RIIO-ED2 Engineering Justification Paper (EJP)

Harvard Lane 22/11kV Primary Substation

Investment Reference No: 50/SEPD/LRE/HARL

Contents

1 Executive Summary

Our proposed investment at Harvard Lane 22/11 kV primary substation will deliver P2/7 compliance for investment of £3.737m during RIIO-ED2.

The primary investment driver for this scheme is load related P2/7 compliance issue under N-1 outage conditions for supply to Harvard Lane 22/11 kV primary substation in RIIO-ED2. The P2/7 compliance issue is apparent under four scenarios (System Transformation, Consumer Transformation, Leading the way, and Steady Progression) due to the forecast demand growth from our Stakeholder supported Distribution Future Energy Scenario (DFES).

Accelerating progress towards a net zero world

This project is required under our accelerating progress towards net zero priority, as Harvard Lane 22/11 kV primary substation will see approximately 12% of its demand in 2027/28 driven by low carbon technologies (LCT), such as heat pumps and electric vehicles (EVs). Without intervention to make it P2/7 compliant, we will experience increased overloading issue. This will significantly impact our ability to meet the minimum level of security of supply to consumers, as we move towards a Net Zero network in RIIO-ED2.

The EJP considers an exhaustive 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. We also considered the Local Area Energy Plans from Ealing council through our stakeholder engagement activities in the option analysis.

The Cost Benefit Analysis results shown in Table 1 below demonstrate that the most cost-effective solution, that delivers the best value for consumers in terms of the 45 years Net Present Value (£m), is option 4 'Flexible Solution Followed by Asset Replacement'. This option involves utilising flexibility to defer the reinforcement for two years, followed by replacing several overloaded 22 kV cable sections and an overloaded 22/11 kV primary transformer at Harvard Lane primary substation.

Options	Net Present Value (NPV) After 45 Years (£k)	Investment (£k)
Option 3 – Asset Replacement	-1,164	3,707.2
Option 4 – Flexible Solution Followed by Asset Replacement	-1,082	3,737.0

Table 1: CBA and investment results for viable options

Our CBA quantifies the benefits associated with each option to support our assessment. For this investment scheme the societal benefits are predominantly attributed to avoided losses and the associated reduction in CO_2. For our preferred Option 4, the monetary associated benefit totals in £0.52m during RIIO ED2.

Our load related investments contribute very minor CI and CML benefits, as result of their low counterfactual health indices and our licence obligations around overloading of the network. A more detailed explanation can be found in our ***Cost Benefit Analysis Process (Annex 15.8)***.

Following the optioneering and detailed analysis, as set out in this paper, the proposed scope of works for the preferred Option 4 is detailed in Table 2:

Assets & Services	Volume	Costs (£k)
33kV UG Cable (Non-Pressurised) (km)[1]	9.4	[redacted]
33kV Transformer (GM) (no.)	I	[redacted]
London Region - Increased High way management (No.)	I	[redacted]
Flexibility Solution (years)	2	[redacted]
Total		[redacted]

Table 2: Proposed scope of works and cost breakdown in the preferred investment option

This scheme delivers the following outputs and benefits:

- Ensures Harvard Lane 22/11 kV primary substation compliant with P2/7.
- Facilitates the continued uptake of low carbon technologies (LCTs) in Greater London and helps support the climate change targets of Ealing Council.
- Uplifts network capacity of 9.9 MVA to meet the needs of our customers
- Facilitates the efficient , economic, and co-ordinated development of our Distribution Network for Net Zero.

The current Load Index (LI) for Harvard Lane Primary is LI2 (96%) and it will be LI5 (105%) by the end of ED2 period without intervention. With the preferred reinforcement option, the LI will be LI1 (76%) with a risk point reduction of 1,280,664 by the end of the ED2 price control.

The cost to deliver the preferred solution is £3.737m and the works are planned to be completed in 2026 taking into consideration our deliverability requirements. This EJP investment sits within our Net Zero Totex ask in Figure 1.

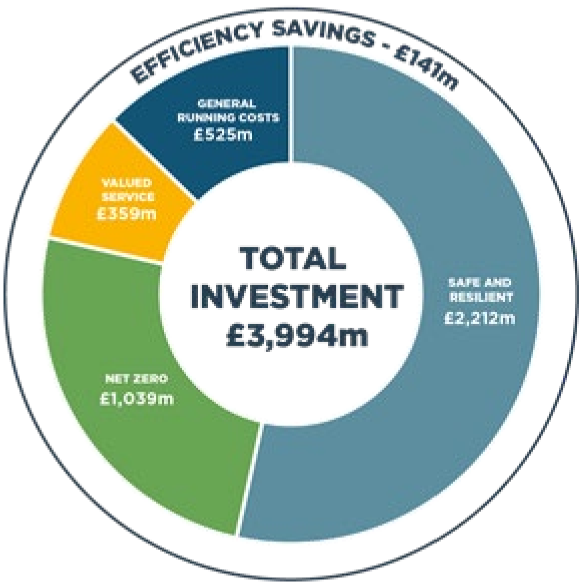


Figure 1: SSEN total investment cost within RIIO ED2

[1] The unit rate of 33 kV underground cable and 33/11 kV transformer is applied for 22 kV cable and 22/11 kV transformer in the CBA model.

2 Investment Summary Table

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

Name of Scheme	Harvard Lane 22/11kV transformer and 22kV circuits		
Primary Investment Driver	Load – P2/7 compliance – (Demand Driven Security of Supply)		
Scheme Reference	50/SEPD/LRE/HARL		
Output References/Type	22/11kV Transformer 22kV Circuits Flexibility		
Cost	£3.737m		
Delivery Year	2025/26		
Reporting Table	CV1: Primary Reinforcement		
Outputs included in RIIO-ED1 Business Plan	No		
Spend Apportionment	ED1	ED2	ED3+
	0	**£3.737m**	**0**

Table 3: Investment Summary

3 Introduction

Our ***Load Related Plan Build and Strategy (Annex 10.1)***[2] 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 Harvard Lane 22/11 kV primary substation in RIIO-ED2. The primary driver considered within this paper is load related P2/7 compliance issue at Harvard Lane 22/11 kV primary substation 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 arrangements, 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.

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

4 Background Information and Analysis

Harvard Lane Primary is located in Ealing in the SEPD licence area. This substation is supplied from the Ealing BSP. Harvard Lane currently supplies 12,953 customers via 11kV circuits. The 2019/20 peak demand was 23.9MVA and there is currently no embedded generation connected to this primary.

4.1 Existing Network Arrangement

Harvard Lane Primary is currently supplied from Ealing 66/22kV BSP via three 22kV circuits. Two of the 22kV circuits have ratings of 15.3/14/14MVA and the third has a rating of 13.5/12.3/12.3. Two of the 22/11kV Harvard Lane primary transformers are rated at 12.5/12.5/12.5MVA and the third is rated at 24/24/24MVA, which limits the FCO capacity at Harvard Lane Primary to 25MVA.

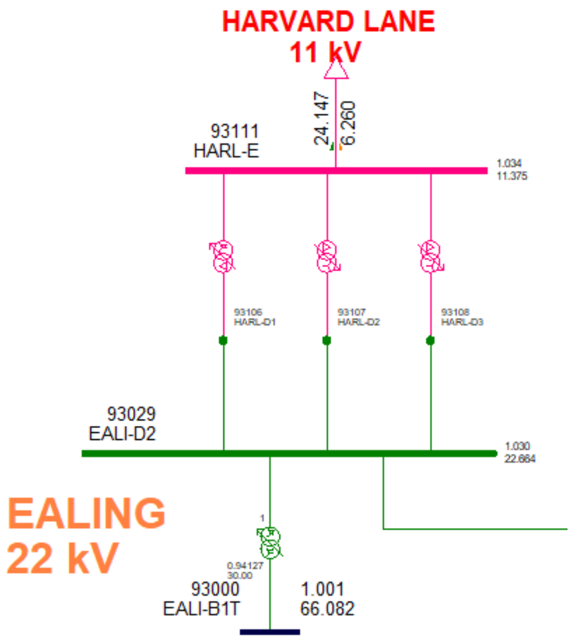


Figure 2: Harvard Lane Network Arrangement SLD

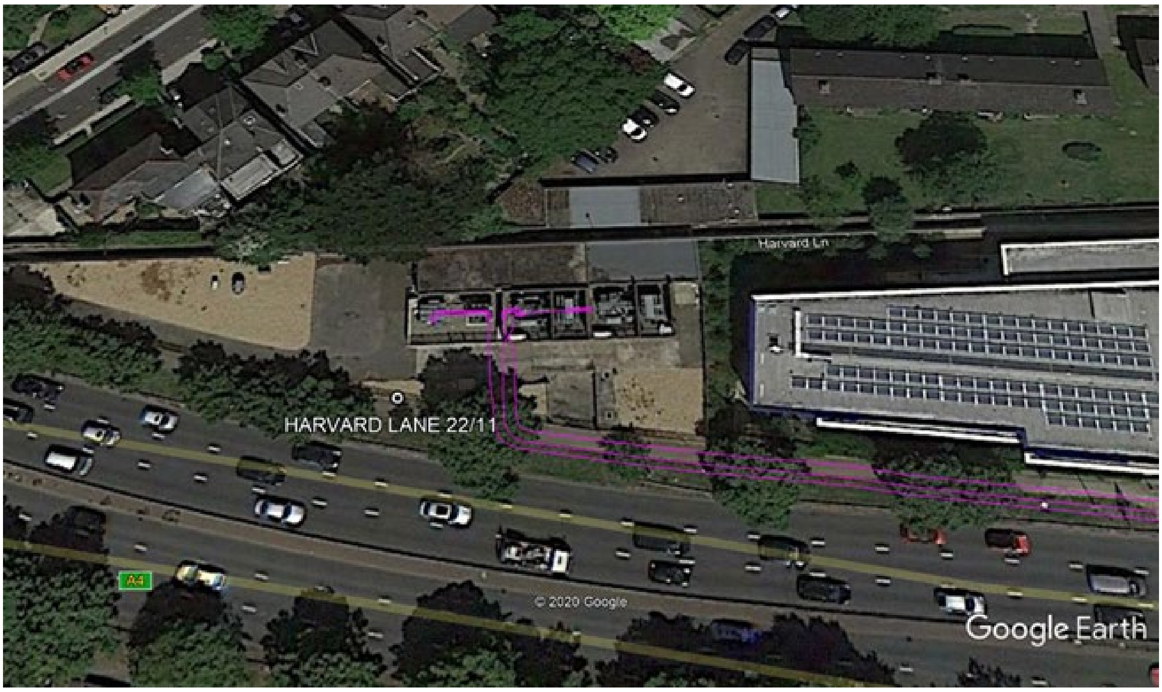


Figure 3: Harvard Lane 22/11 kV Primary Substation

4.2 Local Energy Plan

In April 2019, Ealing council declared a climate emergency and acknowledged the need for Climate Change Strategy and in May 2020 a draft strategy was agreed by the cabinet. The key actions outlined are:

- Complete shift to zero carbon electricity generation – produced both locally and nationally
- Manage electricity demand and implement energy storage solutions
- Significantly improve building energy performance through retrofit
- Ensure all new builds reach their energy and carbon saving potential through planning authority and capital expenditure
- Decarbonisation of heat for buildings, hot water and industry
- Cut transport emissions drastically with a step change to walking,
- cycling and public transport – and transition all essential vehicles to electric
- Dramatically reduce carbon emissions from food production and agriculture
- Reduce waste produced and process waste with lowest carbon emissions possible – transport, processing, food waste, etc.
- Increase carbon capture through tree planting, land management and keeping pace with technological advances

It is believed that the Ealing council's local energy plan would have an impact on demand growth within the area. This impacts visible within the DFES projections and directly contributes to the need for investment discussed within this paper.

4.3 Demand Forecast

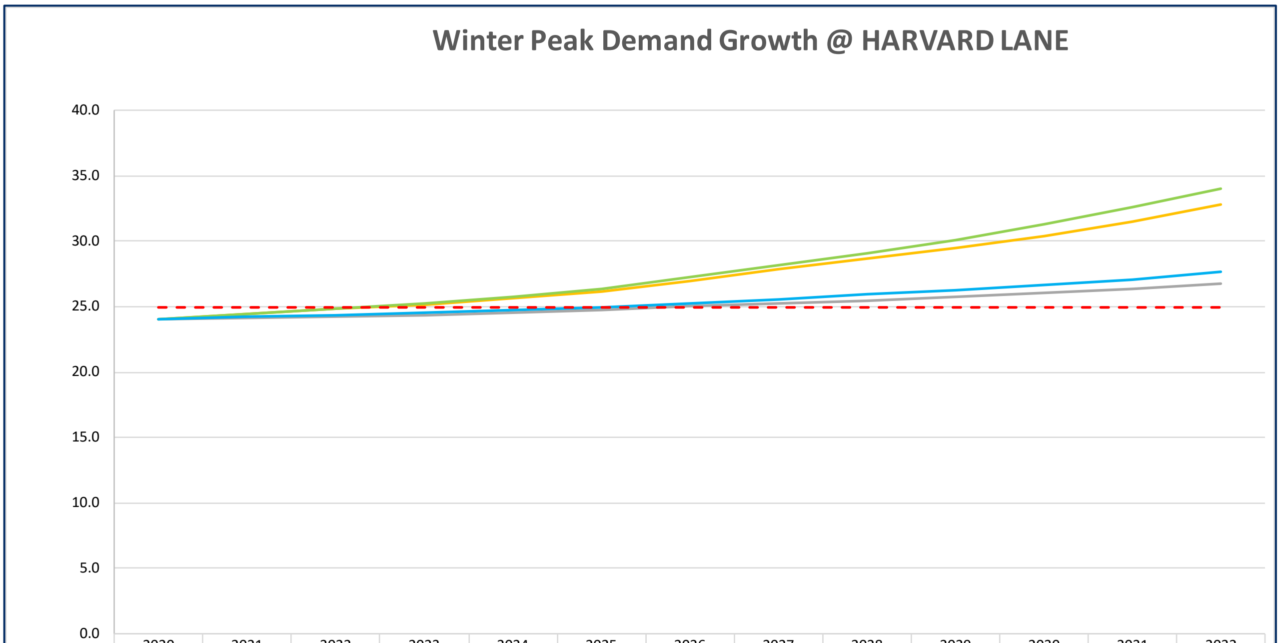
We have carried out extensive scenario studies – the Distribution Future Energy Scenarios (DFES). The basis for this work is National Grid's Future Energy Scenarios (FES) 2020. This framework comprises four potential pathways for the future of energy based on how much energy may be needed and where it 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. We are protecting customers from the impact of forecasting uncertainties through our baseline funding only including 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)***[3].

Figure 4 - Figure 6 below show the demand projections in MW of Harvard Lane primary substation for all forecast scenarios for different seasons. As can be seen, the FCO limit (see section 4.1) is exceeded under the System Transformation (ST – by 2025), Consumer Transformation (CT – by 2023), Leading the Way (LW – by 2023), and Steady Progression (SP – by 2026) scenarios during ED2. This CT scenario modelling confirms the certainty of this investment in RIIO-ED2. The current Load Index (LI) for Harvard Lane Primary is LI2 (96%) and it will be LI5 (105%) by the end of ED2 price control without intervention.

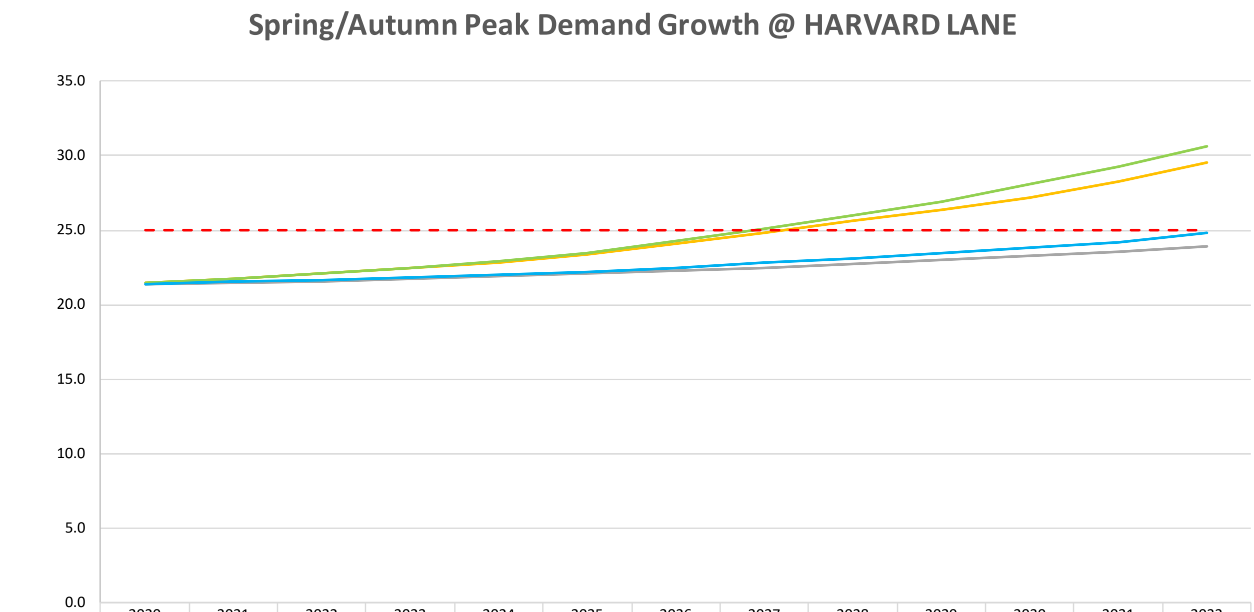
Network interventions are required to address this issue as not doing anything would result in a P2/7 non-compliance and potentially a wide-spread blackout in the areas supplied by Harvard Lane Primary.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	24.0	24.1	24.2	24.4	24.6	24.8	25.0	25.2	25.5	25.8	26.0	26.4	26.8
CT	24.1	24.4	24.8	25.2	25.6	26.2	27.0	27.8	28.6	29.5	30.3	31.5	32.8
LW	24.1	24.5	24.8	25.2	25.7	26.3	27.2	28.1	29.1	30.1	31.3	32.6	34.0
ST	24.1	24.2	24.4	24.5	24.7	25.0	25.3	25.6	25.9	26.3	26.6	27.1	27.7
FCO	25	25	25	25	25	25	25	25	25	25	25	25	25

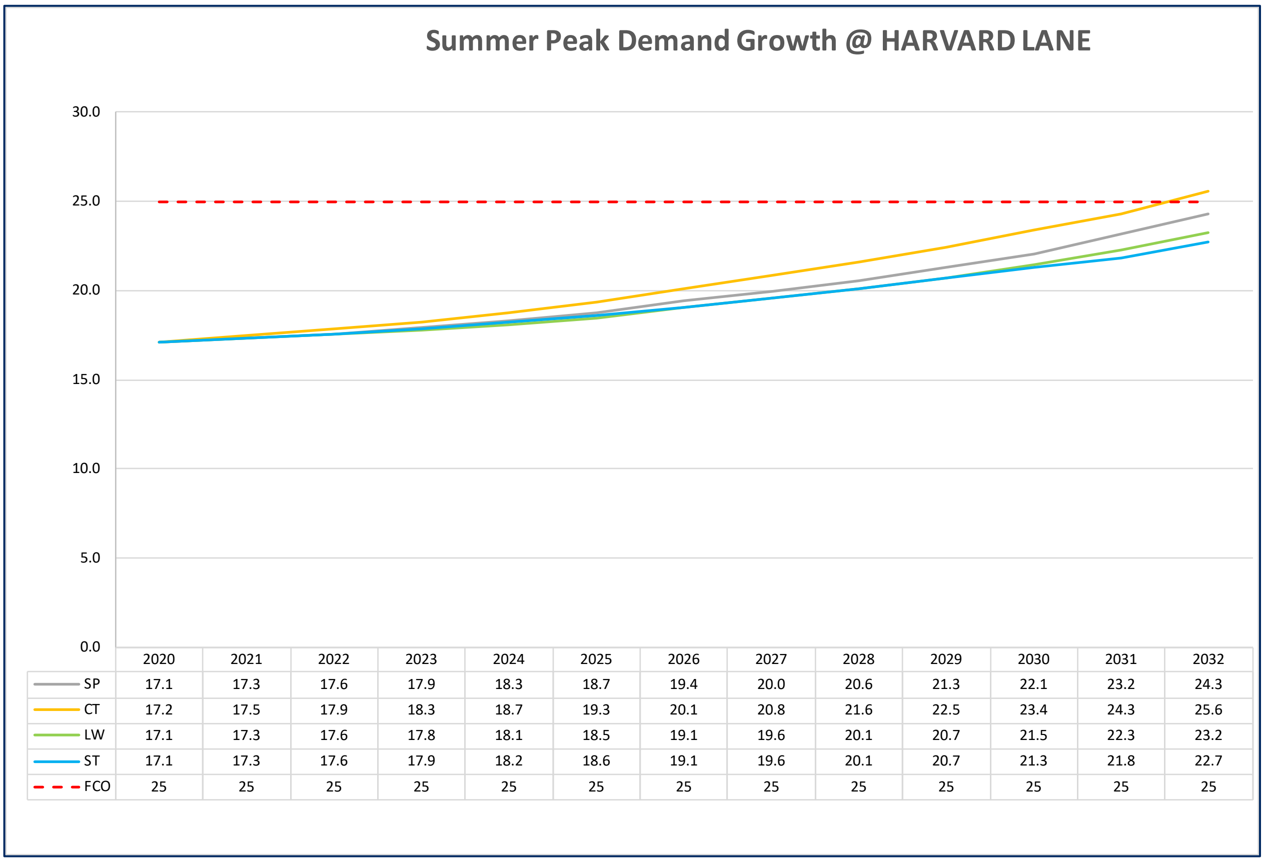
Figure 4: Harvard Lane Primary winter peak demand growth

[3] Link to ***Load Related Plan Build and Strategy (Annex 10.1)***



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	21.4	21.5	21.6	21.7	21.9	22.1	22.3	22.5	22.7	23.0	23.3	23.6	23.9
CT	21.5	21.8	22.1	22.4	22.9	23.4	24.1	24.9	25.6	26.4	27.2	28.3	29.5
LW	21.5	21.8	22.1	22.5	22.9	23.5	24.3	25.1	26.0	27.0	28.1	29.3	30.6
ST	21.4	21.6	21.7	21.8	22.0	22.2	22.5	22.8	23.1	23.4	23.8	24.2	24.8
FCO	25	25	25	25	25	25	25	25	25	25	25	25	25

Figure 5: Harvard Lane Primary spring / autumn peak demand growth



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	17.1	17.3	17.6	17.9	18.3	18.7	19.4	20.0	20.6	21.3	22.1	23.2	24.3
CT	17.2	17.5	17.9	18.3	18.7	19.3	20.1	20.8	21.6	22.5	23.4	24.3	25.6
LW	17.1	17.3	17.6	17.8	18.1	18.5	19.1	19.6	20.1	20.7	21.5	22.3	23.2
ST	17.1	17.3	17.6	17.9	18.2	18.6	19.1	19.6	20.1	20.7	21.3	21.8	22.7
FCO	25	25	25	25	25	25	25	25	25	25	25	25	25

Figure 6: Harvard Lane Primary summer peak demand growth

Peak demand is expected to increase at Harvard Lane primary by approximately 3.9MVA from 2019/20 to 2027/28 when following the CT scenario in winter. The projected primary demand of 27.8 MVA (Winter Peak) by the end of ED2 is split by demand type as in Figure 7 below. The chart shows the largest impact on demand in the area is from EVs and heat pumps, equating to 6% and 6% of the overall projected demand increase respectively.

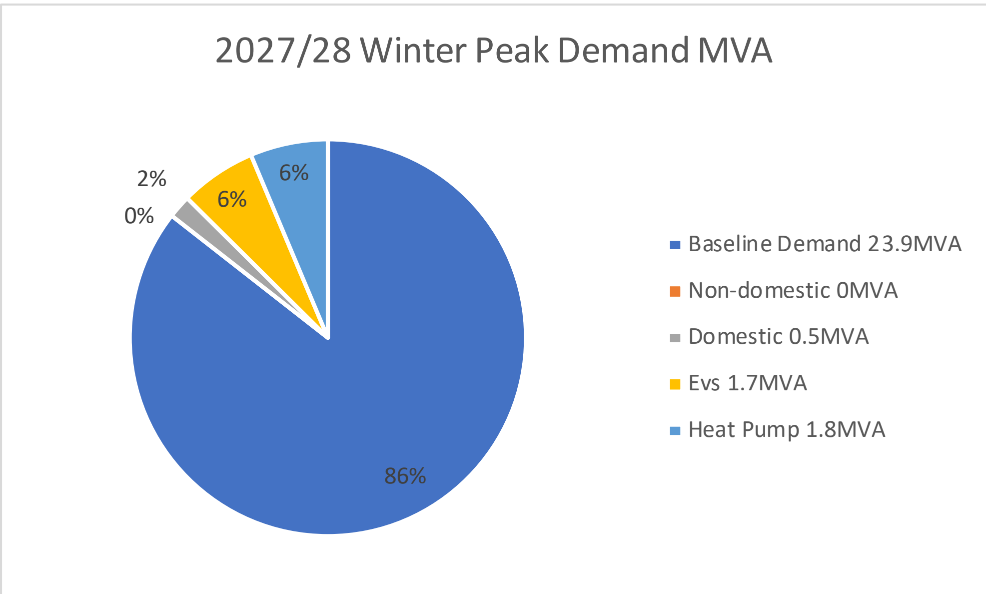


Figure 7: Harvard Lane Primary Winter peak demand split by 2027/28

4.4 Existing Asset Condition

The Harvard Lane Transformer D1MT is currently of Health Index HI1 and is expected to stay at HI1 during ED2. Both D2MT and D3MT transformers are currently of HI4, however D2MT is forecasted to stay at HI4 and D3MT is predicted to move to HI5 by the end of ED2. It is part of the non-load investment portfolio to refurbish the D3MT to mitigate the risk of asset failure.

4.5 Thermal Flow Analysis

First Circuit Outage (FCO) Analysis in 2023/24 under CT Scenario:

Demand Group	Season	Group Class	Contingency	Loaded Circuit / Transformer	FCO Demand to be Met (MVA)	FCO Available Capacity (MVA)
Harvard Lane Primary T1, T2 & T3	Winter	C	Fault on Harvard Lane Primary T1	Harvard Lane Primary T2/T3	25.6	**25**
Harvard Lane Primary T1, T2 & T3	Spring/ Autumn	C	Fault on Harvard Lane Primary T1	Harvard Lane Primary T2/T3	22.4	25
Harvard Lane Primary T1, T2 & T3	Summer	C	Fault on Harvard Lane Primary T1	Harvard Lane Primary T2/T3	18.3	25

Table 4 Thermal Flow Analysis Results

Reinforcement at Harvard Lane Primary is required due to P2/7 non-compliance under FCO conditions as shown in Table 2.

4.6 Voltage Level Assessment

Voltages at the 22kV and 11kV busbars remain within statutory limits. The results of this analysis are shown in Appendix 2.

4.7 Fault Level Assessment

The fault levels at the 66kV, 22kV bus bars at Ealing BSP and 11kV bus bars at Harvard Lane Primary were assessed for both three phase and single phase to ground faults. The results of this analysis are shown in Appendix 2. The analysis shows that there are no fault level issues at Harvard Lane 11KV during the RIIO-ED2 price control period, however there are fault level issues identified at Ealing 22kV and 66kV busbars. The reinforcement schemes to address the fault level issues at Ealing are discussed in separate EJPs with investment reference number 214/SEPD/LRE/EALING and 215/SEPD/LRE/EALING.

4.8 Network Analysis Summary

The analysis above has shown that intervention to reinforce Harvard Lane 22/11 kV Primary will be required within RIIO-ED2. The DFES forecasted 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. Also, the thermal overloading issues identified will slow both our own and stakeholder ambitions for a Net Zero network.

5 Optioneering

This section of the report sets out the investment options that were considered when resolving overload issues at Harvard Lane 22/11 kV 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 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 5 below provides a high-level 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 sub-sections.

Option	Description	Advantages	Disadvantages	Outcome
1. Do Minimum	It is normally done by monitoring the MVA flow over the assets and carrying out demand transfer from the overloaded demand group to another whenever needed.	Minimum cost and workload; Small impact to existing network; Short delivery time.	Do not increase network capacity, further reinforcement may still be required.	Considered but not progressed to CBA
2. Add in New Assets	New equipment will be added into existing network. This involves: • a new 22/11kV transformer at Harvard Lane • a new 5 km 22kV circuit from Ealing to Harvard Lane • a new 22KV circuit breaker	Increase network capacity; Shorter outage time; Long term benefit.	Can incur large civil costs; Require new control strategy.	Considered but not progressed to CBA

3. Asset Replacement	The replacement of the full overloaded equipment including: • Transformer • Circuit Breaker • Circuit	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.	Progressed to CBA Analysis
4. Flexible Solution Followed by Asset Replacement	Flexible service contracts to reduce peak demand and defer capital investment for two years in accordance with deliverability plan	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 (Preferred Option)

Table 5: Summary of Investment Options

5.3 Detailed Option Analysis

5.3.1 Option 1: Do-Minimum

Estimate Cost: £N/A

For Harvard Lane Primary, there is very limited capacity in the 11kV network for load transfer. The capacity headroom for primary substations nearby (Southfield Road, Ealing and Brentford) is restricted as well. Southfield Road Primary will be overloaded in 2026/27, Brentford will be overloaded in 2027/28 and Ealing is very close to its capacity by the end of the ED2 period with their demand growths. Therefore, load transfer would not be considered as viable in this case.

As this option does not resolve the P2/7 non-compliance entirely and would result in poorer guaranteed standard performance and customer interruptions, it is rejected. Option 1 is not progressed to the Ofgem CBA.

5.3.2 Option 2: Add in New Assets

Estimated Cost: £N/A

To increase capacity at this site an additional transformer could be installed, together with a new 22kV cable back to Ealing BSP. The cable route could follow the existing circuit route, which is approximately 5km in length. A new 22kV circuit breaker will be added at Ealing BSP to replace one of the inadequately rated spare circuit breakers for the new 22kV cable installation.

There is not enough space for a new transformer installation at Harvard Lane substation, and it is extremely difficult to extend the substation as Harvard Lane is located within an urban area next to the M4 motorway and residential and commercial properties, as indicated in Figure 8.

Figure 8 Harvard Lane Primary Substation with Boundaries Highlighted

Due to the location being in West London, land is not conveniently available therefore the substation is unlikely to be extended. This option is, therefore, rejected and not progressed to the Ofgem CBA.

5.3.3 Option 3: Asset Replacement

Estimate Cost: £3,707k

The overloaded equipment for Harvard Lane Primary is the 22/11kV transformers, two of which are rated at 12.5/12.5/12.5MVA and the third is rated at 24/24/24MVA. It is possible to replace transformer D2MT with another unit rated at 24/24/24MVA from SSEN existing suppliers.

The following 22kV circuits will also become overloaded in RIIO ED2:

- 22kV circuits between Ealing and Harvard Lane, consist of the following sections:
    - Ealing to Harvard Lane 1 (4.82km @ 15.3 MVA in winter):
        - 0.27km cable rated 21.4/19.4MVA
        - 2.11km cable rated 15.3/14.0MVA
        - 0.07km cable rated 19.5/17.7MVA

        - 0.53km cable rated 19.5/17.7MVA
        - 1.84km cable rated 17.0/15.4MVA
    - Ealing to Harvard Lane 2 (4.79km @15.3 MVA in winter):
        - 0.07km cable rated 19.5/17.7MVA
        - 1.84km cable rated 17.0/15.4MVA
        - 0.28km cable rated 21.4/19.4MVA
        - 0.1km cable rated 19.5/17.7MVA
        - 2.5km cable rated 15.3/14MVA
    - Ealing to Harvard Lane 3 (4.72km @13.5 MVA in winter):
        - 2.12km cable rated 18.3/16.6MVA
        - 0.22km cable rated 19.5/17.7MVA
        - 2.5km cable rated 13.5/12.3MVA

The proposed replacements are as follows:

- Replace the Harvard Lane Primary Transformer D2MT with a 24/24/24MVA rated transformer.
- Upgrade sections of the Ealing to Harvard Lane 1 and Ealing to Harvard lane 3x22kV circuits to the new ratings of 21.4/19.4MVA. This equates to 9.4km of cable in total (traffic management in London area for replacement of the 22 kV cables considered).

With this option, Harvard Lane's LI will be LI1 (76%) with a risk point reduction of 1,280,664 by the end of the ED2 price control.

This option is the preferred conventional investment option which is used to feed into the Common Evaluation Methodology (CEM)[4] Flexibility CBA to determine if there are economic benefits in deferring this capital investment.

5.3.4 Option 4: Flexible Solution Followed by Asset Replacement

Estimated Cost: £3,737k.

This option considers utilising customer generation capacity or flexible demand to actively manage the peak power flow on existing assets. This will allow SEPD to utilise the existing network effectively and may defer or remove the need for reinforcement action.

Figure 9 below shows that the peak demand at Harvard Lane 22/11 kV primary substation in the DFES CT scenario in 2027/28 exceeds the FCO capacity for approximately 5.5 hours over the winter months with a requirement of flexible generation between 0-2.8MW. It shall be noted that the peak demand appears in a short period from 16:00 pm to 21:00 pm of the day.

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

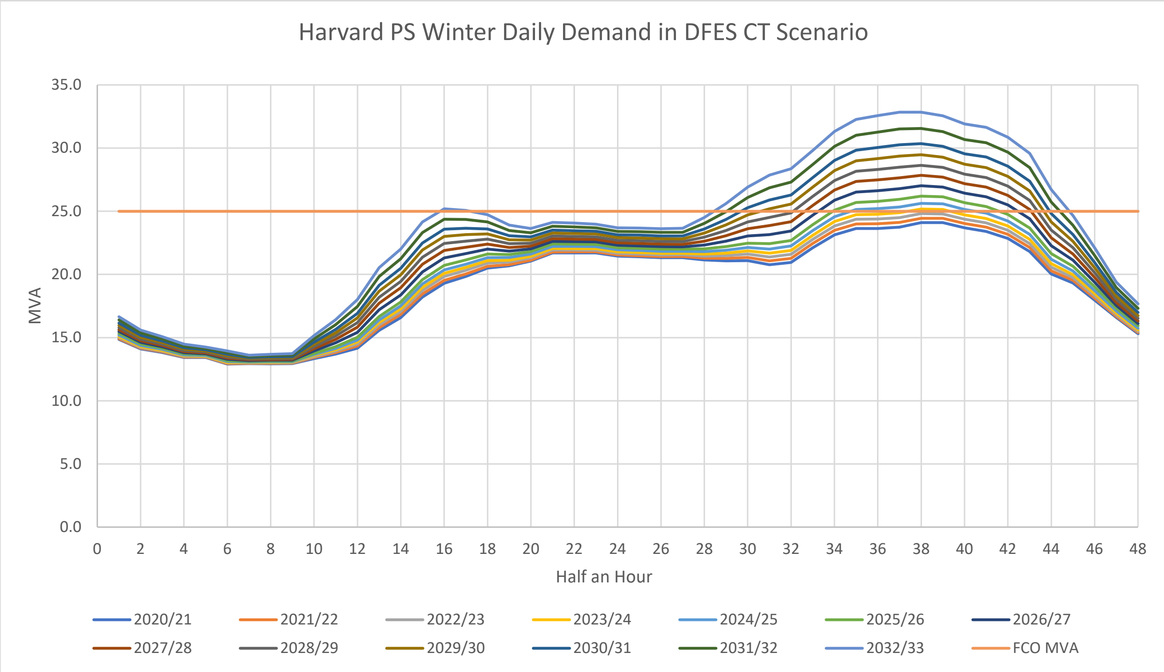


Figure 9: Harvard Lane Primary winter daily demand without flexibility services.

The most economically viable conventional solution was obtained from the Ofgem CBA and input into the Flexibility CBA to determine if there are economic benefits in deferring the capital investment.

The CEM framework evaluates options around the 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.

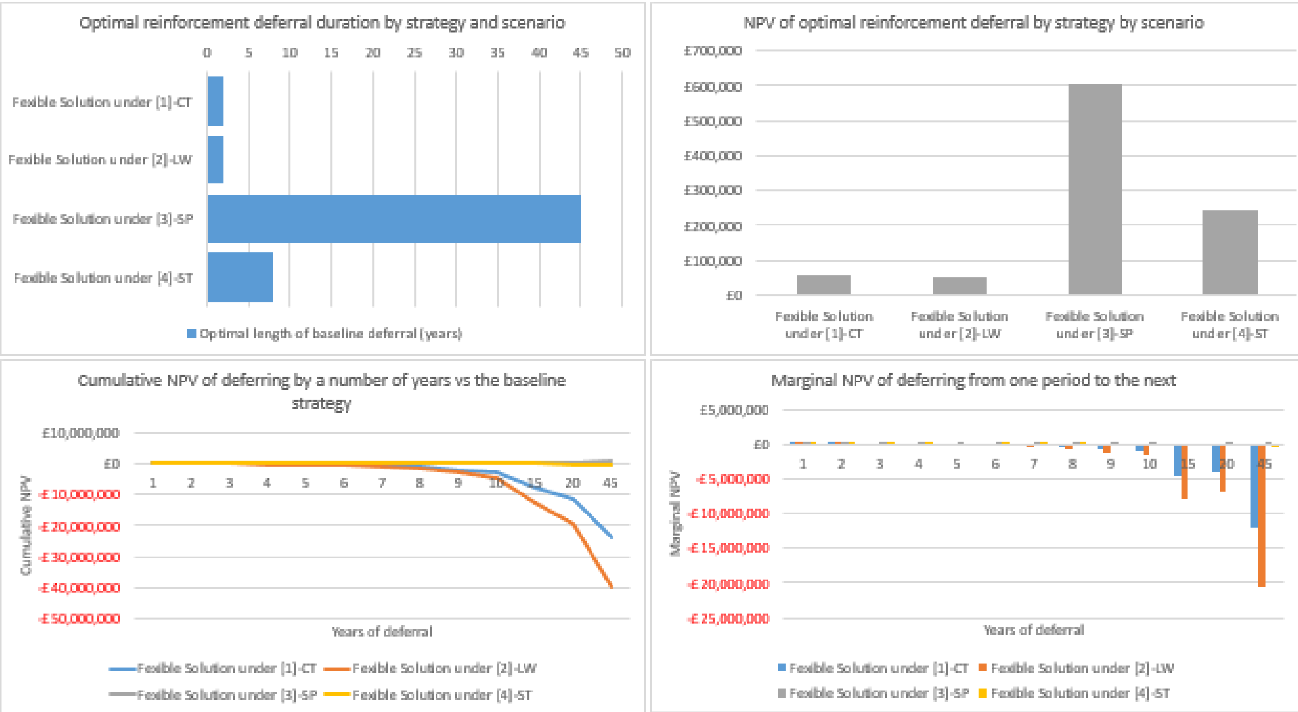
The MW exceedance, the daily availability and utilisation hours, the annual available and utilisation days (Table 6 below), and the flexibility unit costs of £150 per MW per hour and £150 per MWh were used as input parameters in the CEM CBA model (full details of the flexibility methodology can be found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

Input to the CEM CBA	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28
Availability capacity (MW)	0.0	0.0	0.0	0.2	0.6	1.2	2.0	2.8
Hrs/day of availability	0	0	0	1.0	3.0	4.0	4.5	5.5
Days/a year required	0	0	0	64.0	64.0	64.0	64.0	64.0
Utilisation (MWh)	0	0	0.0	5.8	60.3	153.8	289.6	499.0

Table 6: Estimated availability and utilisation requirements for flexibility solution.

The CEM model outcome in Figure 10 shows that there is benefit in deferring the reinforcement at Harvard 22/11 kV primary substation proposed in Option 3 by using flexibility. For the demand forecasts under the DFES CT and LW scenarios, there is benefit to customers in deferring the reinforcement for two years in RIIO

ED2. For the demand forecasts in the DFES SP and ST scenarios, the reinforcement can be deferred much longer outside of the RIIO-ED2 price control period. We will continue to monitor the load growth at this substation at the beginning of RIIO-ED2 and reassess flexibility options. If the load then follows the SP or ST projection the capital reinforcement funding might not be required and consumer bills will be protected via the Uncertainty Mechanism. However, our stakeholder-backed CT scenario is believed to take place in ED2 and its associated two year flexible solution followed by asset replacement is taken forward into the Ofgem CBA model.



Cumulative benefit of deferral (excluding benefit from further deferral, but including multi-year discount)	Baseline	1 Defer by 1 year(s) to 2025	2 Defer by 2 year(s) to 2026	3 Defer by 3 year(s) to 2027	4 Defer by 4 year(s) to 2028
Fexible Solution under [1]-CT	£0	£42,676	£55,593	£22,861	-£70,240
Fexible Solution under [2]-LW	£0	£42,085	£50,417	£10,925	-£109,391
Fexible Solution under [3]-SP	£0	£45,340	£84,979	£118,212	£145,118
Fexible Solution under [4]-ST	£0	£45,340	£84,979	£118,212	£141,716

Figure 10: Net benefit of deferring reinforcement with the four DFES scenarios

With this Option 4, an investment of £3.737m would be needed in RIIO-ED2 including the availability and utilisation cost of [redacted] for flexible generation or flexible demand and [redacted] for asset replacement.

The CBA results in Table 7 show that flexible solution followed by assets replacement in Option 4 is the best option in terms of the NPV over the 45 years as compared with the other option and is therefore our preferred option.

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 at least two 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 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 the ***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) for the considered options were calculated based on the potential overloads and the probability of failure, and the CI and CML values are shown in Appendix 1. The network losses (MWh) in Option 3 were calculated as the MWh difference after and before the proposed reinforcement works taking into consideration the yearly average loading condition of 22 kV circuits and 22/11 kV transformers feeding Harvard Lane 11 kV busbars. 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 in Table 7 below demonstrate that the most cost-effective solution is option 4 'Flexible Solution', as it has the least NPV against the required investment. It is clear that the investment would remove the CI and CML for supply to Harvard Lane 22/11 kV 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 4 is the preferred solution to address the P2/7 compliance issue at Harvard Lane 22/11 kV primary substation.

Options	Net Present Value (NPV) After 45 Years (£k)	Investment (£k)
Option 3 – Asset Replacement	-1,164	3,707.2
Option 4 – Flexible Solution Followed by Asset Replacement	-1,082	3,737.0

Table 7: Summary of CBA results

Options	Unit	2024	2025	2026	2027	2028	ED3	Total
Option 3 – Asset Replacement	£k	3,707	0	0	0	0	0	3,707
Option 4 – Flexible Solution Followed by Asset Replacement	£k	[redacted]	[redacted]	[redacted]	0	0	0	3,737

Table 8: Summary of capital costs in the options

6.3 Options Summary

Option 1 has the lowest capital costs and may appear to be the attractive option. However, this option is unable to resolve the P2/7 compliance issue entirely and would result in poorer guaranteed standard performance and customer interruptions. Option 1 is not considered as a cost effective, long term enduring solution.

Option 2 is technically feasible to resolve the P2/7 issue in the RIIO ED2. Due to the location of Harvard Lane primary substation be within West London, land is not conveniently available and the substation is unlikely to be extended. Therefore, this option is rejected.

Option 3 is technically feasible to resolve the P2/7 issue in the RIIO ED2 and is regarded as the preferred conventional solution. Due to its poorer NPV over 45 years as compared with the best option, option 3 is not considered as a cost effective, long term enduring solution.

Option 4 has the benefit to defer the proposed solution in Option 3 for at least three years. Due to its most favourite NPV over 45 years as compared with other options, option 4 is considered as a cost effective, long term enduring solution. Option 4 is the preferred option. In accordance with our deliverability plan, flexible solution will be applied in 2023/24 and 2024/25 followed by assets replacement in 2025/26.

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)***. 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.

Given the asset and service unit cost, Table 9 shows the cost breakdown for reinforcement works in the final preferred Option 2 taking into consideration unique and site-specific costs. Through our detailed bottom-up project assessment, no other additional costs were identified in this reinforcement scheme.

Category	Sub-category	Unit Cost (£k)	Unit	Asset Count	Predominant Costing Approach	Cost £k
Cable	33kV UG Cable (Non-Pressurised)	[redacted]	km	9.4	ED1 6yr average actual unit rates	[redacted]
Transformer	22/11kV transformers	[redacted]	#	1	ED1 6yr average actual unit rates	[redacted]
					Project Sub Total	[redacted]
Category	Regional Variations and Site-Specific Factors Driving Costs				Predominant Costing Approach	Impact Cost £k
Civil Works Driven Costs	- Uprating of the existing 22 kV circuits from Ealing BSP to Harvard Lane primary substation would require coordination of traffic in highway in West London area, which incurs the traffic management cost.				Utilisation of tendered Framework Rates/ED1 Actual Realised Costs	[redacted]

Flexible solution	- Availability and utilisation cost for flexible generation is needed in order to remove and mitigate the overloads under an FCO condition in 2024 and 2025.	Flexibility unit costs of £150 per MW per hour and £150 per MWh were used in the CEM CBA model	[redacted]
		Total Project Cost	[redacted]

Table 9: Cost breakdown for the preferred option

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 ***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

Table 10 below sets out the revised investment phasing based on the outcome of our deliverability assessment for reinforcement at Harvard Lane 22/11 kV primary substation. The CEM model results show that there is benefit on deferring the reinforcement proposed in Option 3 for three years. Our draft deliverability plan for this scheme is the third year, i.e. 2025/26 in RIIO ED2. As a result, the revised investment phasing is in line with the draft deliverability plan and flexibility is to be utilised for two years prior to the reinforcement scheme.

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

Table 10: Revised investment phasing of deliverability

This investment scheme is part of the wider load-related investment portfolio in RIIO-ED2. We have developed a strategy to deliver a much larger volume of work in comparison with the level of investment in ED1. Our deliverability testing has identified a major strategic opportunity which is relevant to all EJPs.

- In ED2 we will change the way Capital Expenditure is delivered, maximising synergies within the network to minimise disruptions for our customers. This is particularly relevant for a Price Control period where volumes of work are increasing across all work types.
- The principle is to develop and deliver Programmes of work, manage risk and complexity at Programme level and to develop strategic relationships with our Suppliers and Partners to enable efficiency realisation.
- The Commercial strategy will explore the creation of Work Banks (WB) and identify key constraints. The Load work will be the primary diver for a WB, supplemented by Non-Load work at a given Primary Substation. This approach will capitalise on synergies between the Load and Non-Load work, whereby the associated downstream work from a Primary Substation will maximise outage utilisation, enabling the programme to touch the network in a controlled manner with the objective of touching the network once. Where there is no Primary Load scheme to support the Non-Load work, these will be considered and packaged separately, either insourced or outsourced dependant on volume, size and complexity.
- Transparency with the Supplier in terms of constraints, challenges, outage planning and engineering standards will capitalise on efficiencies, supported by a robust contracting strategy

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

- 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. We have carefully planned the future workforce with the right skills and competencies to deliver capital projects in ED2.
- In ED1, we have delivered a number of 33 kV and 22 kV cable projects and transformer installation projects in house. The experience and skills acquired from these projects lay the foundation for the delivery of the Harvard Lane 22 kV cable installation and transformer replacement.
- Some sections of the existing 22 kV cables are oil-filled. Oil management is hence required which poses a low risk for this investment.
- There is limited space at Harvard Lane primary therefore detailed plan on removal of existing transformers and installation of new transformers required. Temporary backup supply may also require, which is with medium risk.
- Utilising the flexibility services can potentially defer the reinforcement for two years with £203,007 benefit based on the output of the CEM CBA model under the CT scenario. However, the amount of flexibility depends on location-specific resources and market interests. Uncertainties associated with the flexibility market can be addressed through market testing nearer the time and also via relevant uncertainty mechanisms.

This scheme was originally included in our baseline for delivery during the RIIO-ED1 period, however, through changes in the demand or generation background the need has not materialised as expected. This means it is not economic or efficient to progress with this project within RIIO-ED1. Our decision to defer this scheme means that, where necessary, we are able to use this allowance to efficiently deliver other projects which may have arisen within RIIO-ED1. This allows us to continually meet the requirements of our network and the needs of our customers throughout the price control.

8 Conclusion

This EJP has raised the need for load related investment at Harvard Lane 22/11kV primary substation within the ED2 price control period. This need for investment is driven by the compliance with P2/7 under an FCO condition. Given the increasing forecasted demand and significant impact on customers connected to this primary substation, reinforcement is required to remove this non-compliance in RIIO-ED2.

Four investment options have been considered and the preferred solution is Option 4, which involves applying flexible solution to remove the peak demand at the primary substation in 2024 and 2025 before uprating 9.4 km 22 kV underground cable and relacing a 22/11 kV transformer at Harvard Lane primary substation in 2026. All options are supported by a Cost Benefit Analysis (CBA) which provides further breakdown of economic viability over a 45-year period.

The current Load Index (LI) for Harvard Lane Primary is LI2 (96%) and it will be LI5 (105%) by the end of ED2 period without intervention. With the preferred reinforcement option, the LI will be LI1 (76%) with loading risk point decrement of 1,280,664 by the end of ED2 period.

The proposed ED2 investment with the combined scheme total of £3.737m. It is proposed that after applying the flexible solution for two years first, all reinforcement works are carried out in the 2025/26 financial year to minimise the risk of thermal overload and network non-compliance. This is in line with our deliverability requirement.

Appendix 1: Assumptions

CI/CML Tables

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028
CT	24.1	24.4	24.8	25.2	25.6	26.2	27.0	27.8	28.6
Firm Capacity	25	25	25	25	25	25	25	25	25
Difference	0.0	0.0	0.0	0.2	0.6	1.2	2.0	2.8	3.6
Customer No. 1% Growth	12953.	13082.	13213.	13345.	13478.	13613.	13749.	13887.	14026.
MW per customer	0.00186	0.00186	0.00187	0.00188	0.00189	0.00192	0.00196	0.00200	0.00203
No. Faults per Year	0.33859	0.33859	0.33859	0.33859	0.33859	0.33859	0.33859	0.33859	0.33859
Final Input									
CI	0	0	0	-35.8	-106.9	-211.1	-344.8	-473.5	-597.7
CML	0	0	0	-6455.	-19253.	-38001.	-62074.	-85247.	-107603.

Table 11:CI/CML for Do Minimum Option.

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028
CT	24.1	24.4	24.8	25.2	25.6	26.2	27.0	27.8	28.6
Firm Capacity	25	25	25	36.5	36.5	36.5	36.5	36.5	36.5
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Customer No. 1% Growth	12953	13082.5	13213.3	13345.4	13478.9	13613.7	13749.8	13887.3	14026.2
MW per customer	0.00186	0.00186	0.00187	0.00188	0.00189	0.00192	0.00196	0.00200	0.00203
No. Faults per Year	0.33859	0.33859	0.33859	0.33859	0.33859	0.33859	0.33859	0.33859	0.33859

Final Input									
CI	0	0	0	0	0	0	0	0	0
CML	0	0	0	0	0	0	0	0	0

Table 12: CI/CML for Asset Replacement Option.

Appendix 2: Detailed Network Analysis Results

Voltage Level Assessment Results

SYSTEM VOLTAGE LEVELS						
Season	**Ealing 22kV voltage**	**Harvard Lane Demand**	**Generation**	**Study Scenario**	**Harvard Lane 11kV voltage**	**Busbar Name**
[-]	[p.u.]	[MVA]	[MVA]	[-]	[p.u.]	[-]
Winter maximum	1.034	26.9 MVA	0	Intact	1.032	HARL-E
Winter maximum	1.030	26.9 MVA	0	Fault on Harvard Lane Primary T1	0.997	HARL-E
The Voltage levels are in the limit of ± 10% on 132KV. ± 6% on 33KV under intact condition.						

Table 13 Voltage Assessment Results

Fault Level Assessment Results

Existing Network Three Phase Fault Level												
Bus Number	Bus Name	Nominal Voltage (kV)	Pre-fault Voltage (p.u)	X/R ratio	Ik''-Initial Sym. (kA)	Ip-Peak Make (kA)	RMS Sym. Break (kA)	DC Component (kA)	RMS Asym. Break (kA)	Circuit Breaker Break Rating (kA)	Circuit Breaker Make Rating (kA)	Circuit Breaker Fault Level Index
93111	HARL-E	11	1.03	6.4	9.94	23.2	8.8	2.01	9.02	13.1	33.4	FLI1
93029	EALI-D2	22	1.031	14.8	13,42	34.89	12.02	10.29	15.82	13.1	33.4	FLI5
93015	EALI-D1	22	1.031	14.8	13.42	34.89	12.02	10.29	15.82	13.1	33.4	FLI5
93000	EALI-BIT	66	1.002	18	20.75	54.61	19.24	17.1	25.74	21.9	55.8	FLI5
93001	EALI-B2T	66	1.002	18	20.75	54.61	19.24	17.1	25.74	21.9	55.8	FLI5
93002	EALI-B3T	66	1.002	18	20.75	54.61	19.24	17.1	25.74	21.9	55.8	FLI5

Table 14: Three Phase Fault Level Assessment Results

Existing Network Single Phase to Ground Fault Level												
Bus Number	Bus Name	Nominal Voltage (kV)	Pre-fault Voltage (p.u)	X/R ratio	Ik''-Initial Sym. (kA)	Ip-Peak Make (kA)	RMS Sym. Break (kA)	DC Component (kA)	RMS Asym. Break (kA)	Circuit Breaker Break Rating (kA)	Circuit Breaker Make Rating (kA)	Circuit Breaker Fault Level Index
93111	HARL-E	11	1.03	0.1	1.44	2.08	1.44	0	1.44	13.1	33.4	FLI1
93029	EALI-D2	22	1.031	15.1	16.72	43.64	15.99	12.74	20.45	13.1	33.4	FLI5
93015	EALI-D1	22	1.031	15.1	16.72	43.64	15.99	12.74	20.45	13.1	33.4	FLI5
93000	EALI-BIT	66	1.002	0.2	3.08	4.45	19.24	0.11	3.09	21.9	55.8	FLI1
93001	EALI-B2T	66	1.002	0.2	3.08	4.45	19.24	0.11	3.09	21.9	55.8	FLI1
93002	EALI-B3T	66	1.002	0.2	3.08	4.45	19.24	0.11	3.09	21.9	55.8	FLI1

Table 15: Single Phase to Ground Fault Level Assessment results

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 ***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 16 below outlines our Whole Systems CBA test for Harvard Lane 22/11kV 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?
Harvard Lane 22/11kV Primary Substation	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 16: Whole Systems CBA test for Harvard Lane 22/11kV 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.

Appendix 4: 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 17: Relevant documents

Appendix 5: BPDT Information

Asset & Services	Volume	Costs (£k)	BPDT	Delivery Year
33kV UG Cable (Non-Pressurised) (km)	9.4	[redacted]	CV1	2026
33kV Transformer (GM) (no.)	I	[redacted]	CV1	2026
London Region - Increased High way management (No.)	I	[redacted]	CV1	2026
Flexibility Solution (years)	2	[redacted]	CV1	2024, 2025
Total		[redacted]		

Table 18: BPDT Information

Appendix 6: Acronym Table

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