RIIO-ED2 Engineering Justification Paper (EJP)

33kV circuits around Fulscot 33/11kV primary substation

Investment Reference No: 55/SEPD/LRE/MILT

Table of Contents

Definitions and Abbreviations

Acronym	Definition
AIS	Air-insulated Switchgear
ASCR	Aluminium Conductor Steel Reinforced
BSP	Bulk Supply Point
CBA	Cost Benefit Analysis
CBRM	Condition Based Risk Management
CEM	Common Evaluation Methodology
CI	Customer Interruptions
CML	Customer Minutes Lost
CT	Consumer Transformation
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
EJP	Engineering Justification Paper
ESA	Electricity Supply Area
EV	Electric Vehicle
FCO	First Circuit Outage
FES	Future Energy Scenarios
GIS	Geographic Information System
GM	Ground Mounted
GSP	Grid Supply Point
HI	Health Index
IDP	Investment Decision Pack
LCT	Low Carbon Technology
LEP	Local Enterprise Partnership
LI	Load Index
LRE	Load Related Expenditure
LW	Leading the Way
NPV	Net Present Value
OHL	Overhead Line
PM	Pole Mounted
PV	Photovoltaics
RSN	Relevant Section of Network
SCO	Second Circuit Outage
SSEN	Scottish and Southern Electricity Network
SP	Steady Progression
ST	System Transformation
XLPE	Cross-linked Polyethylene

1 Executive Summary

Our proposed investment at and around Fulscot 33/11kV primary substation will deliver load related thermal compliance for investment of £2.6m during RIIO-ED2.

The primary investment driver for this scheme is load related thermal compliance issue at and around Fulscot primary substation. The load related thermal issues are apparent under four scenarios (System Transformation, Consumer Transformation, Leading the way, and Steady Progression) for investment in ED2 due to forecast demand growth from our Stakeholder supported Distribution Future Energy Scenario (DFES). This project is required under our accelerating progress towards net zero priority, as Oxfordshire County Council sets out an ambitious framework to enable the county to be at the forefront of energy innovation to foster clean growth. We have therefore also considered the Local Area Energy Plans (LAEPs) through our stakeholder engagement activities.

Oxfordshire's targets around low carbon system are expected to have a significant impact on demand growth within the area. Without intervention on this scheme to make it load related thermal compliant, we will experience increased overloading issues which will significantly impact our ability to meet the minimum level of security of supply for consumers, as we move towards a Net Zero network in RIIO-ED2.

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

The Cost Benefit Analysis results shown below in table 1 demonstrates that the most cost-effective solutions for 33kV circuits around Fulscot 33/11kV primary substation, that delivers the best value for consumers in terms of the 45 years Net Present Value (£m).

Options	Net Present Value (NPV) After 45 Years (£k)	Investment (£k)
Option 2 – Reinforcement of existing assets with premium cost	-1,432	2,692
Option 3 – Reinforcement by network extension (adding additional new assets)	-4,898	4,281
Option 4 – Flexibility Solution for 3 years then reinforcement by network extension as option 2 with standard cost	-1,232	2,596

Table 1: Option Summary

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

Asset	Volume	Costs
33kV UG Cable (Non Pressurised) (km)	3	[redacted]
33kV OHL (Pole Line) Conductor	18	[redacted]
HDD - Railway Crossing	1	[redacted]
Network Rail Consultation	1	[redacted]
Flexible Cost		£390k
Total		**£2,596k**

Table 2: Investment Summary

This scheme delivers the following outputs and benefits:

- Ensure 33kV circuits at and around Fulscot primary substation compliant with thermal ratings.
- Facilitate the continued uptake of low carbon technology (LCT) in the Fulscot area and help support the climate change targets of Oxfordshire Council.
- Facilitates the efficient, economic, and co-ordinated development of our Distribution Network for Net Zero.

The cost to deliver the preferred solution is £2.60m and the works are planned to be completed in 2027. This EJP investment sits within our Net Zero Totex ask.

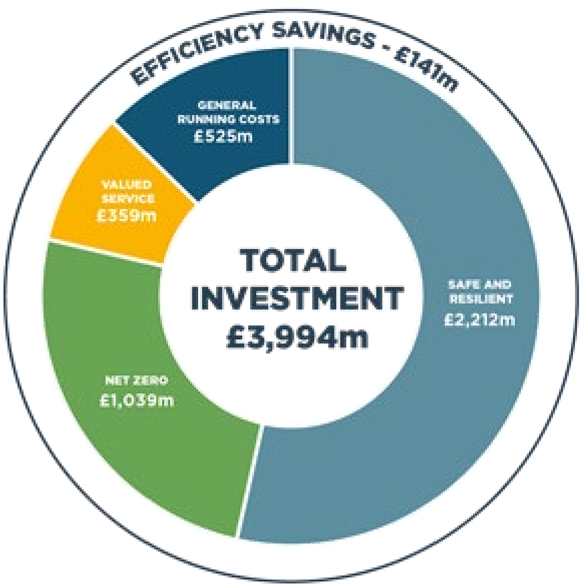


Figure 1: SSEN total investment cost within RIIO ED2

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 around Fulscot 33/11kV Primary substation.

Name of Scheme/Programme	33kV circuits around Fulscot 33/11kV primary substation		
Primary Investment Driver	Load – P2 compliance – Thermal		
Scheme reference/mechanism or category	55/SEPD/LRE/MILT		
Output references/type	33kV Circuits Flexibility		
Cost	£2.60m		
Delivery year	2023/24-2026/27		
Reporting table	CV1: Primary Reinforcement		
Outputs included in RIIO-ED1 Business Plan	No		
Spend apportionment (£m)	**ED1**	**ED2**	**ED3+**
	0	2.60	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 which provides a credible forward projection of load-related expenditure for the ED2 period and reflects strongly evidenced support from our stakeholders. Our ex-ante baseline funding request is based on the minimum investment required under all credible scenarios. Our plan will create smart, flexible, local energy networks that accelerate progress towards net zero – with an increased focus on collaboration and whole-systems approaches.

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

Section 4 of this Engineering Justification Paper (EJP) describes our proposed load related investment plan for the reinforcement of 33kV circuits around Fulscot primary substation in RIIO-ED2. The primary driver considered within this paper is load related P2/7 compliance issue around Fulscot 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 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 and Analysis

4.1 Background Information

Fulscot Primary is located within the Cowley Osney Drayton region of the SEPD licence area. Fulscot, Milton and Cholsey Primary Substations are supplied via an interlinked ring type network from Drayton BSP. Demand at Milton is mainly supplied by the 33KV circuits Drayton-Milton and Drayton-Milton Tee 3 under intact network and it would get back-feed from 33kV circuits between Drayton BSP and Fulscot under N-1 contingency. There are no thermal overload issues identified with those two 33KV circuits supplying Milton, therefore, the details of Milton Primary would not be discussed in the paper. The 33kV circuits Drayton -Milton C1 Tee -Fulscot and Drayton -Milton C4 Tee-Sutton Courtney -Fulscot between Drayton BSP and Fulscot mainly supply the demands at Fulscot and Cholsey. Fulscot currently supplies 8534 customers via 11 kV circuits. The 2019/20 peak demand was 11.9 MVA and there is currently no embedded generation connected. Cholsey

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

currently supplies 3506 customers and the 2019/20 peak demand was 8.3MVA. There is currently 0.61 MW generation connected at Cholsey.

As we move into RIIO-ED2 we will experience increased demand and reliance on the network, resulting in increased issues of compliance. This will significantly impact our ability to meet the minimum level of security of supply that should be achieved for all consumers, regardless of location on our network, within the RIIO-ED2 period as we move towards a Net Zero network.

Therefore, investment is required to make 33kV circuits around this substation compliant within the RIIO-ED2 price control.

4.2 Local Energy Plan

In 2019, Oxfordshire County Council published Oxfordshire Energy Strategy[2] to set out an ambitious framework to enable the county to be at the forefront of energy innovation to foster clean growth. Their objectives include:

1. Secure a smart, modern, clean energy infrastructure – including increased electricity grid capacity - which supports our planned housing, industrial and commercial growth, and changing energy requirements;
2. Lead nationally and internationally to reduce countywide emissions by 50% compared with 2008 levels by 2030 and set a pathway to achieve zero carbon growth by 2050. The council will realise the economic benefits of this low carbon transition by supporting:
    - ambitious and innovative clean generation projects across the county, both in urban and rural areas, and in growth locations;
    - projects that reduce energy demand and increase energy efficiency for domestic, industrial, commercial buildings and transport energy
3. Enhance energy networking and partnership working across Oxfordshire to focus on the low carbon energy challenges and funding opportunities created through the Clean Growth Strategy and the Oxfordshire Industrial Strategy.

4.3 Demand Forecasts for Fulscot Primary and Cholsey Primary

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.

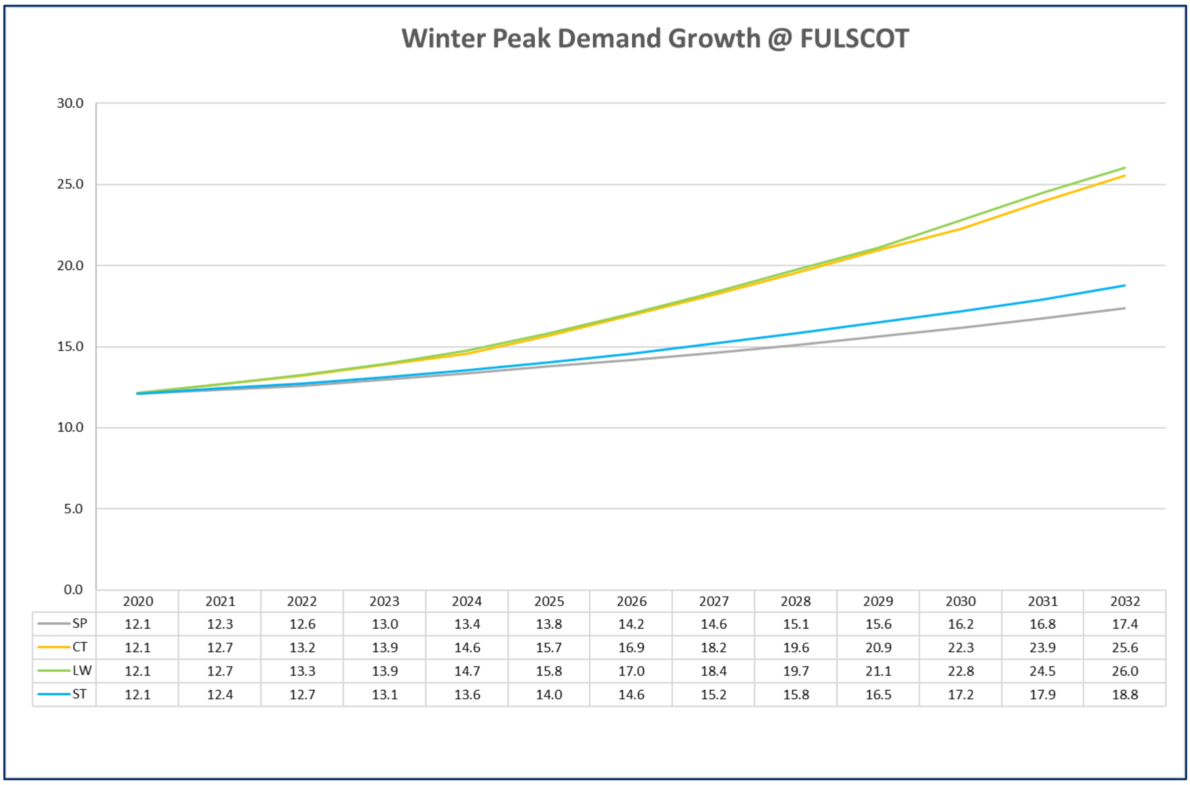
Based on the enhanced stakeholder engagement feedback, we have chosen Consumer Transformation as the baseline scenario for our investment. We are protecting customers from the impact of forecasting uncertainties through our baseline funding only including load related investment required in the first two years in the RIIO-ED2 period, unless it is also required by other net zero scenarios. Full details on our DFES

[2] https://www.oxfordshirelep.com/sites/default/files/uploads/Oxfordshire%20Energy%20Strategy.pdf

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 2 - 4 show the demand projections for Fulscot substation for all FES scenarios for different seasons. Figure 5 - 7 show the demand projections for Cholsey substation for all FES scenarios in different seasons. The first circuit outage (FCO) capacity is limited by the Spring/Autumn minimum circuit rating 24.5MVA between Fulscot and Sutton Courtney 33kV, where this circuit supplies the demand at Fulscot and Cholsey. With estimated network losses in Spring/Autumn, FCO limit is exceeded under Consumer Transformation (CT – by 2023/24), and Leading the Way (LW – by 2023/24) and System Transformation (ST – by 2024/25) scenarios during ED2 as indicated in Figure 8.

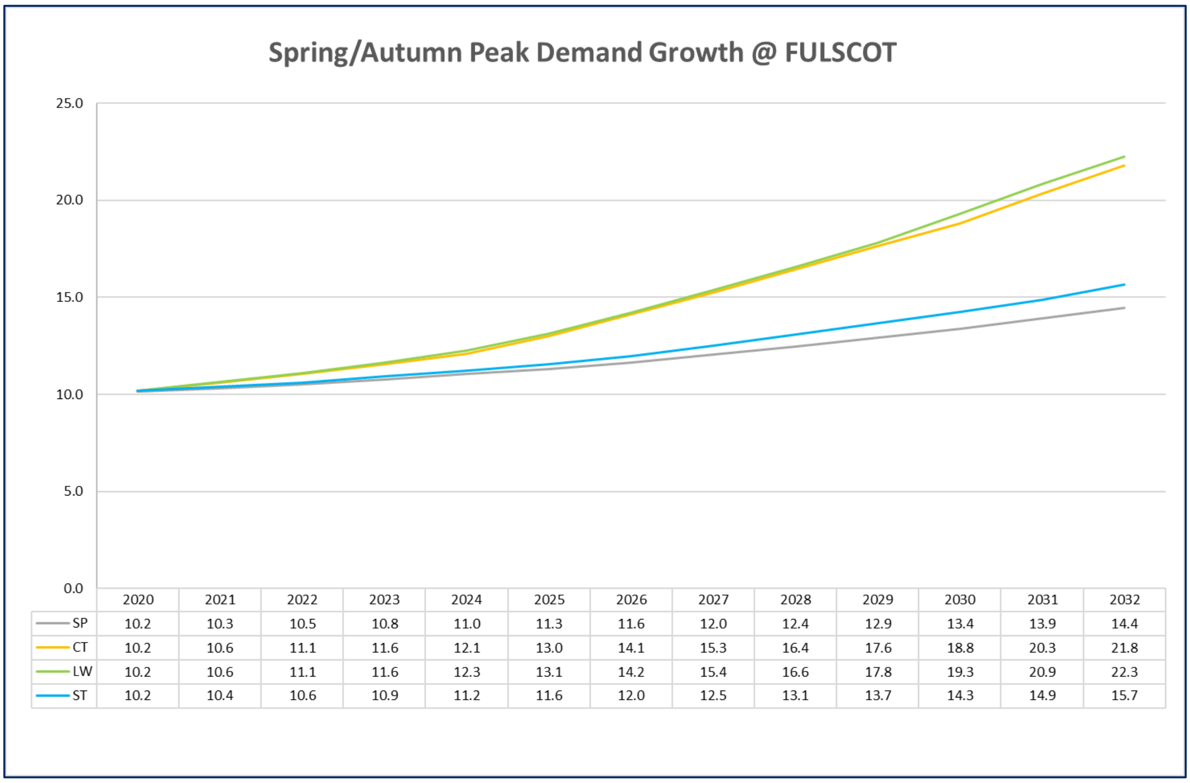
Network interventions are required to address this issue as not doing anything would result in a licence condition breach, hindering the LCT deployment and potentially a wide-spread blackout in the areas supplied by Fulscot and Cholsey primary.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	12.1	12.3	12.6	13.0	13.4	13.8	14.2	14.6	15.1	15.6	16.2	16.8	17.4
CT	12.1	12.7	13.2	13.9	14.6	15.7	16.9	18.2	19.6	20.9	22.3	23.9	25.6
LW	12.1	12.7	13.3	13.9	14.7	15.8	17.0	18.4	19.7	21.1	22.8	24.5	26.0
ST	12.1	12.4	12.7	13.1	13.6	14.0	14.6	15.2	15.8	16.5	17.2	17.9	18.8

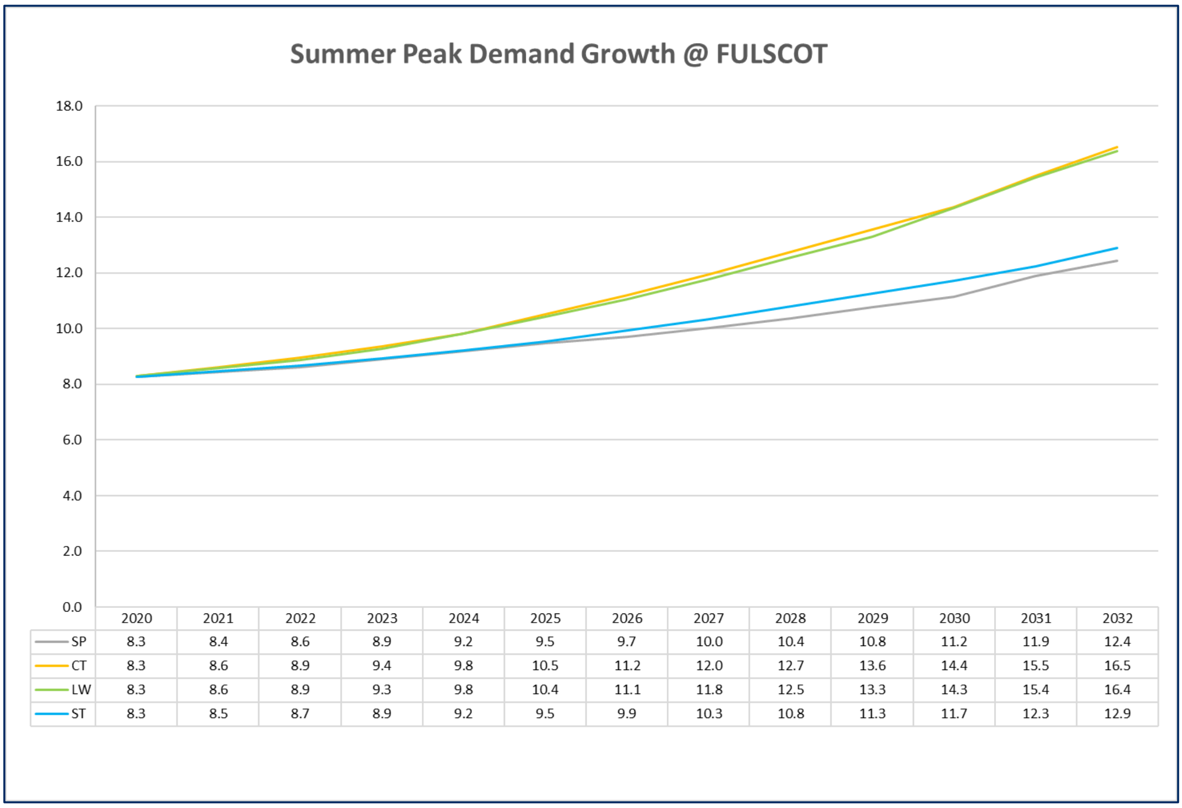
Figure 2: Fulscot Winter peak demand projections

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



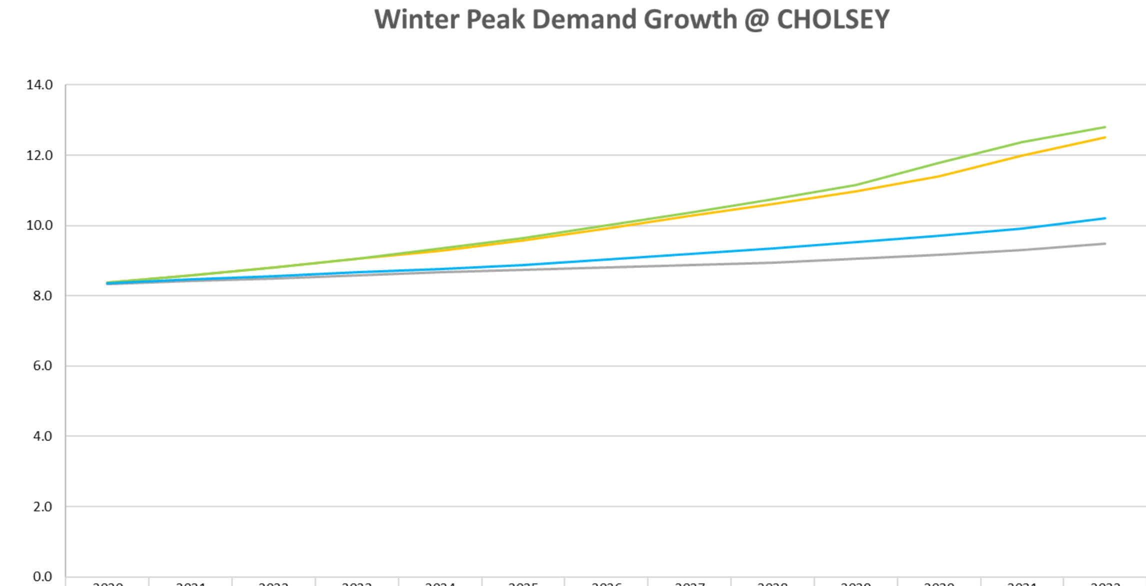
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	10.2	10.3	10.5	10.8	11.0	11.3	11.6	12.0	12.4	12.9	13.4	13.9	14.4
CT	10.2	10.6	11.1	11.6	12.1	13.0	14.1	15.3	16.4	17.6	18.8	20.3	21.8
LW	10.2	10.6	11.1	11.6	12.3	13.1	14.2	15.4	16.6	17.8	19.3	20.9	22.3
ST	10.2	10.4	10.6	10.9	11.2	11.6	12.0	12.5	13.1	13.7	14.3	14.9	15.7

Figure 3: Fulscot Spring/Autumn peak demand projections



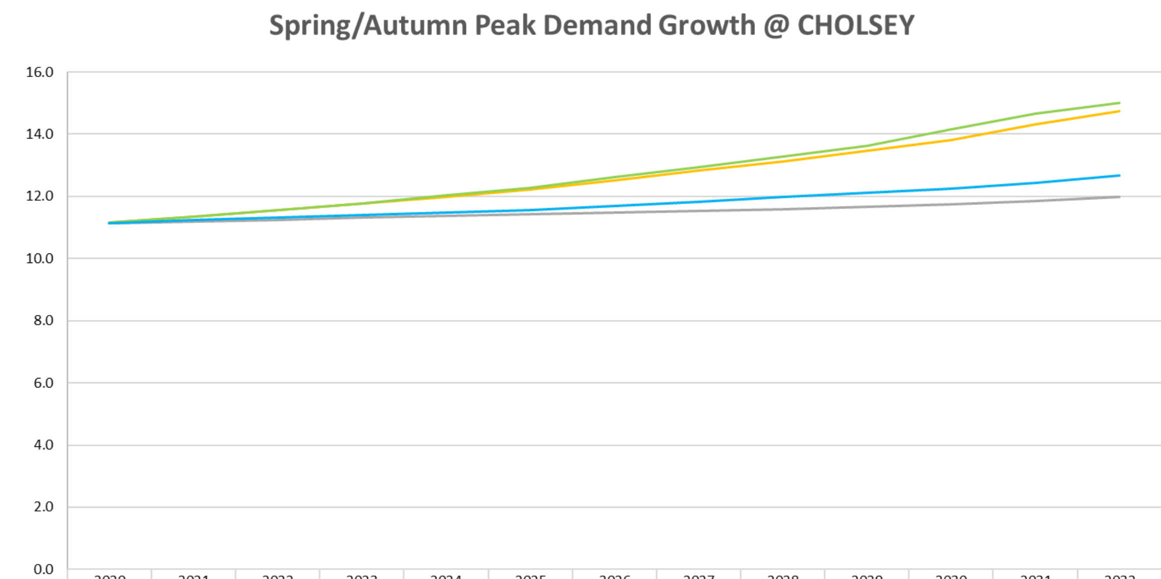
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	8.3	8.4	8.6	8.9	9.2	9.5	9.7	10.0	10.4	10.8	11.2	11.9	12.4
CT	8.3	8.6	8.9	9.4	9.8	10.5	11.2	12.0	12.7	13.6	14.4	15.5	16.5
LW	8.3	8.6	8.9	9.3	9.8	10.4	11.1	11.8	12.5	13.3	14.3	15.4	16.4
ST	8.3	8.5	8.7	8.9	9.2	9.5	9.9	10.3	10.8	11.3	11.7	12.3	12.9

Figure 4: Fulscot Summer peak demand projections



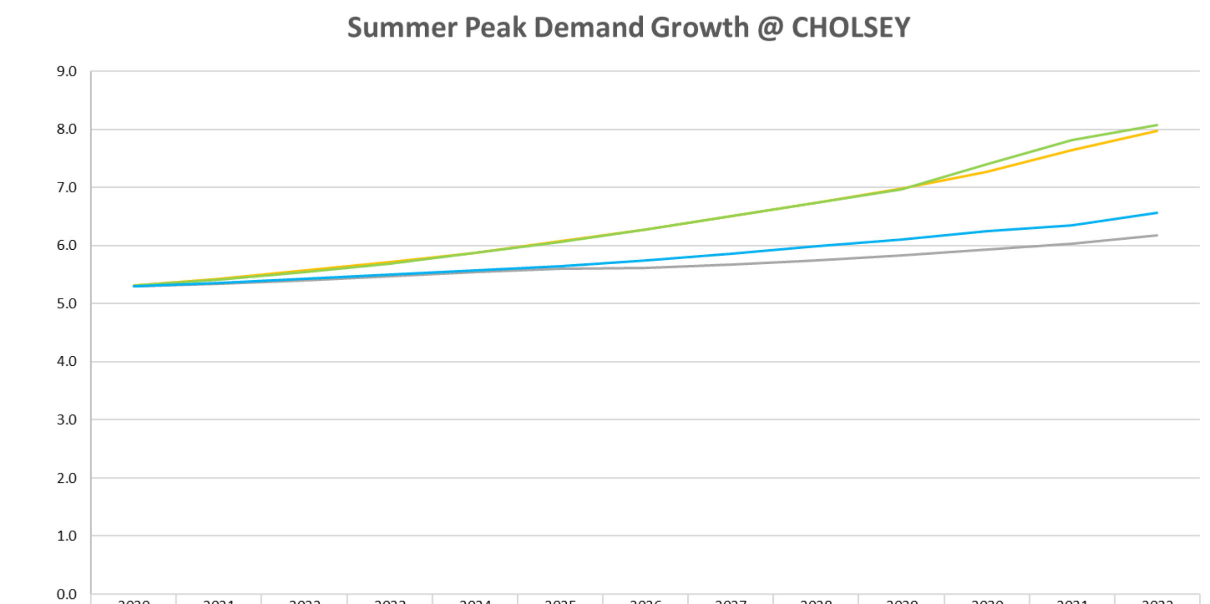
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	8.3	8.4	8.5	8.6	8.7	8.7	8.8	8.9	8.9	9.0	9.2	9.3	9.5
CT	8.4	8.6	8.8	9.0	9.3	9.6	9.9	10.3	10.6	11.0	11.4	12.0	12.5
LW	8.4	8.6	8.8	9.1	9.4	9.6	10.0	10.4	10.8	11.1	11.8	12.4	12.8
ST	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.2	9.4	9.5	9.7	9.9	10.2

Figure 5: Cholsey Winter peak demand projections



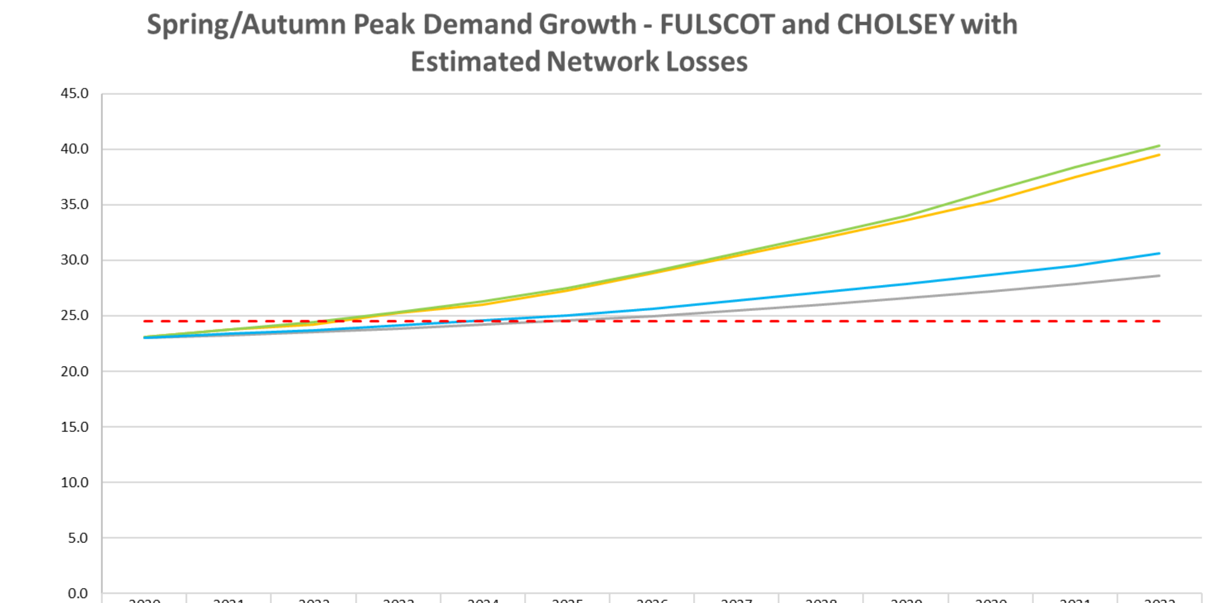
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	11.1	11.2	11.2	11.3	11.4	11.4	11.5	11.5	11.6	11.7	11.7	11.9	12.0
CT	11.2	11.3	11.6	11.8	12.0	12.2	12.5	12.8	13.1	13.5	13.8	14.3	14.8
LW	11.2	11.4	11.6	11.8	12.0	12.3	12.6	12.9	13.3	13.6	14.2	14.7	15.0
ST	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	12.0	12.1	12.3	12.4	12.7

Figure 6: Cholsey Spring/Autumn peak demand projections



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	5.3	5.3	5.4	5.5	5.5	5.6	5.6	5.7	5.7	5.8	5.9	6.0	6.2
CT	5.3	5.4	5.6	5.7	5.9	6.1	6.3	6.5	6.7	7.0	7.3	7.6	8.0
LW	5.3	5.4	5.5	5.7	5.9	6.1	6.3	6.5	6.7	7.0	7.4	7.8	8.1
ST	5.3	5.4	5.4	5.5	5.6	5.6	5.7	5.9	6.0	6.1	6.2	6.4	6.6

Figure 7: Cholsey Summer peak demand projections



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	23.0	23.3	23.5	23.9	24.2	24.6	25.0	25.5	26.0	26.6	27.2	27.9	28.6
CT	23.1	23.8	24.2	25.2	26.0	27.3	28.8	30.4	32.0	33.6	35.3	37.5	39.5
LW	23.1	23.8	24.4	25.3	26.3	27.5	29.0	30.6	32.3	34.0	36.2	38.4	40.3
ST	23.1	23.4	23.7	24.1	24.6	25.0	25.6	26.3	27.1	27.9	28.7	29.5	30.6
FCO	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5

Figure 8: Aggregated Spring/Autumn Peak Demand Projection of Fulscot and Cholsey with Estimated Network Losses

Peak demand is expected to increase at Fulscot primary by approximately 6.3 MVA from 2019/20 to 2027/28 when following the CT scenario. The projected primary demand of 18.2 MVA is split below by demand type. The chart shows the largest impact on demand in the area is from heat pumps, equating to 16% of the overall projected demand.

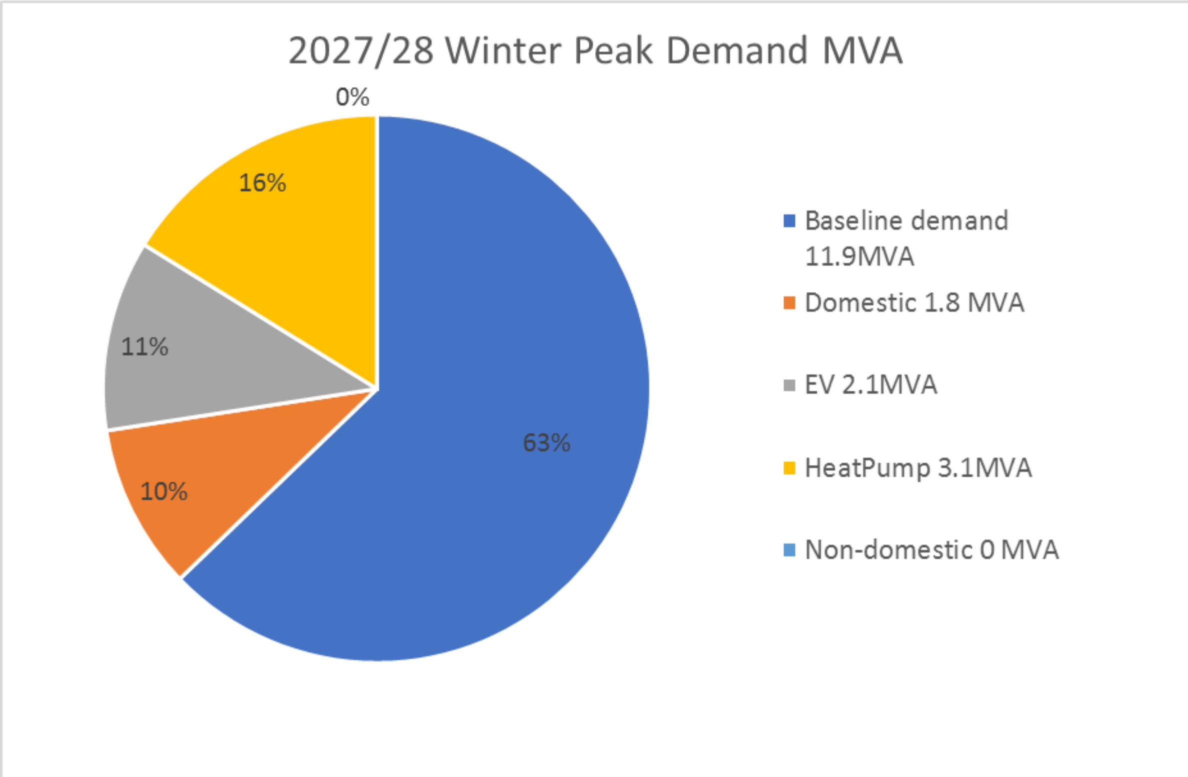


Figure 9: Fulscot Primary Winter peak demand split by 2027/28 - CT scenario

Peak demand is expected to increase at Cholsey primary by approximately 2 MVA from 2019/20 to 2027/28 when following the CT scenario. The projected primary demand of 10.3 MVA (Winter Peak) is split below by demand type. The chart shows the largest impact on demand in the area is from heat pumps, equating to 10% of the overall projected demand.

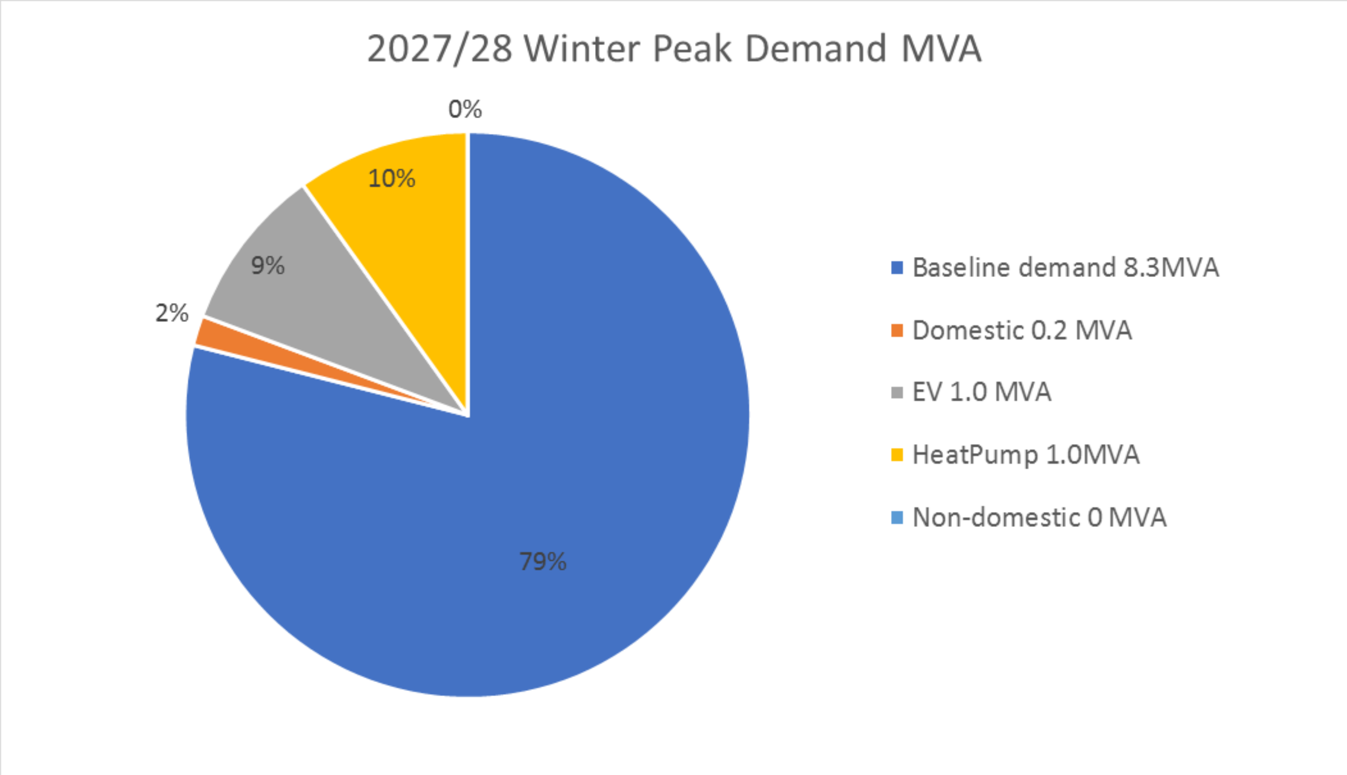


Figure 10: Cholsey Primary Winter peak demand split by 2027/28 - CT scenario

4.4 Existing Network Arrangement

Milton, Fulscot and Cholsey 33/11kV substations are all connected via shared 33kV circuits to Drayton BSP as shown in figure below. There is currently a project underway to provide a dedicated 33kV circuit from Drayton to Air Products with the current connection being switched out. This will change the network arrangement to give two dedicated 33kV circuits between Drayton and Milton with two circuits running from Drayton to Fulscot with tee connections to Milton and one circuit connecting to a generator at Sutton Courtney. Cholsey primary substation is then fed via a 33kV circuit from Fulscot, with a second normally open connection to Streatley. There is another normally open connection from Fulscot 33kV to Wallingford 33kV.

Based on detailed network analysis, the 33kV circuits between Drayton and Fulscot are overloaded under a First Circuit Outage (FCO) condition in Spring/Autumn in RIIO-ED2 period (limited by the Spring/Autumn minimum circuit rating 24.5MVA between Fulscot and Sutton Courtney 33kV) when supplying demands at Fulscot and Cholsey taking network losses into account.

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

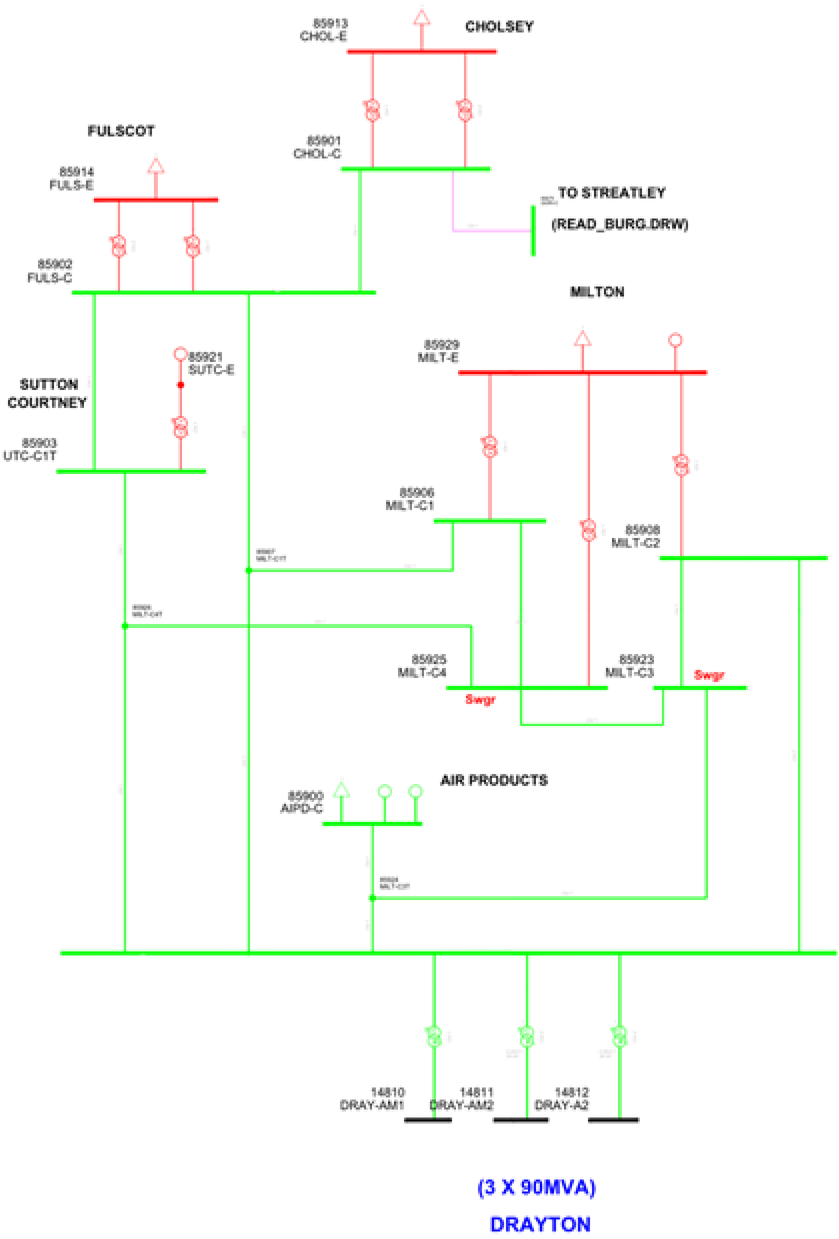


Figure 11: Fulscot Network Arrangement SLD.

Fulscot substation is located near to Didcot, Oxfordshire and is positioned adjacent to a railway line. The substation primarily supplies Didcot in conjunction with Milton, with Fulscot supplying the mainly domestic demand, with Milton supplying the mainly industrial demand to the north.

Figure 12: Fulscot Substation

4.5 Existing Asset Condition

The existing assets at Fulscot are in good condition and are either HI1 or HI2 with no plans for non-load investment within the ED2 period.

The two transformers at Cholsey are both with a Health Index of HI5 and the replacement of transformers are proposed in ED2 business plan.

4.6 Thermal Flow Analysis in 2023/24 under CT scenario

The table below shows the non-compliant circuit sections from the load flow results. Reinforcement is required due to non P2/7 compliance under FCO conditions. The Sutton Courtney to Fulscot 33kV circuit will be overloaded when Drayton to Fulscot via Milton Tee 1 33kV circuit is in outage, therefore the reinforcement is required due to non P2/7 compliant under FCO conditions.

Demand Group	Season	Group Class	Contingency	Loaded Circuit / Transformer	FCO Demand to be Met without network losses	FCO Demand to be Met with network losses	FCO Available Capacity
Fulscot & Cholsey	Spring/Autumn	C	Fault on Drayon to Fulscot via Milton Tee 1 33kV Feeder	Drayton to Milton Tee 4 to Sutton Courtney to Fulscot 33kV Circuit	23.3 MVA	**25.1MVA**	**24.5 MVA**
Fulscot & Cholsey	Spring/Autumn	C	Fault on Drayton to Milton Tee 4 to Sutton Courtney to Fulsot 33kV Circuit	Drayton to Fulscot via Milton Tee 1 33kV Feeder	23.3 MVA	**24.9MVA**	**25.9 MVA**

Table 4 Thermal Flow Analysis Results

4.7 Voltage Level Assessment

Reinforcement is not required as voltage compliance is met and the results of analysis can be found in Appendix 2.

4.8 Fault Level Assessment

There are no fault level issues as shown in the analysis in Appendix 2.

4.9 Summary

In summary, the fast-increased demand around Fulscot 33/11kV primary substation will have significant impact on the network capability and cause the non-compliance issues with P2 in ED2. The need for the network reinforcement works is apparent in ED2 to maintain the compliance with thermal ratings of the circuits and improve network security of supply.

5 Optioneering

This section of the report sets out the investment options that are considered when resolving overload issues detailed above. As described below a holistic approach is taken to ensure investment options which are both least regrets and represents 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 scheme might have wider Whole System interactions due to recent connection interests in this area and at the old Didcot Power Station. We will continue to work with National Grid, stakeholders and customers on the network solutions if and when demand interests materialise.

5.2 Summary of Options

Table 5 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	Result
1. Do Minimum	It is normally done by carrying out demand transfer from the overloaded demand group to another.	Minimum cost and workload; Small impact to existing network; Short delivery time.	Does not increase network capacity, further reinforcement is still be required.	Considered but not progressed to CBA
2. Reinforcement of existing assets **With premium cost**	The replacement of the full overloaded equipment including: • 20.4 km 33kV Circuits	Allow latest and most efficient technology to be installed; Increase network capacity; Reduce environmental impact.	Can incur long outages if replacement cannot be built offline; Some non-overloaded asset may also need to be replaced in-line with the new equipment.	Taken forward to CBA
3. Reinforcement by network extension (adding additional new assets)	When overloaded equipment is already reached maximum rating, new equipment will be added into existing network. • 10km 33kV circuit • Two 33kV Switchgears	Increase network resilience; Shorter outage time; Long term benefit.	Additional land purchase maybe required; Can incur large civil costs; Required new control strategy.	Taken forward to CBA
4. Flexibility Solution for 3 years followed by reinforcement of existing assets with standard cost	Flexible service contracts to reduce peak demand and defer capital investment	Relatively low cost Creates option value to monitor load growth closely	Amount of flexibility depends on location-specific resources and interests. CAPEX may still be required.	Taken forward to CBA (Preferred Option)

Table 5: Summary of Investment Options

5.3 Detailed Option Analysis

5.3.1 Option 1: Do-Minimum

Estimated Cost: N/A

Fulscot and Milton primary substations are interconnected to some degree on the 11kV network. This is primarily for load switching under outage conditions on the 11kV network with loads on both substations. The forecast load for Milton is nearing the firm capacity towards the end of the ED2 period. Any load transfer would lead to the overload of Milton.

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.

5.3.2 Option 2: Reinforcement of Existing Assets with Premium Cost

Estimated Cost: £2,692k

The cable and overhead line sections of 33kV circuits between Drayton BSP and Fulscot Primary, as highlighted in Figure 13, will be replaced and upgraded to/above rating 43.5/39.4MVA due to the overload under FCO condition. The section with oil filled cable will be replaced with XLPE cable. The combined total of 33kV circuit requiring reinforcement is 17.81km of Overhead Line and 2.56km of underground cable.

The deliverability of this reinforcement option in 2023/24 has also been considered. Premium unit rates, instead of standard unit rates, have been used to capture the capital cost of this reinforcement due to it being delivered in the first year of ED2 alongside with many other projects. Ofgem's RIIO-ED2 standard CBA template was used to assess costs and benefits of the conventional Options 2 and 3. As a result of the CBA assessment, Option 2 came out as 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.

Figure 13: Circuit route between Fulscot and Drayton BSP

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

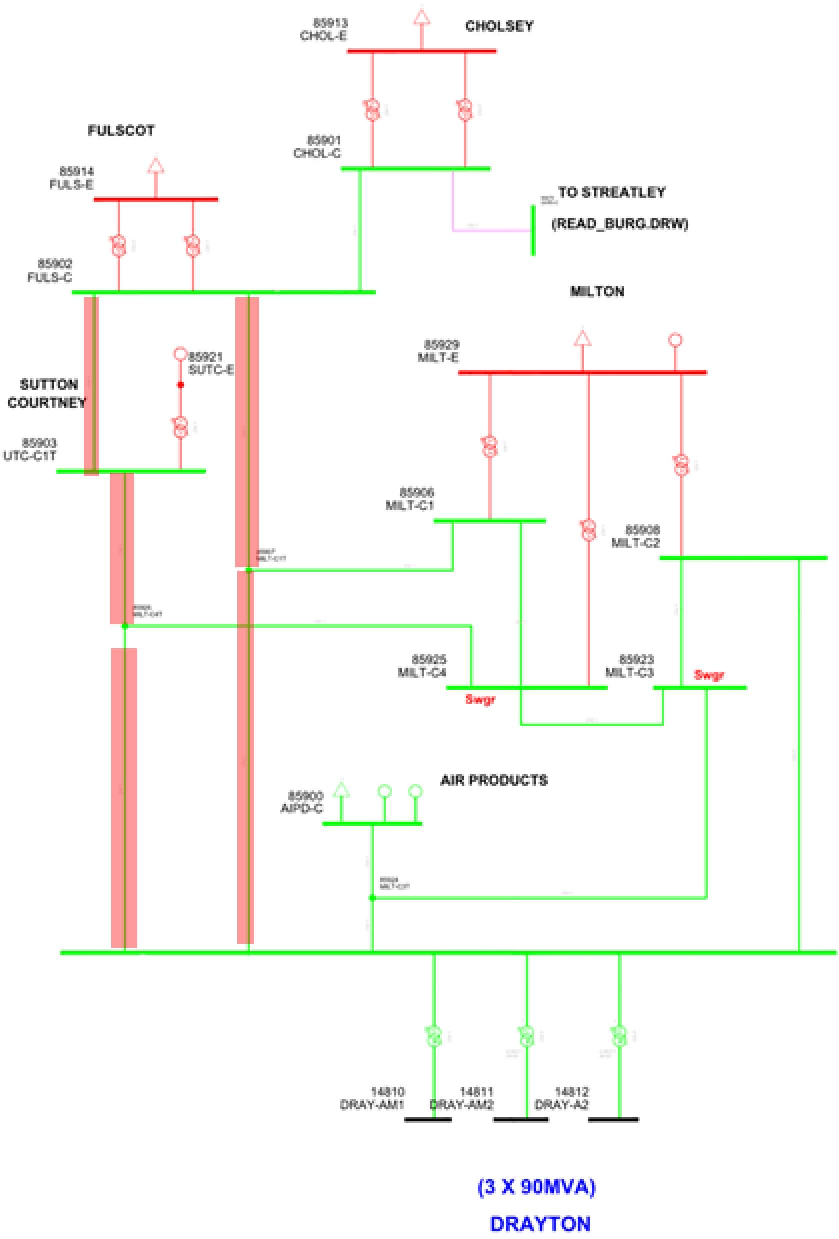


Figure 14: Option 2-Network arrangement SLD with proposed asset replacement highlighted

5.3.3 Option 3: Reinforcement by network extension (adding additional new assets)

Estimated Cost: £4,281k

In order to provide suitable new assets to support the forecasted load growth a new 33kV circuit would be required from Drayton BSP to Fulscot Primary. This option would require the extension of the existing 33kV compound at Drayton BSP and Fulscot Primary to accommodate the additional switchgears for the new circuit. A new 33kV cable circuit with length approximately 10 km in total will be required between Drayton BSP and Fulscot Primary. The route would look to follow part of the existing 33kV overhead line route over mainly arable land with railway crossing. The expenditure for this option is highest among all the options and It might be challenging to gain consent from the landowners for the proposed cable route, therefore it is rejected.

Figure 15: Proposed New Cable Route between Drayton and Fulscot

5.3.4 Option 4: Flexible Solution

Estimated Cost: £2,596k

For this option, the Common Evaluation Method (CEM) CBA model has been used to assess if there are benefits in deferring the reinforcement. The most economically viable conventional solution was obtained from the CBA (Option 2) and fed into the CEM Flexibility CBA.

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

Flexibility services in the form of increasing generation export or decreasing demand import could be used to reduce the peak. The MW exceedance, the daily and annual overload hours (Table 6) and the flexibility unit costs of £150 per MW per hour and £150 per MWh were used as input parameters in the CEM CBA model (full details of the flexibility methodology can be found in the ***Load Related Plan Build and Strategy (Annex 10.1)***.

	2021	2022	2023	2024	2025	2026	2027	2028
Hrs/day required	0	0	0	0.5	2.0	2.8	3.7	4.2
Days/yr required	0	0	0	128	128	192	192	192
Av MVA	0	0	0	0.2	1.2	2.6	4.1	5.6
MWh	0	0	0	8	150	708	1442	2250

Table 6: Estimated dispatch requirements for flexibility solution.

The CEM CBA outcome in Table 7 shows that, under the CT scenario, there is a benefit of deferring option 2 for 1 year. This outcome is two years short of the suggested delivery year (2026/27) in our deliverability plan unless the future demand follows the ST trajectory which recommends a 4 year deferral. Although the CEM CBA suggests a negative benefit if deferred to 2026/27 (standard capital costs applied), further CBA analysis was carried out to understand whether this option is still better than delivering the capital reinforcement in 2023/24 with premium costs. The NPV results in Section 6.2 indicate a better NPV value for this option compared to Option 2.

Cumulative benefit of deferral (excluding benefit from further deferral, but including multi-year discount)		**Defer by 1 year(s) to 2025**	**Defer by 2 year(s) to 2026**	**Defer by 3 year(s) to 2027**	**Defer by 4 year(s) to 2028**
[1] under Consumer Transformation	£0	£18,816	-£60,235	-£345,083	-£926,227
[2] under Leading the Way	£0	£15,711	-£86,672	-£395,100	-£1,099,379
[3] under Steady Progression	£0	£22,367	£42,952	£61,930	£79,464
[4] under System Transformation	£0	£22,367	£42,952	£61,930	£67,690

Table 7: Net benefit of deferring reinforcement.

In line with our Flexibility First Approach, this project is technically compatible with a Flexibility Solution. We 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 use 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. SSEN will also assess the opportunity to extend the Flexible solution beyond three years should the scheme be successful and demand growth is lower than currently forecasted.

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

6 Analysis and Cost

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 options progressed.

The options were assessed with standard pricing and premium pricing. The concept of premium pricing has been developed by the Commercial and Deliverability workstream to provide a way to capture the cost of delivering a project earlier than is feasible to help with deliverability of the plan. The premium cost has been based upon tender returns for representative model projects across a variety of asset categories. The premium cost is the difference between evaluated tender rates for lowest submitted tender and highest submitted tenders. In this EJP, the premium price relates to 33kV OHL works and attracts a 17% uplift on the lowest submitted tender. For Cable works, we have undertaken a bottom up analysis of a representative sample of ED1 projects to calculate the premium cost, which is the difference between the internal and external delivery rates of historic cable projects.

From the outcome of CBA analysis, we revised our investment phasing accordingly to ensure our Business Plan is deliverable, meets our consumers' needs and is most cost efficient for our consumers.

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

6.2 CBA Results

The CBA results below, demonstrate that the most cost-effective solution for each circuit as the preferred option for each circuit has the least NPV against the required investment, providing efficient and enduring long-term security of supply as we move towards a Net Zero network.

Where premium cost has been applied, the option title below will contain (*).

Options	Unit	2024	2025	2026	2027	2028	ED3+	Total £k
Option 2 – Reinforcement of existing assets with premium cost*	**£k**	2,692	0	0	0	0	0	2,692
Option 3 – Reinforcement by network extension (adding additional new assets)	**£k**	4,281	0	0	0	0	0	4,281
Option 4 – Flexibility Solution for 3 years then reinforcement by network extension as option 2 with standard cost	**£k**	3	68	319	2206	0	0	2,596

Table 8 Summary of Cost

Options	Net Present Value (NPV) After 45 Years (£k)	Investment (£k)
Option 2 – Reinforcement of existing assets *	-1,432	2,692
Option 3 – Reinforcement by network extension (adding additional new assets)	-4,898	4,281
Option 4 – Flexibility Solution for 3 years then reinforcement by network extension as option 2 with standard cost (Preferred Option)	-1,232	2,596

Table 9 Cost Benefit Analysis Comparisons

Option 4 has the best NPV value out of all the options and is, therefore, our preferred option.

6.3 CBA Summary

The CBA results show that Option 4 Flexible Solution followed by conventional reinforcement is the preferred solution due to the superior NPV value. 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.

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)***[5]. 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.

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

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

- Based on our assessment of delivery constraints and the results of CBA analysis, the revised investment phasing for 33kV circuits at and around Fulscot primary substation is proposed to be 2026/27. 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				Revised	

Table 10 Investment phasing on deliverability assessment

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 cable/OHL projects in house. The experience and skills acquired from these projects lay the foundation for the delivery of the Fulscot 33 kV cable/OHL replacement.
- The cables and overhead lines of existing 33kV circuit route are required for replacement. The incoming 33kV circuits to Fulscot run over agricultural land but also through the centre of a golf course. There may be difficulty in agreeing line upgrades with landowners with the need to divert circuits. Oil management is required for the 33KV cable sections of Milton Tee 1-Fulscot and Fulscot-Sutton Courtney. There is medium risk on cable/OHL replacement.
- Utilising the flexibility service can potentially defer the reinforcement for 2 year with benefit based on the output of the Baringa CBA model under CT scenario. However, the amount of flexibility depends on location-specific resources and interests.
- We have chosen CT scenario as the baseline scenario for our investment optioneering based on the enhanced stakeholder engagement feedback. However, there is risk that the demand growth in the future doesn't go as predicted in CT scenario. Therefore, we will monitor the demand development of the surrounding network and review the reinforcement option annually.

8 Conclusion

This EJP has raised the need for load related investment on 33kV circuits at and around Fulscot primary substation within the ED2 price control period. This need for investment is triggered by the forecasted increase in demand around Fulscot primary substation. This load increase is driven by a combination of EV and HP uptake. Reinforcement is required to avoid the risk of non-compliance in RIIO-ED2.

Four investment options have been considered and the preferred solution involves the use of flexibility solution for 3 years and then the replacement of the cable and overhead line sections (20.4km) of 33kV circuits between Drayton and Fulscot. All viable options are supported by a CBA which provides further breakdown of economic viability over a 45-year period.

The proposed ED2 investment with the combined scheme total of £2.60m. It is proposed that all reinforcement is carried out in the 2026/27 financial year to minimise the risk of thermal overload and network non-compliance.

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. Network Analysis

Voltage Level Assessment

SYSTEM VOLTAGE LEVELS_FULSCOT PRIMARY						
Season	Drayton BSP 33kV voltage	Demand	Generation	Study Scenario	Fulscot 11KV Voltage	Busbar Name
[-]	[p.u.]	[MVA]	[MVA]	[-]	[p.u.]	[-]
Spring/Autumn	1.031	23.3 MVA	0	Intact	1.026	FULS-E
Spring/Autumn	1.025	23.3 MVA	0	Fault on Drayton to Fulscot via Milton Tee 33kV Feeder	0.988	FULS-E
The Voltage levels are in the limit of ± 10% on 132KV. ± 6% on 33KV under intact condition.						

Table 12 Voltage Level Assessment Results

Fault Level Assessment

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	Circuit Breaker Make Rating	Circuit Breaker Fault Level Index
3 Phase Fault Level Results at the End of ED2 2027/2028												
85903	SUTC-C1T	33.	1.010	3.5	13.15	26.81	11.81	0.31	11.82	25	62.5	FLI1
85902	FULS-C	33.	0.995	2.8	9.13	17.55	8.3	0.06	8.3	25	62.5	FLI1
85914	FULS-E	11.	1.029	5.3	11	24.54	10.09	0.96	10.14	13.1	33.4	FLI1
85901	CHOL-C	33.	0.976	1.7	3.96	6.65	3.73	0	3.73	25	62.5	FLI1
85913	CHOL-E	11.	1.027	3.2	5.85	11.51	5.46	0.05	5.46	13.1	33.4	FLI1
Single Phase to Ground Fault Level Results at the End of ED2 2027/2028												
85903	SUTC-C1T	33.	1.010	1.7	4.67	8.67	4.61	1.6	4.88	25	62.5	FLI1
85902	FULS-C	33.	0.995	2.0	3.51	6.59	3.47	0.81	3.56	25	62.5	FLI1
85914	FULS-E	11.	1.029	0.1	1.23	1.77	1.23	0	1.23	13.1	33.4	FLI1
85901	CHOL-C	33.	0.976	2.1	1.79	3.3	1.78	0.1	1.78	25	62.5	FLI1
85913	CHOL-E	11.	1.027	0.8	3.78	8.97	3.72	0.68	3.78	13.1	33.4	FLI1

Table 13: 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 14 below outlines our Whole Systems CBA test for 33kV circuits of Fulscot 33/11kV and Milton 33/11KV primary substations.

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?
33kV circuits of Fulscot 33/11kV and Milton 33/11KV primary substations	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 14:Whole Systems CBA test for 33kV circuits of Fulscot 33/11kV and Milton 33/11KV primary substations

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.