11kV CB (GM) Primary	34	£1.4m
	Total	£5.2m

Table 8 – Option 3 Cost Breakdown

Option 4: Reinforcement by replacing existing assets with three new higher capacity transformers.

This provides for the replacement of the existing transformers only at UXBRIDGE PSS Substation. The 66kV circuits upstream to IVER 66kV GSP Substation as well as the 11kV switchboard shall remain. This is the cheapest option, and the proposed works provide sufficient capacity to meet the demand forecasted until 2036.

This option is technically viable and will therefore be progressed to the Ofgem CBA.

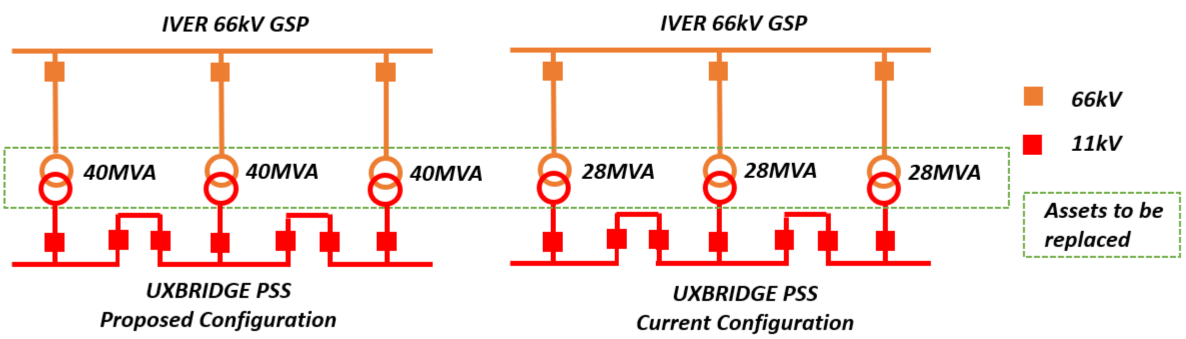

Figure 8 – Option 4 Proposed Works

[redacted]

7 Cost Benefit Analysis (CBA)

A sensitive analysis of the preferred options is illustrated in Table 10, including assets, results from a CBA perspective, the rationale for the selected options, costs, timing, declared outputs and delivery year.

Option	Meets 2035 Forecasted Demand	Meets 2050 Forecasted Demand	Carry Forward to Ofgem CBA	Whole Life NPV (£m)	Output Type	Cost (£m)	Delivery Year	Justification
1. Do Nothing	No	No	No	N/A	Load Index	None	N/A	[redacted]
2. Flexible Solution	No	No	No	N/A	Load Index	N/A	N/A	There is no benefit on postponing the upgrade of existing transformers. Not economically viable according to CEM results.

3. Reinforcement by replacing existing assets with 2 new higher capacity transformers	Yes	Yes	No	N/A	Load Index	[redacted]	2028	Technical difficulties in this option, major issue is the space constrains to install 80MVA transformers and limited space in switch room to install new switchgears.
4. Reinforcement by replacing existing assets with 3 new higher capacity transformers	Yes	Yes	Yes	[redacted]	Load Index	[redacted]	2028	The only technically and economically long-term viable solution. Load Index to be improved.

Table 10 – CBA Summary Table

8 Deliverability and Risk

The following has been identified as impacting deliverability and risk for this project:

- The outputs for the preferred option are listed in **Error! Reference source not found.**. It is expected that all plant items to be delivered by the estimated first year of construction, or 2026.
- Flooding mitigation measures should be considered for the new transformers.

9 Outlook to 2050

The recommended option provides enough capacity to the network at Uxbridge primary substation to meet the forecasted demand until 2036. Anything further will require significant reinforcement works in compound with very limited space. Therefore, the outstanding capacity from 2036 should be covered by establishing a new substation elsewhere.

10 Conclusion and Recommendation

This EJP has raised the need for investment at UXBRIDGE PSS by replacing the existing 28MVA transformers with 40MVA units within RIIO-ED2 price control period. The 11kV switchboard will not need replacement, neither the circuits upstream to IVER 66kV GSP Substation. This is driven by thermal issues as well as forecasted demand as per DFES 2022 data.

This will ensure sufficient capacity for this group demand to facilitate local projects and developments that will support the local economy whilst aligning with the local government's ambition to transition to Net Zero carbon emission until at least 2036.

Flexibility is deemed not viable as the cost to deliver the additional capacity is not substantially higher than the NPV, according to the CEM study provided in this report.

As the substation footprint is very limited, any additional works or larger assets could not be accommodated within it. The compound is next to a water canal and surrounded by housing development. Therefore, any site expansion is not deemed possible. Thus, any additional capacity further than what is proposed under this paper will require a new substation to be established elsewhere. Nevertheless, the transformers replacement is considered a low-cost investment to maximise the capacity of this substation.

11 Revision History

No	Overview of Amendments	Previous Document	Revision	Authorisation
01				
02				

Appendix A Definitions and Abbreviations

Acronym	Definition
AIS	Air-insulated Switchgear
ASCR	Aluminium Conductor Steel Reinforced
BSP	Bulk Supply Point
CBA	Cost Benefit Analysis
CBRM	Condition Based Risk Management
CEM	Common Evaluation Methodology
CI	Customer Interruptions
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 Sensitivity Analysis

For each investment proposed in this EJP, we have reviewed the annual maximum 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 11.

Table 11

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	✓ (1)
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	

(1) As stated in the main body of this document, due to space issues, any additional capacity than what is proposed under this paper should be addressed with a different solution rather than any other works within this compound. The released capacity is maximised for this substation, considering the area available, with no room for expansion of the compound.

Justification for Categorisation:

[redacted] The proposed reinforcement works are sufficient to meet peak demand at different timescales, depending on the chosen scenario. However, as the capacity of the substation will be maximised, future analysis will tell when a new site will be needed, based on the confirmation of which one of the scenarios this group demand will be taken.

[redacted]