



Title: City of London 33kV Network

LPN Regional Development Plan No 5

Version: 1.8

Date: March 2014

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1 Executive Summary

The City of London, although little more than 1 square mile is one of the world's leading international financial, business and maritime centres contributing 12% to London's and 8.5% of the UK's GDP.

Despite the recent turmoil in the financial sector, requests for new connections from flagship developments have continued with new land marks such as the 'Walkie Talkie' and 'Cheese Grater' under construction.



122 Leadenhall Street (Cheese Grater)



20 Fenchurch Street (Walkie Talkie)

Due primarily to computing and environmental services, the power requirements of the new developments are significantly greater than the buildings they replace with point loads typically in the range 8 to 15MW. Connection applications currently exceed 100MW and analysis confirmed that this increased could not be accommodated within the capacity headroom of the existing local 11kV substations which are space constrained with little, if any, scope for extension for additional transformers or switch panels.

However, 33kV capacity headroom was identified at Back Hill and Finsbury Market and a strategy has been developed to supply the larger point loads from 2x 60MVA feeder groups (designated 'red' and 'green') installed between these two substations which boarder the City. Installation of the network is now substantially complete and part energised with overall project completion programmed for mid-2014. The network design providing the benefits of:

- resilient dual supplies sourced from diverse super grid exit points (St John Wood & City Road)
- ability to maintain supplies should either primary source substation (Back Hill or Finsbury Market) suffer a complete shutdown
- increased fault level capacity headroom to facilitate connection of distributed generation
- avoiding the need for expensive and high deliver risk reinforcement of existing 11kV substations
- less disruption from street excavation due to a reduced number of cables required to achieve the same power transfer (33kV cables have treble the capacity of an equivalent 11kV cable).
- reduced system losses which are proportional to I^2R (I =current, R =circuit resistance), at given power transfer, increasing the operating voltage from 11kV to 33kV will decreases losses by $2/3^{rds}$

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This Development Plan proposes 4 stages of future enhancements.

Stage 1: Establish a 3rd (blue) feeder group to supply new developments to the east of the Square Mile between Finsbury Market and Wellclose Square

Stage 2: Uprate the 'red' feeder group to 90MVA to cater for increased connection activity which is currently being experienced in the southern sector of the Square Mile

Stage 3: Uprate the 'green' feeder group to 90MVA to supply the expected increase in connection activity in the northern sector

Stage 4: Uprate/replace L42 switchgear at Back Hill with higher short circuit capacity equipment to facilitate distributed generation connections.

The existing 33kV network was planned with a high emphasis on achieving harmonisation with other asset replacement and reinforcement work to achieve cost optimisation and reduce outage planning constraints. This objective is to be continued during the next phase with the increase to 90MVA rated feeder groups linked to the asset replacement of transformers at Back Hill and Finsbury Market, establishment of the new 33kV Wellclose Square main substation developed in conjunction with the collocated 11kV main substation and the need for new 132kV supply cables and disruptive open-cut works avoided by utilising capacity headroom in the New Cross to Osborn Street circuits which are installed in the new deep cable tunnel.

Based on intelligence from key stakeholders, these developments are considered to have a high to medium high probability of delivery during ED1. As a customer orientated network it is recognised that timescales will be influenced by wider economic factors and to cater for this uncertainty an incremental approach can be adopted to each stage to achieve a balance between customer requirements, value for money and wider network requirements.

Proposed Project > £1M

Asset Replacement

- | | |
|--|--------|
| • 7854 Back Hill Replace GT4B | £1.44M |
| • 7855 Finsbury Market 'B' Replace GT1B, 2B & 3B | £4.23M |

Reinforcement

- | | |
|--|--------|
| • 6156 Finsbury Market 'B' feeder reconfiguration | £1.14M |
| • 5591 Finsbury Market: Establish 132kV interconnection to Osborn Street | £4.89M |
| • 6112 Back Hill ITC | £5.87M |
| • 6330 St Johns Wood to Back Hill increase 132kV circuit capacity | £5.82M |
| • 4388 City of London: Install 'blue' feeder group | £1.21M |
| • 6111 Wellclose Square: Establish 132/33kV MSS | £3.43M |

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Costs Profile

Cat.	Reference	Description	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
A		Asset Replacement Total	0	0	82,565	492,809	495,731	3,794,234	1,385,927	0	0	87,278
R		Reinforcement Total	182,295	-203,947	251,267	9,807,965	7,329,908	1,078,993	41,199	25,510	193,876	3,214,259
		Grand Total	182,295	-203,947	333,832	10,300,774	7,825,639	4,873,227	1,427,126	25,510	193,876	3,301,537

Principal Risks, Dependencies & Assumptions

The phasing of each stage will be dependent on demand for new office and commercial premises with location dictating the most appropriate feeder group for connection.

Construction works at Wellclose Square 132/11kV substation are assumed to precede the 33kV substation.

Impact of the New Cross – Wellclose Square Tunnel Construction Programme

Construction of the New Cross-Wellclose tunnel has been delayed due to third party land issues associated with the location of an intermediate shaft in Southwark. There are consequential delays to the commissioning of Osborn Street 'B' substation which is not now expected until mid-2016.

Osborn Street is required to facilitate demand transfers thereby increasing capacity headroom on the 3x132kV City Road-Finsbury Market cables which will become a constraint for supplying customers connected on the 'green' feeder group and, under abnormal running arrangements, the 'red' feeder group. Mitigation works involving advancement of Back Hill reinforcement, commissioning Osborn Street from an alternative 132kV source and installation of the first sections of the 'blue' feeder group are available for implementation dependent on the 33kV network demand 'pick-up' rate and background incremental growth.

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Green Group:

- Supplies customers in the central and northern areas of the City of London
- 4x 630 sq mm copper cables installed in ducts
- Normally supplied from Back Hill with the bussing bar at Finsbury Market

Red Group (schematic included at Appendix E):

- Supplies customers in the central and south of the City of London
- Normally supplied from Finsbury Market with a bussing bar at Back Hill
- 4x 630 sq mm copper cables installed in ducts between Finsbury Market and Paternoster
- 4x 630 sq mm aluminium cables installed in the existing deep cable tunnel between Paternoster and Back Hill

2.3 Bussing Bar Concept

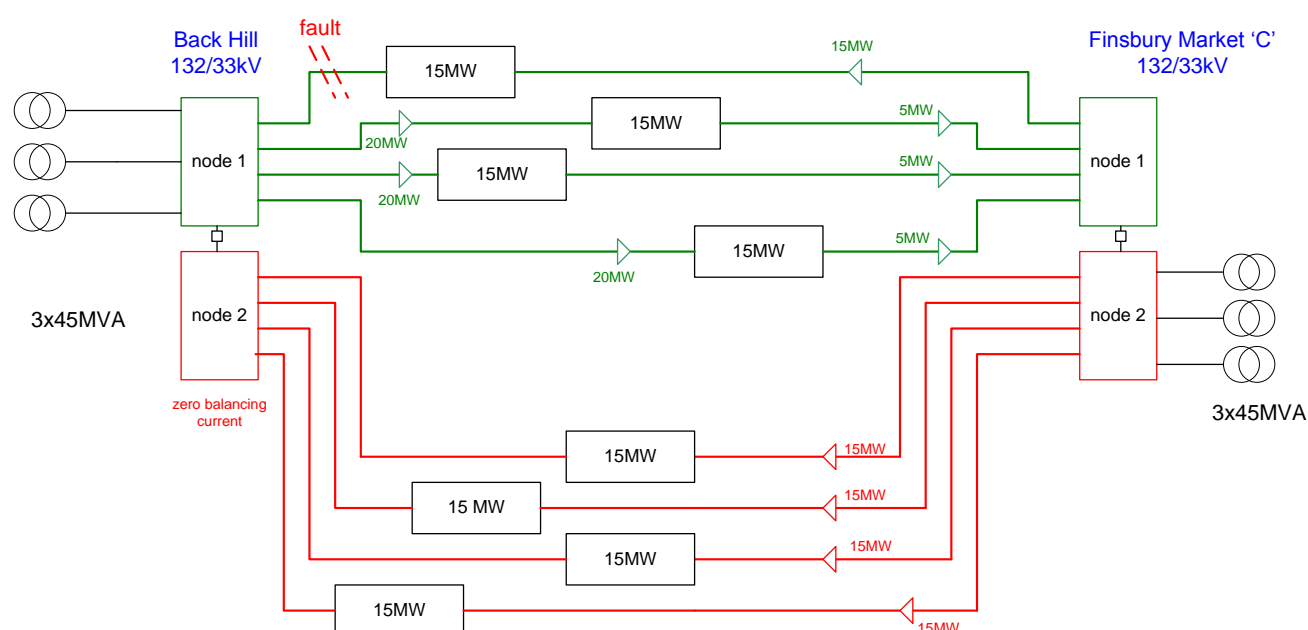
The 'bussing bar' design is illustrated in Figure 2 with both feeder groups evenly loaded and fully utilised at 60MW.

The 'red' group is shown intact and supplied from the 3x 45MVA Finsbury Market transformers. The 4 feeders are connected to a separate bussing bar at Back Hill. Under these conditions each feeder carries 15MW from Finsbury Market with only a small amount of equalising current flowing via the Back Hill bussing bar.

The 'green' group is shown with an onerous (n-1) condition close to Back Hill. Under these conditions the power flow on the remaining 3 circuits would increase to 20MVA. The customers connected to the faulted feeder would experience no interruption with unit protection isolating the faulted cable section and supply continuity maintained via the Finsbury Market bussing bar.

For the instantaneous loss of all 3 transformers at either Back Hill or Finsbury Market customers would experience a transient interruption during auto-closure of the bus section switches at both substations. Supply integrity would be maintained from the intact source.

Figure 2: Intact and (n-1) Network Conditions



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2.4 Upstream Constraints

Although the feeder group cables are rated to achieve a firm capacity of 90MVA, the maximum permissible rating of the 'red' and 'green' groups is currently 60MVA constrained by the existing network capacity at Finsbury Market 'C', Back Hill and the 3x132kV City Road-Finsbury Market cables.

Projects are currently in the delivery phase to increase capacity headroom to 120MVA (2x60MVA) by the removal of the following constraints:

Constraint 1: Fisher Street transferred to Bankside 132kV to establish an additional 50MW of capacity headroom at Back Hill.

Constraint 2: Paternoster transferred to Bankside 11kV to establish an additional 43MW of capacity headroom at Finsbury Market 'C' (this scheme was completed and commissioned Q3 2013).

Constraint 3: Finsbury Market is a complex site comprising 5 substations designated 'A to D' with a combined summer maximum demand of 240MVA. The site is supplied by the 3x 132kV City Road to Finsbury Market cables which are operating within 6% of their summer firm capacity. Transferring Paternoster demand establishes transformer capacity headroom at Finsbury Market 'C' but does not fully eliminate the City Road cable constraint. This is to be resolved by current projects (a) the construction of the New Cross deep cable tunnel (b) the transfer of the reinforced Osborn Street to New Cross and (c) installation of a 3x 132kV cable interconnection between Finsbury Markey and Osborn Street.

Note: the demand transfers have been co-ordinated with 132kV reinforcements at Fisher Street and Osborn Street.

2.5 Back Hill – Paternoster Deep Cable Tunnel

A section of the 'red' feeder group is installed in the Back Hill to Paternoster deep cable tunnel. Although thermal modelling confirms that the maximum tunnel air temperatures will not exceed 40°C at summer peak demand levels, it is recommended that the 'red' feeder group is normally supplied from Finsbury Market. Under this operating regime the tunnel section of the feeders will carry only minimal balancing currents thereby reducing the overall heat burden and reduce the utilisation of ventilation equipment and mutual heating on the other tunnel cables.

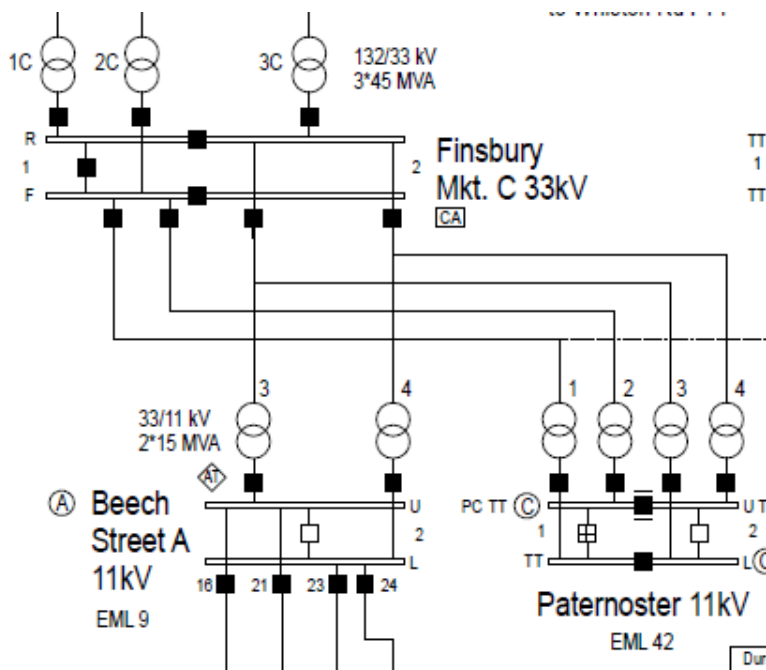
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2.6 Finsbury Market 'C'

Finsbury Market 'C' is an existing 132/33kV substation supplied by 3x45MVA transformers connected to a 17 panel, Reyrolle L42T3, 1200/800amp switchboard (spare panels not shown).

Figure 4: Finsbury Market 'C' Existing Network (2013)



The 33kV network enabling works at Finsbury Market currently being delivered include:

- the transfer of Paternoster to Bankside to establish transformer capacity headroom at Finsbury Market 'C'
- Finsbury Market 'C' switchboard replacement with 23 panels of 2000amp rated equipment to cater for the increased feeder rating and higher fault levels.
- reinforcement and reconfiguration of Osborn Street from Finsbury Market 'B' to New Cross thereby establishing capacity headroom on the 3x City Road- Finsbury Market 132kV cables

The replacement switchboard includes 2 panels to connect the 24MVA Interxion Brick Lane Data Centre and 4 feeder panels to cater for the future 'blue' feeder group which is envisaged to be routed across the south eastern sector of the Square Mile to the proposed Wellclose Square 132/33/11kV substation.

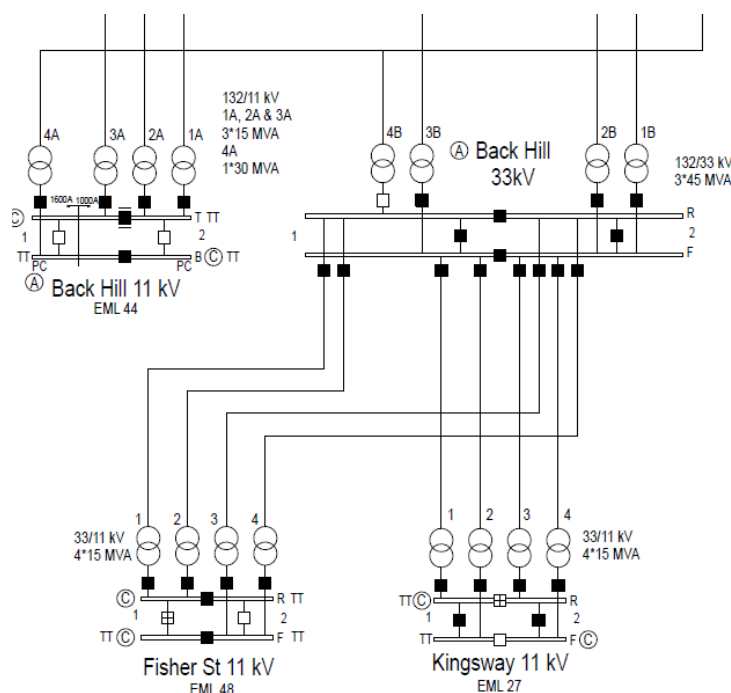
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2.7 Back Hill

Back Hill is an existing 132/33kV substation supplied by 4x45MVA transformers connected to a 1200/800amp, 20 panel, Reyrolle 33L42T switchboard (ex-Whitfield panels not shown).

Figure 3: Back Hill Existing Network (2013)



Three transformers (T1B, T2B & T3B) are supplied from St Johns Wood 132kV with the 4th transformer supplied from City Road. Transformer T4B is normally on 'open-standby' to avoid parallel operation between the two super grid exit points.

The 33kV network enabling works include currently being delivered:

- the transfer of Fisher Street to Bankside to establish capacity headroom at the 33kV busbars
- partial 33kV switchboard replacement to install 20 panels of 2000amp rated equipment to cater for the increased feeder rating and higher fault levels.

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3 Customer Connections

3.1 Demand

Despite the financial crisis, connection applications from ‘flagship’ developments have continued to be received during DPCR5. These high profile developments are an important factor in maintaining the status of London both as a leading financial centre and a world class capital city with the Corporation of London often adopting a facilitating role in the provision of resilient infrastructure services. Significant examples are illustrated below:

The Pinnacle (Bishops Gate Tower/Helter-Skelter)



122 Leadenhall Street (Cheese Grater)



20 Fenchurch Street (Walkie Talkie)



100 Bishopsgate



The highly resilient nature of the 33kV network has made it extremely attractive as the preferred connection for many developments. The current connection status is summarised in Tables 1 & 2 below:

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Table 1. Red Feeder Group Accepted Connection Offers

Conection Site	Max Demand	Forecast Commisioning	
Red Feeder Group			
The Pinnacle	12.5	2012	Q4
20 Fenchurch St	10.0	2013	Q1
100 Bishopsgate	12.5	2013	Q4
122 Leadenhall St	10.0	2012	Q4
Bloomberg Sq	14.0	2014	Q3
Marks Place	2.5	2013	Q1
Lime St	5.5	2015	Q2
Project Vanquish	12.0		
Total (MVA)	79.0	@0.9pf	
Total (MW) Summer	71.1		
Diversity factor	0.9		
Diversified Total (MW)	64.0		

Note: Project Vanquish – new application work in progress

Table 2. Green Feeder Group Accepted Connection Offers

Conection Site	Max Demand	Forecast Commisioning	
Green Feeder Group			
5 Broadgate	15.0	2013	Q3
Bishops Place	11.6	2014	Q1
Great Sutton St	9.0	2012	Q4
St Alphage	12.0	2013	Q4
Hillgate House	8.0	2014	Q1
Total (MVA)	55.6		
Total (MW) Summer	50.0	@0.9pf	
Diversity factor	0.9		
Diversified Total (MW)	45.0		

Note: Hillgate House (Old Bailey) may connect at 11kV

3.2 Embedded Generation

Enquiries for distributed generation are at the preliminary stage with 4 applications totalling 17MW received (20th May 2013). It is expected that the majority of the new connections will request long term parallel operation to benefit from:

- energy efficiency technologies (CHP, PV and wind)
- economic benefits from STOR (short term operational reserve) tariffs
- economic benefits of DSR (demand side response) tariffs.

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4 Network Changes in Progress

4.1 Back Hill Enabling Works

Two projects are in progress to facilitate commissioning of the 33kV network:

Back Hill (5558): Partial replacement of the 33kV switchboard with higher capacity panels

Fisher Street (5655, 5578, 5581, & 5582): Substation reinforcement with 3x33MVA transformers replacing the existing 4x15MVA units and permanent reconfiguration of the substation to Bankside 132kV thereby releasing circa 50MW of capacity headroom at Back Hill 33kV. These projects are detailed in the St Johns Wood RDP.

Table 3. **Back Hill Enabling Works NAMP Provision**

Cat.	Reference	Description	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
R	1.33.03.5655	Fisher Street 11kV Switchboard Extension	24,866	159,142	253,632	0	0	0
R	1.36.01.5578	Fisher St 132/11kV Reinforcement: ITC	1,334,146	1,874,670	893,444	0	0	0
R	1.37.06.5582	Fisher St 132/11kV Reinforcement: Install 132kV Cables from Bankside	1,055,167	492,378	96,239	0	0	0
R	1.36.01.5581	Fisher St 132/11kV Reinforcement: Extend Bankside 132kV Busbars	575,465	0	0	0	0	0
R	1.36.03.5558	Back Hill 33kV: Switchboard Extension Aug 13	835,755	0	0	0	0	0

4.2 Finsbury Market 'C' Enabling Works

Two projects are required to facilitate commissioning of the 33kV network:

Cat.	Reference	Description	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
R	1.36	Finsbury Market C 33kV: Switchboard Extension	24,566	0	0	0	0	0

Table 4. **Finsbury Market Enabling Works NAMP Provision**

Paternoster (4225): The transfer of demand to Bankside via new cables installed in the Paternoster – Bankside tunnel is now commissioned thereby releasing 43MW of capacity to the 33kV network.

Finsbury Market 'C' (5550): Replacement of the L42 switchgear with higher capacity panels (final layout is shown in Appendix D).

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4.3 City Rd - Finsbury Market 132kV Cables

In order to release capacity on the City Road - Finsbury Market 3x132kV cables, Osborn St is currently being reinforced with 3x66MVA 132/11kV transformers and permanently reconfigured to New Cross GSP to be supplied by new cables installed in the New Cross-Wellclose Square-Osborn Street-Finsbury Market deep cable tunnel which is currently under construction.

Linked to this project a 3rd 240MVA 275/132kV super grid transformer is programmed for commissioning at New Cross in 2014.

The projects are detail in Table 5 below:

Table 5. **NAMP provision for 132kV Infrastructure from New Cross to Finsbury Market**

Cat.	Reference	Description	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
5 R	1.36.01.3661	New Cross 132kV Substation: Reinforcement and Extension	1,497,794	323,030	0	0	0	0		
R	1.37.06.5591	Finsbury Market: Establish 132kV Interconnection to Osborn Street	0	0	159,115	1,334,117	2,778,390	624,220	0	0
R	1.37.09.3525	Construct Wellclose Square to Finsbury Market Cable Tunnel	1,505,986	14,507	0	0	0	0		
R	1.37.09.4379	Finsbury Market: Deep Cable Tunnel Extension	2,525,532	0	0	0	0	0		
R	1.37.09.5470	New Cross - Wellclose Square Cable Tunnel Construction	8,311,696	9,660,027	0	0	0	0		
R	1.35.01.2622	Osborn St: Establish New Osborn Street B 132/11kV Substation	7,473,137	1,808,289	0	0	0	0		
R	1.37.09.6106	New Cross-Osborn Street - Install 3x132kV Circuits	0	0	1,524,211	0	0	0		

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Network Development Considerations

5.1 Development areas

The City of London 2013 Draft Local Plan states:

“Although little more than 1 square mile in size the area is densely developed and is the world’s leading international finance, business and maritime centre. It is a leading driver of the London and national economies contributing 12% of London’s GDP and an estimated 8.5% of the UK’s. It provides employment for 370,000 people. Offices account for 70% of all buildings many of which are occupied by financial and business services”.

Within this context the Corporation of London often act in a facilitating role with utilities for new developments and linked this approach, regular meetings are held between UK Power Networks and CPAT (City of London Property Advisory Team).

The proposals presented in this 33kV Network Development Plan are influenced by intelligence received from these and other key customer forums. In addition, consideration has been given to the Core Strategy adopted in 2011 and updates that will be incorporated into the 2013 Local Plan which is currently in the consultation phase.

The Draft Local Plan was published in January 2013 and when it is adopted it will replace both the Core Strategy and Unitary Development plan. Of particular relevance to electricity supply are:

Section 3.7/Policy CS7 Eastern Cluster. The eastern cluster contains the greatest density of businesses and jobs in the Square Mile with increasing demand for larger offices and tall building.

Section 3.8 Aldgate. Aldgate is positioned between the City’s eastern cluster and Tower Hamlets one of the most deprived boroughs in England. The City Corporation is participating in a number of cross border partnerships to bring lasting social, economic and physical regeneration. This initiative is associated with the Mayor of London’s CFOAP City Fringe Opportunity Area Planning Framework.

Figure 5: City of London Boundary



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5.2 Asset Replacement

Three asset replacement projects are proposed in ED1 which impact on the 33kV network detailed in Table 3.

Table 6. ED1 proposed Asset Replacement Projects

Cat.	Reference	Description	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
A	1.51.01.7854	Back Hill 33kV - Replace Grid Transformers (GT4B)	0	0	0	0	419,075	1,022,374	0	0
A	1.51.01.7855	Finsbury Market B 33kV - Replace Grid Transformers (GT1B, GT2B, GT3B)	0	0	0	0	76,656	2,771,861	1,385,927	0
A	1.29.01.7947	Backhill-Kingsway St (Circuit 1A & Circuit 3A) - 33kV FFC Replacement	0	0	448,581	0	0	0	0	0

7854 Back Hill 45MVA 132/33kV GT4B: This 1961 vintage transformer is one of 4 units supplying the 33kV busbars. This project presents the opportunity to harmonise with reinforcement by installing a 60MVA rated replacement as the first stage of up rating the feeder groups from 60MVA to 90MVA. This project is covered in the St. John's Wood RDP.

Note: the remaining 132/33kV transformers T1B, T2B & T3B were installed in 1960, 1963 and 1966 respectively.

7855 Finsbury Market 'B': Asset replacement of these transformers offers the option of installing higher rated 60MVA units to support the increased demand from the 33kV network.

7947 Back Hill to Kingsway Cable Replacement (part): The replacement provides a 'window of opportunity' to install spare ducts at marginal cost to provide future 33kV routes towards Holborn and the west of the Square Mile. This project is covered in the St. John's Wood RDP.

5.3 Operational and Technical Constraints

To reduce the heat burden within the Back Hill to Paternoster deep tunnel the 'red' group is to be normally to be supplied from Finsbury Market. Under these conditions only equalising current will flow in these sections of cable.

Partial replacement of the Back Hill 33kV switchboard is forecast for completion in 2014 with 1 section of L42 switchgear remaining in service to supply Kingsway. Under certain outage conditions it will be necessary to operate Kingsway in parallel with the 'green' feeder group and, dependent on the short circuit in feed from distributed generation, this section of switchboard may become a constraint due to the lower rated short circuit capacity.

At Back Hill, to avoid coupling City Road and St Johns Wood GSP's via the 33kV busbars, T4B is unable to operate in parallel with the 3 other transformers T1B, T2B & T3B.

Back Hill to Paternoster Cable Tunnel: The four 'red' route 33kV feeders are routed in the tunnel and, although installed on wall steelwork on either side of the tunnel are at risk to a HILP (high impact low probability) event.

Open cut installation: Sections of both feeder groups are installed in 2x2 duct blocks and may be at risk of common 3rd party damage.

Should either of these HILP (high impact low probability) events occur the network unit protection would isolate the faulted sections of cables with customers remaining connected via the intact feeders and, if necessary, operation of the busbar section switch auto-close schemes at Back Hill and/or Finsbury Market.

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5.4 National Grid

At New Cross a 3rd 240MVA, 275/132kV super grid transformer is currently being installed to provide capacity for Osborn Street 'B' 3x66MVA 132/11kV substation and the associated interconnection to Finsbury Market. Provision for a 4th SGT has been included under 1.36.01.6336 for commissioning in 2022 but the exact timing will be dependent on demand growth.

No reinforcement works are planned at St Johns Wood or City Road GSP's (grid supply points).

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6 Recommended Strategy

Establishing the 33kV network was in response to customer requirements for highly resilient supplies to large point load developments for which 11kV capacity was either unavailable or impractical to connect.

Customer requirements will also be the principal driver for further enhancements with the high level strategy designed to;

- Satisfy customer timescales for connection of new demand
- Facilitate constraint free connection of distributed generation

Connection applications are influenced by wider economic factors and, due to these uncertainties, it is recommended that an incremental approach is adopted with 4 stages considered to have a medium to high probability for delivery in ED1, listed below:

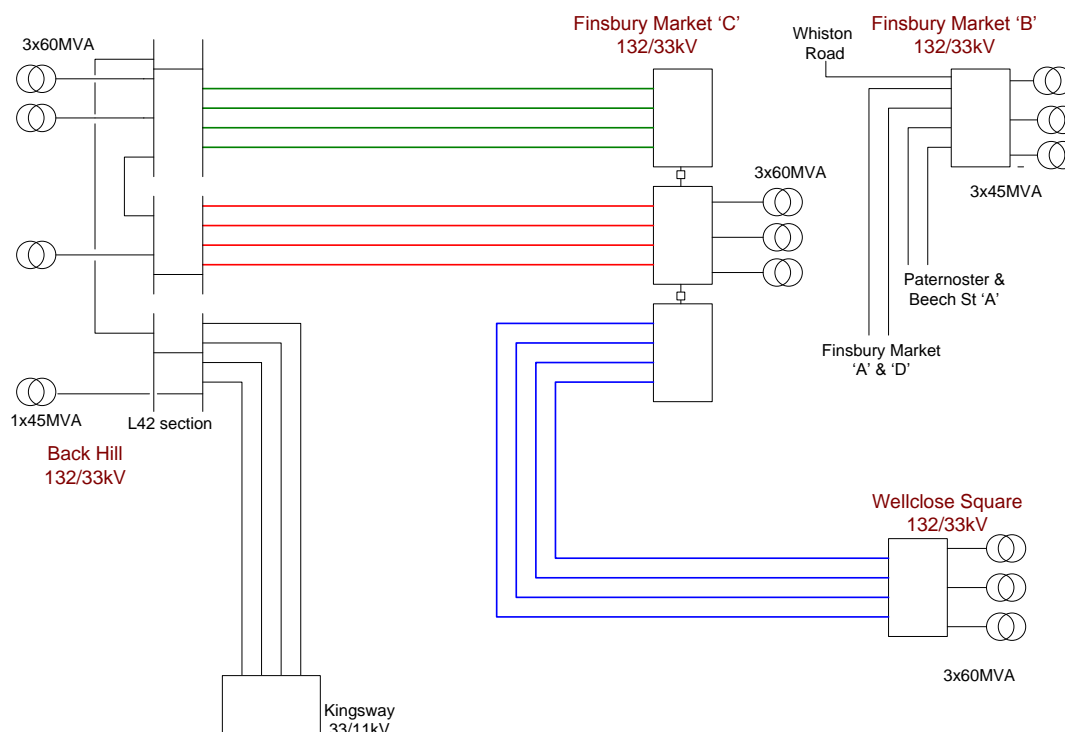
Stage 1: Establish a 3rd (blue) feeder group to supply new developments to the east of the Square Mile

Stage 2: Uprate the 'red' feeder group to 90MVA to cater for increased connection activity which is currently being experienced in the southern sector of the Square Mile

Stage 3: Uprate the 'green' feeder group to 90MVA to supply the expected increase in connection activity in the northern sector

Stage 4: Complete the uprating/replacement of L42 switchgear at Back Hill to facilitate connection of distributed generation and avoid the need for a generation inhibit during outage conditions

Figure 6: Nodal Representation of the completed 4 Stages



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7 Proposed interventions

7.1 Install the 'Blue' Feeder Group

The third feeder group (designated 'blue') will be required if there is an increase in connection activity in the Aldgate, Whitechapel, Houndsditch and east City of London areas.

The network design will align with the 'red' and 'green' groups and provide up to 90MVA of firm capacity supplied by 4 feeders.

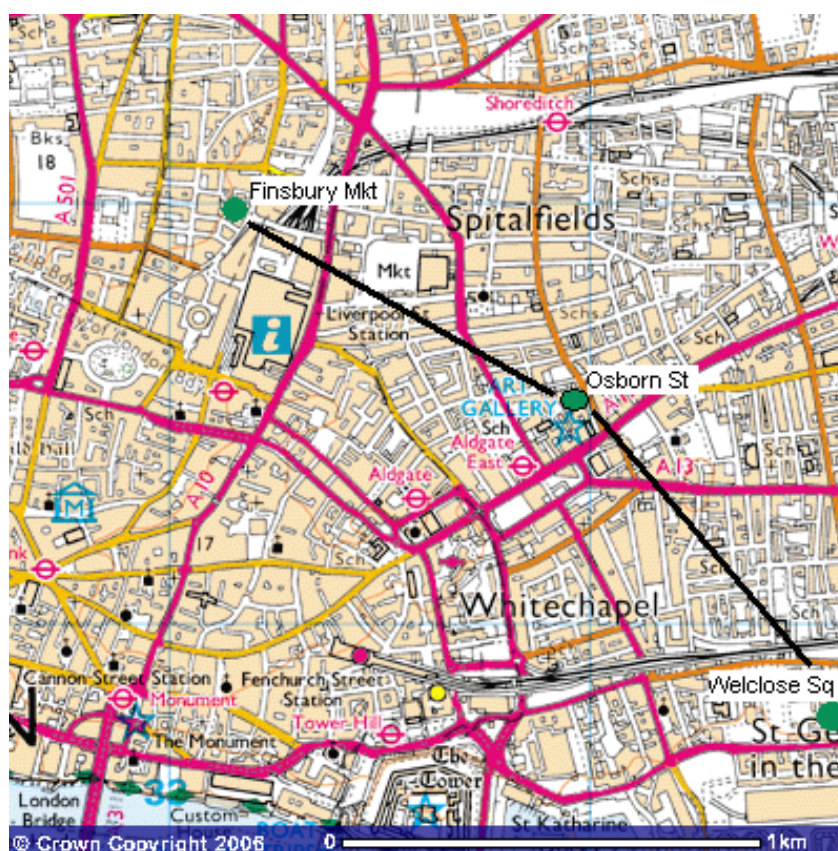
Note: the 90MVA (n-1) firm capacity is based on the 30MVA/525amp rating of 630 sq mm Cu cable installed in ducts

Wellclose Square and Finsbury Market sites are ideally located to become the 'supply' and 'bussing bar' locations respectively.

At Finsbury Market 'C' four additional panels are currently being installed to connect the 'blue' feeder group.

Wellclose Square is supplied at 132kV from cables installed in the New Cross to Osborn Street-Finsbury Market cable tunnel. There are existing proposals to establish a new 132/11kV primary substation to relieve the heavily loaded substations at Glaucus Street, Devonshire Square and Simpsons Road (1.35.07.3668, RDP 10 refers). As part of the civil design work space is to be allocated to facilitate the installation of 132/33kV transformers and 33kV switchgear to connect the blue feeder group; the exact cable routes will be dictated by customer enquiries but are expected to cover the Spitalfields and Whitechapel areas between Finsbury Market and Wellclose Square shown in Figure 7, below.

Figure 7: East City of London



City of London 33kV Network

All of the cost numbers displayed in this document are before the application of on-going efficiencies and real price effects.

The scope of work involves:

- installation of 4x 630 sq mm Cu 33kV cables between Finsbury Market and Wellclose Square
- termination of the cables onto existing 33kV switchgear at Finsbury Market 'C'
- Installation of 132/133kV transformers and associated 33kV switchgear at the UK Power Networks owned Wellclose Square site supplied from the New Cross-Osborn Street 132kV cables which are to be installed as part of the Osborn Street reinforcement project.

At Wellclose Square, 3x45MVA transformers would provide sufficient firm capacity to supply 90MVA to the 'blue' feeder group however; it is recommended that 60MVA units are installed together with reserving space for additional panels of 33kV switchgear. The 60MVA units are justified as standard design items allowing procurement efficiencies with reduced strategic spare requirements and, although there are currently no firm proposals, it is not unreasonable to expect that future reinforcement of the East London network towards Canary Wharf will be required during the expected 50 year operational life of the transformers. In support of this recommendation, a feasibility request was received in May2013 for connection of a 20MW data centre close to the Royal London Hospital, Whitechapel (1.7km /1.1 miles from Wellclose Sq). This is not an atypical enquiry and demonstrates the potential for future large point load connections in this relatively under developed part of the capital.

7.2 Up-rate Red & Green Feeder Groups to 90MVA: Back Hill Works

The existing Back Hill 33kV substation has a summer firm (n-1) capacity of 135MVA (116MW @ 0.86pf). Following completion of the enabling works, Back Hill will normally supply Kingsway and the 'green' feeder group which have a combined installed firm capacity of 105MVA which is well within the rating of the existing transformers.

Increasing the 'green' feeder group rating by 30MVA to 90MVA would reduce the (n-1) capacity headroom to zero and, if the 'red' feeder group is also increased to 90MVA the combined potential demand would exceed the summer intact capacity of 180MVA (4x45MVA).

Increasing the 33kV network capacity can therefore only be realised by reinforcing the substation to cater for both normal and abnormal running arrangements.

Back Hill is space constrained and surrounded by high density residential and commercial properties. The existing transformers are installed in noise enclosures with external coolers. Site surveys confirm that there is little, if any, scope to increase the chamber size however, 60MVA transformers could be accommodated without the need for structural civil modifications.

The proposed scope of work therefore involves:

- Replacement of 3x4MVA transformers with 3x60MVA units installed in the existing chambers (replacement of 1 transformer is also required for asset condition).
- The replacement transformers to be terminated onto the new 33kV switchboard to supply the 'green' and 'red' feeder groups
- The remaining 45MVA transformer to be normally configured to supply Kingsway with an interconnector between the L42 and new switchboard sections
- Installation of ventilation in the St Johns Wood to Back Hill deep cable tunnel to control air temperatures with the increased 132kV circuit loadings and/or the installation of additional tunnel cables

The remaining section of L42 switchgear includes 4 spare 800amp (45.7MVA) feeder panels which could be utilised for future radial connections. Should this occur the remaining 45MVA transformer would require replacement with a 60MVA unit which could be accommodated by the existing 1200amp (68.6MVA) incomer panel.

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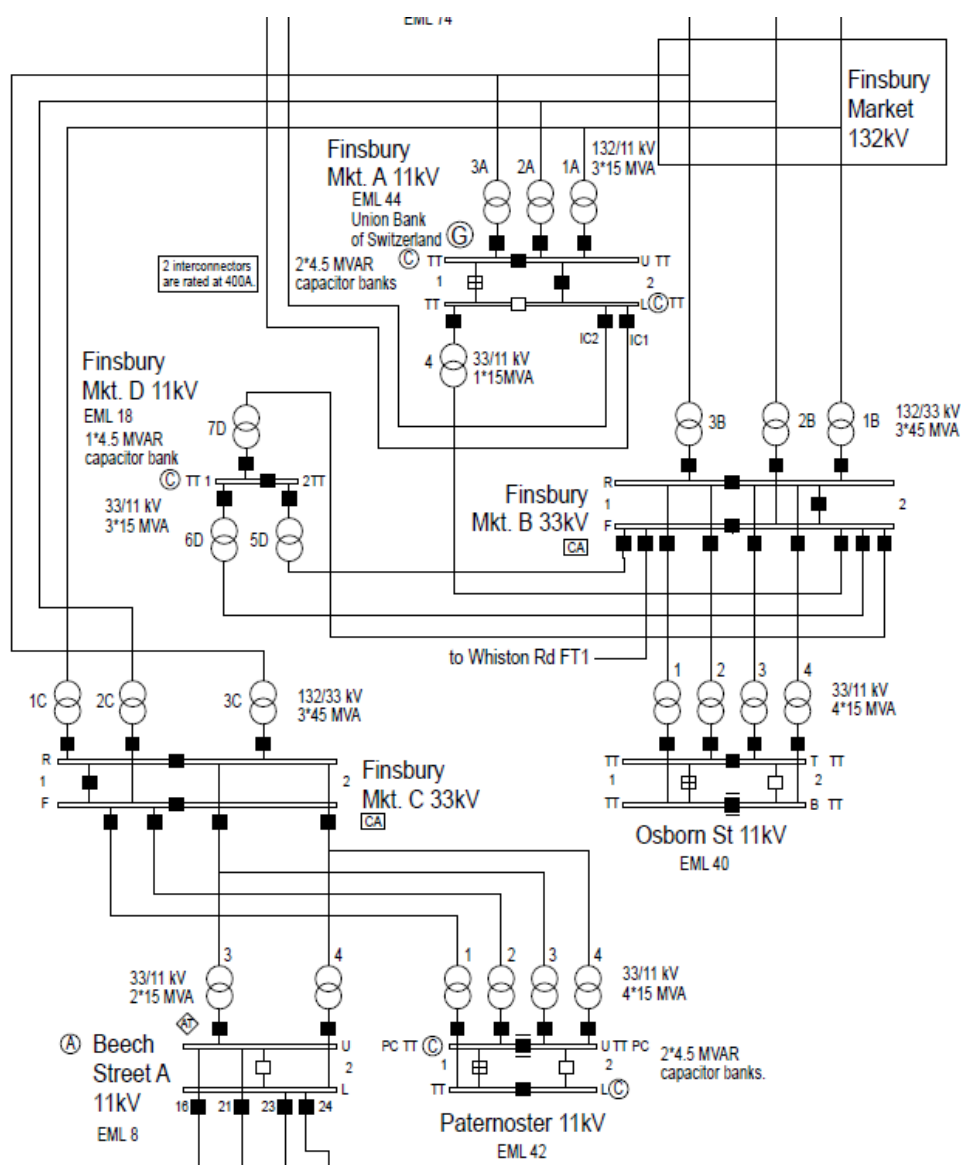
All of the cost numbers displayed in this document are before the application of on-going efficiencies and real price effects.

7.3 Up-rate Red & Green Feeder Groups to 90MVA: Finsbury Market Works

Finsbury Market is a complex site containing 5 separate switchboards. Substations A-D are shown in Figure 8.

To achieve a 90MVA feeder group rating the recommended interventions involve a combination of works at both Finsbury Market 'B' & 'C' and their downstream substations harmonised with the asset replacement of the 3 Finsbury Market 'B' transformers.

Figure 8: Existing Finsbury Market Substations (2012)



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7.3.1 Finsbury Market 'C'

Following completion of the enabling works, Paternoster will have been transferred to Bankside with Finsbury Market 'C' normally supplying the 'red' feeder group, Beech Street 'A' and the Interxion Data Centre, The potential combined maximum demand is 94MVA.

Although 94MVA exceeds the summer firm capacity of 90MVA (2x 45MVA transformers with no assigned summer cyclic rating) this maximum demand is not expected to be attained until 2016 or beyond due to project delays at the Pinnacle (12.5MVA) and Interxion (24MVA) where superstructure construction has not yet commenced.

Interventions are required to maintain supply integrity irrespective of whether the feeder groups are to be up rated to 90MVA. The recommended solution involves a combination of works at both Finsbury Market 'B' & 'C' and is linked to the condition based requirement to asset replace Finsbury Market T1B, T3B. The scope of work involves:

Intervention Stage 1

- Asset replacement of the 3 Finsbury Market 'B' 45MVA transformers with 3x60MVA units
- Reconfigure the replacement 60MVA transformer LV tails to supply Finsbury Market 'C' with the existing 45MVA transformers reconnected to Finsbury Market 'B'

This combined reinforcement, asset replacement and reconfiguration provides 120MVA of firm capacity to Finsbury Market 'C' which satisfies the existing supply requirements. The replacement transformers will be specified with a summer cyclic rating of 30% allowing both the 'red' and 'green' feeder groups to each be re-designated with a 90MVA firm capacity.

7.3.2 Finsbury Market 'B'

Finsbury Market 'B' is equipped with a 3 section, 18 panel Reyrolle L42T3 switchboard:

- 12 feeder panels
- 3 incomers
- 3 sections/couplers

Following the transfer of Osborn Street to New Cross the number of spare panels will increase from three to seven.

The substation has a firm summer capacity of 90MVA offering the opportunity to optimise feeder connections and demand between the 'B' and 'C' substations and it is recommended to:

Intervention Stage 2

- Reconfigure Beech Street 'A' from Finsbury Market 'C' to 'B'
- Reconfigure the 4x Paternoster circuits to Finsbury Market 'B' and re-commission the 4x15MVA Paternoster transformers

These proposed modifications will increase the utilisation of installed Finsbury Market B' transformers and addresses the Paternoster anomaly of decommissioning transformers in the high load density Ludgate Hill area.



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7.4 City Road- Finsbury Market 132kV Cables

The City Road- Finsbury Market cables are heavily utilised. Table 7 is an extract from the July 2012 PLE's shows that the cables are operating within 6% (15MW) of their summer maximum capacity.

Table 7. 2013 Planning Load Estimates

					ACS 10/11 2010 AHS	ACS 11/12 2011 AHS	Firm	Actual	Date of Peak MD	P F	Winter Summer	ACS 12/13 AHS 2012	13/14 2013	14/15 2014
City Road to Finsbury Circuits		132kV			0.96 248.1	0.98 234.5	296.3	206.3	23/01/13 13:00	0.96	Winter 0.96	198.8	218.9	219.9
MVA					259.8 1.00	251.4 1.00	260.8	213.4	27/06/12 13:00	0.92	Summer 1	213.4	231.8	232.7

The net effect of the proposed changes is to increase the demand initially by 60MW to supply the 'red' feeder group which is to be off-set by Osborn Street and Paternoster demand transfers. Whereas the Paternoster transfer is now complete (43MW), Osborn Street has been delayed by 3rd party issues associated with tunnel easements and is not now forecast to be energised until March 2016. The rating of the City Road cables is therefore a constraint to accepting additional demand and up rating the feeder groups to 90MVA.

This constraint will be removed following commissioning of Osborn Street 'B' and the completion of the 132kV interconnection between Finsbury Market and Osborn Street. The recommended configuration is to install a single switch mesh within the Finsbury Market 'E' transformer chambers to allow a staged transfer of demand between City Road and New Cross super grid exit points. The proposed GIS 'tee' point and final configuration are shown below.

Figure 9: Proposed Finsbury Market E 'H' Point (to replace existing AIS connections)

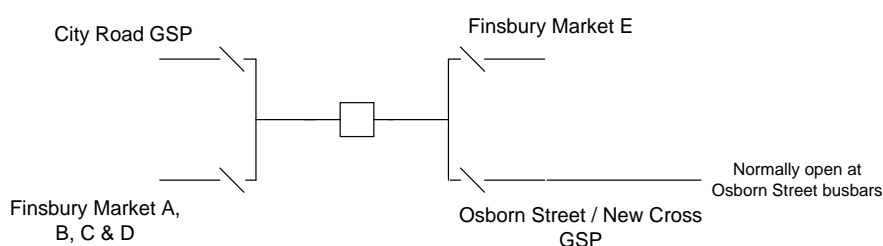
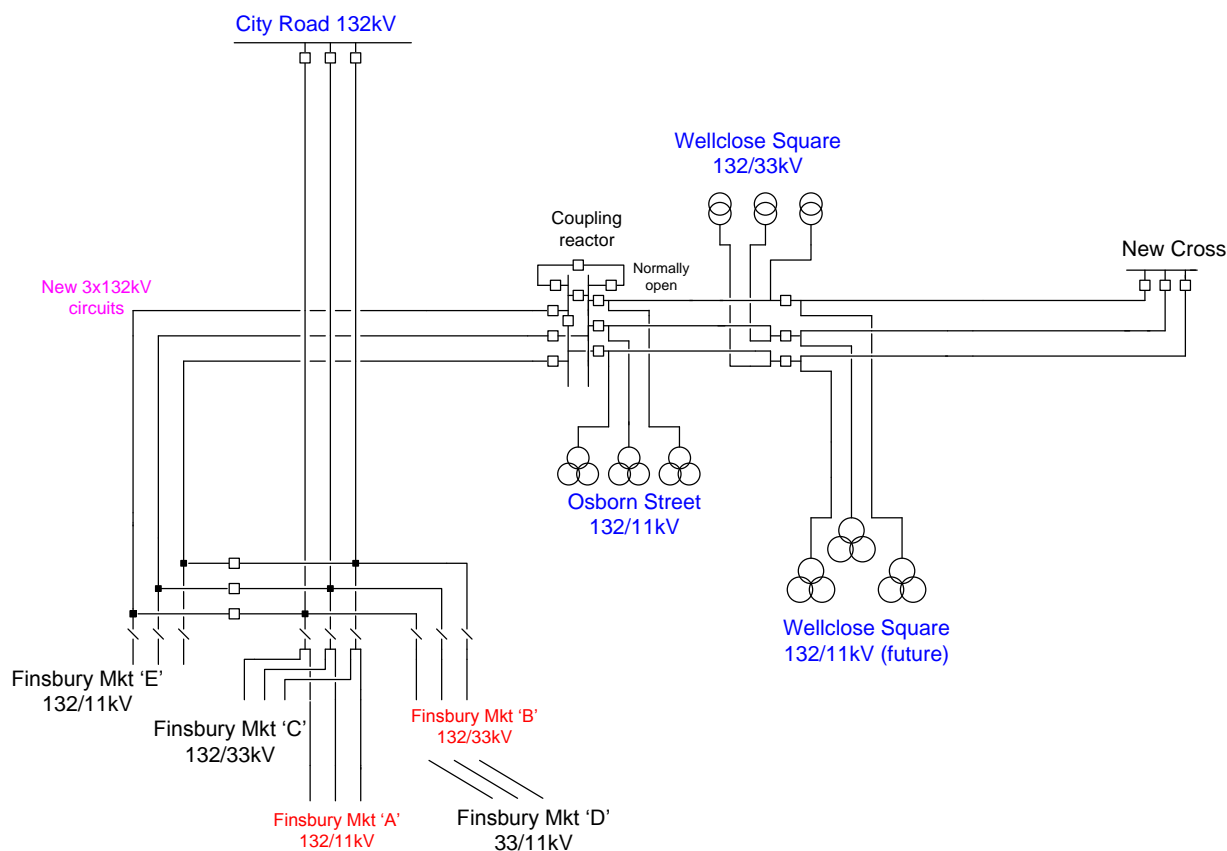


Figure 10: Proposed City Road – New Cross 132kV Interconnection

All of the cost numbers displayed in this document are before the application of on-going efficiencies and real price effects.



7.5 Back Hill L45 Switchgear Fault Level Capacity

On completion of the approved enabling works, Back Hill will comprise 2 sections of new Siemens 33kV switchboard with an interconnector to the remaining section of Reyrolle L42 with a 25kA and 13.1kA short circuit ratings respectively.

The switchboard layout is shown in Appendices B & C.

Under certain single transformer outages the most secure arrangement would be to operate the remaining 3 transformers in parallel on a solid section of switchboard. Depending on the level of distributed generation the short circuit in feed may exceed the rating of the L42 equipment. There is insufficient space within the site to install a series reactor with two solutions available;

- Up rate the L42 switchgear
- Replace the L42 switchgear

Siemens have an approved factory refurbishment process to increase the rating of their equipment. Adopting this approach would remove the need for civil works and allow the feeder cables to be undisturbed.

The capital cost of replacement switchgear is expected to be lower than refurbishment but when the cost of associated works and feeder cable reconnection is included the two options are likely to be of a similar cost.

A full cost assessment will be made at Gate B and the recommended strategy based on market prices at that time.

City of London 33kV Network

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7.6 Costs and Phasing

Budget provision for the proposed intervention works detailed above has been included in the table detailed below. The phasing is based on current intelligence and may require to be amended to align with wider network and Customer programmes.

Table 8. Proposed Interventions 2013-2023 NAMP Provision

Cat.	Reference	Description	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
A	1.51.01.7854	Back Hill 33kV - Replace Grid Transformers (GT4B)	0	0	0	0	419,075	1,022,374	0	0	0	0
A	1.51.01.7855	Finsbury Market B 33kV - Replace Grid Transformers (GT1B, GT2B, GT3B)	0	0	0	0	76,656	2,771,861	1,385,927	0	0	0
A	1.48.02.7782	Finsbury Market B 33kV - Refurb 33kV Switchgear	0	0	0	0	0	0	0	0	0	87,278
A	1.51.03.7870	Paternoster - Replace Primary Transformer (T4)	0	0	82,565	492,809	0	0	0	0	0	0
R	1.35.02.6331	Paternoster 33/11kV - Reconfiguration to Finsbury Market B (33kV circuits)	0	0	0	0	0	175,637	41,199	0	0	0
R	1.36.03.6156	Finsbury Market B 33kV Feeder Reconfiguration	0	0	0	184,692	821,422	132,485	0	0	0	0
R	1.36.03.8642	Back Hill 33kV: Replace Remaining Existing Reyrolle L42 33kV Switchgear	182,295	182,295	0	0	0	0	0	0	0	0
R	1.37.06.5591	Finsbury Market: Establish 132kV Interconnection to Osborn Street	0	0	159,115	1,334,117	2,778,390	624,220	0	0	0	0
T	3.35.01.6112	Back Hill: Replace 132/33kV Transformers	0	0	684,369	3,910,681	1,124,321	146,651	0	0	0	0
T	3.37.06.6330	Longford St to Back Hill 132kV Circuits: Increase Capacity	0	0	48,492	2,909,494	2,861,002	0	0	0	0	0
T	3.37.07.4388	City of London 33kV Network: Feeder Group C	0	-386,242	-640,708	1,468,981	-255,228	0	0	0	0	0
R	1.35.07.6111	Wellclose Square New 132/33kV Substation - (2x60MVA)	0	0	0	0	0	0	0	25,510	193,876	3,214,259
A		Asset Replacement Total	0	0	82,565	492,809	495,731	3,794,234	1,385,927	0	0	87,278
R		Reinforcement Total	182,295	-203,947	251,267	9,807,965	7,329,908	1,078,993	41,199	25,510	193,876	3,214,259
		Grand Total	182,295	-203,947	333,832	10,300,774	7,825,639	4,873,227	1,427,126	25,510	193,876	3,301,537

8 New Cross-Wellclose Square Tunnel Construction Programme

The forecast commissioning of the New Cross-Osborn Street 132kV cables and hence Osborn Street 'B' has been delayed to mid-2016 due to third party Consents issues.

In addition to the budgetary and plant warranty implications there are potential network risks in 3 main areas:

- exceeding the firm capacity of the 3x132kV City Road-Finsbury Market cables
- reliability of HI 4 & 5 equipment at Osborn Street 'A'
- failure to meet agreed 33kV network customer connection dates

As a consequence, interim mitigation measures are currently under investigation involving:

- Advancement of Back Hill reinforcement replacing the 3x45MVA 132/33kV transformers with 60MVA units
- Installation of 4x33kV cables between Finsbury Market and Osborn Street
- Install a 4th 132kV circuit from City Road to support Finsbury Market via Osborn Street

All of the cost numbers displayed in this document are before the application of on-going efficiencies and real price effects.

8.1 Capacity Constraint on the City Road-Finsbury Market 3x132kV cables

These circuits are currently operating within 6% of their firm summer capacity a margin which provides minimal headroom for incremental demand growth and the new 33kV network customer connections.

This can be resolved by advancing replacement of the 3 x45MVA 132/33kV transformers at Back Hill with 60MVA units. This intervention would partially control the demand increase on the City Road-Finsbury Market circuits by allowing both feeder groups to be temporarily supplied from Back Hill. Associated works will include ventilation improvements to the St Johns Wood to Back Hill tunnel and/or install an additional 132kV tunnel circuit. This work will be required to achieve the future 90MVA rating per feeder group.

This approach would also remove any risk of failing to meet agreed customer connections on the 33kV feeder groups although at reduced security without the ability to cater for the total loss of Back Hill.

A further control measures is outlined in paragraph 8.3.

8.2 Asset Condition at Osborn Street 'A' 33/11kV

Transformers: A practical solution to manage transformer deterioration is to introduce an enhanced maintenance regime and install additional cooling. Another solution would be to have a strategic spare on standby.

33kV Gas Cables: Historically, the gas cables have had a low reliability. A solution would be to install a new 4x 33kV cable connection from Finsbury Market. The replacement cables could be installed in the deep cable tunnel or ideally 'open cut' to reduce tunnel shaft congestion and for re-use as the first section of the planned 'blue' feeder group to Wellclose Square.

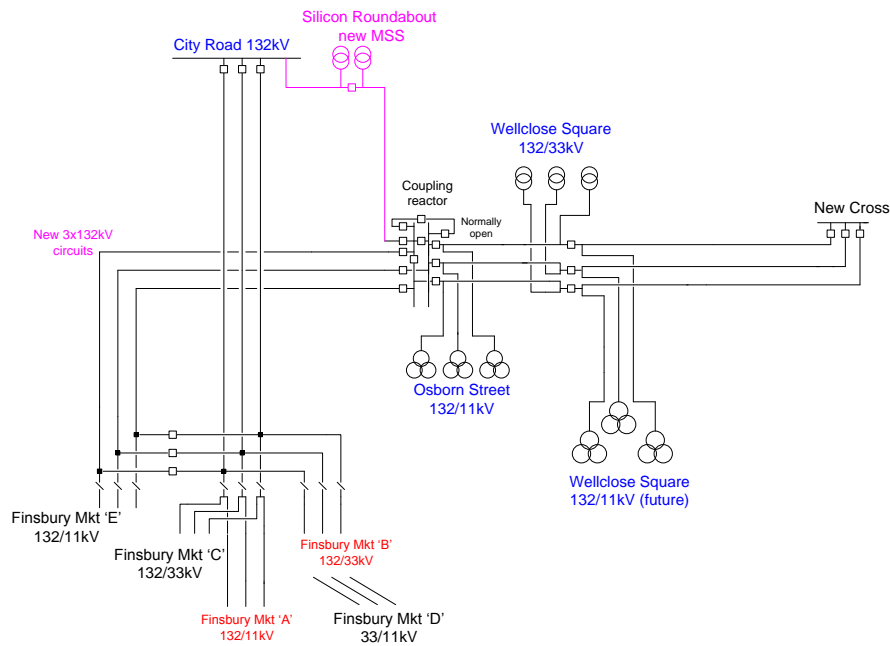
8.3 Delayed Commissioning of Osborn Street 132kV Switchboard

A solution under investigation is to install an additional (4th) 132kV circuit from City Road to Osborn Street which would allow commissioning of the new Osborn Street 'B' busbars. The cable would follow an 'open cut' route to the Holywell Lane mid tunnel shaft then tunnel installation to Osborn Street to connect onto existing switchgear. The new circuit capacity would allow demand to be transferred to Osborn Street 'B' and also reduce the network risks at Finsbury Market during the long ERTS (emergency return to service) outages required to make the permanent connections for the Osborn Street-Finsbury Market 132kV interconnection.

The circuit would be routed in close proximity to the Old Street/Silicon Roundabout and would be available to supplying the expected increased Connections activity in this area.

All of the cost numbers displayed in this document are before the application of on-going efficiencies and real price effects.

Figure 11: 132kV Network with Silicon Roundabout new MSS



9 Rejected Strategies

There is no overall rejected strategy, however, it is recognised that connection timescales will be influenced by wider external economic factors both within and external to the UK and the proposed increases in supply capacity will evolve within the proposed framework rather than follow a rigid master plan.

All of the cost numbers displayed in this document are before the application of on-going efficiencies and real price effects.

10 References

References	Description
Reference 1	LPN Planning Load Estimates (PLE's) 30 August 2013
Reference 2	Standard Running Arrangements 2013
Reference 3	Baseline NAMP: 19 th February 2014
Reference 4	City of London Draft Local Plan January 2013
Reference 5	Asset Strategy Asset Replacement Report December 2012

10.1 Appendices

Appendix	Description
Appendix A	Geographical Layout: red & green feeder groups
Appendix B	Single Line Diagram – Back Hill 33kV with L42 switchgear
Appendix C	Single Line Diagram – Back Hill 33kV L42 switchgear fully replaced

10.2 Document History

Version	Date of Issue	Author	Details
1.1 / 1.2	May 2013	C Winch	1 st Draft & 2 nd draft issued for review
1.3	31 st May 2013	C Winch	Amendments incorporated
1.4	24 June 13	C Winch	Final following 2 nd review
1.5	20 th March'14	C Winch	Resubmission
1.6	23 rd March'14	C Winch	Re-formatted
1.7	25 rd March'14	C Winch	Editorial changes

All of the cost numbers displayed in this document are before the application of on-going efficiencies and real price effects.

11 Document Sign Off

Recommended by:

Name	Role	Signature	Date
Chris Winch	Infrastructure Planner		
Sophie Motte	IDP Coordinator LPN		
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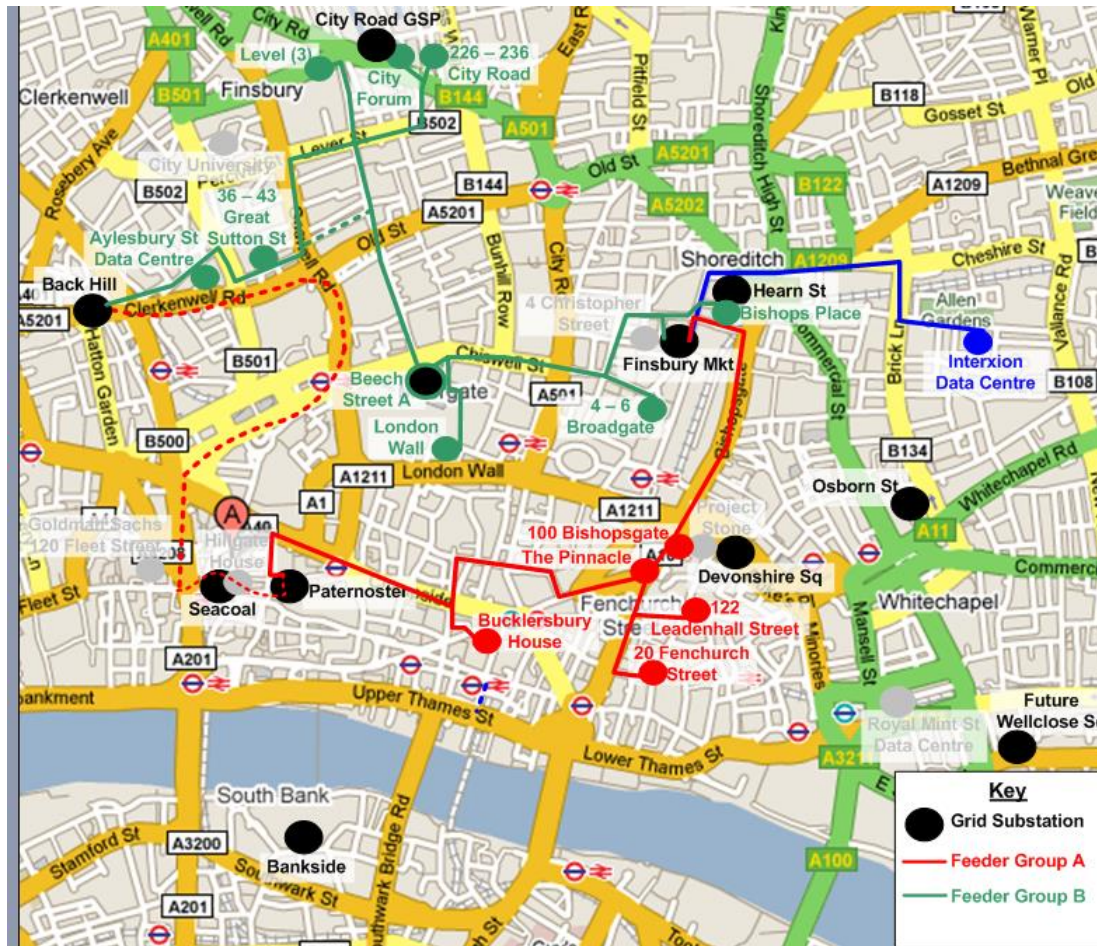
Approval by:

Name	Role	Signature	Date
Robert Kemp	Head of System Development		
Barry Hatton	Director of Asset Management		

Regional Development Plan

City of London 33kV Network

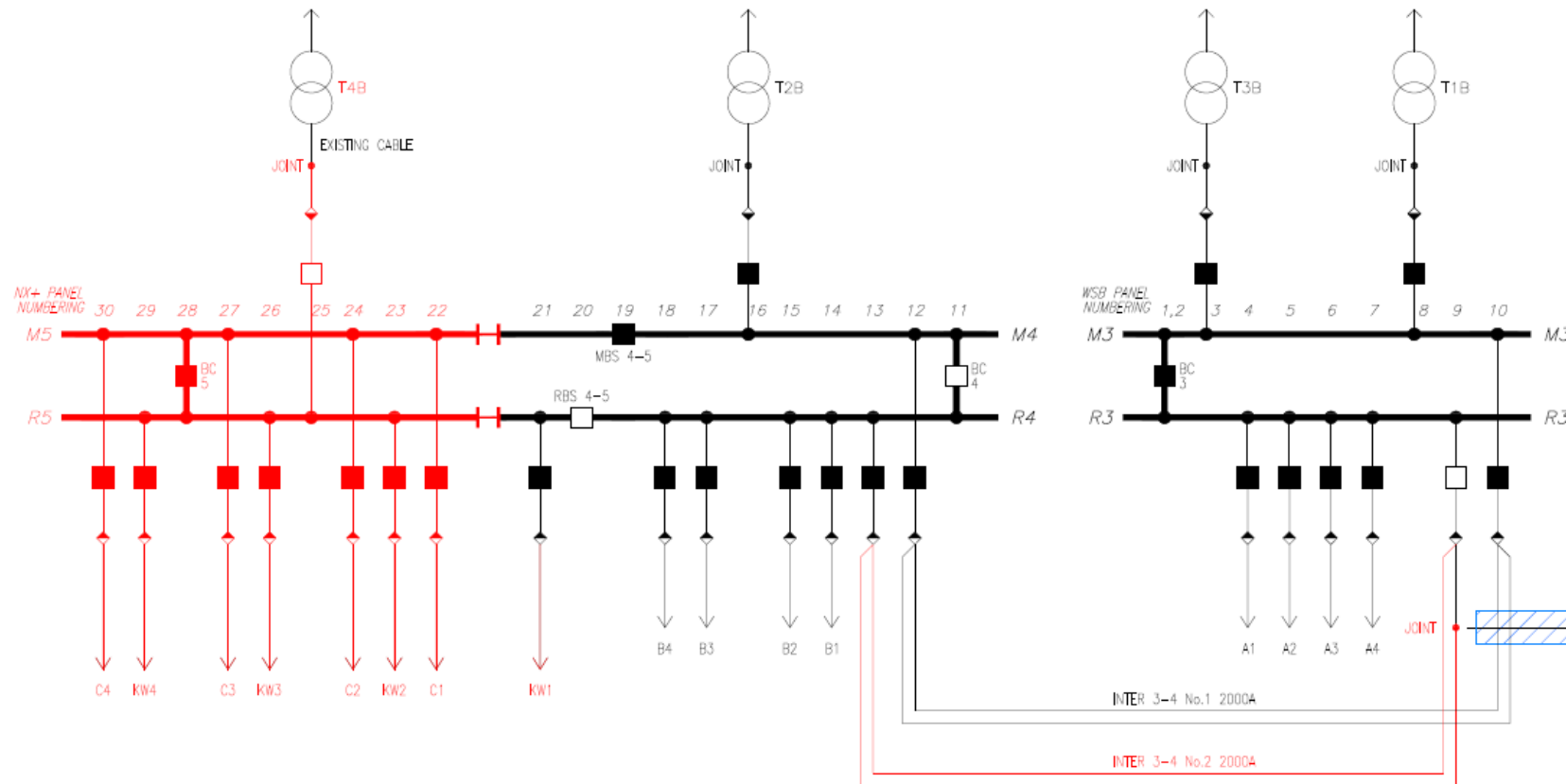
APPENDIX A: FEEDER GROUP GEOGRAPHICAL



APPENDIX B: SINGLE LINE DIAGRAM – BACK HILL 33KV WITH L42 SWITCHGEAR

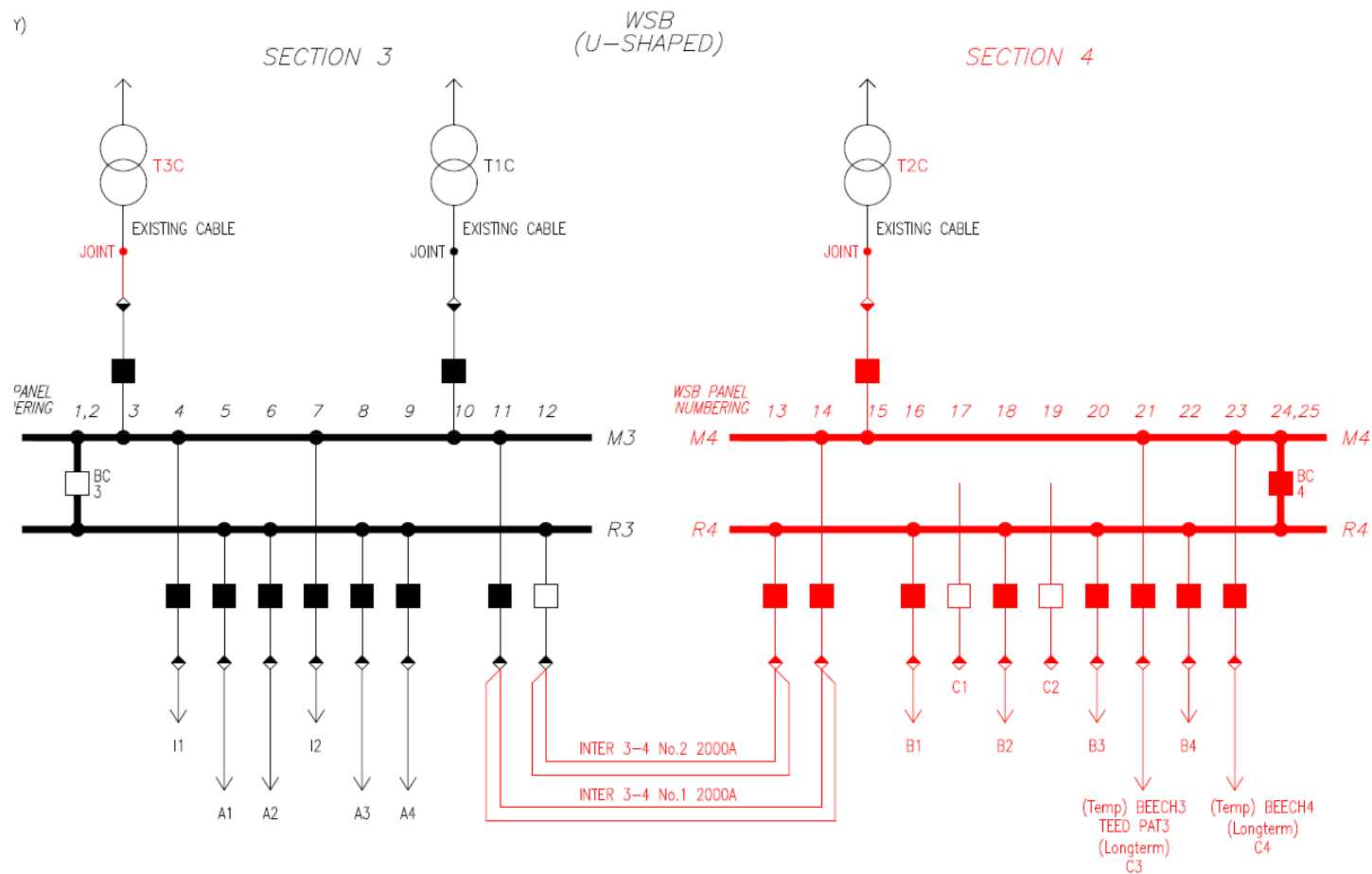


APPENDIX C: SINGLE LINE DIAGRAM – BACK HILL 33KV SWITCHBOARD FULL REPLACEMENT



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APPENDIX D: FINSBURY MARKET 'C' REPLACEMENT 33KV SWITCHBOARD



APPENDIX E: RED FEEDER GROUP SCHEMMATIC

