RIIO-ED2 Engineering Justification Paper (EJP)

Beaconsfield 22/6.6 kV Primary Substation

Investment Reference No: 47/SEPD/LRE/BEAC

Contents

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

1 Executive Summary

Our proposed investment at Beaconsfield 22/6.6 kV primary substation will deliver P2/7 compliance for investment of £4.96m during RIIO-ED2.

The primary investment driver for this scheme is load-related, specifically thermal overload at Beaconsfield primary substation. The thermal overload issues are apparent under all of the three Net Zero scenarios (System Transformation, Consumer Transformation and Leading the way) for investment in ED2 due to forecast demand growth from our Stakeholder supported Distribution Future Energy Scenario (DFES). This project is required under our accelerating progress towards Net Zero priority, as Buckinghamshire council declares a climate emergency and uptake of low carbon technologies (LCT) such as EVs and HPs has large impact. The secondary driver is associated with the health condition of the existing transformers.

The EJP considers an exhaustive range of options to address the thermal overloading issues, setting out the options that have been considered and rejected prior to the CBA analysis, and the short list of those options included within the analysis, with a clear rationale for including or excluding each option.

The Cost Benefit Analysis results shown below in Table 1 demonstrates that the most cost-effective solution, that delivers the best value for consumers in terms of the 45 years Net Present Value (£k), is option 3 which is reinforcement by adding new assets (network extension).

Options	Net Present Value (NPV) After 45 Years (£k)	Investment (£k)
Option 2 – Reinforcement of existing assets (asset replacement)	-6,546	8,430
Option 3 – Reinforcement by adding new assets (network extension)	-987	4,956

Table 1 Options Summary

Following the optioneering and detailed analysis, as set out in this paper, the proposed scope of works for Option 3 is:

Asset	Volume	Costs
33kV UG Cable (Non Pressurised)	12	[redacted]
33kV CB (Air Insulated Busbars) (OD) (GM)	2	[redacted]
33kV Transformer (GM)	2	[redacted]
6.6/11kV CB (GM) Primary	2	[redacted]

Total		[redacted]

Table 2 Investment Summary

This scheme delivers the following outputs and benefits:

- Create 3.4 MVA additional capacity at Beaconsfield primary substation hence compliance with P2/7. The substation will be LI2 by the end of RIIO-ED2.
- Improve asset health condition to minimise unforeseen outages in the area.
- Facilitate the continued uptake of low carbon technology (LCT) with the local area and help support the climate change targets of Buckinghamshire Council.
- Facilitates the efficient, economic, and co-ordinated development of our Distribution Network for Net Zero.

The cost to deliver the preferred solution is £4.96m and the works are planned to be completed in 2026. This EJP investment sits within our Net Zero Totex ask.

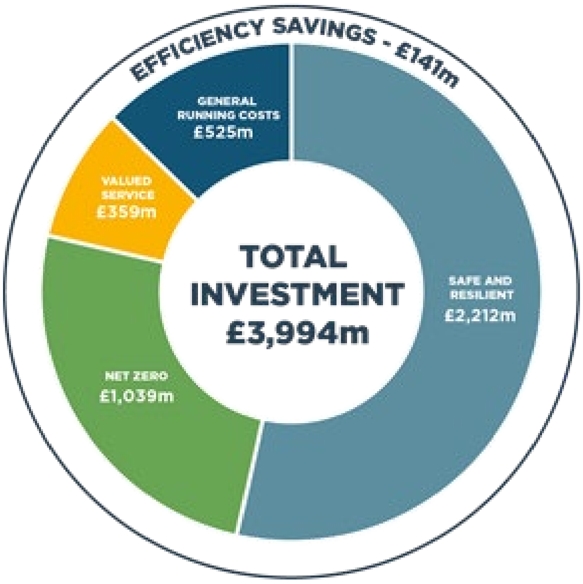


Figure 1: SSEN total investment cost within RIIO ED2

2 Investment Summary Table

Table 3 provides a high level summary of the key information relevant to this Engineering Justification Paper (EJP) and the Cost and Volume (CV) impacts within our Business Plan Data Templates.

Name of Scheme/Programme	Beaconsfield 22/6.6 kV Primary Substation		
Primary Investment Driver	Load related – substation thermal overload		
Scheme reference/ mechanism or category	47/SEPD/LRE/BEAC		
Output reference/type	33kV UG Cable (Non Pressurised) 33kV CB (Air Insulated Busbars) (OD) (GM) 33kV Transformer (GM) 6.6/11kV CB (GM) Primary		
Cost	£4.96m		
Delivery Year	2025/26		
Reporting Table	CV1: Primary Reinforcement		
Outputs in RIIO ED1 Business Plan?	No		
Spend Apportionment	**ED1**	**ED2**	**ED3+**
	-	£4.96m	-

Table 3 Investment Summary

3 Introduction

Our ***Load Related Plan Build and Strategy (Annex 10.1)***[1] sets out our methodology for assessing load-related expenditure and describes how we use the Distribution Future Energy Scenarios (DFES) 2020 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 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 for the reinforcement of Beaconsfield primary substation in RIIO-ED2. The primary driver considered within this paper is load-related, specifically thermal overloading triggered by the demand forecasts.

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

Section 5 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 6, 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.

Finally, **Section 7** of this EJP also sets out the deliverability of the plan for RIIO-ED2 and this proposed investment.

[1] ***SECTION D: (Chapter 10), Responding to the net zero Opportunity, (Annex 10.1), Load Related Plan Build and Strategy***

4 Background Information and Analysis

4.1 Existing Network Arrangements

Beaconsfield primary substation is located within Buckinghamshire - c20 miles due West of London. This substation is supplied from Denham and Upton BSPs. Beaconsfield currently supplies 6,893 customers via 6.6kV circuits. The 2019/20 peak demand for the middle bus sections (fed from Denham BSP) is 10.5MW and that for the end bus sections (fed from Upton) is 4.5MW and there is currently no embedded generation connected to this substation.

Beaconsfield primary substation comprises of (Figure 1):

- Two 10 MVA transformers supplied via two circuits from Denham 132/22kV BSP substation – one direct (with a tee to Wapseys Wood generation) and one via Cokes Lane substation.
- Two banked 5 MVA transformers supplied from Upton 132/22 kV BSP substation.
- A four section 6.6 kV switchboard with:
    - The two 10 MVA transformers connected to the two middle sections.
    - The two 5 MVA transformers connected to the two end sections.

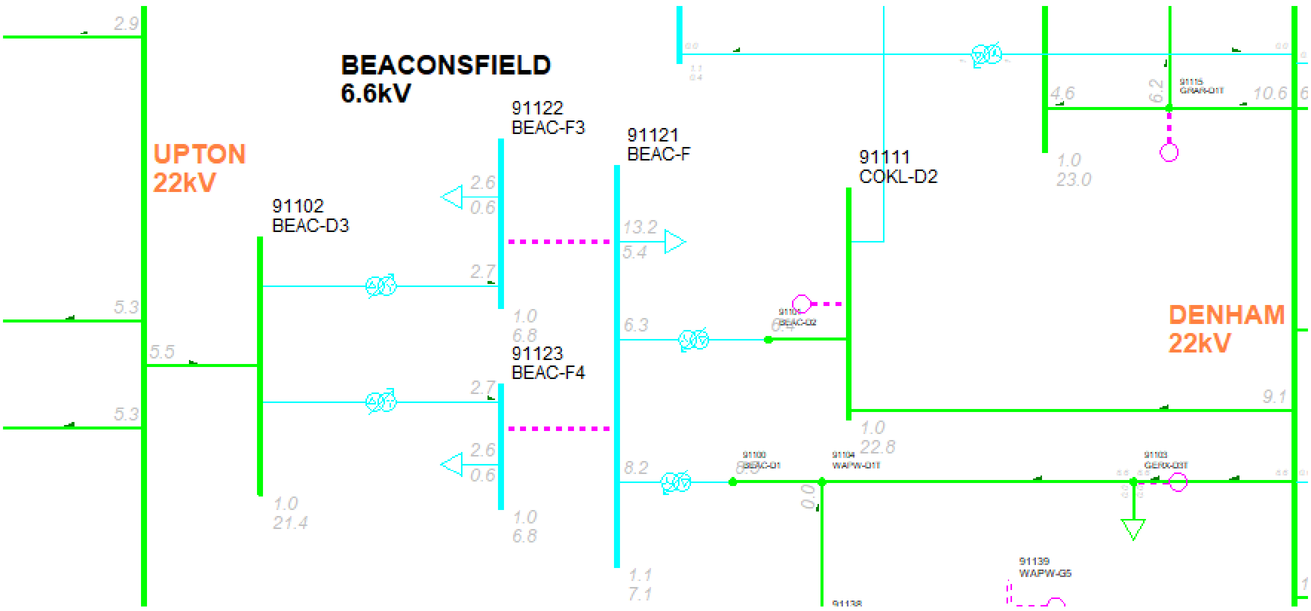


Figure 2 Beaconsfield Primary Network Arrangement SLD.

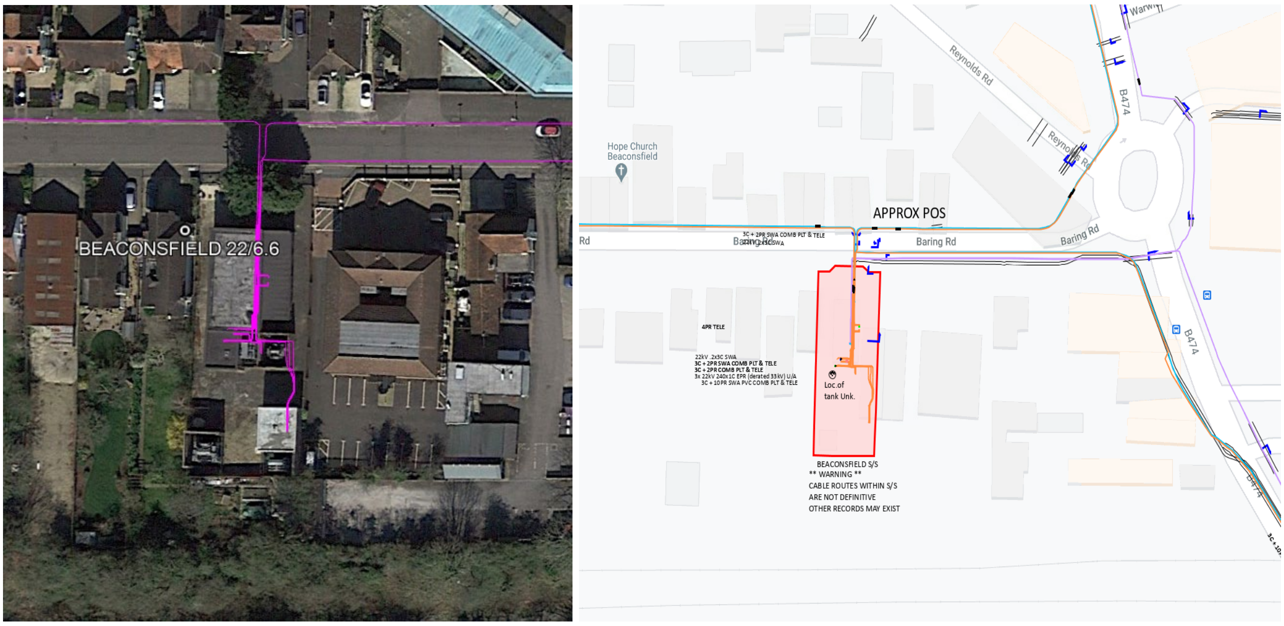


Figure 3 Beaconsfield Primary Substation geographical layouts.

4.2 Local Area Energy Plan (LAEP)

In 2019, Buckinghamshire council declared a climate emergency and acknowledged the need for Climate Change Strategy which has not yet been published as it is in the draft phase. However, the council has agreed to:

1) Recognise that the rate of climate change is a global emergency.

2) Recognise that, although the UK constitutes 1% of global carbon emissions, it must nevertheless play its part in leading the way in promoting change both in the UK itself and, importantly, globally.

3) Note the significant progress that Buckinghamshire County Council has made to date in addressing climate change.

4) Agree that the new Buckinghamshire Council should consider addressing climate change as a key issue.

5) Acknowledge the net-zero 2050 UK target, as contained in the 2008 Climate Change Act (as amended).

6) Commission a carbon audit pre assessment to gain an insight into the Council's carbon usage.

7) Recommend that Cabinet should further consider this issue, including what proposals, ahead of vesting day, the authority could implement to support this agenda. These proposals to include using the carbon audit gap analysis report to inform the policy decisions of the new Buckinghamshire Council.

4.3 Demand Forecast for Beaconsfield Primary Substation

In order to understand the future pathways for demand and generation at Beaconsfield primary substation, SSEN has carried out extensive scenario studies – the Distribution Future Energy Scenarios (DFES). The basis for this work is National Grid's Future Energy Scenarios (FES) 2020. 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.

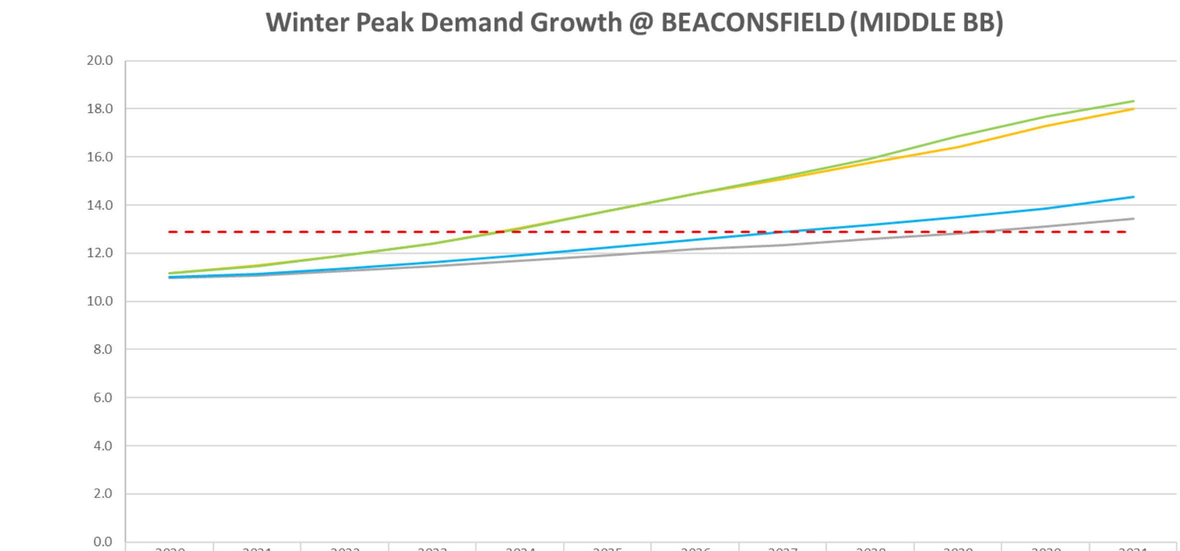
The variables for the four scenarios are driven by government policy, economics and consumer attitudes related to the speed of decarbonisation and the level of decentralisation of the energy industry. We have worked closely with our partner Regen to develop the forecasts between 2020 and 2050 through 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. In order to protect consumer's bill against forecasting uncertainties, our baseline funding only includes load related investment required in the first two years in the RIIO-ED2 period unless it is also required by other net zero scenarios. Full details on our DFES methodology, stakeholder input and regulatory treatments of load related investment can be found in the ***Load-Related Plan Build and Strategy (Annex 10.1).***

Beaconsfield primary substation has two bus sections (middle section and end section) which are currently fed from two different BSPs. We have identified an overload at Beaconsfield middle bus section from our demand forecast.

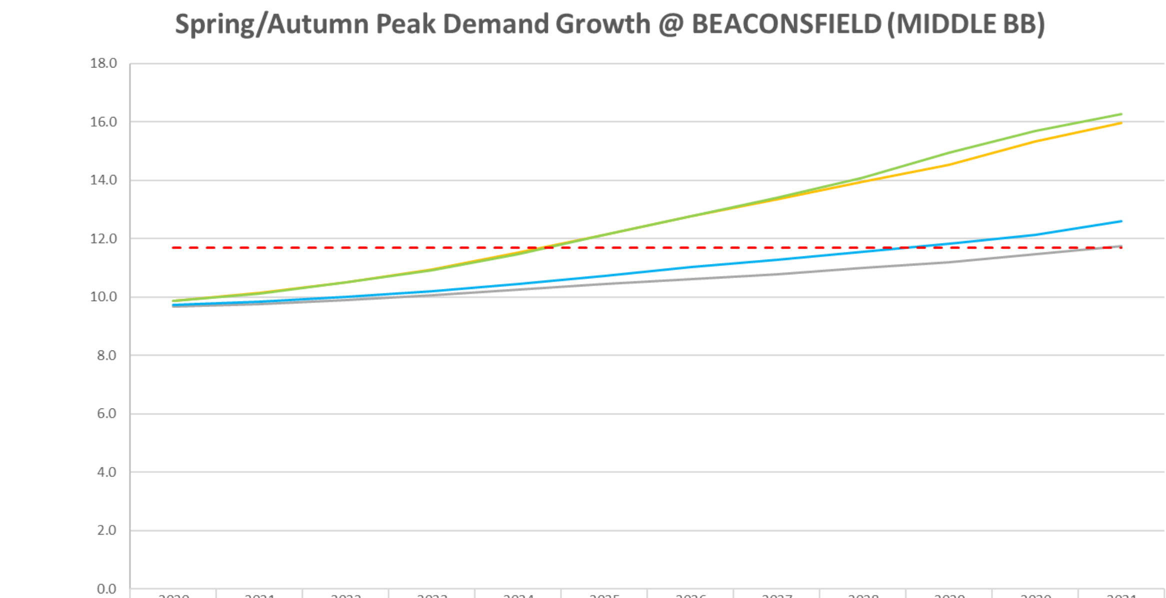
Figure 3 and Figure 4 below shows the demand projections in MVA at Beaconsfield's middle bus section for all forecast scenarios in winter and spring/autumn. In this case, the first circuit outage limit set by the transformers is exceeded under Consumer Transformation (CT – by 2025), Leading the Way (LW – by 2025) and System Transformation (ST – by 2027) scenarios during ED2. This scenario modelling confirms the certainty of this investment in RIIO-ED2.

Network interventions are required to address this issue as not doing anything would result in a licence condition breach, hindering the LCT deployment and potentially a wide-spread blackout in the areas supplied by Beaconsfield Primary.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
SP	11.0	11.1	11.3	11.5	11.7	11.9	12.2	12.3	12.6	12.8	13.1	13.4
CT	11.2	11.5	11.9	12.4	13.0	13.8	14.5	15.1	15.8	16.4	17.3	18.0
LW	11.2	11.5	11.9	12.4	13.0	13.8	14.5	15.2	15.9	16.9	17.7	18.3
ST	11.0	11.1	11.4	11.6	11.9	12.2	12.6	12.9	13.2	13.5	13.8	14.3
FCO Limit	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9

Figure 4 Beaconsfield Primary Middle Bus Section Winter peak demand growth.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
SP	9.7	9.8	9.9	10.1	10.3	10.4	10.6	10.8	11.0	11.2	11.5	11.7
CT	9.9	10.1	10.5	10.9	11.5	12.1	12.8	13.3	13.9	14.5	15.3	16.0
LW	9.9	10.1	10.5	10.9	11.5	12.1	12.8	13.4	14.1	14.9	15.7	16.3
ST	9.7	9.8	10.0	10.2	10.5	10.7	11.0	11.3	11.6	11.8	12.1	12.6
FCO Limit	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7

Figure 5 Beaconsfield Primary Middle Bus Section spring/autumn peak demand growth.

Peak demand is expected to increase at Beaconsfield Middle Bus Section by approximately 3.9MVA from 2020/21 (2020 in Figure 3) to 2027/28 (2027 in Figure 3) when following the CT scenario. The projected primary demand of 15.1MVA (Winter Peak) is split below by demand type. The chart below shows the largest impact on demand in the area is from Heat Pumps and EVs, equating to 11% each of the overall projected demand respectively.

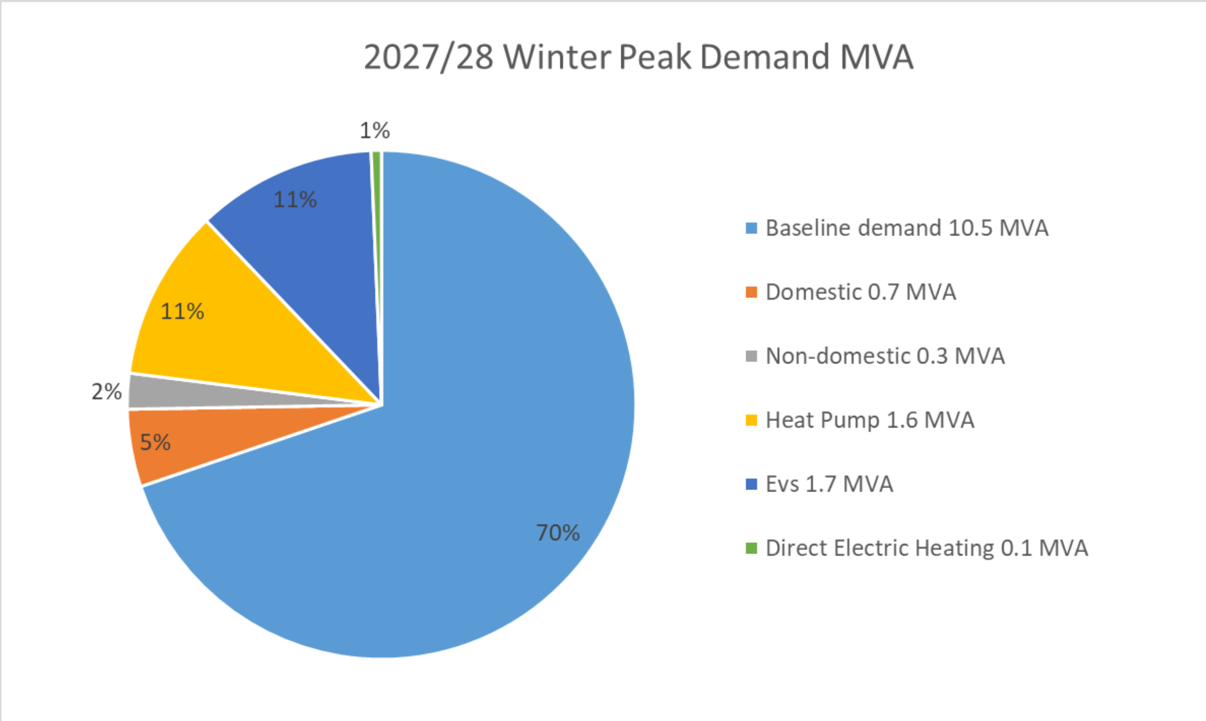


Figure 6 Beaconsfield middle bus section Winter peak demand split by 2027/28 - CT scenario.

4.4 Existing Asset Conditions

The 22/6.6 kV transformers were manufactured in 1959, 1963, 1956 and 1959. D1MT (10MVA) is currently HI 3 and will be HI 4 at the end of ED2. D2MT (10MVA) is currently HI 2 and will be HI 2 at the end of ED2. D3MTA (5MVA) is currently HI 4 and D3MTB (5MVA) is currently HI5. Both transformers will be HI 5 at the end of ED2. There is currently no non-load investment proposed to replace these assets.

4.5 Thermal Flow Analysis

Thermal flow analysis has been carried out using peak demand in 2027/28 under CT scenarios. It can be seen from Table 4 that Beaconsfield middle bus section is overloaded in winter and spring/autumn under first circuit outage (FCO) condition, therefore reinforcement is required to resolve the overload issue as substation load index will become LI2 by the end of ED1 and LI5 by the end of ED2. Network assessment for second circuit outage (SCO) is not required as per Engineering Recommendation P2/7 – Security of Supply.

Demand Group	Season	Group Class	Contingency	Loaded Circuit / Transformer	FCO Demand to be Met	FCO Available Capacity
Beaconsfield Middle Busbar	Winter	C	Fault on Beaconsfield D1MT	Beaconsfield D2MT	15.1 MVA	**12.9 MVA**

Beaconsfield Middle Busbar	Spring/ Autumn	C	Fault on Beaconsfield D1MT	Beaconsfield D2MT	13.3 MVA	**11.7 MVA**
Beaconsfield Middle Busbar	Summer	C	Fault on Beaconsfield D1MT	Beaconsfield D2MT	9.6 MVA	**10 MVA**

Table 4 First Circuit Outage (FCO) Analysis in 2027/28 - CT scenario.

4.6 Voltage Level Assessment

Appendix 3 shows that voltage level reinforcement is not required as voltage compliance is met.

4.7 Fault Level Assessment

Appendix 3 shows that fault level reinforcement is not required as fault level compliance is met.

4.8 Network Analysis Summary

The analysis above has shown that intervention to reinforce Beaconsfield primary substation will be required within RIIO-ED2, and that derogation from the P2/7 engineering standard is not appropriate. The DFES 2020 forecast increase in demand, and in turn the increased reliance on the network will impact a larger number of customers and more severely considering the LCT uptake.

5 Optioneering

This section of the report sets out the investment options that were considered when resolving overload issues at Beaconsfield primary substation. As described below, a holistic approach is taken to ensure investment options represent best value for money for network customers are identified.

5.1 Whole System Considerations

We have additionally considered the potential for using Whole System solutions (involving collaboration with third parties) to deliver this investment programme. We set out our assessment in Appendix 4. This follows our standardised approach for embedding Whole System considerations into our load and non-load investment decisions (in line with Ofgem's ED2 business plan guidance), as described in our ***Whole System (Annex 12.1)***.

Our assessment enables us to take a proportionate consideration of Whole System options, based on the feasibility of such options existing and materiality of the costs involved.

In this case, our Whole Systems assessment finds that this programme is not expected to have any wider Whole System interactions and there are no feasible Whole Systems solutions.

5.2 Summary of Options

Table 5 below provides a summary of the four investment options under consideration along with the advantages and disadvantages associated with each. A more detailed description of each option is then provided within the proceeding section.

Option	Description	Advantages	Disadvantages	Result
1. Do Minimum (Load Transfer)	It is normally done by carrying out demand transfer from the overloaded demand group to another.	Minimum cost and workload; Small impact to existing network; Short delivery time.	Does not increase network capacity, further reinforcement may still be required.	Not progressed to CBA
2. Reinforcement of existing assets (Asset Replacement)	The replacement of the full overloaded equipment including: • 2 x 22/6.6kV Transformers • 23.9km of 22kV Circuits	Allow latest and most efficient technology to be installed; Increase network resilience; Reduce environmental impact.	Can incur long outages if replacement cannot be built offline; Some non-overloaded assets may also need to be replaced in-line with the new equipment.	Taken forward to CBA
3. Reinforcement by network extension	New equipment will be added into existing network. This involves:	Increase network resilience; Shorter outage time; Long term benefit.	Additional land purchase maybe required; Can incur large civil costs;	Taken forward to CBA (Preferred Option)

(Add New Assets)	• 2 new 33/6.6kV transformer at Beaconsfield primary • New 33kV switchgear at Beaconsfield primary • New 6.6kV switchgear at Beaconsfield primary • New 5.5km dual 33kV circuits from Loudwater BSP to Beaconsfield primary		Requires new control strategy.	
4. Flexible Solution	Flexible service contracts to reduce peak demand and defer capital investment	Relatively low cost Defers need for network reinforcement	Amount of flexibility depends on location-specific resources and interests. CAPEX may still be required.	Not progressed to CBA

Table 5 Summary of Load Related Investment Options.

5.3 Detailed Option Analysis

5.3.1 Option 1: Do-Minimum (Load Transfer)

Estimated Cost: N/A.

Beaconsfield Primary is interconnected at 6.6kV to nearby primary substation at Gerrards Cross, due to limitations of 6.6 kV feeders there is not sufficient load transfer to accommodate the new demand.

In addition, Gerrards Cross primary is one of the uncertainty schemes identified in our business plan for ED2 which means this substation will have limited available capacity by the end of ED2 under the System Transformation scenario or will be overloaded towards the second half of ED2 under the Consumer Transformation scenario. We have investigated the possibility of proposing a single investment scheme to resolve non-compliance for both sites however we have concluded that this would not be the most economical solution for consumers.

As this option does not resolve the P2/7 non-compliance entirely and the substation load index will still be LI5 by the end of ED2 therefore result in poorer guaranteed standard performance and customer interruptions, it is rejected.

5.3.2 Option 2: Reinforcement of existing assets

Estimated Cost: £8,430k.

The overloaded equipment for Beaconsfield Primary is the 2 x 2.2/6.6kV transformers feeding the middle bus section and 23.9km of 22kV cable from Denham BSP to Beaconsfield Middle Bus Section.

Access to the existing 22kV cable can be difficult due to its proximity to rail tracks and crossing large woodland areas. As a result, a new cable route will be required which may incur even longer cable installation along the diverted route. This option can bring the LI of Beaconsfield End Bus Section and Middle Bus Section to LI3 and LI1 respectively therefore is taken forward to CBA. However, this is not our preferred option due to potential challenges of designing the new cable route and high overall expenditure.

5.3.3 Option 3: Reinforcement by network extension (Add New Assets)

Estimated Cost: £4,956k.

As the distance between Beaconsfield Primary and Denham BSP is very long and the existing 22/6.6kV transformers are close to the end of their life spans, it is suggested to transfer the whole Beaconsfield Primary to Loudwater 132/33 kV Bulk Supply Point (BSP). The proposed solution includes the installation of two new 33 kV bays with outdoor circuit breakers at Loudwater BSP, 6 km of dual 33 kV cable circuit from Loudwater BSP to Beaconsfield Primary (proposed cable route shown in Figure 6 below), two new 33/6.6 kV transformers and two new 6.6kV incoming circuit breakers at Beaconsfield Primary (shown in Figure 7 below). The new Beaconsfield Primary will be LI2 by the end of ED2.

Figure 7 Proposed new 33kV route from Loudwater BSP to Beaconsfield Primary.

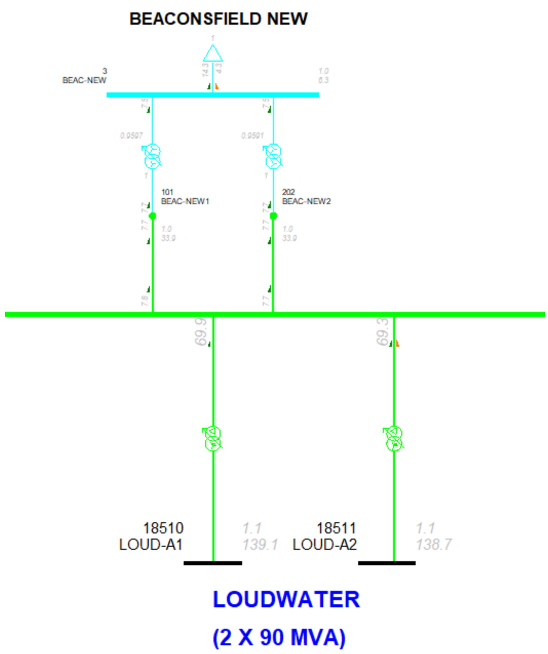


Figure 8 Proposed new Beaconsfield Primary Network Arrangement SLD.

5.3.4 Option 4: Flexible Solution

Estimated Cost: N/A.

Our flexible solution assessment makes use of the Common Evaluation Method (CEM) published by the ENA. The framework evaluates options around timing of network investments, in particular taking into account:

- the range of different options available (e.g., reinforcing the network, using flexibility, or doing nothing);
- the time periods in which actions can be taken; and
- the existence of uncertainty, and the impact of incremental information which becomes available over time.

Figure 8 shows a typical load profile of a 2026 Spring/Autumn day when the peak demand at Beaconsfield Middle Bus Section exceeds the FCO rating for approximately two hours. Flexibility services in the form of increasing generation export or decreasing demand import could be used to reduce the peak.

The MW exceedance, the daily and annual overload hours (Table 6) and the flexibility unit costs of £150 per MW per hour and £150 per MWh were used as input parameters in the CEM CBA model (full details of the flexibility methodology can be found in the ***Load Related Plan Build and Strategy (Annex 10.1)***.

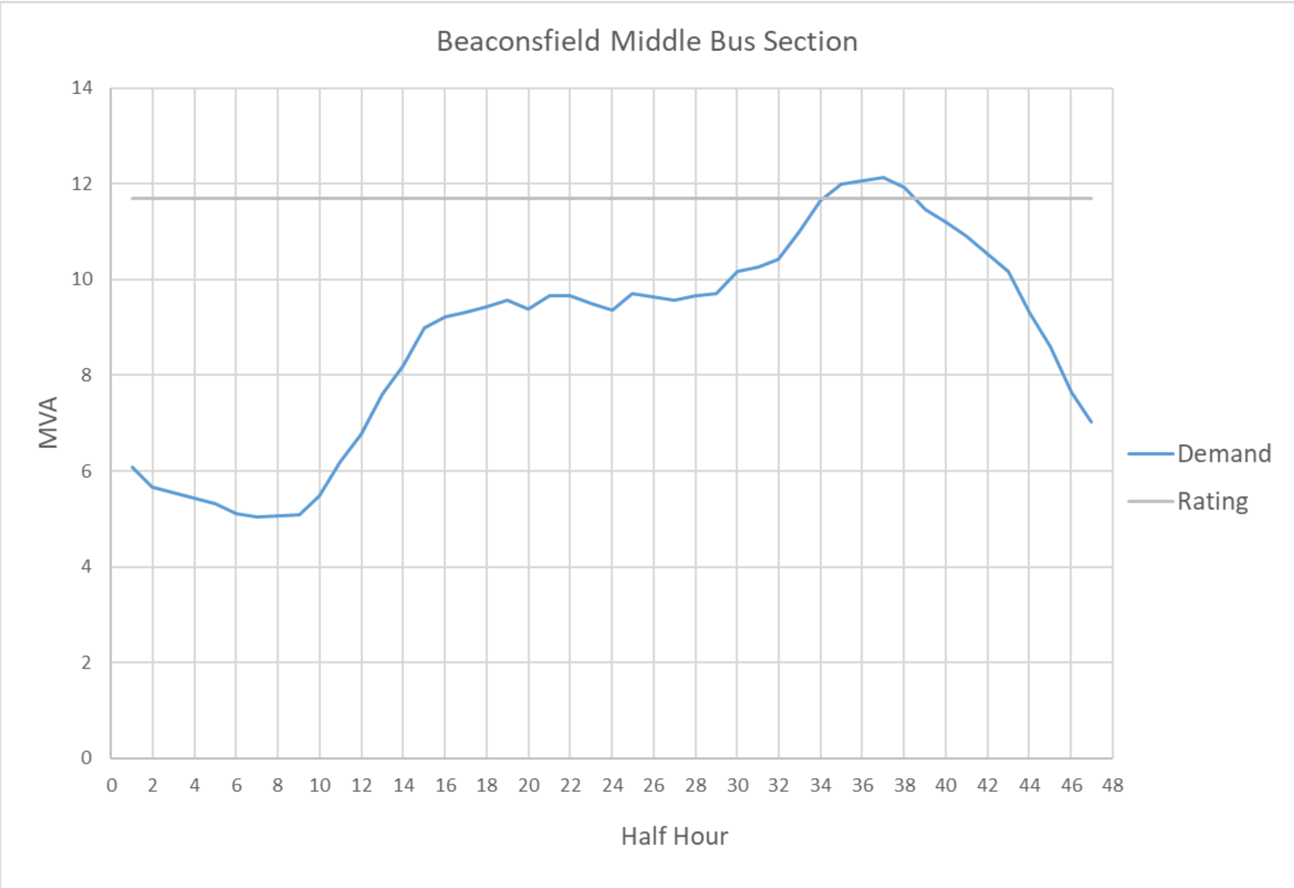


Figure 9 Beaconsfield Middle Bus Section Spring/Autumn peak demand 2026 without flexibility services.

	2021	2022	2023	2024	2025	2026	2027	2028
Hrs/day required	0.0	0.0	0.0	0.0	0.0	2.0	3.3	4.7
Days/yr required	0.0	0.0	0.0	0.0	0.0	64.0	192.0	192.0
Utilisation (MWh)	0.0	0.0	0.0	0.0	0.0	8.9	184.5	548.0

Table 6 Estimated dispatch requirements for flexibility solution.

The CEM model outcome in Figure 9 below shows that there is no benefit in deferring this scheme under all four scenarios. This is mainly due to the significant reduction of network losses coming from switching Beaconsfield primary substation to Loudwater BSP. The CEM CBA therefore favours this conventional solution over the flexible solutions under the existing network arrangements. The conventional solution also addresses the poor asset conditions of the existing primary transformers and the high risk of having a second circuit outage (SCO) at this substation (see Appendix 2 for the record of Beaconsfield Primary outages since 2015). Although an SCO assessment is not required for this demand group, customers would face significant interruptions when it happens. After reviewing the overall benefit, flexible solution is not our preferred option.

Cumulative benefit of deferral (excluding benefit from further deferral, but including multi-year discount)		Defer by 1 year(s) to 2027	Defer by 2 year(s) to 2028	Defer by 3 year(s) to 2029	Defer by 4 year(s) to 2030
[1] under Consumer Transformation	£0	-£18,297	-£111,334	-£349,668	-£596,917
[2] under Leading the Way	£0	-£17,516	-£109,336	-£351,068	-£612,786
[3] under Steady Progression	£0	-£14,467	-£30,911	-£48,930	£78,237
[4] under System Transformation	£0	-£14,467	-£30,911	-£48,930	£78,237

Figure 10 Net benefit of deferring reinforcement.

Despite our commitment to the Flexibility First approach, this project is not technically compatible with a Flexible Solution due to the benefits of lower network losses from Option 3.

However, flexibility may provide OPEX benefits to SSEN and our customers during scheme delivery by;

a) Avoiding/reducing the risk of outages during planned works through load/generation management
b) Avoiding/reducing the need for Mobile Diesel Generation in planned or unplanned outage scenarios
c) Reducing the scale of the works through the implementation of a 'Hybrid' scheme, part reinforcement and part Flexibility.

These opportunities will be reviewed annually, and Flexibility secured should the CEM CBA prove more beneficial, with justification of the decisions/reviews presented as required.

Further detail of our Flexibility First approach and assessment methodology can be found in our ***DSO Strategy (Annex 11.1), Appendix F - Delivering Value through Flexibility.***

6 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.

6.1 CBA of investment options

Ofgem's RIIO-ED2 standard CBA template was used to assess costs and benefits of the conventional options for each circuit individually. Capital reinforcement costs, CI/CML penalties, network losses and other societal benefits are the key parameters used in the CBAs of the three options progressed. The customer interruptions

/ customer minutes lost (CI/CML) were calculated based on the potential overload and the probability of a failure.

Further information on our Cost Benefit Analysis (CBA) approach is set out within our ***Cost Benefit Analysis Process (Annex 15.8)***.

6.2 CBA Results

The CBA results below, demonstrate that the most cost-effective solution is Option 3 'Reinforcement by adding new assets (network extension)', as it has the least negative NPV against the required investment. It is clear that the investment increases network resilience at Beaconsfield primary substation immediately within RIIO-ED2, while providing efficient and enduring long-term security of supply as we move towards a Net Zero network. Therefore, based on the CBA results Option 3 is preferred solution to address the P2/7 compliance issue.

Cost Benefit Analysis comparisons

Options	Net Present Value (NPV) After 45 Years (£k)	Investment (£k)
Option 2 – Reinforcement of existing assets (asset replacement)	-6,546	8,430
Option 3 – Reinforcement by adding new assets (network extension)	-987	4,956

Table 7 Cost Benefit Analysis comparisons

Summary of Cost

Options	Unit	2024	2025	2026	2027	2028	ED3+	Total £k
Option 2 – Reinforcement of existing assets (asset replacement)	**£k**	0	0	8,430	0	0	0	8,430
Option 3 – Reinforcement by adding new assets (network extension)	**£k**	0	0	4,956	0	0	0	4,956

Table 8 Summary of cost

6.3 Options Summary

Option 1 is the lowest capital costs and may appear to be the attractive option. However, this option does not provide sufficient capacity to meet the projected network requirements and is not considered a cost effective, long-term enduring and compliant solution.

Options 2 and 3 satisfy P2/7 requirements therefore provide the required security of supply at Beaconsfield primary substation. Option 3 is the preferred option due to its superior NPV value.

Option 4 is not considered as the CEM model shows there is no benefit in deferring the scheme.

6.4 Costing Approach

Our RIIO ED2 Business Plan costs are derived from our outturn RIIO ED1 expenditure. We have modified costs per activity, capturing and reporting those adjustments in our cost-book. By tying our costs back to reported, outturn, real life data this approach provides multiple data points on which both the Regulator and we can benchmark cost efficiency.

It provides a high level of cost confidence in our Business Plan cost forecast for RIIO ED2. Through our benchmarking analysis, we recognised that not all Non-Load related RIIO-ED1 actual unit costs sit within the upper quartile efficiency band. Where this is the case, we have applied a catch-up efficiency to those cost categories.

Further detail on our unit cost approach, cost efficiency and cost confidence for RIIO-ED2 can be found within our ***Cost Efficiency (Annex 15.1)***[2]. Following our draft Business Plan, we have continued to develop project scopes and costs, utilising valuable stakeholder feedback. We have included developments of our Commercial Strategy within the updated project scope and delivery strategy.

Unlike asset replacement, large load projects will include more unique and site-specific costs for example civils, waterway, road or rail crossings and local planning considerations. Through detailed bottom-up project assessment, we have identified projects that are impacted by Regional and Premium factors driving additional costs. Cost and volumes breakdown are presented in Table 9.

Asset	Volume	Unit	Costs
33kV UG Cable (Non Pressurised)	12	km	[redacted]
33kV CB (Air Insulated Busbars) (OD) (GM)	2	#	[redacted]
33kV Transformer (GM)	2	#	[redacted]
6.6/11kV CB (GM) Primary	2	#	[redacted]
Total			[redacted]

Table 9 Cost and Volumes Breakdown

[2] Link to ***Cost Efficiency (Annex 15.1)***.

7 Deliverability and Risk

Between our draft and final Business Plans we have carried out a more detailed deliverability assessment of our overall plan as a package and its component investments. Using our draft Business Plan investment and phasing as a baseline we have followed our deliverability assessment methodology. We have assessed any potential delivery constraints to our plan based on:

- In-house workforce capacity and skills constraints based on our planned recruitment and training profile and planned sourcing mix as well as the efficiencies we have built into our Business Plan ***(detailed in our Workforce Resilience Strategy in (Annex 16.3)*** and ***Cost Efficiency (Annex 15.1))***
- Assessment of the specific lead and delivery timelines for the asset classes in our planned schemes
- We have evaluated our sourcing mix where there were known delivery constraints to assess opportunities to alleviate any constraints through outsourcing
- We have engaged our ***Supply Chain Strategy (Annex 16.2)*** to explore how the supply chain could support us to efficiently deliver greater volumes of work and how we could implement a range of alternative contracting strategies to deliver this
- We have also engaged with the supply chain on the delivery of work volumes that sit within Uncertainty Mechanisms to ensure we have plans in place to deliver this work if and when the need arises
- Specific to load schemes: We have carried out flexibility assessments at all voltage levels in order to understand when we can defer reinforcement through paying for flexibility services, therefore ensuring our investment profile is deliverable and at the lowest cost to consumers ***see Flexibility within Load Related Plan Build and Strategy (Annex 10.1***)
- We have assessed the synergies between our planned load, non-load and environmental investments to most efficiently plan the scheduling of work and minimise disruption to consumers
- Based on our assessment of delivery constraints and potential solutions to resolve them, we have revised our investment phasing accordingly to ensure our Business Plan is deliverable, meets our consumers' needs and is most cost efficient for our consumers

The table below sets out the revised investment phasing based on the outcome of our deliverability assessment:

	2023/24	**2024 /25**	**2025/26**	**2026/27**	**2027/28**
Revised Investment Phasing			x		

Table 10 Revised investment phasing

The specific considerations for deliverability based on the scope of this EJP are detailed below:

- Low risk on cable installation - The proposed new 33kV cable route from Loudwater BSP to Beaconsfield Primary is to follow the existing 33kV and 22kV cable route. As the existing 22kV cable from Denham BSP between Tee of Wapseys Wood and Beaconsfield primary has a section of oil filled cable, oil management of that 22kV cable section is required after decommissioning existing Beaconsfield Primary.

- Low risk on 33kV switchgear installation – There is sufficient space at Loudwater BSP to accommodate additional 33kV switchgears without extending existing substation boundary.
- Medium risk on 33/6.6kV transformer and 6.6kV switchgear installation – There is limited space at Beaconsfield primary therefore detailed plan on removal of existing transformers/switchgear and installation of new transformers/switchgear is required. Temporary backup supply may also be required.
- Medium risk on scheme dependency – Upgrading Loudwater BSP is one of the LRE scheme in our business Plan for ED2. The new Beaconsfield primary may need to wait until the completion of Loudwater BSP upgrade (currently scheduled for 2025/26) subject to actual demand growth.

This investment scheme is part of the wider load-related investment portfolio in RIIO-ED2. SSEN have developed a strategy to deliver a much larger volume of work in comparison with the level of investment in ED1. We have engaged with our supply chain to negotiate the most effective unit costs and we have taken measures to ensure we secure a future workforce with the right skills and competencies to deliver capital projects in ED2.

In RIIO-ED1, SEPD have delivered a number of 33kV circuit and substation projects using internal workforce. The experience and skills acquired from these projects lay the foundation for the delivery of the proposed option within this paper.

8 Conclusion

This EJP has raised the need for load related investment at Beaconsfield primary substation within the ED2 price control period. This need for investment is driven by the compliance with P2/7, given the significant forecasted demand increase and significant impact on existing and new customers, reinforcement is required to remove this non-compliance in RIIO-ED2.

Four investment options have been considered and the preferred solution involves transferring the whole Beaconsfield primary substation to Loudwater BSP by installing two new 33 kV bays with outdoor circuit breakers at Loudwater BSP, 6 km dual 33 kV underground cable circuit from Loudwater BSP to Beaconsfield primary substation, two new 33/6.6 kV transformers and two new 6.6kV incoming circuit breakers at Beaconsfield Primary in 2025/26.

The proposed ED2 investment is £4.96m. It is proposed that all reinforcement is carried out in the 2025/26 financial year to minimise the risk of thermal overload and network non-compliance.

9 Appendix 1. Relevant Policy, Standards, and Operational Restrictions

The policies, manuals and standards and operational restrictions relevant to the content of this paper.

Policy Number	Policy Name / Description
TG-NET-OHL-010	Load Ratings of Overhead Lines – Data Sheet
TG-NET-OHL-012	Short Circuit Ratings of Overhead Lines – Data Sheet
TG-NET-OHL-104	Electrical Constants for Overhead Lines- Data Sheet
TG-NET-CAB-009	Load Ratings of LV to 33kV Underground Cables – Design Data
TG-NET-CAB-010	Electrical Constants for LV to 33 kV Underground Cables- Data Sheet
TG-NET-CAB-011	Short Circuit Ratings of 6.6kV to 33kV Underground Cables - Design Data

Table 11 Relevant documents

10 Appendix 2. Historic Beaconsfield Primary Outages

Outage No	Substation	Equipment Out / Work Details and Remarks	Voltage	Status	Type	Date	Eng Wk	Rest	Rest Eng Wk	Start Time	Rest Time	PTW Time	ERTS	Other
159378	BEACONSFIELD	DENH D9L5 TO BEAC E1T0 TO WAPW (BEAC D1MT)	22KV	Auth		11/05/2015	20. 1	20/05/2015	21. 3	07:30	10:00	08:30		
160119	BEACONSFIELD	F1LR	33KV	Auth	Daily	24/06/2015	26. 3	24/06/2015	26. 3	09:00	11:00	09:15	30 MINS	
161864	BEACONSFIELD	F1S0 & F3S0 IN TURN	6.6KV	Auth	Daily	25/11/2015	48. 3	25/11/2015	48. 3	11:00	12:00	11:30	15 MINS	
162060	BEACONSFIELD	F3S0	6.6KV	Auth		07/12/2015	50. 1	07/12/2015	50. 1	08:00	14:00	08:30	1 HOUR	
163468	BEACONSFIELD	UPTO BEAC CABLE **FAULT**	22KV	Auth		23/02/2016	8. 2	08/03/2016	10. 2	12:09	18:00	12:30	12	
163257	BEACONSFIELD	UPTO D4L5 TO BEAC D3MTA & D3MTB	33KV	Auth	Daily	02/03/2016	9. 3	02/03/2016	9. 3	07:00	16:00	08:00	3HRS	
163764	BEACONSFIELD	F3S0	6.6KV	Auth	Daily	12/04/2016	15. 2	12/04/2016	15. 2	09:00	15:00	09:30	1HR	
164802	BEACONSFIELD	F2S0	6.6KV	Auth	Cont.	17/10/2016	42. 1	21/10/2016	42. 5	07:00	15:00	08:00	4DAYS	
167167	BEACONSFIELD	D3MTA & D3MTB	22KV	Auth	Daily	24/11/2016	47. 4	24/11/2016	47. 4	07:00	16:00	08:00	3 HOURS	
173906	BEACONSFIELD	D2MT & D3MTA, D3MTB IN TURN	22KV	Auth	Daily	20/11/2017	47. 1	21/11/2017	47. 2	07:30	12:00	08:00	10 MINS	
174083	BEACONSFIELD	D1MT, F1S0, F2S0, F3S0 IN TURN	22KV	Auth	Daily	12/01/2018	2. 5	12/01/2018	2. 5	08:00	14:00	08:30	30 MINS	
176636	BEACONSFIELD	D3MTA+ D3MTB	22KV	Auth	Daily	17/07/2018	29. 2	17/07/2018	29. 2	07:30	15:00	08:30	2 HOURS	
176637	BEACONSFIELD	D3MTB + D3MTA	22KV	Auth	Daily	19/07/2018	29. 4	19/07/2018	29. 4	07:30	15:00	08:30	2 HOURS	
176638	BEACONSFIELD D2MT		22KV	Auth	Daily	21/08/2018	34. 2	21/08/2018	34. 2	07:30	16:00	08:30	3 HOURS	
177988	BEACONSFIELD D2MT		22KV	Auth	Daily	22/10/2018	43. 1	22/10/2018	43. 1	08:00	15:00	09:00	3 HOURS	
178527	BEACONSFIELD	D2MT D2H0	22KV	Auth	Daily	16/11/2018	46. 5	16/11/2018	46. 5	08:00	15:00	09:00	3 HOURS	
182400	BEACONSFIELD	BEAC F2T0 TO COKL D4L5	22KV	Auth	Daily	17/10/2019	42. 4	18/10/2019	42. 5	07:30	16:00	08:00	1 HOUR	IVER 58038
184181	BEACONSFIELD	D1MT	22KV	Auth	Daily	18/02/2020	8. 2	18/02/2020	8. 2	07:00	16:00	08:00	3 HOURS	

185615	BEACONSFIELD	22KV	24/04/2020	17. 5	09:00	09:30
D2H0		Auth	24/04/2020	17. 5	13:00	
	FIX DEFECT ON F2T0 RUNNING ARRANGEMENT: - CLOSE F1S0 +F3S0 - TURN OFF AUTO-CLOSE SECT 2+3 ~6 MVA +SECT 1+4	Daily	30 MINS			
	*O ~3 MVA N 2*5 MVA TX +10 MVA TX*					
185121	BEACONSFIELD	22KV	07/07/2020	28. 2	08:00	09:00
D3MTA & D3MTB		Auth	09/07/2020	28. 4	16:00	
		Cont.	4 HOURS			
186524	BEACONSFIELD	6.6KV	09/07/2020	28. 4	08:00	08:30
	FAULT F3S0	Auth	11/09/2020	37. 5	14:00	
		Cont.	1 HOUR			
187202	BEACONSFIELD	22KV	07/09/2020	37. 1	06:00	07:00
	F3S0 - F3T0A	Auth	10/09/2020	37. 4	14:00	
		Cont.	2HRS			
187203	BEACONSFIELD	22KV	22/09/2020	39. 2	06:30	06:45
	F1S0 - F3T0B	Auth	24/09/2020	39. 4	14:00	
		Cont.	2H			
187204	BEACONSFIELD	22KV	05/10/2020	41. 1	06:00	07:00
	F1T0	Auth	05/10/2020	41. 1	14:00	
		Daily	2H			
187252	BEACONSFIELD	22KV	14/10/2020	42. 3	06:00	07:00
	F2T0	Auth	16/10/2020	42. 5	14:00	
		Daily	2H			
188907	BEACONSFIELD	22KV	19/03/2021	11. 5	08:00	08:30
	DENH D9L5-WAPW-BEAC D1MT.	Auth	19/03/2021	11. 5	16:00	
		Daily	<1HR			
188908	BEACONSFIELD	22KV	22/03/2021	12. 1	07:00	07:15
	COKL D4L5 - BEAC F2T0	Auth	22/03/2021	12. 1	16:00	
		Daily	<1HR			
188909	BEACONSFIELD	22KV	23/03/2021	12. 2	06:45	07:00
	UPTO D4L5 - BEAC D3MTA/D3MTB	Auth	24/03/2021	12. 3	16:00	
		Cont.	<1HR			
188910	BEACONSFIELD	22KV	25/03/2021	12. 4	08:00	08:30
	BEAC F1S0 / F3S0 / F2S0	Auth	25/03/2021	12. 4	18:00	
	Daily <30 MINS	Daily	<30 MINS			
190327	BEACONSFIELD	22KV	10/05/2021	19. 1	06:45	07:00
	FAULT UPTO D4L5 - BEAC D3MTA/D3MTB	Cont.	ON COMP			

Table 12 Historic outages for Beaconsfield Primary

11 Appendix 3. Network Assessments

Voltage level assessment

SYSTEM VOLTAGE LEVELS BEACONSFIELD PRIMARY						
Season	BSP voltage	Demand	Generation	Study Scenario	Highest/ Lowest Voltage	Busbar Name
[-]	[p.u.]	[MVA]	[MVA]	[-]	[p.u.]	[-]
Winter maximum	1.0284	15.1 MVA	0	Intact	0.9464	BEAC-D2
Winter maximum	1.0297	15.1 MVA	0	Fault on Beaconsfield D1MT	0.9232	BEAC-D2
The Voltage levels are in the limit of + 10% on 132KV. + 6% on 33KV under intact condition.						

Table 13 Voltage level assessment in 2027/28 - CT scenario.

Fault level assessment

Three Phase Fault														
Bus Number	Bus Name	Nominal Voltage	Pre-fault Voltage	X/R ratio	Ik"-Initial Sym.	Ik"-Angle	Ip-Peak Make	RMS Sym. Break	Angle Sym. Break	DC Component	RMS Asym. Break	Circuit Breaker Break Rating	Circuit Breaker Make Rating	Circuit Breaker Fault Level Index
					(0ms)	(0ms)	(10ms)	(50ms)	(50ms)	(50ms)	(50ms)	(Minimum CB rating at substation)	(Minimum CB rating at substation)	(Minimum CB rating at substation)
		(kV)	(pu)		(kA)	(degrees)	(kA)	(kA)	(degrees)	(kA)	(kA)	(kA)	(kA)	(kA)
14640	DENH-D	22.	1.029	11.4	16.62	-84.70	42.19	14.26	-87.16	11.58	18.37	25.0	62.5	FLI1
24640	UPTO-D	22.	1.032	18.4	14.92	-86.72	39.45	13.92	-88.21	12.91	18.99	25.0	62.5	FLI1
91121	BEAC-F	6.6	1.028	3.3	9.97	-72.44	20.35	9.08	-73.92	0.41	9.09	25.0	62.5	FLI1
91122	BEAC-F3	6.6	1.025	2.1	3.59	-63.29	6.32	3.40	-63.24	0.00	3.40	25.0	62.5	FLI1
91123	BEAC-F4	6.6	1.026	2.1	3.53	-63.62	6.24	3.34	-63.58	0.00	3.34	25.0	62.5	FLI1

Single Phase Fault														
Bus Number	Bus Name	Nominal Voltage	Pre-fault Voltage	X/R ratio	Ik"-Initial Sym.	Ik"-Angle	Ip-Peak Make	RMS Sym. Break	Angle Sym. Break	DC Component	RMS Asym. Break	Circuit Breaker Break Rating	Circuit Breaker Make Rating	Circuit Breaker Fault Level Index
					(0ms)	(0ms)	(10ms)	(50ms)	(50ms)	(50ms)	(50ms)	(Minimum CB rating at substation)	(Minimum CB rating at substation)	(Minimum CB rating at substation)
		(kV)	(pu)		(kA)	(degrees)	(kA)	(kA)	(degrees)	(kA)	(kA)	(kA)	(kA)	(kA)
14640	DENH-D	22.	1.029	1.5	4.25	-56.22	9.55	4.21	-56.79	4.73	6.33	25.0	62.5	FLI1
24640	UPTO-D	22.	1.032	0.5	2.28	-27.19	3.43	2.28	-27.39	0.75	2.40	25.0	62.5	FLI1
91121	BEAC-F	6.6	1.028	0.1	1.19	-5.73	1.72	1.19	-5.95	0.00	1.19	25.0	62.5	FLI1
91122	BEAC-F3	6.6	1.025	0.1	0.58	-7.16	0.83	0.58	-7.30	0.00	0.58	25.0	62.5	FLI1
91123	BEAC-F4	6.6	1.026	0.1	0.58	-7.33	0.83	0.58	-7.48	0.00	0.58	25.0	62.5	FLI1

Table 14 Fault level assessment in 2027/28 - CT scenario.

12 Appendix 4. Whole Systems consideration

In augmenting our decision-making processes to consider Whole System solutions, we have introduced an assessment to identify where a Whole Systems CBA would be a useful decision-making tool for ED2 load and non-load schemes. While our work with the ENA to undertake Whole Systems CBAs is ongoing, we have introduced the 'Whole Systems CBA test' to identify where a scheme may be suitable for a Whole Systems CBA to be conducted. Where a Whole Systems CBA is determined to be a useful decision-making tool, these would be conducted in addition to the standard Ofgem CBA and/or SSEN's flexibility CBA. We have introduced this test in line with Ofgem's expectations for "proportionality when submitting a Whole System CBA. For example, smaller or simple projects following the standard CBA template, whereas larger or more complex projects requiring bespoke analytical approaches" (Ofgem BPG, section 4.28, p.34).

The 'Whole Systems CBA test' involves assessing each investment scheme of over £2m (the threshold to develop an EJP for load and non-load investments) against 5 tests. These 5 tests help determine whether a Whole Systems CBA is a useful decision-making tool based on the characteristics of the scheme, including whether it will have wider cross sector or societal impacts.

Details on each of the tests are provided in case study 6 in ***Whole Systems (Annex 12.1).*** Tests 1-3 are aligned with the ENA's guidance for Whole System CBA tests. We have added Tests 4 and 5 to clarify whether a Whole Systems CBA is required based on the materiality / proportionality of the investment (Test 4) and whether a flexibility CBA only is sufficient (Test 5). Table 15 below outlines our Whole Systems CBA test for Beaconsfield 22/6.6kV Primary Substation.

Scheme	Test 1: Are there Whole Systems interactions, or is there potential for it?	Test 2: Could a Whole Systems CBA drive you to make a different decision?	Test 3: Is a Whole Systems CBA reasonable?	Test 4 - Is the project valued at over £2m?	Test 5 - Is the investment plan related to procuring flexible solutions only?
Beaconsfield 22/6.6kV Primary Substation (SEPD)	No – We consider there to be limited potential for Whole Systems interactions with third parties to deliver this investment programme, and accordingly we do not consider there to be potential	No – As noted under Test 1 we do not consider there to be potential for Whole Systems solution(s) in this case.	No – As noted under Test 1 we do not consider there to be potential for Whole Systems solution(s) in this case.	Yes	No

	for Whole Systems solution(s).				

Table 15 Whole Systems CBA test for Beaconsfield 22/6.6kV Primary Substation

As the result of tests 1, 2 and 3 above is “No”, a Whole Systems CBA is not required for this investment. It is not expected to have any wider Whole System interactions or potential Whole Systems solutions.