Reinforcement of Single Transformer Primary Sites

ED2 Engineering Justification Paper

ED2-LRE-SPD-028-CV1-EJP

Issue	Date	Comments
Issue 0.1	Oct 2021	Issue to internal governance and external assurance
Issue 0.2	Nov 2021	Reflect comments from internal governance and external assurance
Issue 1.0	Dec 2021	Issue for inclusion in Final Business Plan submission

Scheme Name	Reinforcement of Single Transformer Primary Sites		
Activity	Primary Reinforcement		
Primary Investment Driver	Network Security & Thermal Constraints		
Reference	ED2-LRE-SPD-028-CV1		
Output	Load Index		
Cost	£4.769m		
Delivery Year	2026-2028		
Reporting Table	CV1		
Outputs included in ED1	~~Yes~~/No		
Business Plan Section	Develop the Network of the Future		
Primary Annex	Annex 4A.2: Load Related Expenditure Strategy: Engineering Net Zero Annex 4A.6: DFES		
Spend Apportionment	**ED1**	**ED2**	**ED3**
	£m	**£4.769m**	**£m**

SP ENERGY NETWORKS

Technical Governance Process

Project Scope Development

IP1(S)

To be completed by the Service Provider or Asset Management. The completed form, together with an accompanying report, should be endorsed by the appropriate sponsor and submitted for approval.
IP1 – To request project inclusion in the investment plan and to undertake project design work or request a modification to an existing project
IP1(S) – Confirms project need case and provides an initial view of the Project Scope
IP2 – Technical/Engineering approval for major system projects by the System Review Group (SRG)
IP2(C) – a Codicil or Supplement to a related IP2 paper. Commonly used where approval is required at more than one SRG, typically connection projects which require connection works at differing voltage levels and when those differing voltage levels are governed by two separate System Review Groups.
IP2(R) – Restricted Technical/Engineering approval for projects such as asset refurbishment or replacement projects which are essentially on a like-for-like basis and not requiring a full IP2
IP3 – Financial Authorisation document (for schemes > £100k prime)
IP4 – Application for variation of project due to change in cost or scope

PART A – PROJECT INFORMATION

Project Title:	**Reinforcement of Single Transformer Primary Sites**
Project Reference:	**ED2-LRE-SPD-028-CV1**
Decision Required:	**To give concept approval to establish double transformer primaries at Easter Road, Lower London Road, Roseburn, Balgreen and decommission Lochend Quadrant**

Summary of Business Need:

A detailed review of all 51 single transformer sites in SPD has been undertaken. Single transformer substations in SPD are legacy arrangements and non-standard design practice. This review has identified 5 higher priority demand groups with insufficient network security or 11kV transfer capacity.

The level of supply security provided by single transformer substations is not adequate for these areas. Any unplanned outages on these transformers or their supply cables result in a short interruption to all customers fed from that transformer and are overly dependent on 11kV transfer capacity. To provide supply security, it is proposed to upgrade the network.

From the identified sites, five demand groups: Roseburn, Balgreen, Lower London Road, Easter Road and Lochend Quadrant, are forecast to provide insufficient network security, or exceed their 11kV transfer capacity, within the RIIO-ED2 price control under our Baseline View.

Further to the transfer capacity constraints, the Roseburn and Balgreen areas are closely located and supply a variety of high profile customers, including Murrayfield National Rugby Stadium, Hearts football stadium, Haymarket train station, Fountain Park leisure complex, Scottish gallery of modern art and Edinburgh zoo.

Summary of Project Scope, Change in Scope or Change in Timing:

The proposed solution is to provide a second feed to high utilisation single transformer sites. This will provide additional network security and increase the available capacity of the following five primary substations: Roseburn Primary, Balgreen Primary, Lower London Road Primary, Lochend Quadrant Primary, & Easter Road Primary.

The estimated cost for the above is £4.769m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure. This will provide a 50MVA capacity uplift, spread across the five identified demand groups.

Expenditure Forecast (in 2020/21)

Licence Area	Reporting Table	Description	Total (£m)	Incidence (£m)				
				2023/24	2024/25	2025/26	2026/27	2027/28
SPD	CV1	Primary Reinforcement	**4.578**				1.593	2.985
SPD	CV1	Flexible Services	**0.191**	0.042	0.037	0.035	0.037	0.041
SPD	**Total**		**4.769**	0.042	0.037	0.035	**1.630**	**3.026**

PART B – PROJECT SUBMISSION

Proposed by	Mark Friese	Signature		Date:	30/11/2021
Endorsed by	Russell Bryans	Signature		Date:	30/11/2021

PART C – PROJECT APPROVAL

Approved by	Malcolm Bebbington	Signature		Date:	30/11/2021

Contents

1 Introduction

Single transformer sites refer to a primary demand group served via a single 33/11kV primary transformer. A small number of sites have two 33/11kV primary transformers, with only a single 33kV feed, these are also referenced as single transformer sites throughout this document.

Inherently, single transformer sites have no intrinsic network capacity[1] for a first circuit outage (FCO). Consequently, single transformer sites must rely on the transfer capacity available on the 11kV network. Transfer capacity relates to the capability of an adjacent network to supply demand of a given demand group during FCO conditions. Hence in addition to being affected by the circuit capacity of the interconnection between the demand groups, transfer capacity is dependent on the capacity of an adjacent demand group(s) to the one being assessed. Utilising 11kV transfer capacity can be problematic in practice for the following reasons:

- Gross and net demand on the circuit used to implement the transfer.
- Unless a Circuit being considered is clean, i.e. there are no customers connected to it, it is necessary to establish the demand headroom available on the Circuit. Hence, before the Circuit is used to transfer demand, the gross demand (demand without DG/DSR Schemes/ES operating) and net demand (demand with DG/DSR Schemes/ES operating) should be established.
- In determining the capacity of a circuit to be used to implement demand transfer, the effects and response of any distributed generation (DG) must be considered once it is operating as a transfer circuit, e.g. fault level implications for connected DG.
- Impact of the demand transfer on the demand group to which the demand (or generation) is transferred.

All fifty-one SP Distribution (SPD) single transformer sites were systematically reviewed to establish a shortlist of high priority sites. The primary drivers for consideration were security of supply and forecast load of the demand group against the net transfer capacity of the interconnected network. Secondary drivers include number and types of customers supplied by each transformer, fault history, seasonal outages, asset condition and asset health. Further to the detailed, and systematic, qualitative analysis of the network, we engaged with district general managers and front-end staff to ensure any particularly problematic areas were sufficiently considered. From the long list of sites, five demand groups: Roseburn, Balgreen, Lower London Road, Easter Road and Lochend Quadrant, are forecast to provide insufficient network security, or exceed their 11kV transfer capacity, within the RIIO-ED2 price control under our Baseline View.

In order to secure supplies at these higher priority sites within the City of Edinburgh, meet the licence obligations under EREC P2/7, and to accommodate future demand growth within the area, it is proposed to establish standard double feed primary substations at Roseburn, Balgreen, Lower London Road, Easter Road and reclaim Lochend Quadrant.

[1] As defined in ENA Engineering Report 130, Intrinsic network capacity is the capacity available within 60s of the commencement of an outage. 60 s relates to an automatic switching facility that does not depend on communications, requires no local manual or remote initiation and which has been appropriately planned and designed considering the load on network assets and protection settings.

The proposed works are:

1. Establish a Double transformer primary at Easter Road:
    a. At Shrubhill "B" Grid Supply Point (GSP) install one new circuit breakers on the existing 33kV switchboard.
    b. Provide a dedicated connection from Shrubhill "B" GSP to the Easter Road primary substation by installing 1.4km of new 33kV underground cable circuit with associated communications infrastructure.
    c. Plant two new 33/11kV 20MVA MIDEL primary transformers and a new 15-panel 11kV board, populated with 9 circuit breakers, at the Easter Road Primary substation.
    d. Install ramp for vehicular access to Easter Road primary substation.
2. Establish a Double transformer primary at Lower London Road:
    a. Install a new 11-panel 11kV board, populated with 8 circuit breakers, at Lower London Road Primary substation.
    b. Utilise Ex Lochend Quadrant 33kV circuit for a second feeder with O.3km of circuit required to facilitate the connection.
    c. Install Comms and fibre from the Lower London substation to Portobello GSP
    d. Plant two new 33/11kV 20MVA primary transformers under asset modernisation
3. Decommission Lochend Quadrant and transfer its demand to Easter Road and Lower London Road by cross jointing onto existing circuits.
4. Establish a Double transformer primary at Balgreen:
    a. Plant one new 33/11kV 20MVA transformer.
    b. At Balgreen primary substation, install one new circuit breaker on the existing 11kV switchboard.
5. Establish a Double transformer primary at Roseburn:
    a. Plant one new 33/11kV 20MVA transformer.
    b. At Roseburn primary substation, utilise an existing circuit breaker on the 11kV switchboard.
    a. Provide a dedicated connection from Gorgie GSP to Roseburn primary substation by cross jointing onto the Gorgie GSP to Sighthill GSP interconnector that passes the site.
6. Procure flexibility services to manage the network risk through the delivery stage at a cost of £191k.

The estimated cost for the above is £4.769m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Due to asset condition and thermal loading, it is proposed to start the works in 2026/27. A capacity release of 50MVA will be claimed in 2027/28 at the end of the project.

2 Background Information

2.1 Existing / Authorised Network – Lower London Rd/Easter Rd/Lochend Quad

Lower London Road substation is served by two 10MVA, Watford, 33/11kV transformers (1956) banked onto a single 33kV feeder. Both transformers are health index 5 and require replacement within RIIO-ED2. Lower London Road has an eight panel 11kV English Electric (1956) switchboard with a health index of 4.

Lochend Quadrant is served by a single 10MVA, Watford, 33/11kV transformers (1956). The transformer is health index 4 and requires replacement within RIIO-ED2. Lochend Quadrant has an eight panel 11kV Reyrolle (1955) switchboard with a health index of 5.

Both substations are fed from Portobello Grid Supply point (GSP). The existing network for Portobello GSP is shown in Figure 2-1.

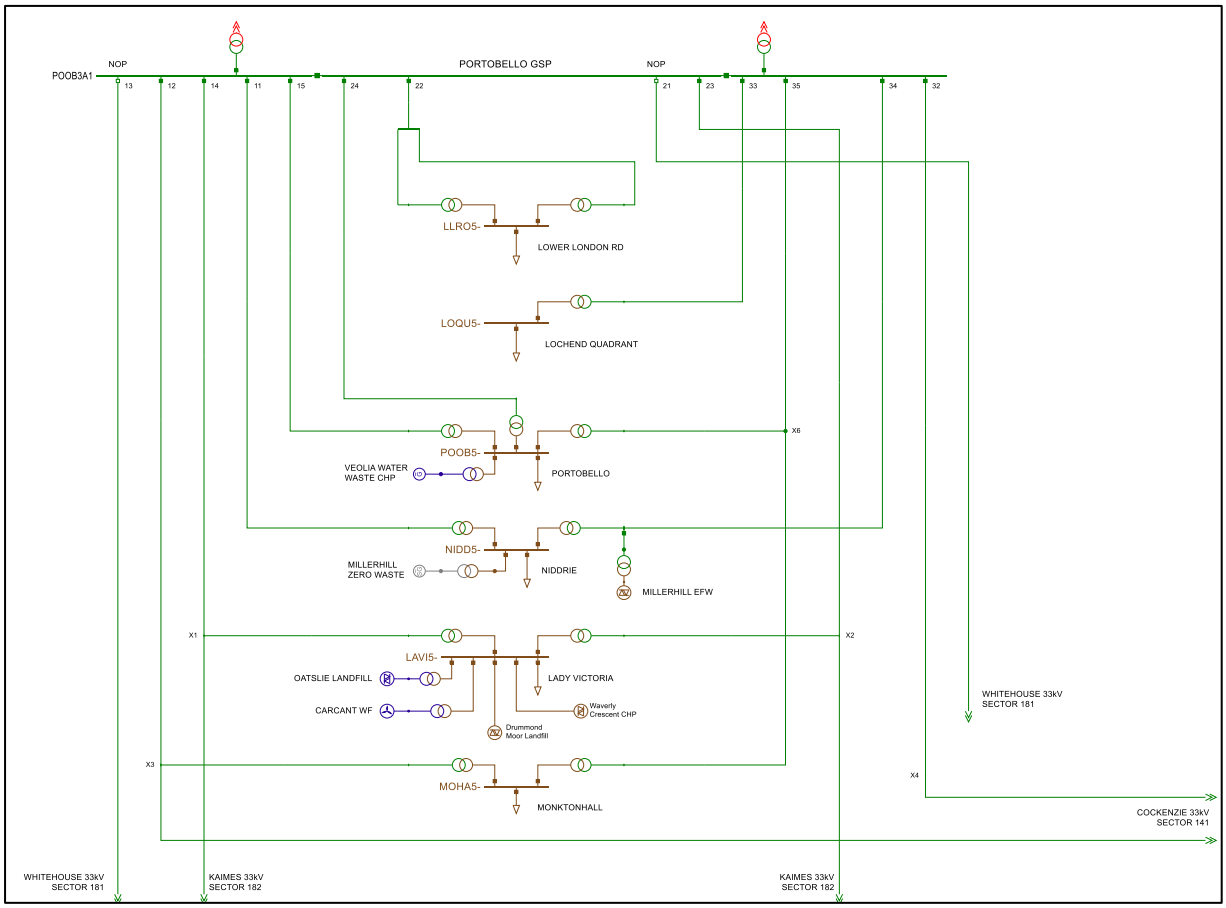


Figure 2-1. Existing 33kV Network at Portobello GSP

Lochend Quadrant and Lower London Road comprise a shared load group. A load transfer scheme provides for restoration between the two primary substations post fault. In recent years the scheme has been unreliable due mainly to the age of the equipment installed. Problems are also experienced due to circuit breaker reliability. A further complication is that the combined load at these sites at

15.9MVA is now in excess of the 13MVA cyclic capacity of the single transformer at Lochend Quadrant following a loss of the Lower London Road circuit.

Easter Road is fed from Shrubhill GSP and is served by a single 15/21MVA, Ferranti (Denis), 33/11kV transformer (1957). The transformer is health index 5 and requires replacement within RIIO-ED2. Easter Road has a nine panel 11kV South Wales (1957) switchboard with a health index of 4.

The 11kV network on Easter Road is closely integrated with both Lochend Quadrant and Lower London Road fed from Portobello GSP. A direct high capacity feeder is also connected from Portobello to Easter Road providing an alternative supply at 11kV via a load transfer scheme. Operating on this network introduces risks as there are multiple points where GSP parallels need to be managed carefully to avoid outages under routine operations for connections and maintenance. The existing network for Shrubhill GSP is shown in Figure 2-2.

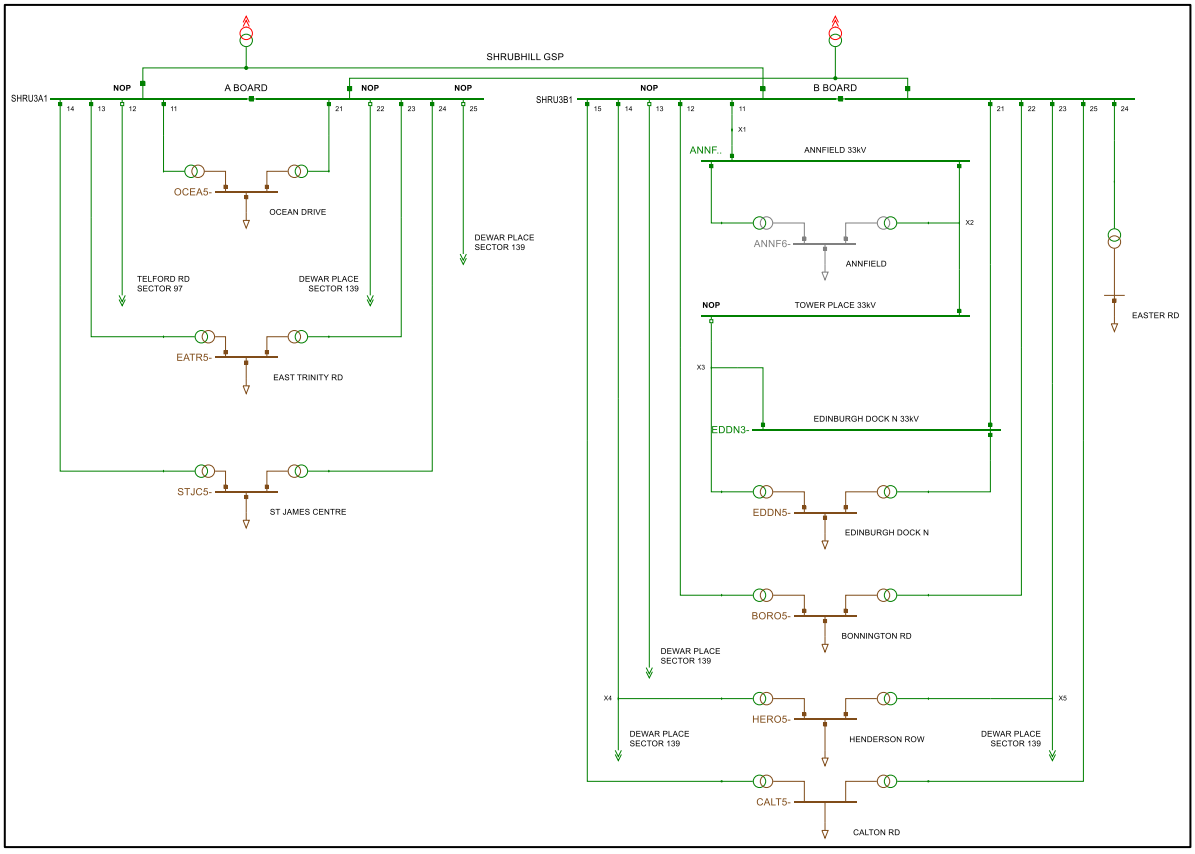


Figure 2-2. Existing 33kV Network at Shrubhill GSP

2.2 Existing / Authorised Network – Roseburn / Balgreen

Balgreen primary substation is served via a single 21MVA, Watford, 33/11kV transformer (1963) fed from Sighthill GSP. The transformer is health index 4 and requires replacement within RIIO-ED2. Balgreen primary has an 8 panel 11kV South Wales (1963) switchboard with a health index of 5.

Roseburn primary substation is served by a single 20MVA, Brush 33/11kV transformers (2010) and is also fed from Sighthill GSP. The transformer is health index 1. Roseburn primary has an 8 panel 11kV Hawker Siddley (2009) switchboard with a health index of 1. The existing network for Sighthill GSP is shown in Figure 2-3.

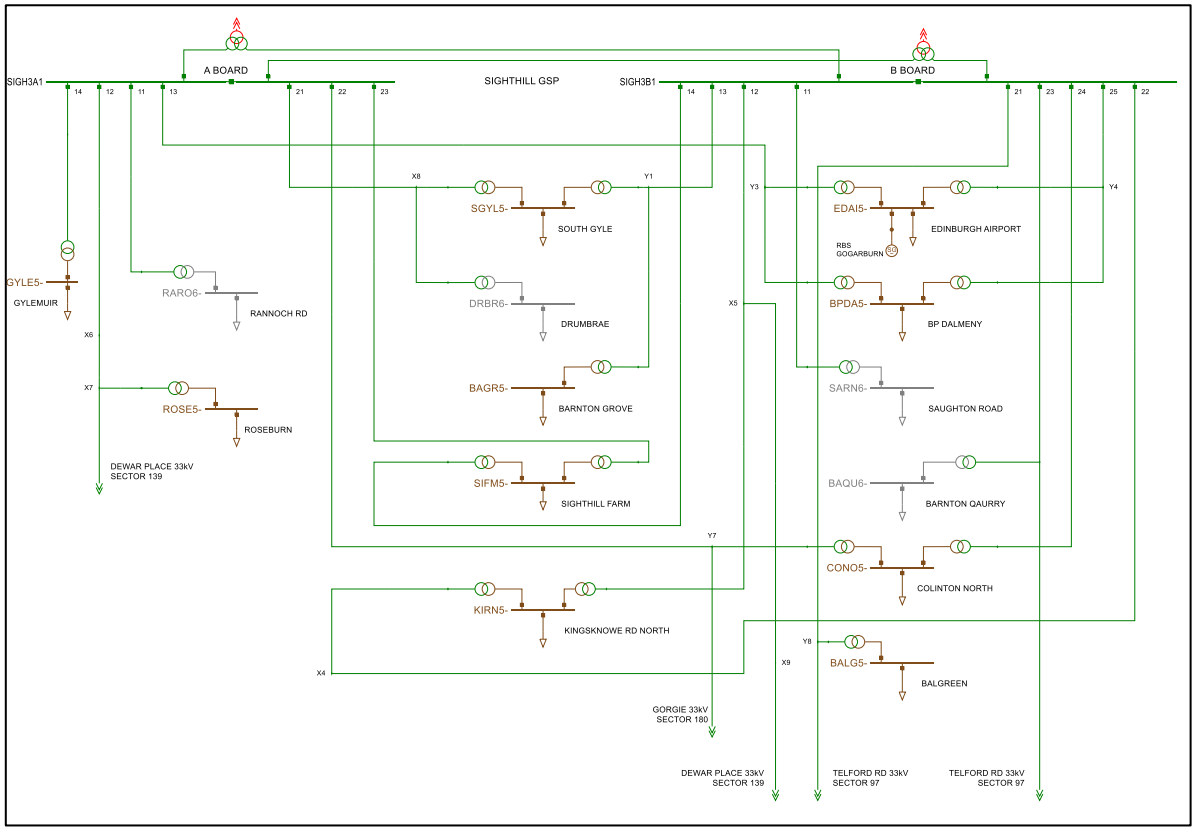


Figure 2-3. Existing 33kV Network at Sighthill GSP

2.3 Group Demand & Security of Supply

The 2021 maximum demand for each of the primary substation under review are shown in Table 2.1. All demand groups are currently a class 'B' of supply as per Energy Network Association (ENA) Engineering Recommendation (EREC) P2/7. However, significant volumes of connection acceptances and enquiries are present in the area.

Table 2.1. Primary group demands under review (2021 DFES)

Demand Group	Customers (#)	Firm Capacity (MVA)	Max Demand (MVA)	Load Index	P2/7 Class of Supply
Balgreen	3,238	20.9	6.9	LI1	B
Roseburn	2,649	20	6.7	LI1	B
Lower London Road	5,557	10	7.1	LI1	B
Easter Road	6,898	21	8.1	LI1	B
Lochend Quadrant	5,012	10	88	LI1	B

A summary of the transformer and switchgear data is presented in Table 2.2 & Table 2.3 respectively.

Table 2.2. Primary Transformer Data

	Balgreen	Roseburn	Lower London Rd	Easter Rd	Lochend Quad
Manufacturer	Watford	Brush	Watford	Ferranti	Watford
Asset Age (years)	57	12	56	55	56
Voltage	33/11kV	33/11kV	33/11kV	33/11kV	33/11kV
Thermal Rating	21MVA	20MVA	10MVA	21MVA	10MVA
Health Index	4	1	5	5	4
No of transformers	1	1	2	1	1

Table 2.3. Primary Switchgear Data

	Balgreen	Roseburn	Lower London Rd	Easter Rd	Lochend Quad
Manufacturer	South Wales	Hawker Siddley	English Electric	South Wales	Reyrolle
Asset Age (years)	58	13	56	55	57
Voltage	11kV	11kV	11kV	11kV	11kV
Health Index	HI5	HI1	HI4	HI4	HI5
No of panels	8	9	8	9	8

2.4 Embedded Generation

There is ca. 0.175MW of embedded generation connected at Balgreen primary.

2.5 Fault Levels

Studies indicate that there are no fault level issues at Roseburn, Balgreen, Lower London Road, Easter Road or Lochend Quadrant primary substations.

3 Needs Case

Lochend Quadrant and Lower London Road comprise a shared load group. At Lower London/Lochend Quadrant, our Baseline View projects a combined peak demand of 15.3MVA by 2028, including an expected uptake of up to 267 electric vehicles and 75 heat pumps. This exceeds 13MVA, cyclic rating, of the Lochend Quadrant transformer by the end of RIIO-ED2.

A load transfer scheme provides for restoration between the two primary substations post fault. In recent years the scheme has been unreliable due mainly to the age of the equipment installed. Problems are also experienced due to circuit breaker reliability. The existing switchgear and transformers at both sites are reaching end of life and require replacement within RIIO-ED2. (See Table 2.2 & Table 2.3 for asset details)

The 11kV network on Easter Road is closely integrated with both Lochend Quadrant and Lower London Road fed from Portobello GSP. A direct high capacity feeder is also connected from Portobello to Easter Road providing an alternative supply at 11kV via a load transfer scheme. Operating on this network introduces risks as there are multiple points where GSP parallels need to be managed carefully to avoid outages under routine operations for connections and maintenance.

Balgreen and Roseburn Primary Substations are closely located (ca. 1km apart), both in the west end of Edinburgh City. The area has many high-profile demands, such as: Murrayfield National Rugby

Stadium, Hearts football stadium, Haymarket train station, Fountain Park leisure complex, Scottish gallery of modern art and Edinburgh zoo. The level of supply security provided by single transformer substations is not adequate for these areas. Any unplanned outages on these transformers or their supply cables result in an interruption to all customers fed from that transformer. To provide supply security it is proposed to upgrade the network.

3.1 Forecast Demand

The system is forecast to grow and exceed network transfer capacity within the RIIO-ED2 period. This forecast is based on actual system measurement data from the Process Instrumentation (PI) system and stakeholder endorsed Distribution Future Energy Scenarios (DFES) and considers our pipeline of known developments.

Distribution Future Energy Scenarios

3.1.1 DFES includes granular forecasts to 2050 for demand, generation and Low Carbon Technologies. They assess credible future scenarios covering a range of uncertainties, including differing levels of consumer ambition, policy support, economic growth and technology development and the forecasts are underpinned by extensive stakeholder engagement.

The peak demand forecasts for primary substations based on the SPD Distribution Future Energy Scenarios, including authorised connections are depicted in Figure 3-4.

The scenario range considers the range of Net Zero compliant scenarios developed by us, the Electricity System Operator (ESO), and the Climate Change Committee (CCC). These are the five scenarios from the CCC 6th carbon budget, and the Leading the Way and Consumer Transformation scenarios from our DFES and the ESO Future Energy Scenarios (FES). We haven't included the System Transformation (ST) scenario as it is an outlier against the other Net Zero compliant scenarios and does not achieve interim carbon targets.

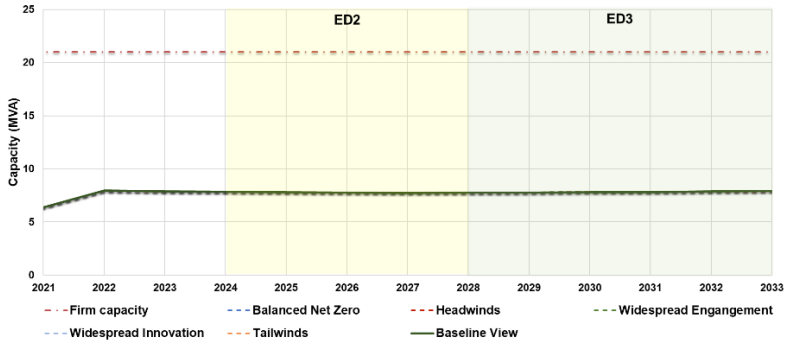


Figure 3-1. Demand (MVA) forecast for Easter Road demand group

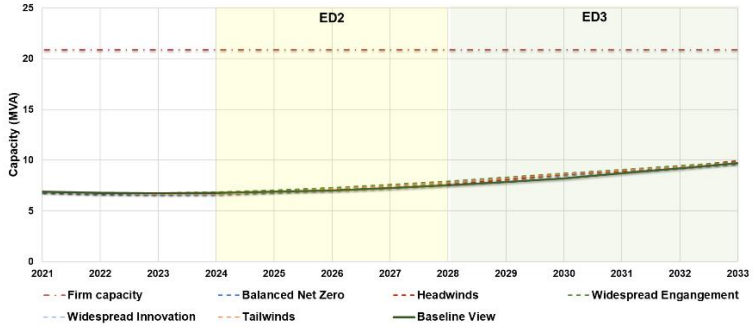


Figure 3-2. Demand (MVA) forecast for Balgreen demand group

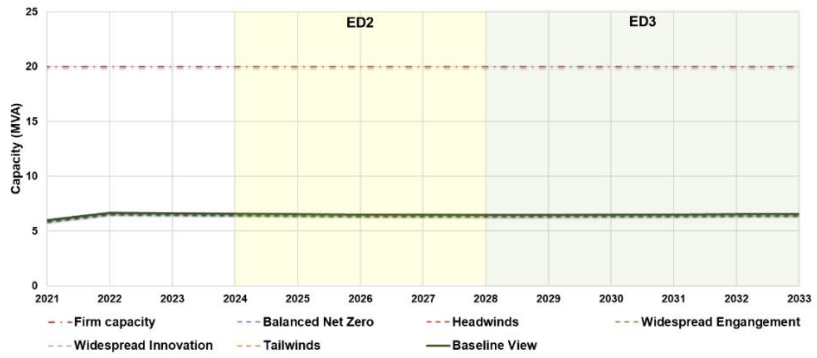


Figure 3-3. Demand (MVA) forecast for Roseburn demand group

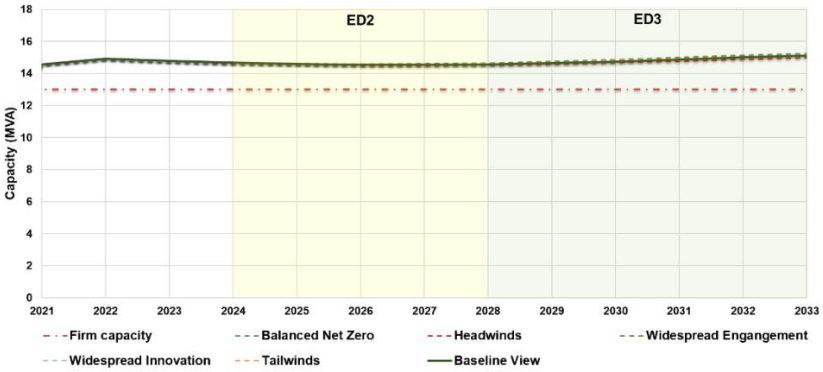


Figure 3-4. Demand (MVA) forecast for Lower London/Lochend Quadrant demand group

For the five identified group demands, the forecast demand growth under our Baseline scenario, along with the firm capacity and utilisation through to RIIO-ED3 period is shown in Table 3.1.

Table 3.1. Baseline View forecast for primary demand groups

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Roseburn													
Forecast Demand (MVA)	6.7	6.7	6.6	6.6	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Firm Capacity (MVA)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Utilisation (%)	34%	33%	33%	33%	33%	32%	32%	32%	32%	32%	33%	33%	33%
Load Index	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII
Balgreen													
Forecast Demand (MVA)	6.9	6.8	6.8	6.8	6.9	7.0	7.2	7.5	7.8	8.2	8.7	9.2	9.7
Firm Capacity (MVA)	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
Utilisation (%)	33%	32%	32%	33%	33%	34%	35%	36%	38%	39%	42%	44%	47%
Load Index	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII
Lower London Road													
Forecast Demand (MVA)	7.1	7.0	7.0	6.9	6.9	6.9	6.9	6.9	7.0	7.0	7.0	7.1	7.1
Firm Capacity (MVA)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Utilisation (%)	71%	70%	70%	69%	69%	69%	69%	69%	70%	70%	70%	71%	71%
Load Index	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII
Easter Road													
Forecast Demand (MVA)	8.1	7.9	7.9	7.8	7.8	7.8	7.7	7.8	7.8	7.8	7.8	7.9	7.9
Firm Capacity (MVA)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Utilisation (%)	38%	38%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	38%
Load Index	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII	LII

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Lochend Quadrant													
Forecast Demand (MVA)	8.4	8.6	8.6	8.5	8.4	8.4	8.4	8.4	8.5	8.5	8.6	8.7	8.8
Firm Capacity (MVA)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Utilisation (%)	84%	86%	86%	85%	84%	84%	84%	84%	85%	85%	86%	87%	88%
Load Index	LI2	LI2	LI2	LI2	LI2	LI2	LI2	LI2	LI2	LI2	LI2	LI2	LI2

3.2 Network Impact Assessment

Detailed network studies covering network intact and outage (N-1) conditions and fault level assessments were carried out for the 33kV network fed from the identified groups considering the different demand forecast scenarios.

The network thermal constraint during the most onerous outage was identified and time profile-based simulations (17,520 half-hourly simulations/year) were performed considering the historical half hourly measured Supervisory control and data acquisition (SCADA) data at primary substation overlaid with the DFES demand forecasts for each year through the RIIO-ED2 price control period. These studies identify the risk in terms of the thermal capacity exceedances with the forecast demand, the anticipated annual hours at risk and risk window of the constraint. The half-hourly studies performed for years starting from 2023 through 2028 determined the risk hours and the capacity required to overcome the constraint by using flexibility services.

Thermal Constraints

3.2.1 Table 3.2 shows the identified thermal constraints on the 33/11kV network level.

Table 3.2. Thermal constraints at 33/11kV level

Network Item	Voltage	Outage
Lochend Quadrant Transformer	33/11kV	N-1

Voltage Constraints

3.2.2 There were no voltage constraints associated with Roseburn, Balgreen, Lower London Road, Easter Road or Lochend Quadrant primary demand groups.

EREC P2/7 – Security of Supply

3.2.3 Lower London Road/Lochend Quadrant shared demand group has a forecast peak demand of 14.5MW (15.3MVA) by the end of RIIO-ED2. EREC P2/7 defines group demands of 12MW-60MW as a class 'C' of supply.

EREC P2/7 states that a group demand with a as a class 'C' of supply must secure the following minimum demand for a first circuit outage:

a) Smaller of group demand minus 12MW; and 2/3 of group demand;
b) Group demand must be met within 3 hours.

3.2.4 Lower London Road/Lochend Quadrant shared demand has a transfer capacity of 13MVA. Therefore, demand group is predicted to be non-compliant under EREC P2/7 by the end of the RIIO-ED2 price control period; consequently, mitigating action is required.

Flexibility Services

As the present level of utilisation at Lower London/Lochend Quadrant constrains routine operational activities, there are now limited opportunities to transfer demand from Lower London Primary during

periods of high demand or for planned outages. In order to manage the network risk on the 11kV network, our assessment indicates that the risk of thermal overload on the 33/11kV Lochend Quadrant primary transformers starts from the year 2023/24 throughout to the year 2028 for the most onerous scenario; including an additional 5% for the asset protection margin. This is shown Table 3-3.

Table 3-3. Network annual hours at risk and flexible capacity tendered in Spring 2021

Year	2023/24	2024/25	2025/26	2026/27	2027/28
Annual hours at risk (Hrs)	98	92	88	92	97
Required Flexible Capacity (MW)	1.06	1.02	0.99	1.01	1.05

4 Optioneering

Table 4.1 shows a summary of the options considered for this reinforcement. The baseline option represents the lowest cost conventional option, i.e. the minimum level of intervention without application of innovation.

Table 4.1. Longlist of solution options

#	Options	Status	Reason for rejection
(a)	Do nothing	Rejected	Not compliant with security of supply requirements as per EREC P2/7.
(b)	Intervention plan using only Energy Efficiency	Rejected	Discounted due to lower cost effectiveness (peak MW reduction per £) and the number of individual interventions required across the wide area supplied by this network.
(c)	Establish double feed primary substation at Roseburn, Balgreen, Lower London Road and Easter Road. Decommission Lochend Quadrant.	Shortlisted as **Baseline** option in Detailed Analysis	
(d)	Establish double feed primary substation at Roseburn, Lower London Road Lochend Quadrant and Easter Road. Decommission Balgreen.	Shortlisted as **Option 1** in Detailed Analysis	
(e)	Utilise flexibility services to defer reinforcement into RIIO-ED3. (Innovation)	Rejected	Flexibility does not resolve network security or asset health. This option is not technically viable and has been discounted.
(f)	Real Time Thermal Rating (RTTR). (Innovation)	Rejected	Asset condition is not suitable for RTTR. This option is not technically viable and has been discounted.
(g)	Install active network management on the 11kV network to enable dynamic transfer of demand between substations. (Innovation)	Rejected	Due to increasing demand and projected LCT uptake, neighbouring groups and the local HV network is reaching capacity. Consequently, insufficient transfer capacity is available.

5 Detailed Analysis & Costs

5.1 Proposed Option (Baseline) – Establish double feed primary substation at Roseburn, Balgreen, Lower London Road and Easter Road. Decommission Lochend Quadrant.

To mitigate the thermal constraints associated with single transformer primary substations in the City of Edinburgh, it is proposed to establish standard double feed primary substations at Roseburn, Balgreen, Lower London Road and Easter Road. Following the upgrade works, the 11kV network will be re-configured to facilitate the removal of Lochend Quadrant Primary. The demand fed from Lochend Quadrant will be distributed between Lower London Road Primary and Easter Road Primary. Table 5.1 shows the scheme summary. The option would enable 50MVA additional network capacity.

Table 5.1. Proposed option summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Conventional	Reinforcement of Single Transformer Primary Substations	Establish double feed primary substation at Roseburn, Balgreen, Lower London Road and Easter Road. Decommission Lochend Quadrant.	4.769	-

5.1.1 Lower London Road/Lochend Quadrant/Easter Road

It is proposed to upgrade the sites at Easter Road and Lower London Road to standard double fed 20MVA primary substations and remove the unsuitable, and landlocked, single transformer primary at Lochend Quadrant. The current capacity of this group is restricted to 13MVA due to dependence on common 33KV network and the 11kV interconnector used as a back- up feed post fault.

The existing transformer at Easter Road has a 15/21MVA rating and is connected to a 9-panel C4X 11kV switchboard. The site is bounded on two sides by public roads and is adjacent to a single track infrequently used railway freight line. The substation ground level is approximately 4 metres below the road surface. To comply with The Construction Design and Management (CDM) regulations, while delivering heavy plant to site, it is proposed to reconfigure the site layout and install a ramp for vehicular access. Although not having good access, the site is well positioned within the 11kV network and is geographically advantageous to serve incremental growth in its vicinity.

To reconfigure the site, the switchboard and existing transformer at Easter Road will require to be replaced. The single 21MVA transformer will be replaced with two new MIDEL filled 20MVA transformers. A new 11kV switchboard will be established with foundation for 15 panels and populated with 9 circuit breakers. The existing assets are reaching end of life and would otherwise require replacement within the RIIO-ED2 period, regardless of these proposals. The proposed option releases capacity, improves access to the site, keeps the well positioned location of Easter Road Primary and reduces network risk with the replacement of aging assets.

Easter Road primary will continue to be supplied from Shrubhill GSP by installing a new circuit breaker on the 33kV switchboard at Shrubhill B GSP and 1.4km of 33kV underground cable circuit with associated comms infrastructure from Shrubhill GSP to the Easter Road site. The 33kV network

schematic, an aerial view of the site and the proposed route are shown in Figure 5-1, Figure 5-2 and Figure 5-3, respectively.

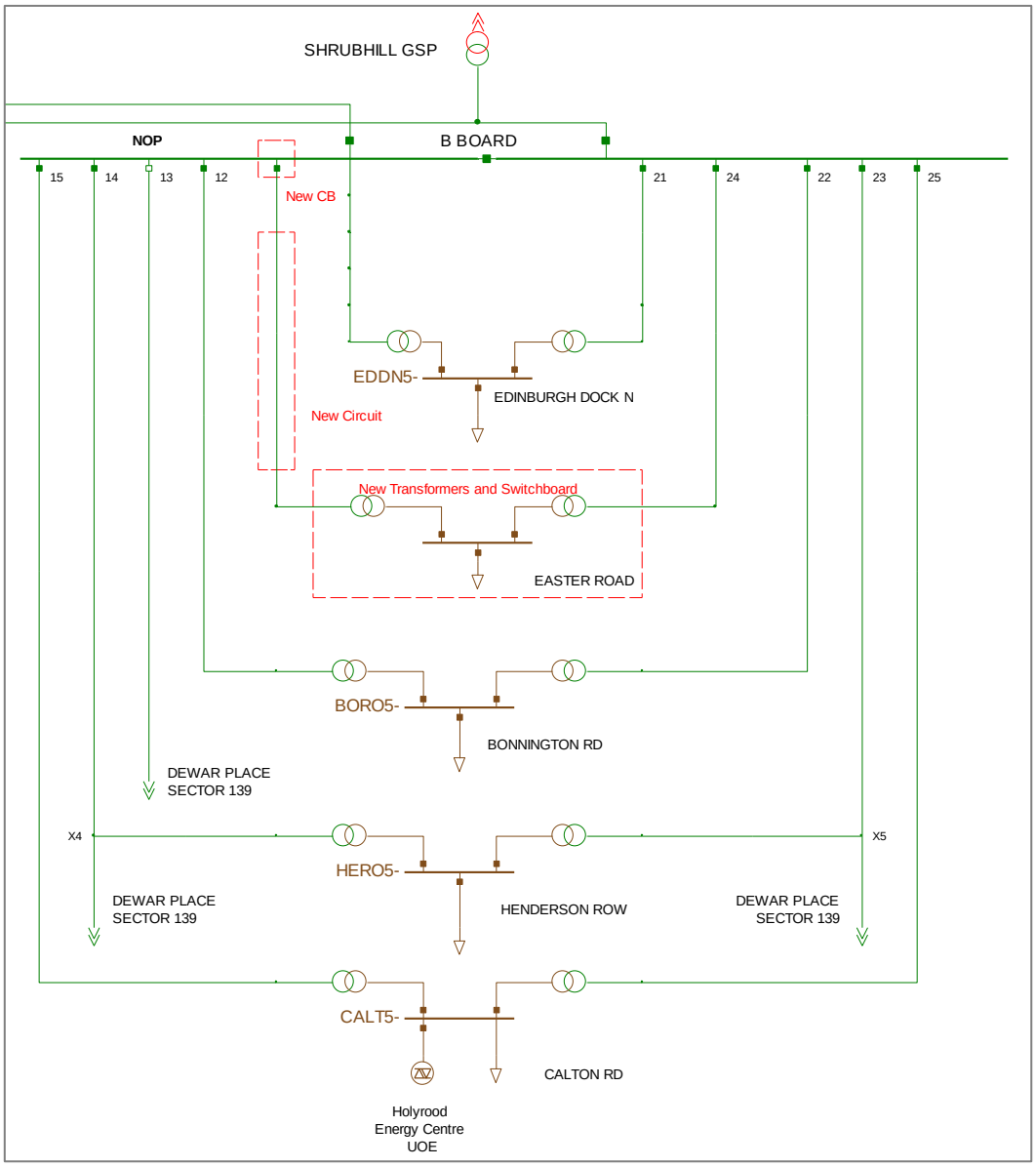


Figure 5-1: 33kV schematic diagram

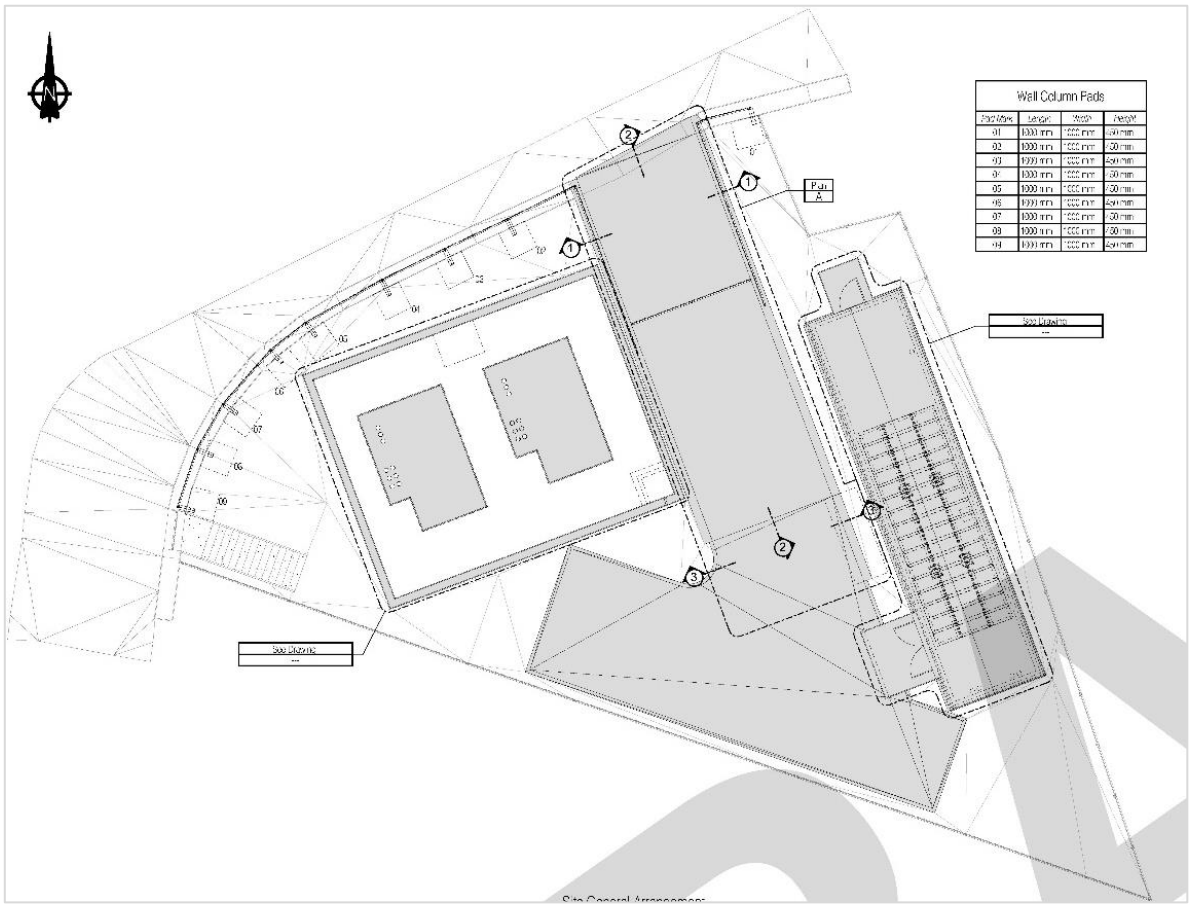


Figure 5-2: Ariel View of Proposed Site

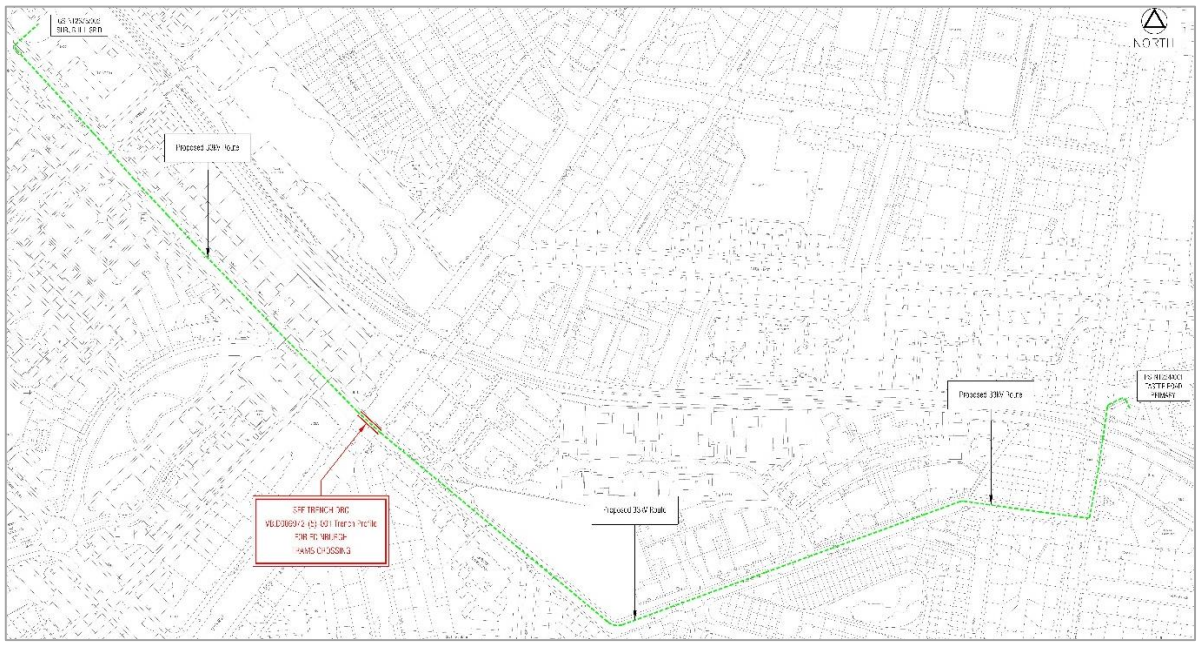


Figure 5-3: Proposed route from Shubhill GSP to Easter Road Primary

Lower London Road substation is served by two 10MVA, Watford, 33/11kV transformers (1956) banked onto a single 33kV feeder. Both transformers are health index 5 and require replacement within RIIO-ED2. Lower London Road has an eight panel 11kV English Electric (1956) switchboard

with a health index of 4. In order to facilitate the additional demand from Lochend Quadrant, it is proposed to establishment of a new 33/11kV 20MVA double transformer primary substation. Due to the existing asset condition and asbestos issues at the site, it is required to replace the existing assets and reconfigure the layout of the site. It is therefore proposed to:

- Establish new 11kV switchboard with foundation for 11 panels, populated with 8x CB
- Plant 2x 20MVA Tx at new site (under asset replacement)
- Utilise Lochend Quadrant 33kV circuit for a second feeder with O.3km of circuit required to facilitate the connection.
- Install Comms and Fibre from the site to Portobello GSP

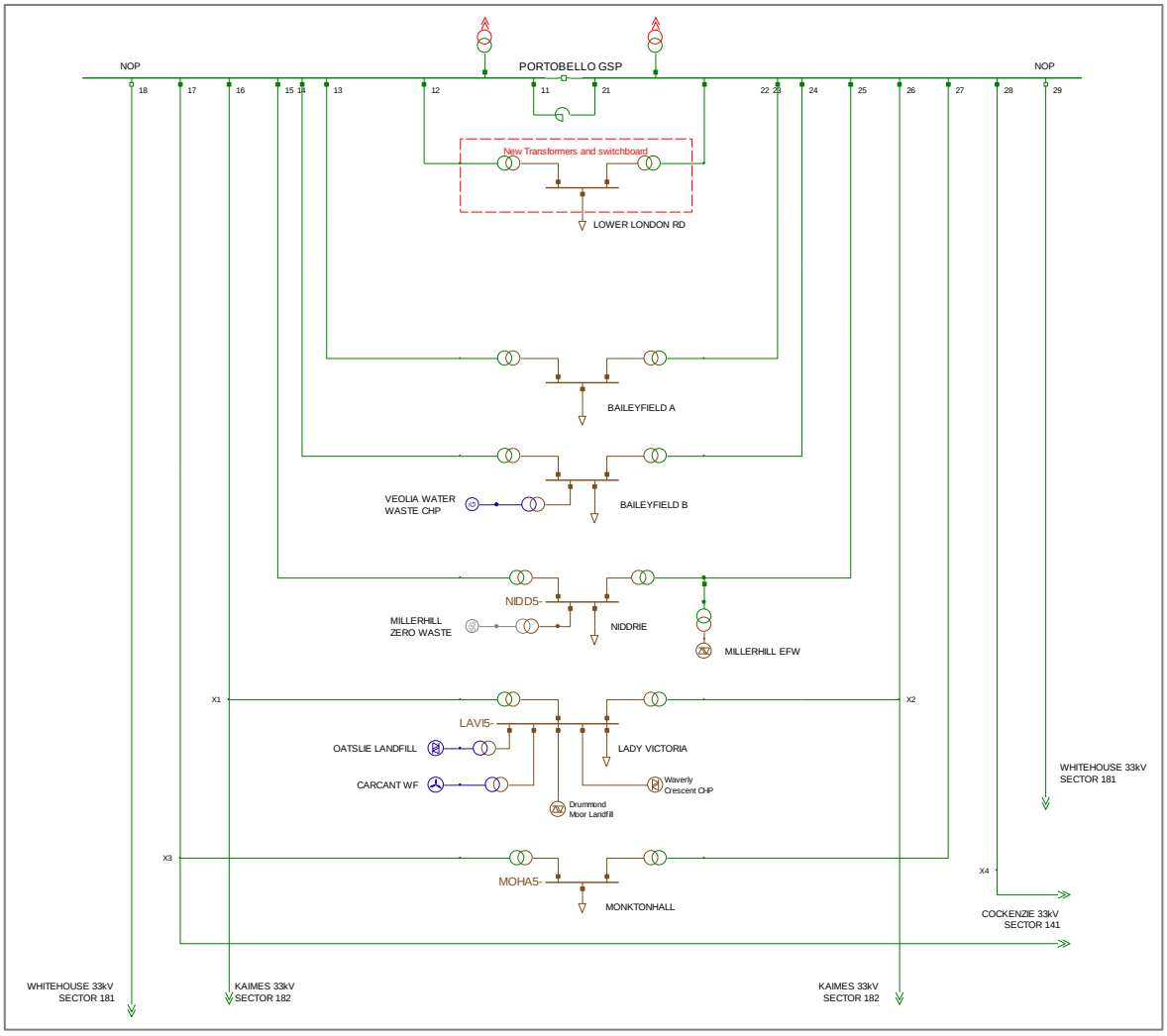


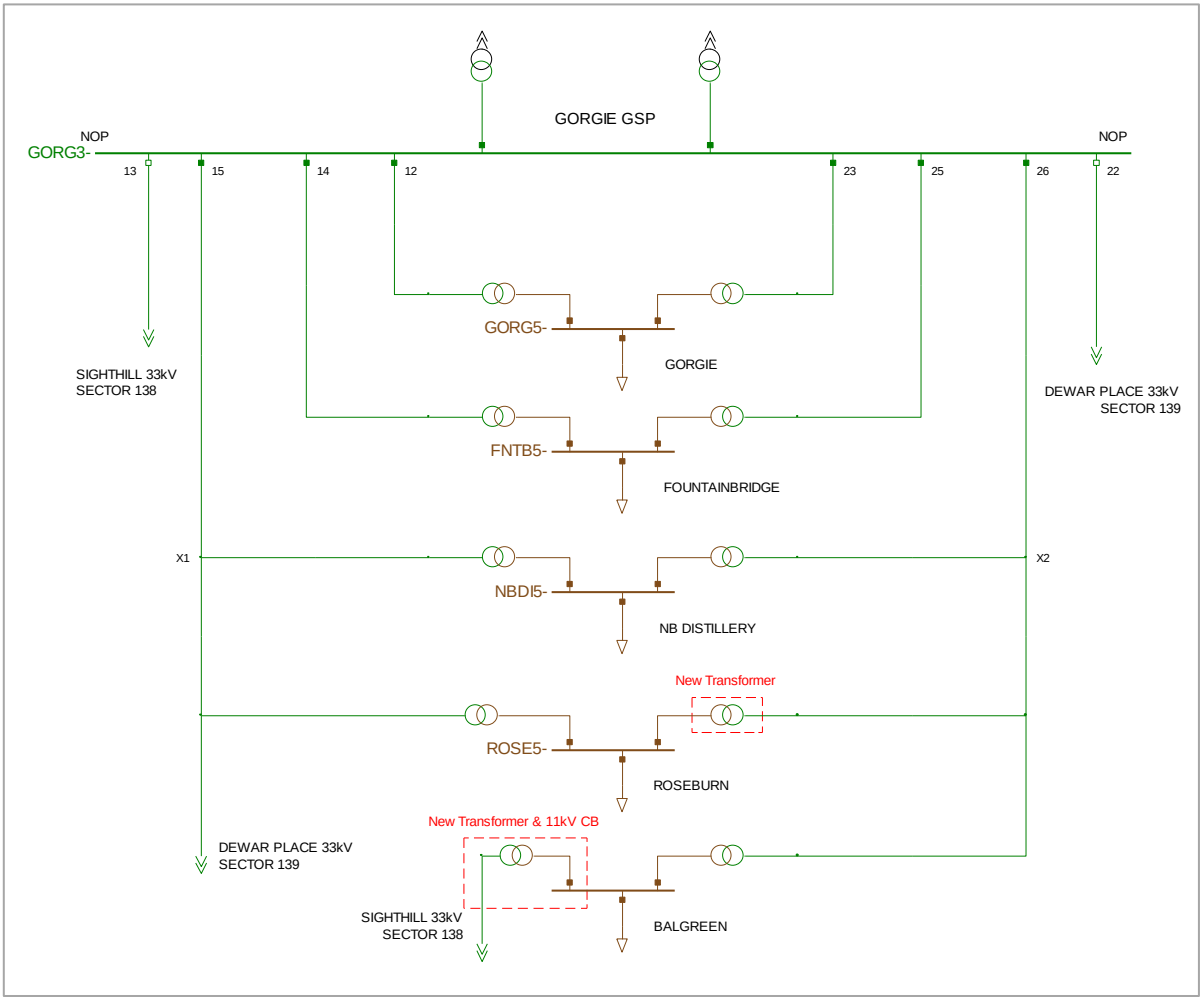
Figure 5-4: 33kV schematic diagram

Lochend Quadrant is served by a single 10MVA, Watford, 33/11kV transformers (1956). The transformer is health index 4 and requires replacement within RIIO-ED2. Lochend Quadrant has an eight panel 11kV Reyrolle (1955) switchboard with a health index of 5. In addition to the asset condition, the site is also in an unsuitable landlocked location with very poor vehicular access or room for expansion. Consequently, following completion of the works at Lower London and Easter Road, it is proposed to decommission Lochend Quadrant and transfer its demand to Easter Road and Lower

London Road by cross jointing onto existing circuits. Flexibility services have been procured to manage the network risk through the delivery stage at a cost of £191k.

Roseburn

Roseburn primary substation is served by a single 20MVA, Brush 33/11kV transformers (2010), fed from Sighthill GSP. This option considers the establishment of a new 33/11kV 20MVA double transformer primary substation, by installing a second 20MVA transformer at the site. It is proposed to utilise an existing 11kV circuit breaker to connect to the 11kV switchboard. The new transformer
5.1.2 will be served from Gorgie GSP by utilising an existing 33kV interconnectable circuit between Gorgie GSP and Sighthill GSP, that runs past Roseburn Substation. A normally open point will be in place at Sighthill GSP. The proposed network configuration is illustrated in Figure 5-5.



5.1.3

Figure 5-5: Proposed 33kV schematic

Balgreen

Balgreen primary substation is served via a single 21MVA, Watford, 33/11kV transformer (1963) fed from Sighthill GSP. The transformer is health index 4 and requires replacement within RIIO-ED2. Balgreen primary has an 8 panel 11kV South Wales (1963) switchboard with a health index of 5. This option considers the establishment of a new 33/11kV 20MVA double transformer primary substation,

by installing a second 20MVA transformer at the site. The existing transformer is due for replacement under asset modernisation.

Balgreen Primary will be fed from Gorgie GSP, via an existing interconnectable circuit between Sighthill GSP and Gorgie GSP. The new feed to Balgreen Primary will run normally open at Sighthill GSP, to ensure Sighthill GSP and Gorgie GSP are not run in parallel. An automation scheme will be established to feed Balgeen Primary from Sighthill GSP for a fault on the Gorgie/Balgreen feeder. A new 11kV circuit breaker will be installed on the Balgreen primary 11kV switchboard to facilitate the connection of the transformer. The proposed network configuration is illustrated in Figure 5-5.

Following the proposed investment, Roseburn, Balgreen, Lower London Road and Easter Road demand groups would be EREC P2/7 compliant under all DFES scenarios.

Table 5.2 shows a summary of reinforcement costs and volumes for the proposed scheme under RIIO-ED2.

Table 5.2. Proposed option summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	1	0.117	0.117	-
6.6/11kV CB (GM) Primary	18	0.499	0.499	-
33kV UG Cable (Non Pressurised)	2.1	0.419	0.419	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	1	0.167	0.167	-
33kV Transformer (GM)	4	1.477	1.477	-
Pilot Wire Underground	5.1	0.565	0.565	-
Civil Works at 33 kV & 66 kV Substations		0.710	0.710	-
Wayleaves/Easements/Land Purchase		0.064	0.064	-
Other Costs (Identify Below)		0.560	0.560	-
Flexibility Services		0.191	0.191	-
Total Costs		4.769	4.769	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£90k)				
RTU/SCADA (£5k)				
33kV telecoms (£200k)				
Network Automation (£107k)				
Remote end protection (£21k)				
Environmental consideration (£15.5k)				
Demolition (£121k)				

Due to asset condition and loading, it is proposed to start the works in 2026/27. A capacity release of 50MVA will be claimed in 2027/28 at the end of the project.

5.2 Option 1 – Establish double feed primary substation at Roseburn, Lower London Road, Lochend Quadrant and Easter Road. Decommission Balgreen

To mitigate the thermal constraints associated with single transformer primary substations in the City of Edinburgh, it is proposed to establish standard double feed primary substations at Roseburn, Lochend Quadrant, Lower London Road and Easter Road. Following the upgrade works, the 11kV network will be re-configured to facilitate the removal of Balgreen Primary. The demand fed from Balgreen will be re-distributed to Roseburn Primary. Table 5.1 shows the scheme summary. The option would enable 40MVA additional network capacity.

Table 5.3. Option 1 summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Conventional	Reinforcement of Single Transformer Primary Substations	Establish double feed primary substation at Roseburn, Lower London Road, Lochend Quadrant and Easter Road. Decommission Balgreen.	8.159	-

Lower London Road/Lochend Quadrant/Easter Road

5.2.1 It is proposed to upgrade the sites at Easter Road, Lower London Road and Lochend Quadrant to standard double fed 20MVA primary substations. The current capacity of this group is restricted to 13MVA due to dependence on common 33KV network and the 11kV interconnector used as a back-up feed post fault.

The existing transformer at Easter Road has a 15/21MVA rating and is connected to a 9-panel C4X 11kV switchboard. The site is bounded on two sides by public roads and is adjacent to a single track infrequently used railway freight line. The substation ground level is approximately 4 metres below the road surface. To comply with The Construction Design and Management (CDM) regulations, while delivering heavy plant to site, it is proposed to reconfigure the site layout and install a ramp for vehicular access. Although not having good access, the site is well positioned within the 11kV network and is geographically advantageous to serve incremental growth in its vicinity.

To reconfigure the site, the switchboard and existing transformer at Easter Road will require to be replaced. The single 21MVA transformer will be replaced with two new MIDEL filled 20MVA transformers. A new 11kV switchboard will be established with foundation for 15 panels and populated with 9 circuit breakers. The existing assets are reaching end of life and would otherwise require replacement within the RIIO-ED2 period, regardless of these proposals. The proposed option releases capacity, improves access to the site, keeps the well positioned location of Easter Road Primary and reduces network risk with the replacement of aging assets.

Easter Road primary will continue to be supplied from Shrubhill GSP by installing a new circuit breaker on the 33kV switchboard at Shrubhill B GSP and 1.4km of 33kV underground cable circuit with associated comms infrastructure from Shrubhill GSP to the Easter Road site. The 33kV network schematic, an aerial view of the site and the proposed route are shown in Figure 5-1, Figure 5-2 and Figure 5-3, respectively.

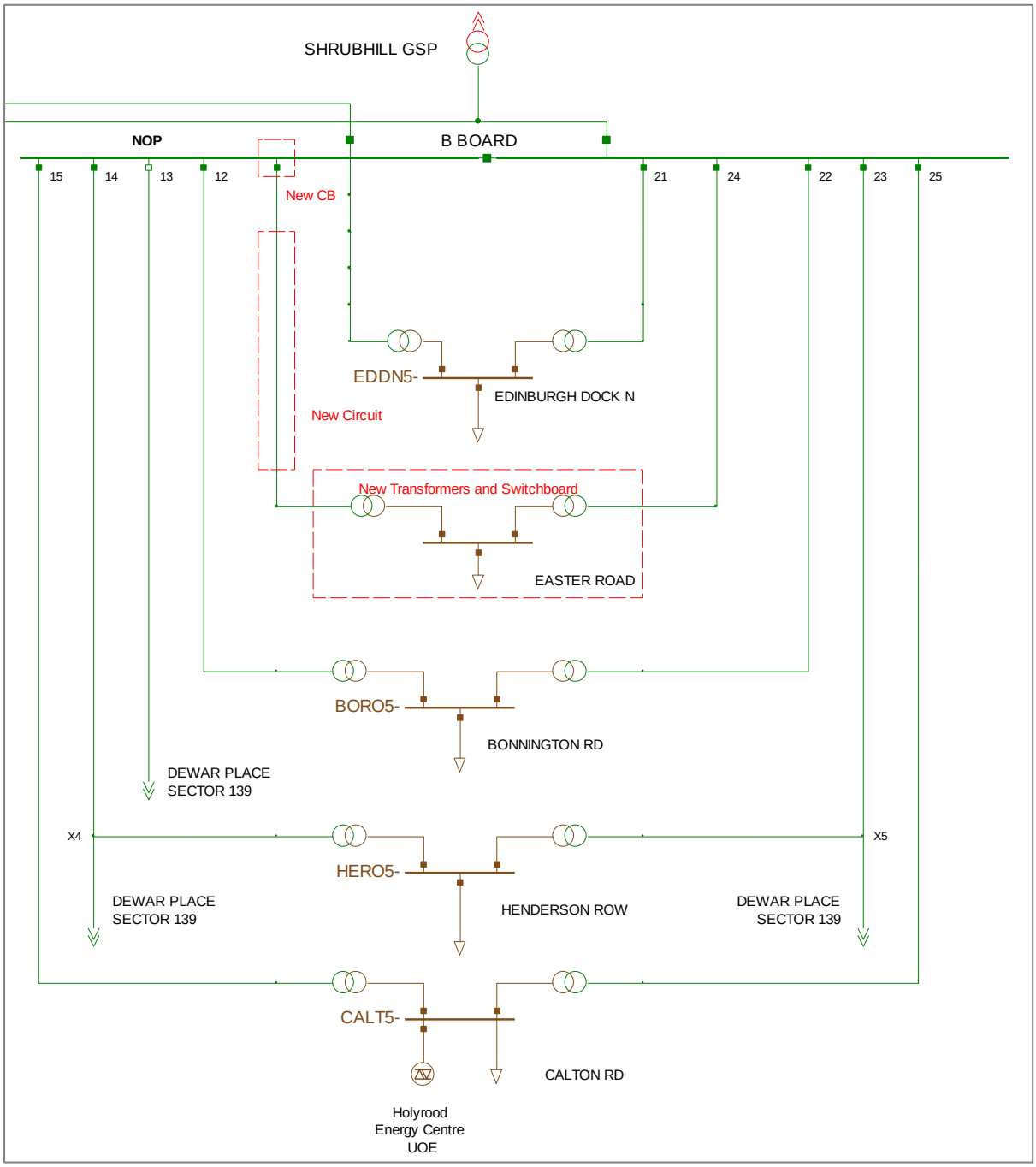


Figure 5-6: 33kV schematic diagram

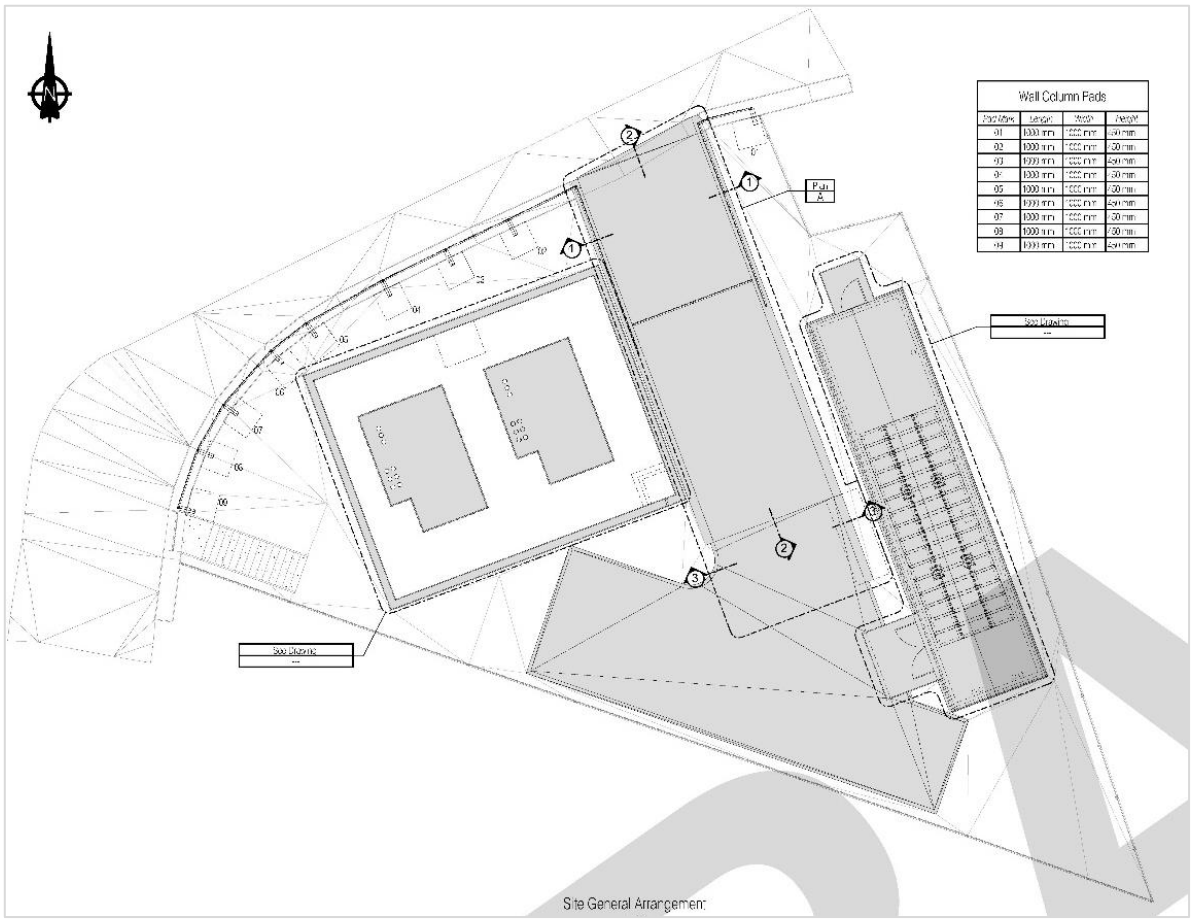


Figure 5-7: Ariel View of Proposed Site

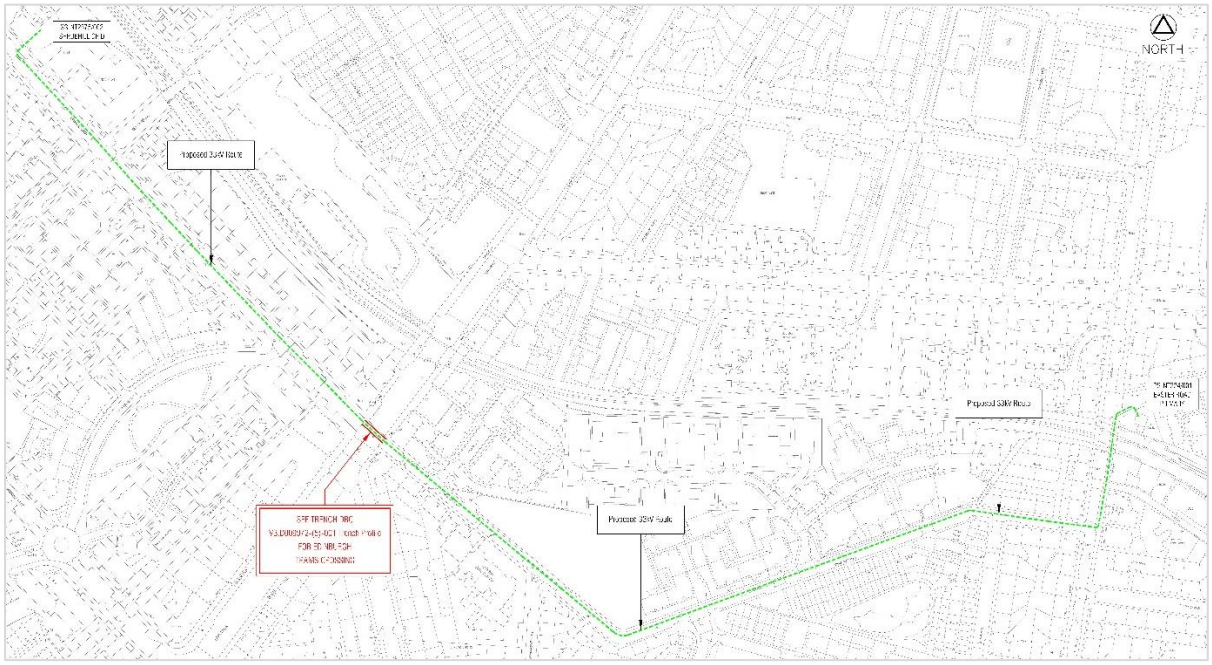


Figure 5-8: Proposed route from Shubhill GSP to Easter Road Primary

Lower London Road substation is served by two 10MVA, Watford, 33/11kV transformers (1956) banked onto a single 33kV feeder. Both transformers are health index 5 and require replacement within RIIO-ED2. Lower London Road has an eight panel 11kV English Electric (1956) switchboard with a health index of 4. In order to facilitate the additional demand from Lochend Quadrant, it is proposed to establishment of a new 33/11kV 20MVA double transformer primary substation. Due to the existing asset condition and asbestos issues at the site, it is required to replace the existing assets and reconfigure the layout of the site. It is therefore proposed to:

- Establish new 11kV switchboard with foundation for 11 panels, populated with 8x CB
- Plant 2x 20MVA Tx at new site (under asset replacement)
- At Portobello GSP, install one new circuit breaker on the existing 33kV switchboard.
- Provide a dedicated connection from Portobello GSP to the Lower London Road primary substation by installing 2.8km of new 33kV underground cable circuit with associated communications infrastructure.

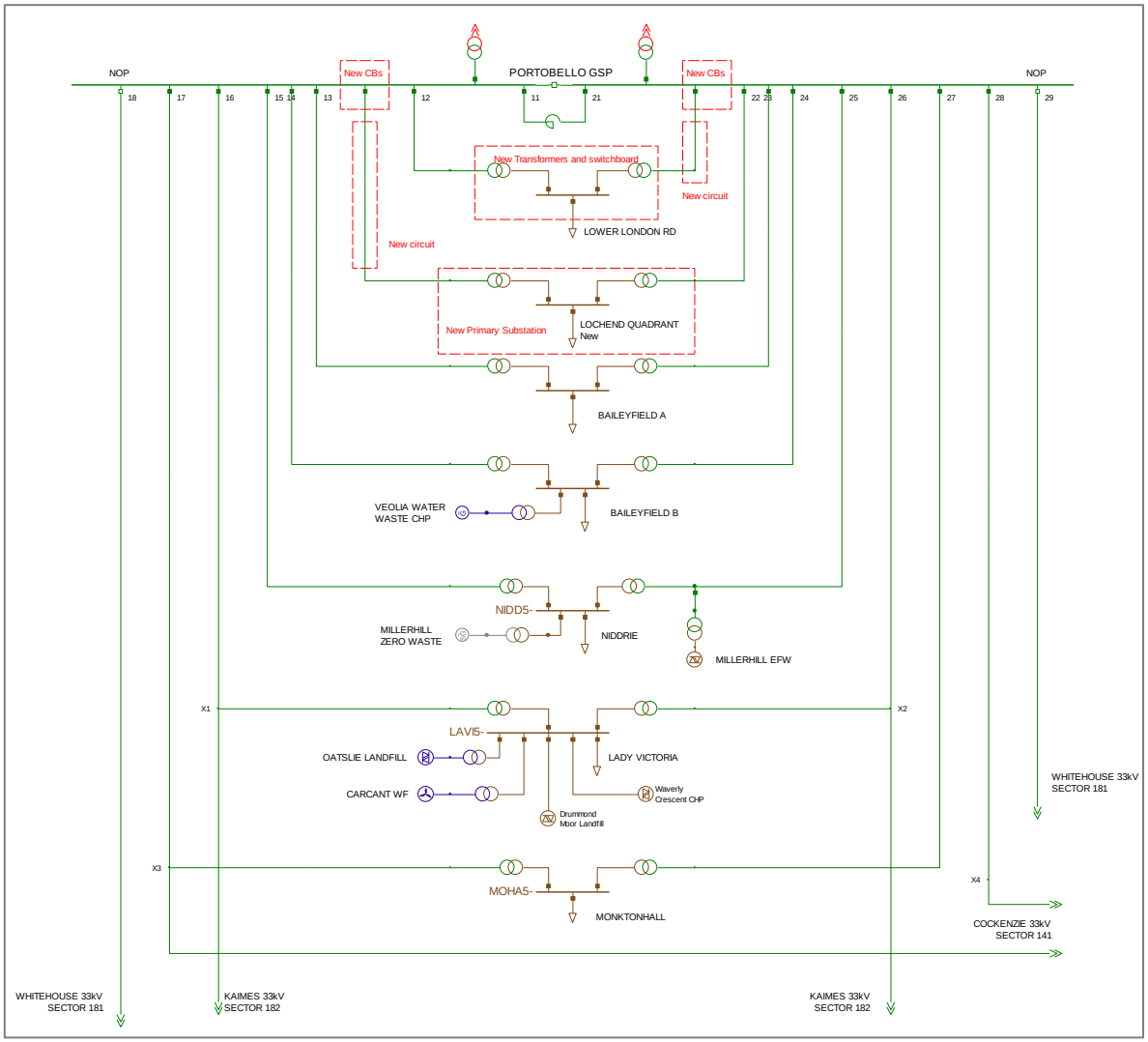


Figure 5-9: 33kV schematic diagram

Lochend Quadrant is served by a single 10MVA, Watford, 33/11kV transformers (1956). The transformer is health index 4 and requires replacement within RIIO-ED2. Lochend Quadrant has an eight panel 11kV Reyrolle (1955) switchboard with a health index of 5. In addition to the asset

condition, the site is also in an unsuitable landlocked location with very poor vehicular access or room for expansion. Consequently, it is proposed to relocate Lochend Quadrant to a new site. At the new site, a new double transformer primary will be established. It is proposed to:

- Purchase land for new substation close to the existing site
- Establish new 11kV switchboard with foundation for 12 panels, populated with 9x CB
- Plant 2x 20MVA Transformers at new site
- At Portobello GSP, install one new circuit breaker on the existing 33kV switchboard.
- Provide a dedicated connection from Portobello GSP to the Lochend Quadrant primary substation by installing 2.5km of new 33kV underground cable circuit with associated communications infrastructure.
- Flexibility services have been procured to manage the network risk through the delivery stage at a cost of £191k.

Roseburn

5.2.2 Roseburn primary substation is served by a single 20MVA, Brush 33/11kV transformers (2010), fed from Sighthill GSP. It is proposed to establish a new 33/11kV 20MVA double transformer primary substation, by installing a second 20MVA transformer at the site. The scheme will utilise an existing 11kV circuit breaker to connect the transformer to the 11kV switchboard. The new transformer will be served from Gorgie GSP by utilising an existing 33kV interconnectable circuit between Gorgie GSP and Sighthill GSP, that runs past Roseburn Substation. A normally open point will be in place at Sighthill GSP. The proposed network configuration is illustrated in Figure 5-10.

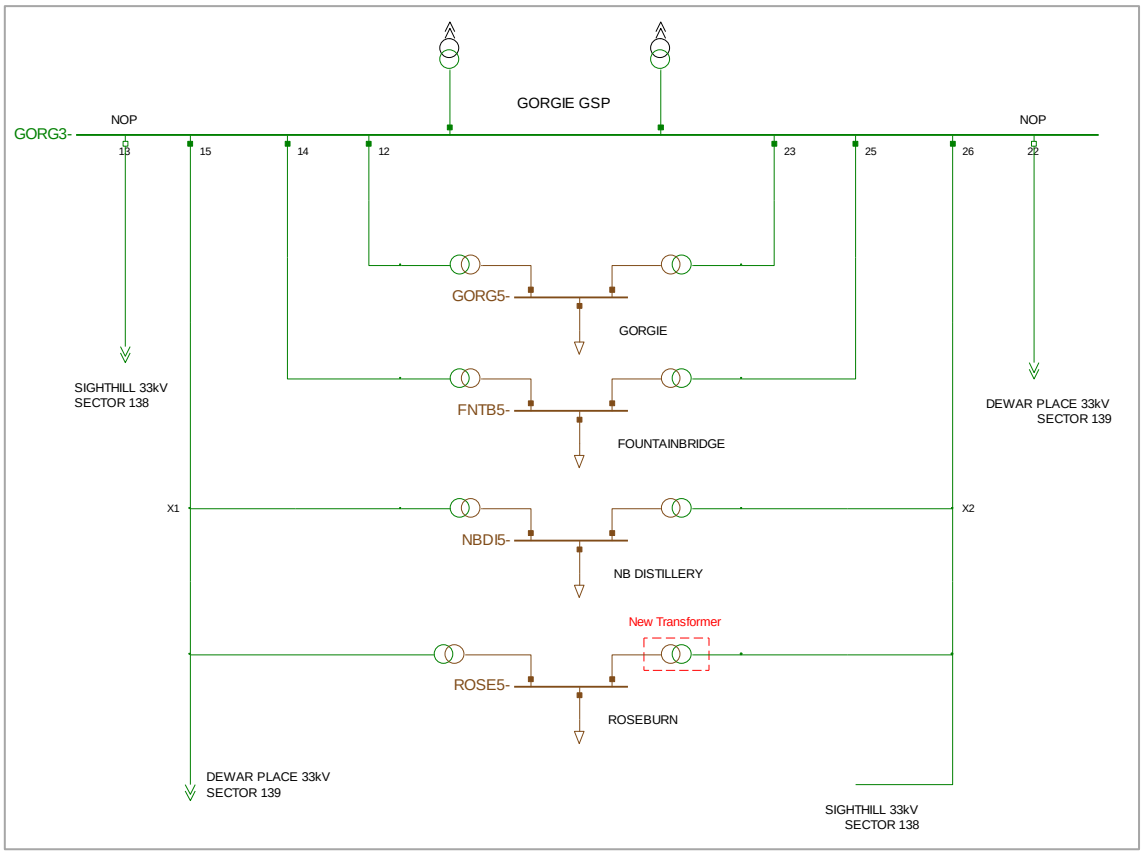


Figure 5-10: Option 1 33kV schematic – Roseburn Primary

Balgreen

Balgreen primary substation is served via a single 21MVA, Watford, 33/11kV transformer (1963) fed from Sighthill GSP. The transformer is health index 4 and requires replacement within RIIO-ED2. Balgreen primary has an 8 panel 11kV South Wales (1963) switchboard with a health index of 5. In addition to the asset condition, the site is also in an unsuitable landlocked location with very poor vehicular access or room for expansion. Consequently, following completion of the works at Roseburn
5.2.3 primary, it is proposed to decommission Balgreen primary and transfer its demand to Roseburn primary by cross jointing onto existing circuits.

Following the proposed investment, Roseburn, Lochend Quadrant, Lower London Road and Easter Road demand groups would be EREC P2/7 compliant under all DFES scenarios.

Table 5.4 shows a summary of reinforcement costs and volumes for the proposed scheme under RIIO-ED2.

Table 5.4. Option1 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	4.9	0.580	0.580	-
6.6/11kV CB (GM) Primary	27	0.749	0.749	-
33kV UG Cable (Non Pressurised)	7.7	1.537	1.537	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	3	0.501	0.501	-
33kV Transformer (GM)	5	1.846	1.846	-
Pilot Wire Underground	12.6	1.400	1.400	-
Civil Works at 33 kV & 66 kV Substations		0.719	0.719	-
Wayleaves/Easements/Land Purchase		0.078	0.078	-
Other Costs (Identify Below)		0.558	0.558	-
Flexibility Services		0.191	0.191	
Total Costs		8.159	8.159	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£180k)				
RTU/SCADA (£15k)				
33kV telecoms (£200k)				
Remote end protection (£63k)				
Environmental consideration (£46.8k)				
Demolition (£121k)				

5.3 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5.5.

Table 5.5. Cost summary for considered options

Options	Option Summary	RIIO-ED2 Cost (£m)
Baseline	Establish double feed primary substation at Roseburn, Balgreen, Lower London Road and Easter Road. Decommission Lochend Quadrant.	4.769
Option 1	Establish double feed primary substation at Roseburn, Lower London Road, lochend quadrant and Easter Road. Decommission Balgreen primary.	8.159

Derivation of costs for these options are based on the SPEN RIIO-ED2 Unit Cost Manual for intervention. This is based on bottom up cost assessment of the components of activity detailed within the RIGs Annex A for the above activities, SPEN's contractual rates for delivery, market available rates and historic spend levels.

6 Deliverability & Risk

6.1 Preferred Options & Output Summary

The adopted option is the baseline option to decommission Lochend Quadrant and establish standard double transformer primary substations at Lower London Road, Easter Road, Roseburn and Balgreen. Flexibility services will be procured to reduce risk during outages of Lochend Quadrand and Lower London Road.

6.2 Cost Benefit Analysis Results

A cost benefit analysis (CBA) was carried out to compare the NPV of the options discussed in the previous sections. Considering the lowest forecast capital expenditure, the proposed option has the highest total NPV against other options. The summary of the cost benefit analysis is presented in Table 6.1. The full detailed CBA is provided within 'ED2-LRE-SPD-028-CV1-CBA – Single Primary Transformer Sites'.

Table 6.1. Cost benefit analysis results

Options considered	Decision	Comment	NPVs based on payback periods, £m (2020/21 prices)			
			10 years	20 years	30 years	45 years
Baseline – Establish double feed primary substation at Roseburn, Balgreen, Lower London Road and Easter Road. Decommission Lochend Quadrant.	**Adopted**					
Option 1- Establish double feed primary substation at Roseburn, Lower London Road, lochend quadrant and Easter Road. Decommission Balgreen primary.	Rejected	Discounted on the basis of no additional capacity uplift compared to the baseline, and higher reinforcement cost.	-1.46	-2.20	-2.65	-2.99

6.3 Cost & Volumes Profile

Table 6.2 shows the breakdown of expenditure for the proposed scheme (in 2020/21 prices) and the cost incidence (in 2020/21 prices) over the RIIO-ED2 period is shown in Table 6.3. The total cost of the proposed scheme is £4.769m.

Table 6.2: Summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	1	0.117	0.117	-
6.6/11kV CB (GM) Primary	18	0.499	0.499	-
33kV UG Cable (Non Pressurised)	2.1	0.419	0.419	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	1	0.167	0.167	-
33kV Transformer (GM)	4	1.477	1.477	-
Pilot Wire Underground	5.1	0.565	0.565	-
Civil Works at 33 kV & 66 kV Substations		0.710	0.710	-
Wayleaves/Easements/Land Purchase		0.064	0.064	-
Other Costs (Identify Below)		0.560	0.560	-
Flexibility Services		0.191	0.191	-
Total Costs		4.769	4.769	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Planning and design (£90k)				
RTU/SCADA (£5k)				
33kV telecoms (£200k)				
Network Automation (£107k)				
Remote end protection (£21k)				
Environmental consideration (£15.5k)				
Demolition (£121k)				

Table 6.3: Cost incidence over the RIIO-ED2 period, £m (2020/21 Prices)

Total Investment	Total (£m)	Incidence (£m)				
		2023/24	2024/25	2025/26	2026/27	2027/28
CV1 Expenditure	**4.769**	0.042	0.037	0.035	1.630	3.026

6.4 Risks

The switchboard and transformer replacement are BaU activities and hence the risks associated with the delivery of the scheme are very minimal. The past track record for delivery of switchgear and transformer replacements are presented in the section 5 of Annex 4A.10: Substations & Switchgear; EHV to LV in our RIIO-ED2 business plan.

The delivery of this scheme will be co-ordinated with the delivery of SPD non-load EHV switchgear and transformer modernisation (under CV7) and for operational efficiencies and minimize the network impact.

All major connections will be secure during the construction period. However, during the changeover from the existing to the proposed system, the demand associated with individual 11kV circuits will be on reduced security of supply. This risk will be minimised by using an offline build approach and/or having suitable plans for the reconnection of lost supplies in the event of loss of remaining infeed's during construction outages.

6.5 Outputs Included in RIIO-ED1 Plans

There are no outputs expected to be delivered in RIIO-ED1 that are funded within this proposal.

6.6 Future Pathways – Net Zero

Primary Economic Driver

The primary drivers for this investment are insufficient transfer capacity & security of supply risk. The investment does not have a strong reliance on environmental benefits. A secondary driver for the investment is asset health.

Payback Periods

6.6.1 The CBA indicates that for the proposed option demonstrates better NPV results in all assessment periods (10, 20, 30 & 45 years) against other options. As the intervention is forecast to carry at least a 45-year asset life expectancy, the CBA at this time justifies the intervention. Consumers will also
6.6.2 benefit from reduced network risk immediately on completion of the project.

Sensitivity to Future Pathways

The network capacity and capability that result from the proposed option is consistent with the network requirements determined in line with the section 9 of the Electricity Act and Condition 21.
6.6.3 Additionally, the proposed option is consistent with the SPEN's Distribution System Operator (DSO) Strategy and Distribution Future Energy Scenarios.

Table 6.4 and Table 6.5 show electric vehicle and heat pump uptakes across a range of future pathways for the demand groups. Table 6.6 shows the sensitivity of the proposed solution and Table 6.7 shows the sensitivity of the proposed RIIO-ED2 expenditure against the full ranges of Net Zero complaint future pathways other Climate Change Committee (CCC) scenarios.

Table 6.4: Electric Vehicle uptakes across a range of future pathways for the demand groups

End of RIIO-ED2	SPEN	DFES		CCC				
	Baseline	Consumer Transformation	Leading the Way	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Roseburn	164	194	226	197	135	214	195	195
Balgreen	1,947	2,051	2,640	2,336	1,608	2,541	2,314	2,314
Lower London Road	79	130	147	95	65	103	94	94
Easter Road	103	83	115	124	85	134	122	122
Lochend Quadrant	188	211	254	226	155	245	223	223

*Note: We have excluded System Transformation from our future pathways assessment as it does not meet interim greenhouse gas emission reduction targets.

Table 6.5: Heat Pump uptakes across a range of future pathways for the demand groups

End of RIIO-ED2	SPEN	DFES		CCC				
	Baseline	Consumer Transformation	Leading the Way	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Roseburn	0	0	0	0	0	0	0	0
Balgreen	1	2	1	1	1	1	1	1
Lower London Road	75	94	91	66	50	76	71	63
Easter Road	0	0	0	0	0	0	0	0
Lochend Quadrant	0	0	0	0	0	0	0	0

*Note: We have excluded System Transformation from our future pathways assessment as it does not meet interim greenhouse gas emission reduction targets.

Table 6.6: Sensitivity of the proposed solution against future pathways

	RIIO-ED1				RIIO-ED2					RIIO-ED3				
Solution Requirements	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Baseline					F	F	F	F	R[1]					
Consumer Transformation					F	F	F	F	R[1]					
Leading the Way					F	F	F	F	R[1]					
Balanced Net Zero Pathway					F	F	F	F	R[1]					
Headwinds					F	F	F	F	R[1]					
Widespread Engagement					F	F	F	F	R[1]					
Widespread Innovation					F	F	F	F	R[1]					
Tailwinds					F	F	F	F	R[1]					

F – Utilise flexibility services

The proposed solution is robust across the range of future pathways. The selected solution is required under all scenarios within the RIIO-ED2 period. In all cases this solution is expected to endure beyond RIIO-ED3.

Table 6.7: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	**Uncertain**
RIIO-ED2 Expenditure (£m)	4.769	0
Comment	Proposed option	Not sensitive to future pathways

6.6.4 Asset Stranding Risks & Future Asset Utilisation

Electricity demand and generation loadings are forecast to increase under all scenarios. The stranding risk is therefore considered to be low.

6.6.5 Losses / Sensitivity to Carbon Prices

Losses have been considered in accordance with Licence Condition SLC49 and the SP Energy Networks Losses Strategy and Vision to "consider all reasonable measures which can be applied to reduce losses and adopt those measures which provide benefit for customers". Reasonable design efforts have been taken to minimise system losses without detriment to system security, performance, flexibility or economic viability of the scheme. This includes minimising conductor lengths/routes, the choice of appropriate conductor sizes, designing connections at appropriate voltage levels and avoiding higher impedance solutions or network configurations leading to higher losses.

Losses have been considered as part of this design solution and it has not been necessary to carry out any losses justified upgrades. MWh losses for each of the options have been included within the cost benefit analysis and solution selection was not found to be sensitive to the impact of the carbon cost of losses.

During the evaluation of the options associated with the proposed scheme, we have embedded within the CBA, where data are available, an assessment of the embodied carbon and the associated carbon cost to inform our NPV evaluation. The mass of carbon dioxide emitted (CO_2e) during the manufacture of the main equipment deployed to deliver this scheme is estimated to be 595 tonnes. The monetised embodied carbon value associated with this emission is £41.5k. It should be noted that the embodied carbon evaluation undertaken has only considered the manufacture and supply of materials. Further collaborative industry-wide work is planned for the RIIO-ED2 price review period to better understand the overall embodied carbon values including, for example installation and

commissioning services, decommissioning and disposal activities as well as refurbishment opportunities. More information regarding this can be found in Section 3.1.2 of our Environmental Action Plan[2].

Whole Systems Benefits

Whole system solutions have been considered as part of this proposal. No alternatives have been identified that could be provided through a whole systems solution. The completion of this scheme will maintain the integrity of the distribution network and its enduring ability to facilitate wider whole system benefits.

6.6.6

6.7 Environmental Considerations

Operational and Embodied Carbon Emissions

The Single Transformer Primary Sites Reinforcement programme has the potential to impact on the embodied carbon resulting from the delivery of the programme. There is likely to be little or no impact

6.7.1 on SPEN's Business Carbon Footprint (BCF).

Supply Chain Sustainability

For us to take full account of the sustainability impacts associated of the Single Transformer Primary

6.7.2 Sites Reinforcement programme, we need access to reliable data from our suppliers. The need for carbon and other sustainability credentials to be provided now forms part of our wider sustainable procurement policy.

6.7.3 Resource Use and Waste

The Single Transformer Primary Sites Reinforcement programme will result in the consumption of resources and the generation of waste materials from the construction of new assets and end of life assets.

Where waste is produced it will be managed in accordance with the waste hierarchy which ranks waste management options according to what is best for the environment. The waste hierarchy gives top priority to preventing waste in the first instance, then preparing for re-use, recycling, recovery,

6.7.4 and last of all disposal (e.g. landfill).

Biodiversity / Natural Capital

The Single Transformer Primary Sites Reinforcement programme will affect all named sites containing existing assets and on undeveloped sites on the route of new underground cables. We will minimise

6.7.5 the area of land take required and will minimise disturbance to soils and vegetation during construction. We will replace and enhance the existing habitat, working with relevant stakeholders to identify the measures required to achieve a net gain in biodiversity and wider ecosystem services.

Preventing Pollution

SPEN will always follow all relevant waste regulations and will make sure that special (hazardous) waste produced or handled by our business is treated in such a way as to minimise any effects on the environment.

[2] Annex 4C.3: Environmental Action Plan, SP Energy Networks, Issue 2, 2021.

Visual Amenity

SPEN continually seeks to reduce the landscape and visual effects of our networks and assets but recognises that the nature of our substations makes it challenging to minimise their visual impact. Our use of underground cables instead of overhead lines helps to minimise our overall visual impact.

Climate Change Resilience

6.7.6 In addition to our efforts to minimise our direct carbon emissions in line with our Net Zero ambitions, we are also conscious of the need to secure the resilience of our assets and networks in the face of a changing climate. We have also modified our policy on vegetation control in the face of higher temperatures and longer growing seasons.

6.7.7

7 Conclusion

In order to secure supplies at high priority sites within the City of Edinburgh, meet the licence obligations under EREC P2/7, and to accommodate future demand growth within the area, it is proposed to establish standard double feed primary substations at Roseburn, Balgreen, Lower London Road, Easter Road and reclaim Lochend Quadrant. The proposed works are:

1. Establish a Double transformer primary at Easter Road:
    a. At Shrubhill "B" Grid Supply Point (GSP) install one new circuit breakers on the existing 33kV switchboard.
    b. Provide a dedicated connection from Shrubhill "B" GSP to the Easter Road primary substation by installing 1.4km of new 33kV underground cable circuit with associated communications infrastructure.
    c. Plant two new 33/11kV 20MVA MIDEL primary transformers and a new 15-panel 11kV board, populated with 9 circuit breakers, at the Easter Road Primary substation.
    d. Install ramp for vehicular access to Easter Road primary substation.
2. Establish a Double transformer primary at Lower London Road:
    a. Install a new 11-panel 11kV board, populated with 8 circuit breakers, at Lower London Road Primary substation.
    b. Utilise Ex Lochend Quadrant 33kV circuit for a second feeder with O.3km of circuit required to facilitate the connection.
    c. Install Comms and fibre from the Lower London substation to Portobello GSP
    d. Plant two new 33/11kV 20MVA primary transformers under asset modernisation
3. Decommission Lochend Quadrant and transfer its demand to Easter Road and Lower London Road by cross jointing onto existing circuits.
4. Establish a Double transformer primary at Balgreen:
    a. Plant one new 33/11kV 20MVA transformer.
    b. At Balgreen primary substation, install one new circuit breaker on the existing 11kV switchboard.
5. Establish a Double transformer primary at Roseburn:
    a. Plant one new 33/11kV 20MVA transformer.
    b. At Roseburn primary substation, utilise an existing circuit breaker on the 11kV switchboard.
    b. Provide a dedicated connection from Gorgie GSP to Roseburn primary substation by cross jointing onto the Gorgie GSP to Sighthill GSP interconnector that passes the site.
6. Procure flexibility services to manage network risk through the delivery stage at a cost of £191k.

The estimated cost for the above is £4.769m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Due to asset condition and thermal loading, it is proposed to start the works in 2026/27. A capacity release of 50MVA will be claimed in 2027/28 at the end of the project.

8 Appendices

Appendix 1. SPD Single Transformer Sites

Single Transformer Sites	Voltage (kV)	Number of Customers
AUCHNEEL	11	2357
AUCHTERMUCHTY	11	2867
BALGREEN	11	5788
BARNTON GROVE	11	3363
BARRHILL	11	579
BELHAVEN FORTH	11	2560
BIGGAR	11	3104
CARRUTHERSTOWN	11	929
COLINSBURGH	11	1692
COLLYDENE	11	4305
CREETOWN	11	603
DARVEL	11	1566
DUNSCORE	11	604
EAST LINTON	11	1486
EASTER ROAD	11	6696
EYEMOUTH	11	2511
FAIRLIE	11	808
FORTH	11	1815
GAUZE ROAD	11	3280
GLENLUCE	11	963
GORDON	11	829
GREENLAW	11	498
HORNCLIFFE	11	687
KIRKBANK	11	417
LARGS	11	8312
LAUDER	11	1785
LINTON LANE	11	3287
LOCHEND QUADRANT	11	6564
LOCHSIDE	11	1086
MIDDLEBIE	11	1200
MOREBATTLE	11	632
MORTONHALL	11	3416
MUIRHOUSE BANK	11	6383
NEWBURGH	11	1526
NEWCASTLETON	11	652
NORHAM	11	791
OXGANGS ROAD	11	4564
PARK ROAD	11	5664
PENCAITLAND	11	2209
PINWHERRY	11	1006
POLTONHALL	11	4897
RANDOLPH LANE	11	5396
ROSEBURN	11	3280
SPOTT ROAD	11	2222
STELRAD	11	1
ST. BOSWELLS	11	4341
STONEHOUSE	11	2388
SYMINGTON	11	1349
WHITCHESTER	11	298
WILLIAM STREET	11	2791
YETHOLM	11	630