RIIO-ED2 Engineering Justification Paper (EJP)

East Bedfont A 132/22kV Substation Reinforcement

Investment Reference No: 65/SEPD/LRE/EBED

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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 East Bedfont A substation will deliver P2/7 compliance for an expenditure of £4.13m during RIIO-ED2.

The primary investment driver for this scheme is load related P2/7 non-compliance identified at East Bedfont substation. The P2/7 non-compliance issue is apparent under four Distribution Future Energy Scenario (DFES) scenarios with overloading apparent under CT & LW from 2023 and under ST & SP from 2024. Therefore, investment in ED2 is required due to forecast demand growth. This project is required under our accelerating progress towards net zero priority, to aid the city of London achieve net zero by 2050 by increasing clean energy generation and supporting the uptake of low carbon technologies such as heat pumps, batteries and electric vehicles.

The EJP considers a range of options to address the P2/7 compliance issue, 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 year Net Present Value (£m), is option 4 which will utilise flexible services to defer followed by asset replacement.

Options	Net Present Value (NPV) After 45 Years (£k)	Investment (£k)
Option 2 – Additional Transformer & 33kV OHL line	-3,831	7,418
Option 3 – Replacement of existing 132/22kV transformers	-2,560	3,984
Option 4 – Flexible Solution	-2,393	4,128

Table 1: Option Summary

Following the optioneering and detailed analysis, as set out in this paper, the proposed scope of works for Option 4 is:

Asset	Volume	Costs
132kV Transformer	2	[redacted]
22kV Switchgear	18	[redacted]
Total		**£3,983.6k**

Table 2 Investment Summary

The costs listed above reflect the costs to replace the existing assets. In addition to this there will also be costs for procuring flexible services to reduce the peak demand. It is anticipated the cost for procuring flexibility will be £144.2k bringing the total project cost to £4,128k.

This scheme delivers the following outputs and benefits:

- Full replacement of the 22kV switchgear removing SF_6 assets from the network

- The uplift in network capacity from 76MVA to 95MVA to meet the needs of our customers.
- Improvement of the load index of the East Bedfont substation to LI2 by the end of RIIO-ED2 compared to LI5 if no network reinforcement is carried out.
- A secondary benefit of this project will see the health index of the 132/22kV transformers improve from HI3 and HI4 (HI4 and HI5 by the end of ED2) to HI1.
- Facilitates the efficient, economic, and co-ordinated development of our Distribution Network for Net Zero.

The cost to deliver the preferred solution is £4.13m and the works are planned to be completed in 2027. This EJP investment sits within our Net Zero Totex ask.

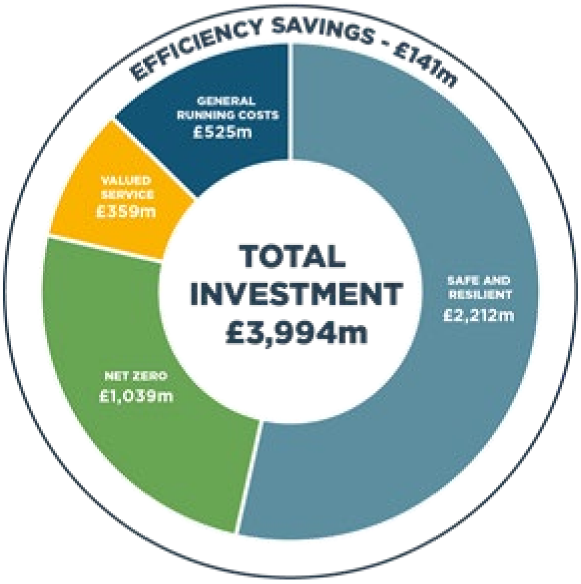


Figure 1: SSEN total investment cost within RIIO ED2

2 Investment Summary Table

Table 3 below provides a high level summary of the key information relevant to this Engineering Justification Paper (EJP) which discusses the investment proposals for East Bedfont A 132/22kV substation.

Name of Scheme	East Bedfont A 132/22kV Substation Reinforcement		
Primary Investment Driver	Load-related - P2/7 non-compliance under first circuit outage		
Scheme reference/mechanism or category	65/SEPD/LRE/EBED		
Output references/type	132 kV transformer 22 kV switchgear Flexibility		
Cost	£4.13m		
Delivery year	2026/27		
Reporting table	CV1: Primary Reinforcement		
Outputs included in RIIO-ED1 Business Plan	No		
Spend apportionment	**ED1**	**ED2**	**ED3+**
	£0	£4.13m	£0

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, providing a robust projection of the drivers of load-related expenditure for the ED2 period. Our ex-ante baseline funding request is based on the minimum investment required under all credible scenarios and is strongly supported by our stakeholders. Our plan will create smart, flexible, local energy networks that facilitate the accelerated 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 East Bedfont A Substation in RIIO-ED2. The primary driver considered within this paper is load related P2/7 compliance issue due to forecast demand growth from our Stakeholder supported Distribution Future Energy Scenario (DFES).

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.

4 Background Information

4.1 Existing Network Arrangement

East Bedfont BSP is located within the London borough of Hounslow of the SEPD licence area and is fed from Laleham GSP via two 132kV circuits. The BSP is split into two; East Bedfont A (132/22kV) and East Bedfont B (132/11kV). The East Bedfont BSP is supplied from Laleham GSP. The 2019/20 peak demand was approximately 58MVA for East Bedfont A and 17MVA for East Bedfont B.

The network schematic can be viewed in Figure 2 and the GIS map can be seen in Figure 3. The 132kV circuits comprise of 2 x 0.5in Cu three core cables with a winter rating of 125MVA and a Summer rating of 107MVA. 132kV circuits are approximately 5km long. East Bedfont A comprises of two 132/22kV transformers each with a winter rating of 78MVA and a summer rating of 60MVA. The 22kV incomer circuit breakers however are rated at 2000A and therefore the substation is limited to a FCO firm capacity of 76MVA. East Bedfont B

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

comprises of two 132/11kV transformers. A1MTB has a winter rating of 26MVA and A2MTB has a winter rating of 44.8MVA therefore this substation has a FCO firm capacity of 26MVA. East Bedfont A substation also has two 22kV interconnecting circuits to North Hyde 66/22kV substations. Each of these circuits have a winter rating of 15MVA and a spring/autumn rating of 14MVA.

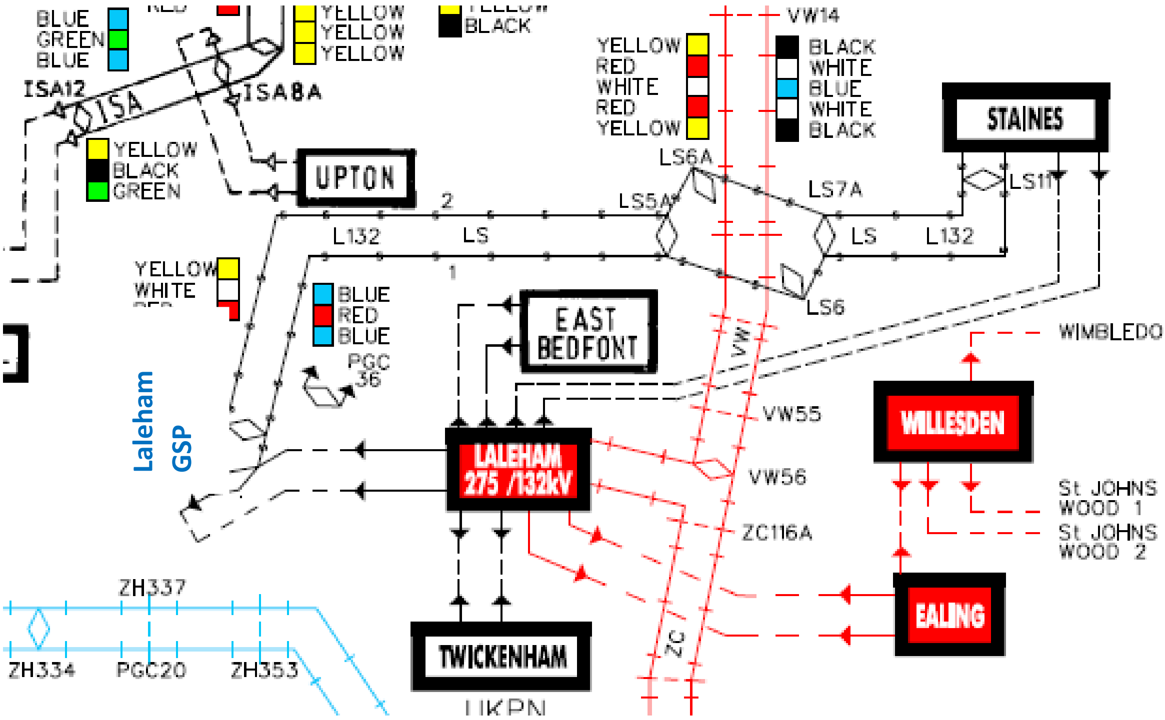


Figure 2: East Bedfont Network Arrangement SLD.

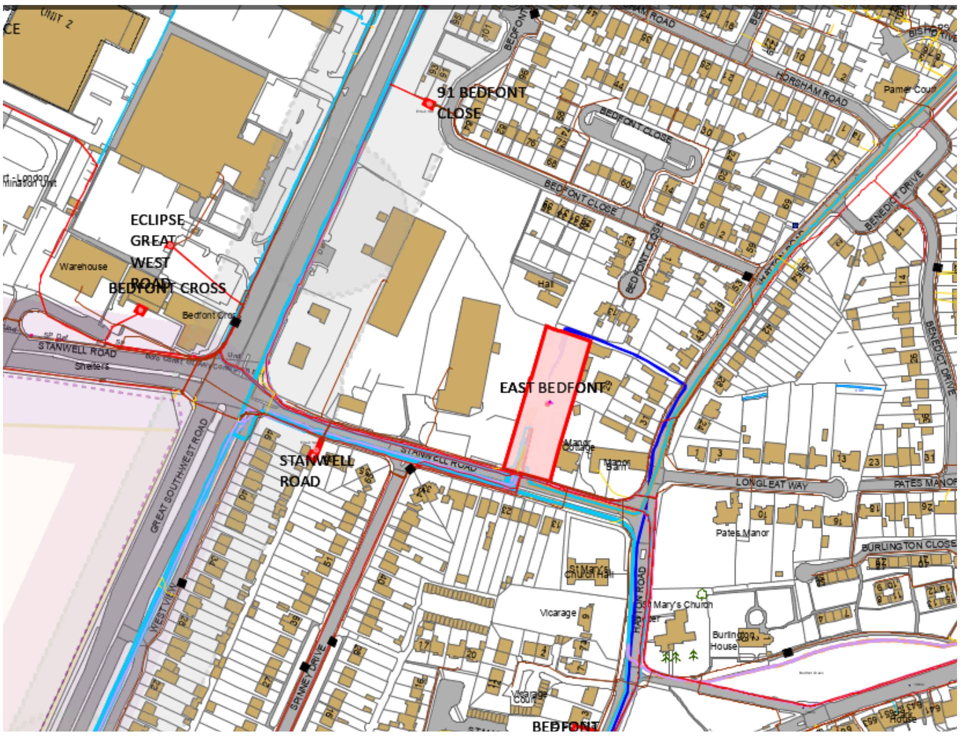


Figure 3: East Bedfont BSP GIS View

4.2 Local Energy Plan

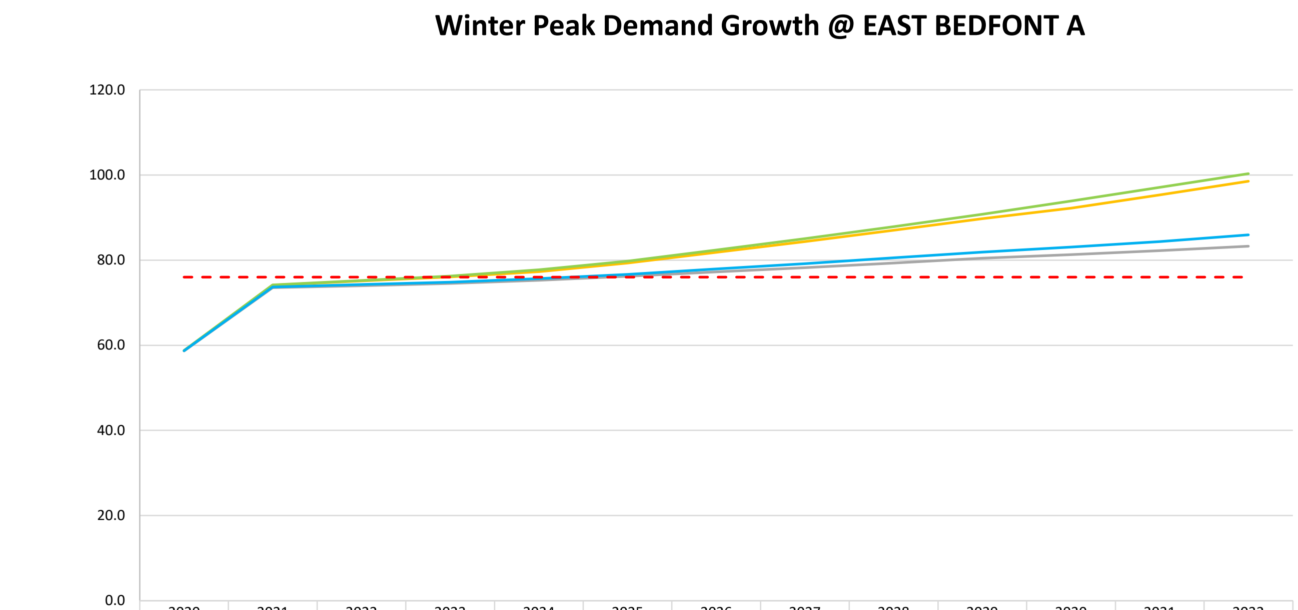
Greater London declared a climate emergency in 2020 and have developed both a climate change strategy and action plan to combat the issue. As a result, the council have agreed to:

- To become a net zero city by 2050
- To become a zero-waste city with the aim to stop non-biodegradable or waste that can be recycled entering landfill by 2026 and 65% of London's municipal to be recycled by 2030
- Provide technical assistance to help increase the number of homes and businesses connected to communal heat networks that use local energy sources
- Help Londoners cut their energy use by supporting efforts to improve the energy efficiency of homes and public buildings, and helping to roll out smart meters
- Increase clean energy generation with a London-wide ambition for there to be 1 GW of installed solar capacity by 2030, with at least 100 MW more solar installed, through the Mayor's programmes alone, such as grants to community groups, pilot projects promoting lower cost solar panels, and by putting solar panels on TfL buildings
- Support programmes to replace old polluting commercial boilers with new cleaner ones
- Ensure that new developments are zero carbon from 2019, with clean supplies of energy and high energy efficiency designed in from the start
- Trial low carbon technologies like heat pumps and batteries and new ways to make expensive insulation more affordable

4.3 Demand Forecast for East Bedfont BSP

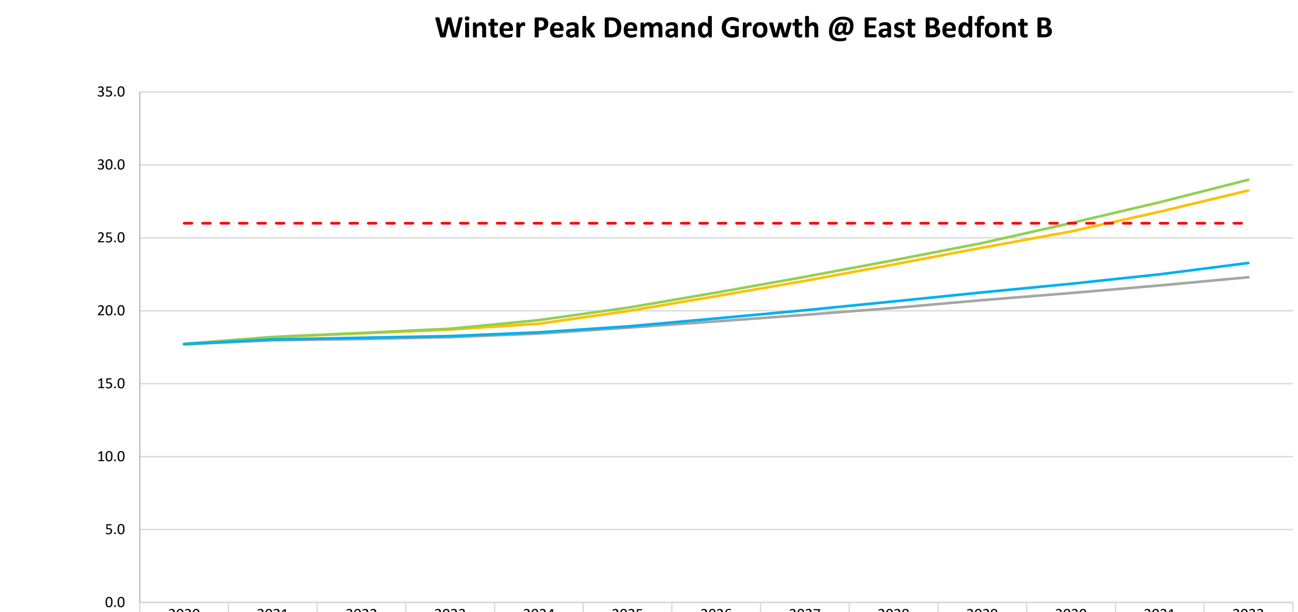
Figures 4 and 5 below show the demand projections in MVA for the East Bedfont A and East Bedfont B BSPs for all DFES forecast scenarios as well as the first circuit outage (FCO) limit for this. In this case, the FCO limit is exceeded for East Bedfont A from the year 2023 for the Consumer Transformation (CT) and Leading the Way (LW) scenarios and from 2025 for the other scenarios. For East Bedfont B the FCO limit is not exceeded during the ED2 price control period. The 2020 DFES forecast shows a step change in demand at East Bedfont A substation. This is largely due to the connection of a data centre connecting within the area, approximately 14.4MVA, and a marginal increase in non-domestic load and heat pumps.

Network interventions are required to address this issue as not doing anything would result in a licence condition breach and potentially a wide-spread blackout in the areas supplied by East Bedfont A substation.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	58.7	73.5	74.0	74.5	75.3	76.2	77.2	78.2	79.3	80.4	81.3	82.3	83.3
CT	58.7	74.1	75.1	76.1	77.3	79.3	81.8	84.4	87.0	89.8	92.2	95.4	98.6
LW	58.7	74.2	75.2	76.3	77.7	79.8	82.4	85.0	87.9	90.8	93.9	97.1	100.3
ST	58.7	73.7	74.3	74.8	75.6	76.7	77.9	79.2	80.5	81.9	83.1	84.4	85.9
FCO Limit	76	76	76	76	76	76	76	76	76	76	76	76	76

Figure 4 : East Bedfont A 22kV Winter Peak Demand Forecast



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	17.7	18.0	18.1	18.2	18.4	18.8	19.3	19.7	20.2	20.7	21.2	21.7	22.3
CT	17.7	18.2	18.4	18.7	19.1	20.0	21.0	22.1	23.2	24.3	25.4	26.8	28.2
LW	17.7	18.2	18.5	18.8	19.4	20.2	21.3	22.3	23.5	24.6	26.0	27.4	29.0
ST	17.7	18.0	18.1	18.3	18.5	18.9	19.5	20.0	20.6	21.3	21.9	22.5	23.3
FCO Limit	26	26	26	26	26	26	26	26	26	26	26	26	26

Figure 5: East Bedfont B 11kV Winter Peak Demand Forecast

Peak demand is expected to increase at East Bedfont A BSP by approximately 29 MVA from 2019/20 to 2027/28 when following the baseline CT scenario. The projected primary demand of 87 MVA (Winter Peak) by the end of ED2 is split as in Figure 6 below by demand type. The chart shows the largest impact on demand in the area is from data centres and heat pumps, equating to 17% and 7% of the overall projected demand increase respectively.

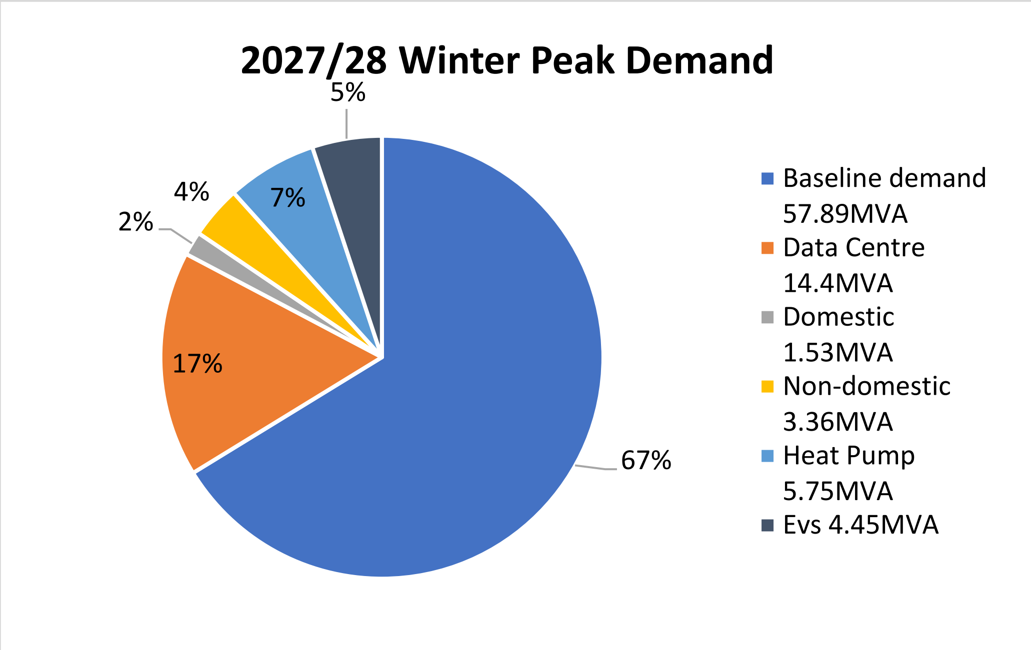


Figure 6: East Bedfont A BSP Winter Peak Demand Split 2027/2028 - CT Scenario

4.4 Existing Asset Condition

CBRM data shows that the 132/22kV transformers each have a current health index (HI) of HI3 and HI4 progressing to HI4 and HI5 by the end of ED2. Health indices 4 and 5 indicate the assets are is very poor condition and at risk of failure. There is currently no plan within the non-load project scope to replace these transformers however, the preferred solution to address the overloading issue discussed in this paper is to replace these transformers. As a result, a secondary benefit of the solution will be the removal of the existing poor condition assets from the network.

4.5 Thermal Flow Analysis

For the East Bedfont A BSP, the 2020 DFES forecast plot shows that by the end of ED2 the CT and LW scenarios the demand will exceed the FCO limit by 14%. The plot also shows that the FCO limit at East Bedfont A BSP will also be exceeded by the ST and SP scenarios by approximately 5%.

Network analysis was conducted using the the Consumer Transformation (CT) Distribution Future Energy Scenario (DFES) 2020 data, to understand how the assets on the network will be impacted during the RIIO-ED2 price control periods under a First Circuit Outage (FCO) conditions. The results of the analysis are shown in the sections below for the year 2027/2028.

The network analysis shows under FCO conditions, in Winter the remaining in service 132kV feeder will be loaded (worse case) to 96% of the circuit rating and therefore reinforcement of the 132kV circuits is not required. In addition, the system analysis showed that remaining in service East Bedfont A transformer will be overloaded to 127% for the worse case presenting a high risk of non compliance with P2/7 by the end of ED2. The remaining East Bedfont B transformer under FCO conditions will be loaded to 93% and therefore compliant with P2/7 by the end of ED2. For this case, failure to address this overloading issue at East Bedfont A, and bring the loading to within equipment ratings, could result in failure of the transformer asset leading to substatial customer interruptions and loss of supply. It is therefore required to deliver a solution to either increase FCO capacity or reduced demand at East Bedfont GSP to prevent equipment failure and distruption to customers.

For type D class demand, SCO requirements are set for demand that is 100MW or greater. In this case SCO requirements will not material until 2027 with a requirement of approximately 6.5MVA in 2027 and 10.2MVA in 2028 (Group Demand (GD) – 100MW) for the East Bedfont demand group. The capacity of 22kV interconnector to North Hyde was analysed to determine if it would be able to support the minimum SCO demand for East Bedfont BSP. This was achieved by adding a lumped load at the 22kV bus bar and increasing the load until the circuit became overloaded. The analysis showed that the 22kV interconnector will provide enough capacity, up to 28MVA, to support East Bedfont BSP under SCO conditions and maintaining compliance with P2/7 under this condition. The option to use this 22kV interconnector to transfer load from East Bedfont A BSP under FCO conditions will be explored as part of the optioneering excerise of this EJP.

Demand Group	Season	Group Class	Contingency	Loaded Circuit/Transformer	Loading (MVA)	Available Capacity (MVA)	%
East Bedfont A	Winter	D	EBED-A2 - LALE-S14	EBED-A1 - LALE-S6	120.7	125	96
				A1MTA(ACT)	96.6	78	127
				A1MTB(ACT)	24.2	26	93
East Bedfont A	Winter	D	EBED-A1 - LALE-S6	EBED-A2 - LALE-S14	120.0	125	96
				A2MTA(ACT)	96.9	78	124
				A2MTB(ACT)	23.4	26	90

Table 4: FCO Thermal Analysis in 2027/2028 Under CT Scenario

The results above show that the East Bedfont A 132/22kV transformers are overloaded under FCO conditions. As a result, reinforcement is required due to P2/7 non-compliance under FCO conditions.
Reinforcement is not required under SCO conditions as P2/7 compliance is met.

4.6 Voltage Level Assessment

No voltage issue were identified on the East Bedfont network.

4.7 Fault Level Assessment

No fault level issues were identified on the East Bedfont Network

4.8 Network Analysis Summary

The system analysis of the East Bedfont network has shown that during the RIIO ED2 price control period the 132/22kV transformers will become overloaded under FCO conditions. As a result, network intervention is required to mitigate this issue.

5 Summary of Option Considered

This section of the report sets out the investment options that were considered when resolving overload issues at East Bedfont 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 3. 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 below provides a high-level summary of the four investment options under consideration along with the advantages and disadvantages associated with each option. A more detailed description of each option is then provided within the proceeding sub-sections.

Option	Description	Advantages	Disadvantages	Result
1. Do Minimum	It is normally done by carrying out demand transfer from the overloaded demand group to another.	Minimum cost and workload; Short delivery time.	further reinforcement will still be required from year 2026.	Not Progressed to CBA
2. Addition of a third 132kV circuit and 132/22kV Transformer	Build a third transformer in the East Bedfont A substation compound and third 132kV circuit	Increases Security of supply Relieves FCO issues Increases SCO capacity	Can incur large civil costs. Site needs to be assessed to determine if there is suitable space to build a third transformer	Progressed to CBA analysis
3. Replacement of the 132/22kV transformers	Replace Existing Transformers	Increases Security of supply Relieves FCO issues	Can incur large civil costs.	Progressed to CBA analysis
4. Flexibility Solution & Replacement of 132/22kV Transformers	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.	Progressed to CBA analysis

Table 5: Summary of Reinforcement Options

5.3 Analysis and Cost

5.3.1 Option 1: Do-Minimum

Estimated Cost: N/A

The minimum scheme for overloading under N-1 conditions would be to transfer some of the load to nearby BSPs. East Bedfont A has a 2 x 22kV interconnecting circuits to North Hyde 22kV substation. Shown in the figure below.

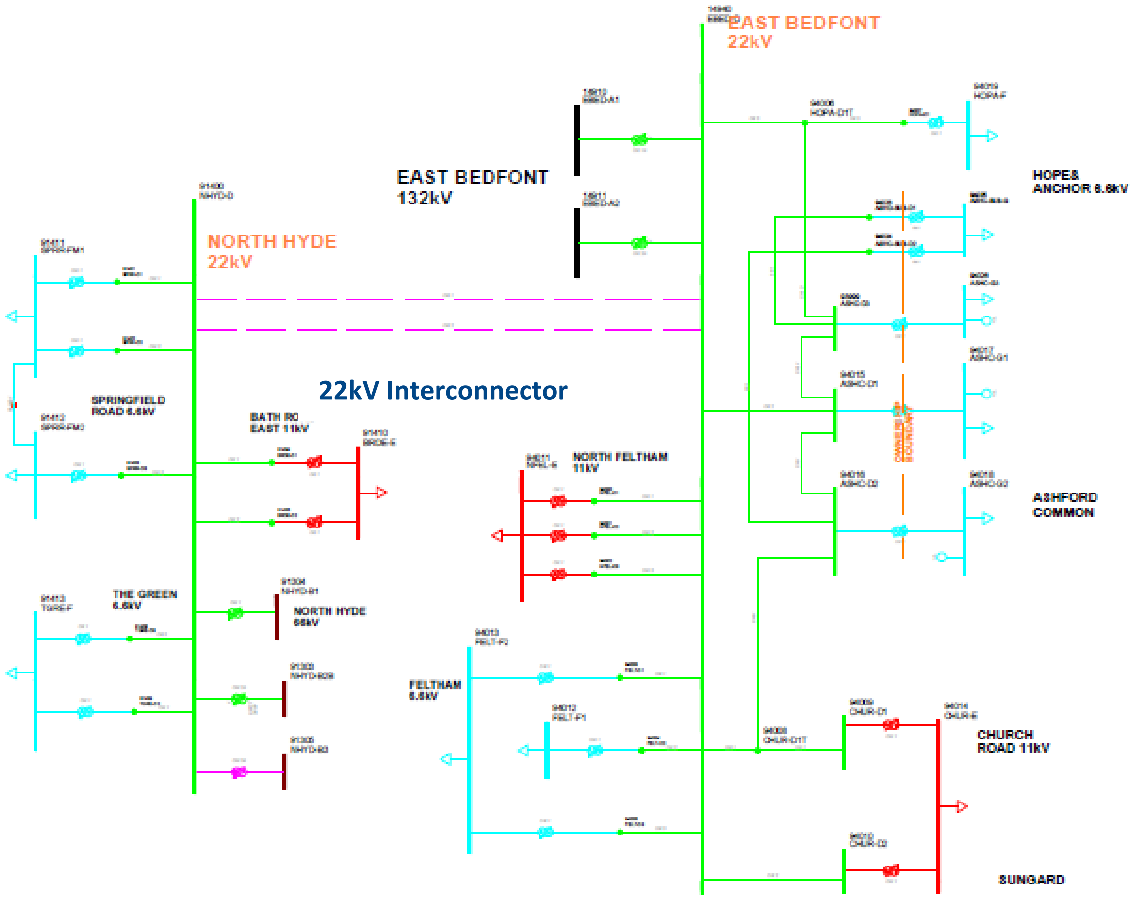


Figure 7: East Bedfont A 22kV Network Schematic

Each of the interconnecting circuits are connected to one half of the East Bedfont 22kV bus bar and are each rated at 15MVA. If these circuits were to be used under N-1 conditions, only one circuit would be energised under these conditions and would subsequently be responsible for supplying half the load at the East Bedfont A substation while the other half is supplied from the remaining in service 132kV circuit.

However, given that the forecasted demand at East Bedfont A is 76.1MVA in 2023 and 87MVA in 2028 the leg of the interconnection which would be energised would need to supply 38MVA in 2023 and 43.5MVA in 2028. Since each of the 22kV interconnection circuits are rated at 15MVA it is clear they do not have enough capacity to support this arrangement without significant reinforcement. An auto-reclose scheme would also be required to facilitate this solution as there is not one in place for N-1 conditions. This would enable to immediate transfer of load should one of the 132/22kV transformers are lost.

As the current network arrangement would not allow the minimum P2/7 demand to be met under FCO conditions, this minimum solution would cause a breach in licence conditions and therefore it is not technically feasible. Consequently, this solution has been rejected and had not been assessed in the Ofgem RIIO-ED2 standard CBA.

5.3.2 Option 2: New Asset – Addition of a Third 132/22kV Transformer

Estimated Cost: £7,420k

In this solution it is proposed to add a third transformer to the East Bedfont A substation to increase the FCO firm capacity. The transformer that will be added to the substation will be of the same type and capacity as the existing transformers. As a result of this solution, under FCO conditions the firm capacity of the substation will increase from 76MVA to 152MVA which is more than adequate to meet P2/7 requirements. A secondary benefit of this scheme is that the SCO capacity will also increase from 28MVA to 88MVA (inclusive of the existing 28MVA interconnection to North Hyde 66/22kV substation).

As part of this solution a 5km 132kV circuit will be required from Laleham GSP to the East Bedfont A substation. This circuit will be a 260mm2 Cu single core cable with a winter rating of 128MVA and a summer rating of 107MVA. An additional 132kV feeder circuit breaker will be added to the Laleham 132kV switchgear and an additional 22kV incomer circuit breaker will be added to the East Bedfont 22kV switchgear. A schematic of this proposed solution is shown below.

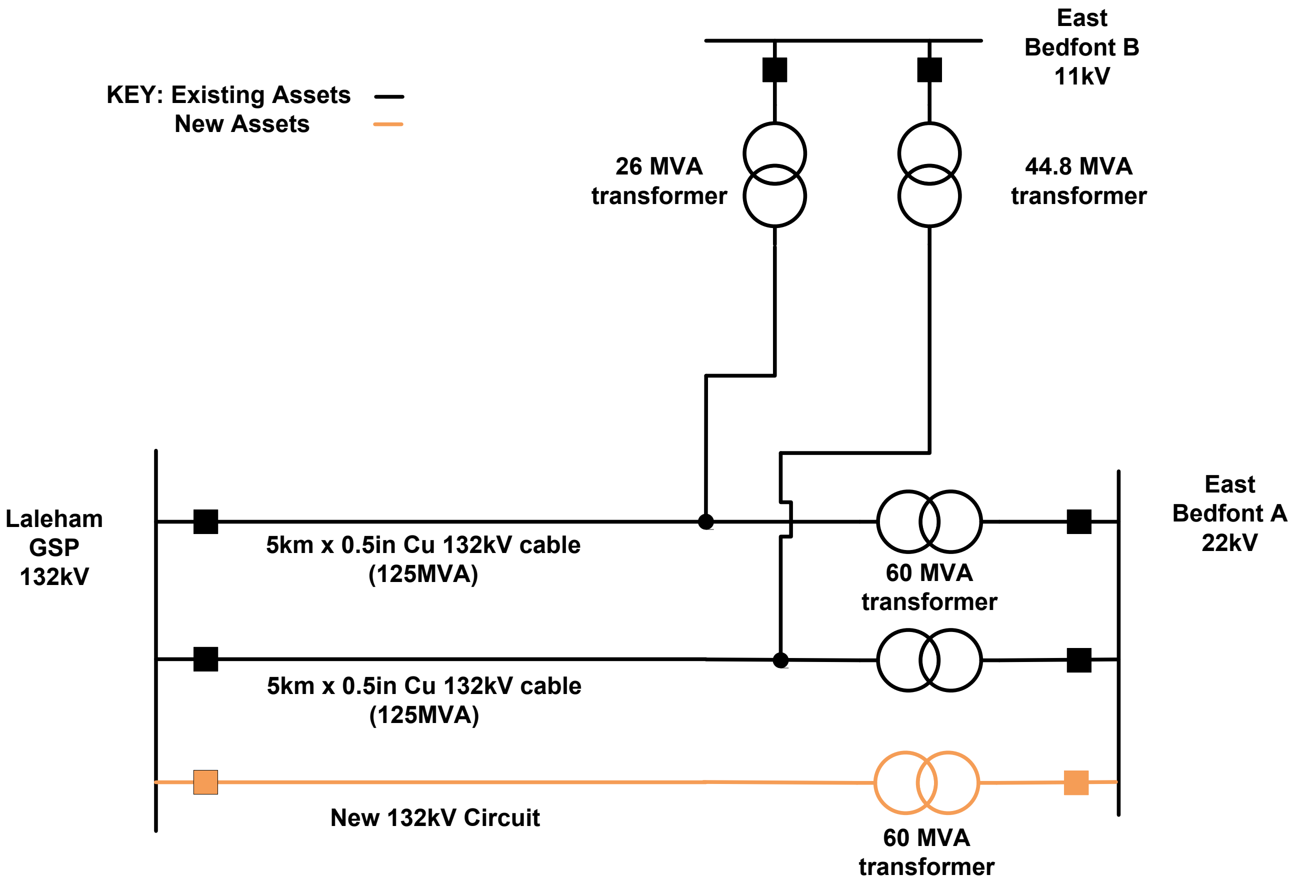


Figure 8: Option 2 Proposal

Figure 9 below shows the existing East Bedfont BSP substation compound. An assessment of this site indicates there is not sufficient space to install a third transformer and the compound would need to be expanded to accommodate this new asset.

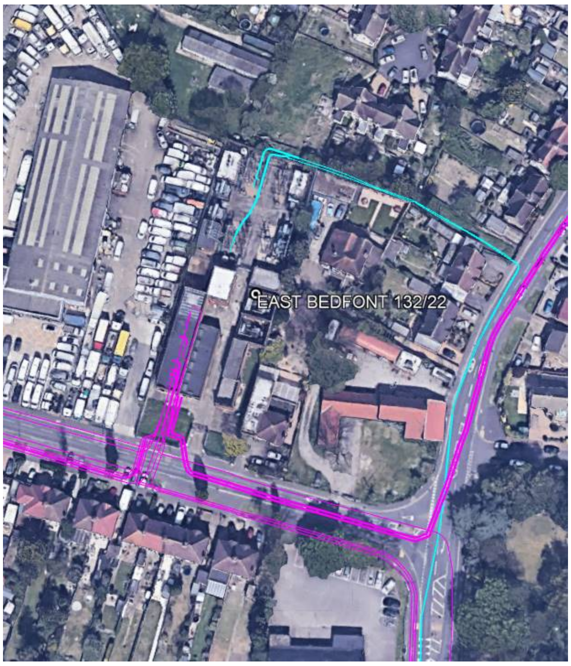


Figure 9: East Bedfont BSP Substation Location

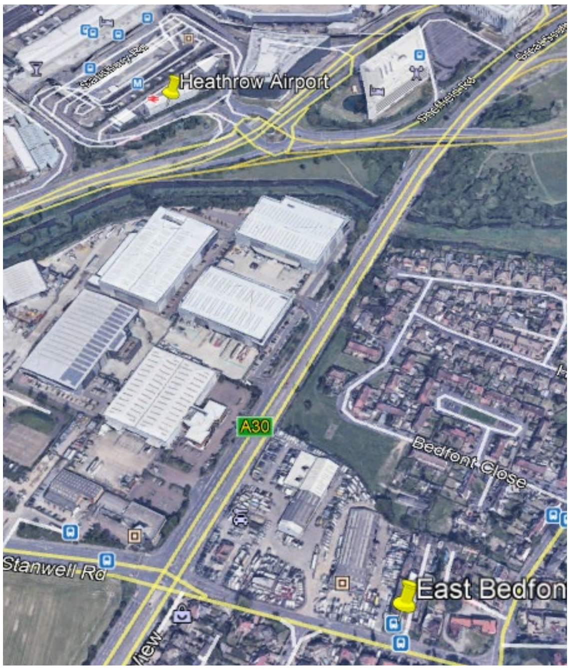


Figure 10: East Bedfont BSP in Relation to Heathrow Airport

The location of East Bedfont BSP raises a deliverability risk for this solution. The substation is within the vicinity of Heathrow airport, approximately 1km, and is surround by residential properties. Securing appropriate land to expand the site is expected to be challenging and could present a risk to delivering this solution within the expected timeframe.

The results of the thermal analysis show that for FCO conditions for East Bedfont BSP, the proposed solution is more than adequate to meet the requirements of P2/7 for this scenario with 61.7MVA of spare capacity. The 132kV circuits and transformers remain within their equipment ratings as result of this solution. The load index for the East Bedfont A substation would now be LI1 due to the implementation of this solution compared to LI5 if no network reinforcement is carried out.

The voltages at the 132kV, 22kV and 11kV bus bars were also investigated for this solution proposal. The voltage study shows that all voltages at the 132kV and 33kV bus bars remain within statutory limits.

The fault levels at the 132kV and 22kV bus bars in the East Bedfont A BSP were assessed for both three phase and single phase to ground faults for the proposed solution. The system intact fault level study shows that this proposed solution will marginally increases the fault levels at the 132kV and 22kV busbars but they will remain within equipment ratings. Under FCO conditions, the fault level at the 132kV and 22kV bus bars remain within equipment ratings for both three phase and single phase to ground faults.

Ofgem's RIIO-ED2 standard CBA template was used to assess costs and benefits of the conventional Options 1-3. Capital reinforcement costs, CI/CML penalties, network losses and other societal benefits are the key parameters used in this CBA. The capital cost for this option was used as the main input to the Ofgem CBA. The capital cost for this solution include:

- 5km of 132kV underground cable
- 1 x 132/22kV 60MVA transformer
- 1 x 132kV circuit breaker
- 1x 22kV circuit breaker
- Land purchase to extend the substation compound.

The results of the Ofgem CBA showed that this option would result in a higher NPV value compared to the other Conventional reinforcement option as highlighted in table 7.

5.3.3 Option 3: Asset Replacement – Replace Existing Transformers

Estimated Cost: £3,980k

In this option is it proposed to replace the existing transformers at East Bedfont A substation with larger capacity units. The current transformers are rated at 60MVA with an emergency rating of 78MVA. The 22kV circuit breakers however are rated at 2000A therefore the power transfer is limited to 76MVA. It is proposed to install larger capacity transformers at the substation. The next standard size of transformers is 90MVA with an emergency rating of 117MVA and it is proposed to replace the existing transformers with unit rated at 90MVA.

The 22kV switchgear will also require upgrading to facilitate the replacement of the East Bedfont A transformers. It is proposed a new 22kV switchboard is installed with the transformer incomer breakers rated at 2500A enabling a power transfer of approximately 95MVA. The new switchboard will also be SF_6 free switchgear providing a further environmental benefit.

As a result of this solution, under the FCO conditions, the remaining in-service transformer will be loaded to 90%, bringing the loading within equipment ratings and maintaining compliance with P2/7. This corresponds to a load index of LI2. With this solution in place the firm capacity of the East Bedfont A substation will increase from 76MVA to 95MVA with approximately 10MVA of spare capacity available.

Ofgem's RIIO-ED2 standard CBA template was used to assess the cost of this solution in comparison to the other options. The capital cost of the assets, 2 x 132/22kV transformers and new 22kV switchgear (18 circuit breakers), was used as the main input to this tool. As a result of the initial CBA assessment, Option 3 was shown to be the preferred conventional investment option based on the NPV. However, discussed in the next section of this paper, section 5.1.5, the use of flexible services was found to provide a greater economic benefit to conventional reinforcement deferral. In light of this, option 3 as a standalone solution has been rejected and will instead be used in conjunction with flexible services, as set out in option 4.

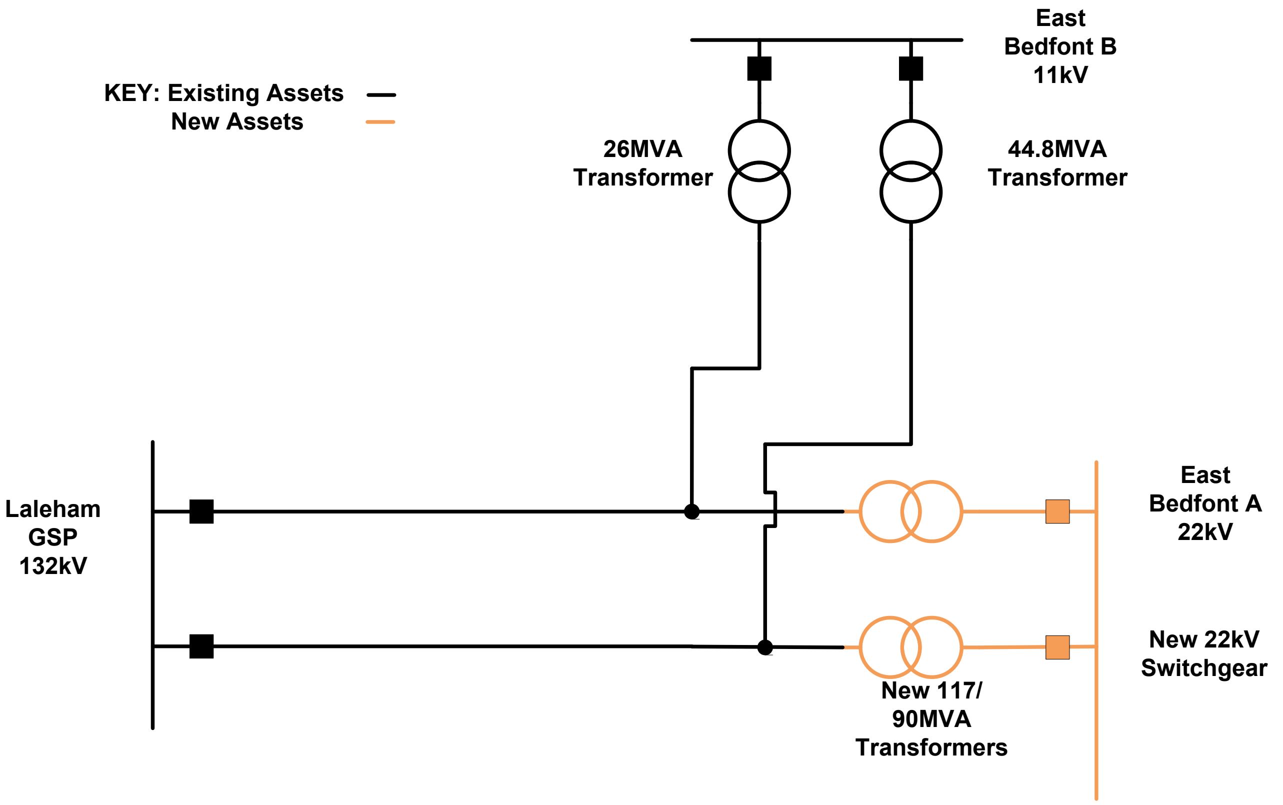


Figure 11: Option 3 Proposal

The results of the thermal analysis for this solution show that for FCO conditions for East Bedfont BSP, the proposed solution will meet the requirements of P2/7 for this scenario. The 132kV circuits and transformers remain well within their rating.

The voltages at the 132kV and 22kV bus bars were also investigated for this solution proposal. The voltage study shows that all voltages at the 132kV and 22kV bus bars remain within statutory limits.

The fault levels at the 132kV and 22kV bus bars in the East Bedfont BSP group were assessed for both three phase and single phase to ground faults for the proposed solution. The system intact fault level study shows that this proposed solution will marginally reduce the fault levels at the 22kV bus bars. Under FCO conditions, the fault level at the 132kV and 22kV bus bars remain within the switchgear ratings for both three phase and single phase to ground faults.

5.3.4 Option 4: Flexible Solution & Asset Replacement

Estimated Cost: £4,130k

An alternative to conventional reinforcement is through the use of flexible service. The Common Evaluation Methodology (CEM) [2] framework would evaluate 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

[2] https://www.energynetworks.org/assets/images/Resource%20library/ON20-WS1A-P1%20Common%20Evaluation%20Methodology-PUBLISHED.23.12.20.pdf

- the existence of uncertainty, and the impact of incremental information which becomes available over time.

The baseline reinforcement cost used as an input into the CEM framework is the costs associated with Option 3 – Asset Replacement, equating to £3.98m. Figure 11 shows a typical load profile of a winter day in 2023 and in 2028. The peak demand exceeds the FCO rating for approximately 0.5 hours in 2023 and for 13 hours in 2028. Flexibility services in the form of increasing generation export or decreasing demand import could be used to reduce the peak.

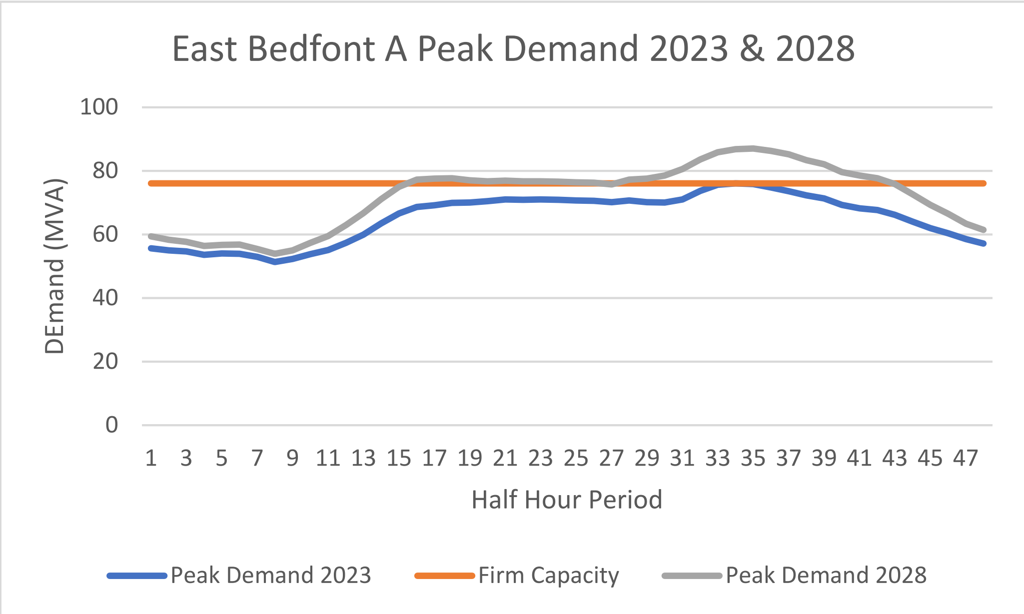


Figure 12:East Bedfont A Winter Peak Demand 2023 and 2028 Without Flexibility Services

The MW exceedance, the daily and annual overload hours (Table 3) 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.

	2024	2025	2026	2027	2028
Hrs/day required	2.0	3.0	4.5	6.0	13.0
Days/yr required	64	64	64	64	64
Utilisation Volumes (MWh)	32.68	127.03	335.68	642.29	1834.37
Dispatch duration	2.0	3.0	4.5	6.0	13.0

Table 6:Estimated Dispatch requirements for Flexibility Solutions

The CEM CBA model suggests that under the CT DFES 2020 scenario, assuming suitable volumes of flexibility can be procured, conventional reinforcement can be deferred by 3 years to 2026/27.

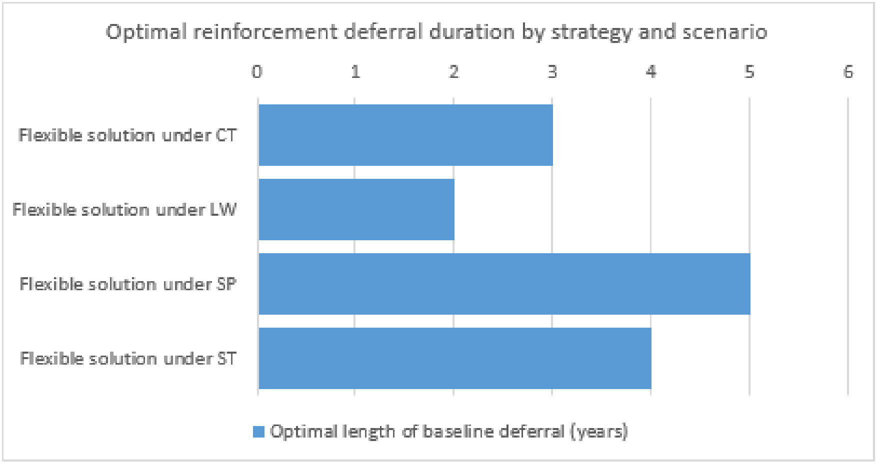


Figure 13:Baringa Flexibility CBA Results

In line with our Flexibility First Approach, this project is technically compatible with a Flexibility Solution. In this case flexibility will allow us to defer the need for a conventional solution by 3 years, as such SSEN will carry out Flexibility market tests to establish the cost, location and technical capabilities of the available flexibility.

If the market test is successful, a Flexibility Solution will be employed offering value to SSEN and our customers in terms of investment deferral and optionality. Should the market test fail or only partially succeed in identifying the required Flexibility, SSEN will utilise the CEM Framework to assess the optimal, secondary solution for this location, be that be a further market test for full Flexibility, accelerating the Conventional solution or a Hybrid Scheme.

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

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 table below summarises the CBA outcome for all the options considered to resolve the thermal constraints at East Bedfont BSP. The CBA results show that the use of flexible services followed by conventional reinforcement is the preferred solution due to the superior NPV value as well as enabling sufficient phasing of the project to ensure deliverability. The cost associated with this option includes the expenditure for the procurement of flexible services as well as the capital cost of the conventional reinforcement in 2027.

Options	NPV After 45 Years (£k)	Total Investment Cost (£k)
Option 2 – Addition of a third 132/22kV transformer and third 132kV circuit	-3,831	7,418
Option 3 – Replacement of the 132/22kV transformers	-2,560	3,984
Option 4 – Flexible Solution & Replacement of 132/22kV transformers	-2,393	4,128

Table 7: CBA Results Summary

Options	Unit	2024	2025	2026	2027	2028	Total
Option 2 – Add New Asset	£m	7.33	0	0	0	0	7.42
Option 3– Asset Replacement	£m	2.91	0	0	0	0	3.98
Option 4– Flexible solution	£m	0.0005	0.03	0.114	3.984	0	4.13

Table 8 Summary of cost

6.1 Options Summary

Option 3 is the lowest capital costs and may appear to be the attractive option. However, option 4 has a lower NPV across a 45 year period. Option 4 also allows reinforcement to be deferred. This enables a balancing (smoothing) of the capital delivery profile for our major project portfolio across the ED2 period which will realise efficiencies in the cost of delivery. Option 2 will technically resolve the overloading issue experienced. However, given the significant increase in CPAEX and subsequently the larger NPV across a 45 year period, this option has been rejected. The preferred option for this case is option 4.

6.2 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)***[3]. 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 Site factors driving additional costs.

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

Category	Sub-category	Unit Cost (£k)	Unit	Asset Count	Predominant Costing Approach	Cost £k
Transformer	132/22kV transformers	[redacted]	#	2	ED1 6yr average actual unit rates	[redacted]
Switchgear	22kV CB (Air Insulated Busbars) (OD) (GM)	[redacted]	#	18	ED1 6yr average actual unit rates	[redacted]
					Project Total	**3,983.6**

Table 9 Preferred option cost breakdown

The costs breakdown above is reflective of the cost of the physical asset and associated works only. The cost for the use of flexible services to defer the reinforcement until 2027 will be in addition of this. Based on the assessment of flexibility it is estimated that cost for procuring flexible services (availability and utilisation) will be £144k. This will bring the total project cost to £4,128k.

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 detailed in 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	0.0005	£0.03m	£0.114m	£3.983	0

Table 10 Investment phasing on deliverability assessment

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 132kV, 33kV and 11kV OHL 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 Engineering Justification Paper (EJP) provides relevant information in relation to the load related investment at East Bedfont A 132/22kV substation in RIIO-ED2.

The thermal overloading of the two 132/22 kV transformers at East Bedfont A under an FCO condition is triggered by all four DFES scenarios during the ED2 price control. The current load index of the substation is LI1 but will increase to LI5 by the end of the RIIO-ED2 price control period if no network reinforcement is implemented.

The following options were considered in the Ofgem's standard CBA and the CEM flexibility CBA

- Option 2: Reinforcement by network extension (adding additional new assets).
- Option 3: Reinforcement through asset replacement.
- Option 4: Flexible Solution followed by a conventional reinforcement.

Option 4, followed by option 3 once the flexible service period has ended, is the preferred option due to its superior NPV value and the reduced risk against deliverability compared to option 2. As a result of this option the load index for the East Bedfont A substation will now be LI2 compared to LI5 if no network reinforcement is carried out.

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

Appendix 2. Assumptions

CI/CML Tables

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028
CR	29.37	37.06	37.55	38.04	38.64	39.65	40.91	42.18	29.37
Firm Capacity	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Difference	14.37	22.06	22.55	23.04	23.64	24.65	25.91	27.18	14.37
Customer No. 1% Growth	22908	23137	23137	23368	23602	23838	24076	24317	22908
MW per customer	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
No. Faults per Year	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Final Input									
CI	-1301.	-2401.9	-2922.	-2977.5	-3032.9	-3094.1	-3175.9	-3267.7	-3357.8
CML	-234186	-432335	-525982	-535949	-545923	-556944	-571657	-588191	-604407

Table 12:CI/CML for Do Minimum Option.

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028
CR	58.74	74.13	75.10	76.08	77.28	79.31	81.83	84.36	87.02
Firm Capacity	152.00	152.00	152.00	152.00	152.00	152.00	152.00	152.00	152.00
Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Customer No. 1% Growth	22908	23137	23137	23368	23602	23838	24076	24317	22908
MW per customer	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
No. Faults per Year	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225
Final Input									
CI	0	0	0	0	0	0	0	0	0
CML	0	0	0	0	0	0	0	0	0

Table 13: CI/CML for Add New Asset Option

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028
CR	58.74	74.13	75.10	76.08	77.28	79.31	81.83	84.36	87.02
Firm Capacity	95	95	95	95	95	95	95	95	95
Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Customer No. 1% Growth	22908	23137	23137	23368	23602	23838	24076	24317	22908
MW per customer	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
No. Faults per Year	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Final Input									
CI	0	0	0	0	0	0	0	0	0
CML	0	0	0	0	0	0	0	0	0

Table 14: CI/CML for Asset Replacement Option.

Appendix 3: 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 our ***Whole System (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 East Bedfont 132/22kV Substation Reinforcement.

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?
East Bedfont 132/22kV Substation Reinforcement	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 for Whole Systems solution(s).	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

Table 15: Whole Systems CBA test for East Bedfont 132/22kV Substation Reinforcement

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.