



Title: Willesden

LPN Regional Development Plan No 1

Version: 1.6

Date: March 2014

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

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1 Executive Summary

This Development Plan reviews the LPN EHV network supplied from Willesden 275/132kV and 275/66kV Grid Supply Points (GSP's) which have an aggregated demand of circa 390MW across five LPN 11kV, five London Underground (LUL) and three Network Rail substations. Willesden 132kV additionally supplies the EPN Leicester Road Grid substation increasing the demand on the GSP by a further 60MW

The network is composed entirely of underground cables the majority of which was installed between late 1930's and 1960. A relatively new addition was the establishment of Fulham Palace 'C' in 1997 supplied by 132kV cables installed in a 6km deep cable tunnel.

Two reinforcements are proposed at Bulwer Street and Kimberley Road which are both forecast to become LI5 during the plan period. Due to space constraints at Bulwer Street, it is proposed to construct a new main substation within the White City area and reconfigure the 11kV network to permanently transfer demand. The new substation will be designed to accept an additional transformer which is expected to be required to supply new developments within the 43 acre White City development area.

No further reinforcements or other major re-design of the network is planned during ED1 with the remainder of the recommended strategy formulated to maintain security of supply and operational reliability.

1.1 Investment Profile

Table 1. Cost Summary 2014 - 2023

| Cat. | 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 | 4,964,411 | 584,610 | 0 | 101,395 | 299,365 | 737,470 | 766,152 | 1,531,656 | 534,973 | 164,710 |
| R | Reinforcement Total | 1,113,216 | 2,810,464 | 7,064,005 | 5,543,361 | 1,933,762 | 251,679 | 1,236,629 | 2,967,909 | 412,210 | 247,326 |
| | Grand Total | 6,077,626 | 3,395,074 | 7,064,005 | 5,644,756 | 2,233,127 | 989,149 | 2,002,781 | 4,499,565 | 947,183 | 412,036 |

1.2 Proposed Project > £1M

Asset Replacement

- 8499 Gibbons Road: Replace 11kV switchboard £1.44M
- 8498 Bulwer Street: Transformers replacement £4.23M

Reinforcement

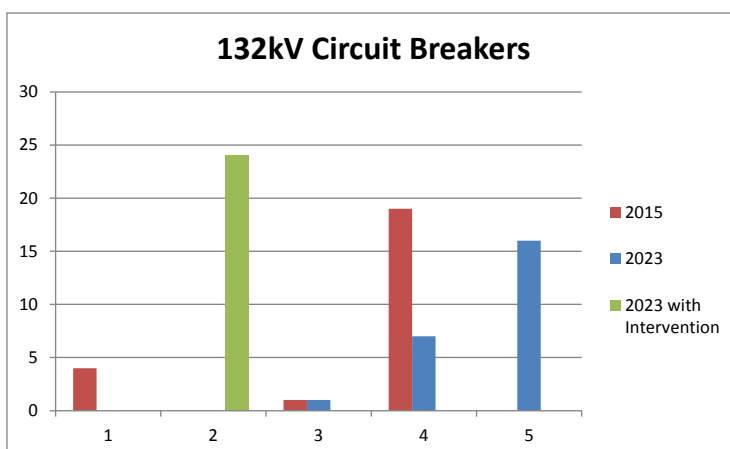
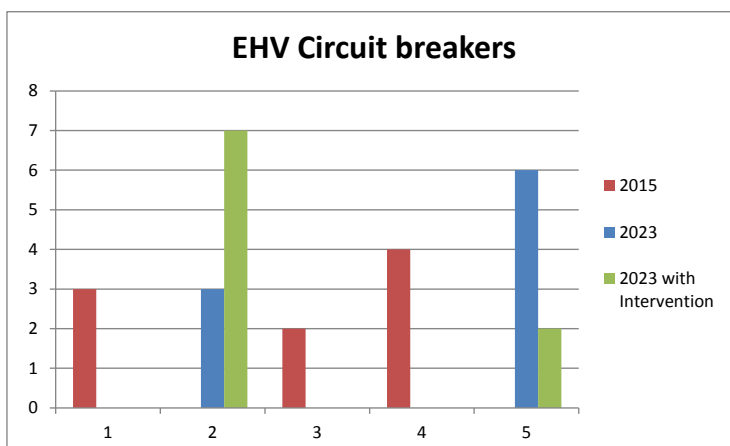
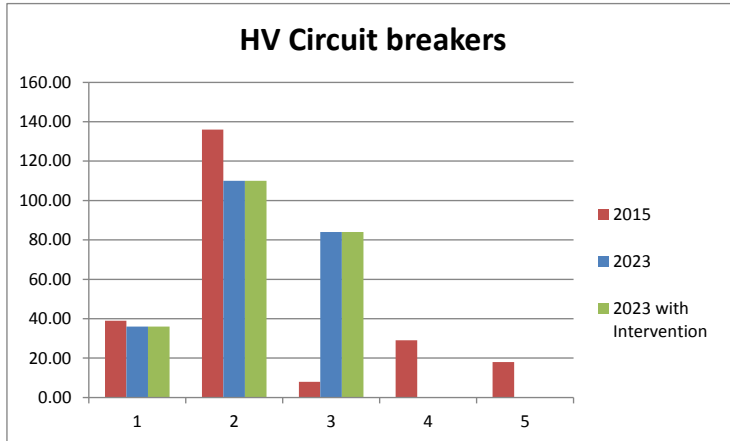
- 8492 Kimberley Road: Install 2x15MVA transformers £1.14M
- 5842 White City: New 132/11kv substation £16.42M

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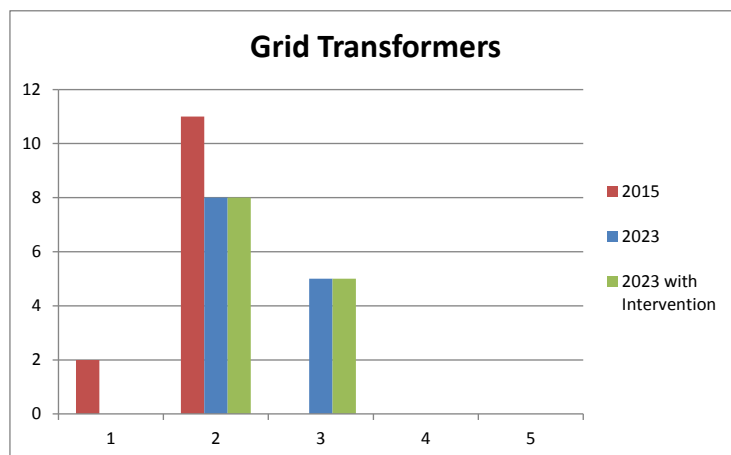
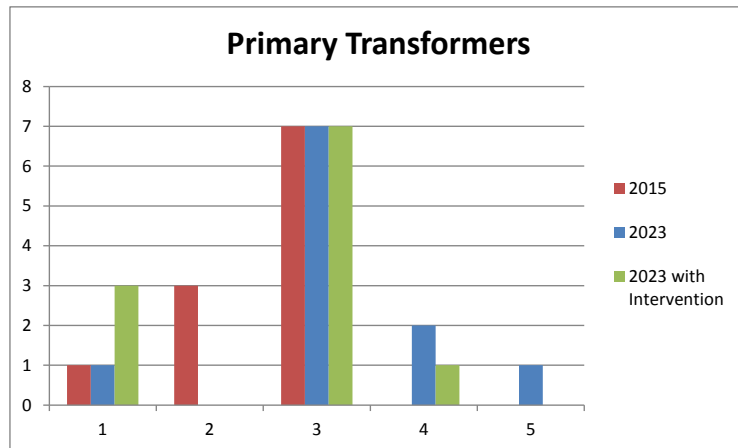
1.3 Output Measures - Health Index

The forecast health indices for 2015 and 2023 with and without intervention, for each plant category are detailed below:



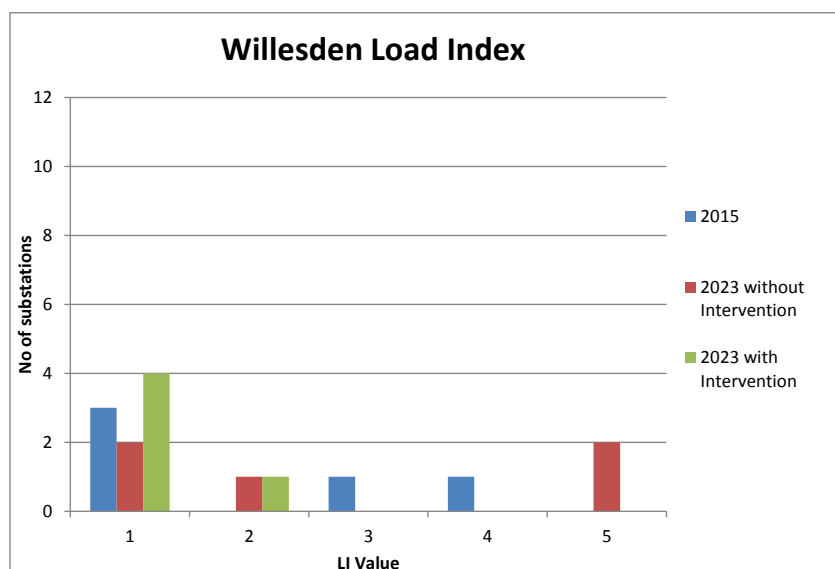
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1.4 Output Measures – Load Index

The forecast load indices for 2015 and 2023 with and without intervention are detailed below:



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1.5 Principal Risks and Dependencies

The development timescales for White City are outside the direct control of UK Power Networks and may impact on the planned delivery programme for the Willesden 4th SGT.

At Bulwer Street, establishing 11kV interconnection to the new White City substation would reduce the risk of customer interruptions during the longer 'return to service times' associated with asset replacement of the two 66/11kV transformers.

Acton Lane is a shared substation; the switchgear asset replacement proposals are to be developed in conjunction with, and influenced by, National Grid and SSE.

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2 Network Configuration

2.1 Existing Network

This Development Plan reviews the LPN EHV network supplied from Willesden 275/132kV and 275/66kV Grid Supply Points (GSP's).

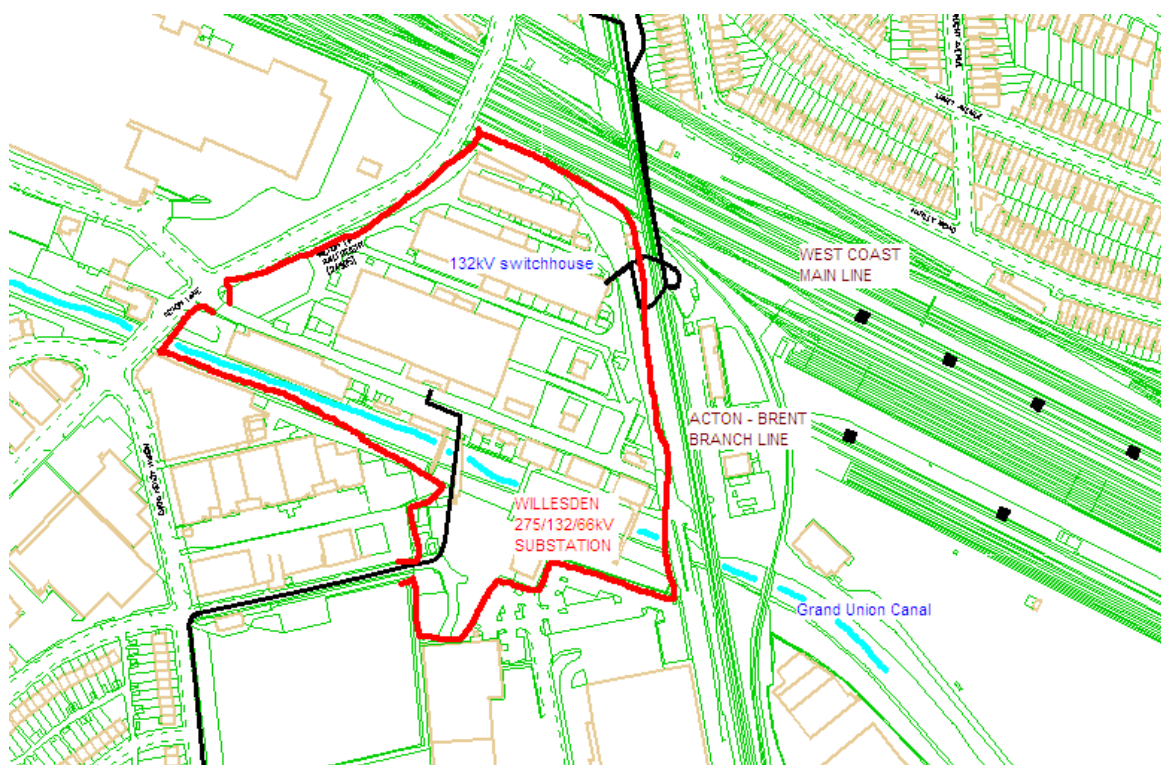
Willesden Substation Site Overview

Willesden is a complex site comprising 275/132/22kV assets supplying LPN, EPN and SSE. The Grand Union Canal bisects the site with associated high level bridges required for cross site cables. Cable routes are further constrained by the proximity of the West Coast Main Line (WCML), Acton to Brent branch line, extensive railway sidings and the Bakerloo underground line.

There is an existing LPN deep cable tunnel south to Fulham and a 2nd northern tunnel is currently under construction to Gibbons Road.

The site supplies a London Underground (LUL) traction substation and three Network Rail trackside supply points. It is the connection point for the 175MVA Taylors Lane gas turbine power station.

Figure 1. **Willesden site plan**



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Willesden 132kV Substation: The Willesden 132kV AIS (air insulated substation) substation comprises 3x240MVA super grid transformers (SGT's). The original design caters for future expansion into a 4 SGT substation. There are spare skeleton bays to accommodate an additional bus coupler, section switch and 6 feeders. Existing feeders supply the primary substations at:

Fulham Palace 3x60 MVA 132/11kV: Connection is via a 6km deep cable tunnel constructed in 1997. The cables are installed in cement based sand (CBS) in the bottom of the tunnel.

Gibbons Road 3x60MVA 132/11kV: The 3x FFC 132kV circuits are currently routed trackside along the Acton–Brent branch line and have suffered from a number of cable fires disrupting services on the West Coast Main Line. The cables connect to tee points located within the Taylors Lane power station fuel compound which additionally connect to the EPN Leicester Road substation and EON 2x87.5MW open cycle gas turbine generators.

Gibbons Road 11kV switchboard has been partially asset replaced with 2000amp equipment with the remaining sections rated at 1200 amp.

Neasden 2x60MVA 132/22 LUL: This substation is supplied by a single circuit connection from Willesden with a dual supply provided from Mill Hill (EPN).

Willesden 66kV Substation: The National Grid owned Willesden 66kV AIS substation comprises 3x180MVA SGT's and is shared with SSE. There are 66kV connections to:

Bulwer Street 4x15MVA 66/11kV: The site is supplied via a 5km open cut cable route.

Townmead Road 3x22.5MVA 66/11kV: Townmead Road supplies the Thames riverside area and Chelsea Harbour. There is a 132kV single switch configuration which interconnects to Lodge Road GSP via Moscow Road. The first 800m of cable are routed across an ex-Power Station site and incur a £100k/per annum easement charge for this short section before entering public highway.

Acton Lane 22kV: The 4x40MVA 66/22kV transformers together with the former Acton Lane Power Station 22kV switchboard are owned by National Grid and shared with SSE. Within LPN it supplies 3 LUL substations and Kimberly Road.

Kimberly Road 4x15MVA 22/11kV: The 22kV primary voltage is a legacy from the now closed Acton Lane Power Station. Connection is achieved via a 5.3 route km solid (paper insulated) cables installed in 1952.

2.2 Embedded Generation

Taylor's Lane power station is the only primary connected generation within this RDP area.

Table 2. **132kV Embedded Generation**

| Generation Plants | Type | DNC (MVA) | F (%) | pf | DG Output = F*DNC | | |
|--------------------|--------------------------|-----------|-------|----|-------------------|----|------------------|
| | | | | | MVA | MW | MVA _r |
| Taylors Lane 132kV | Gas turbine 2x87.5MVA | 175 | 0 | 0 | 0 | 0 | 0 |

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2.3 Projects in Progress

Five major projects are currently in progress. These are summarised below:

Table 3. Summary of Project in Progress

| Cat. | Reference | Description | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 |
|------|--------------|--|-----------|-----------|-----------|-----------|-----------|---------|---------|
| A | 1.50.01.2595 | Kimberley Road 11kV Switchboard Replacement | 1,471,529 | 103,522 | 0 | 0 | 0 | 0 | 0 |
| A | 1.55.02.5683 | Willesden Grid 66kV CB Refurbishment | 205,844 | 0 | 0 | 0 | 0 | 0 | 0 |
| A | 1.29.02.3511 | Willesden to Gibbons Rd FFC - Replacement | 3,287,038 | 481,087 | 0 | 0 | 0 | 0 | 0 |
| R | 1.33.01.2644 | Townmead Rd 66/11kV - ITC (add 1x22.5MVA) | 732,370 | 0 | 0 | 0 | 0 | 0 | 0 |
| R | 1.34.02.5881 | Kimberley Rd: 11kV feeder transfer from the old to new switchboard | 141,700 | 106,275 | 0 | 0 | 0 | 0 | 0 |
| R | 1.35.07.5842 | White City New 132/11kV Substation - (2x33.3MVA) | 239,146 | 2,704,189 | 7,064,005 | 4,930,087 | 1,481,693 | 0 | 0 |

5683: Switchgear refurbishments are in progress at Willesden 66kV.

2595 & 5118:

Kimberly Road 11kV switchboard is being replaced due to poor condition and the inability to retrofit tele-control. Due to space constraints the scope of work includes construction of a new high level switch room to accommodate the replacement equipment.

3511: The Willesden-Gibbons Road 132kV FFC trackside circuits are currently being replaced with XLPE cables installed in a new deep cable tunnel. A tunnel is required due to street service congestion and shallow cover on the West Coast Main Line/Bakerloo line road bridge preventing an 'open cut' installation. The new tunnel removes the risk of further railway bridge fires, associated disruption to Euston train services and removes the need for overnight track possessions for repairs.

2644: To supply incremental demand growth a 3rd 66/11kV 22.5MVA transformer is currently being installed at Townmead Road connecting to a spare panel on the existing 11kV single busbar switchboard.

5842: Detailed design has commenced for the establishment of a new main substation at White City to relieve the heavily loaded Bulwer Street substation (forecast LI5 by end ED1). The substation will initially be equipped with 2x33MMVA 132/11kV transformers supplied by cables installed in the existing Willesden-Fulham palace Road deep cables tunnel. Provision will be made for a 3rd transformer to allow reinforcement to supply the expected White City development area.

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3 Summary of Issues

3.1 Development Areas

Urban regeneration projects at White City and Earls Court are expected to be developed during ED1:

3.1.1 White City

The London Borough of Hammersmith and Fulham (LBHF) and the Mayor of London (GLA) have agreed a planning framework for a White City Development Area, London W12 proposing mixed office, residential and community use. The 43 acre site is close to the BBC Television Centre and Westfield Shopping Centre and is shown in Figure 2 below.

Bulwer Street 66/11kV substation is adjacent to the Development Area boundary but has insufficient capacity headroom to accommodate the forecast 25MW new demand. It is therefore proposed to adopt a co-operative approach with the majority land owners to identify a suitable location for a new main substation.

The proposed substation is to initially comprise 2x33MVA 132/11kV transformers to relieve Bulwer Street supplied by new 132kV cables installed in the existing Willesden-Fulham Palace deep cable tunnel between Willesden and an intermediate shaft at Sheppards Bush. The substation building will be designed for future reinforcement to 3x33MVA transformers to provide capacity to the development area.

Figure 2. White City Development Area



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3.1.2 Project ECO (Earls Court Olympia)

The proposed £8bn redevelopment of the exhibition centres and up to 7,500 new homes has achieved outline planning permission with an expected increase of 20MW of new demand.

There is insufficient capacity headroom at the adjacent Old Brompton Road substation and it will be necessary to establish a new main substation with capacity to support the local network into the longer term. No provision for this work has been included in the plan as it is considered to be reinforcement ahead of need.

Figure 3. Earls Court Olympia Development Area (Project ECO)

KEY FACTS

THE EARLS COURT MASTERPLAN

- ★ 3 landowners – Capco, Transport for London and the London Borough of Hammersmith & Fulham
- ★ 77 acres (31 hectares) including the Seagrave Road site
- ★ Over 7,500 new homes, including 808 on Seagrave Road
- ★ 12,000 new permanent full-time jobs


EC&O VENUES

- ★ £20 million invested in redevelopment of Olympia
- ★ Exhibition venues valued at £510 million

EMPRESS STATE BUILDING

- ★ 50% ownership

EC&O MAP



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Outline planning application approved for £8bn Earls Court regeneration scheme

Thursday September 13, 2012



Above: CGI of the regeneration plans

One of the biggest regeneration projects in London for decades is set to inject billions of pounds worth of private investment into West Kensington and Earls Court.

Hammersmith & Fulham (H&F) Council's planning applications committee last night (Wednesday, September 12) approved the proposal for outline planning permission, subject to conditions and a legal agreement for the redevelopment of 57 acres of land at West Kensington and Earls Court.

Thousands of new homes and jobs will now be created as part of the

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3.1.3 Local Borough Plans

Brent Council Core Strategy (2010) includes a target of 10,100 new homes for the period 2007-17 with 5 designated areas for development at Wembley, Alperton, South Kilburn, Burnt Oak and Church End. The development areas are on the fringe of the supply area and are not expected to impact upon the existing demand growth profile.

Fulham and Hammersmith 2011 Core Strategy has proposed a target of 1,000 new homes in the vicinity of the Hammersmith interchange area for the across same period which is within the Fulham Palace Road substation supply area.

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3.1.1 London Underground

The London Underground 132/22kV 2x60MVA traction supply point at Neasden is currently supplied by a single circuit from Willesden and Mill Hill (EPN). LUL have applied to increase their installed substation capacity to 2x90MVA transformers. Due to geographical constraints confirming deliverable and cost effective replacement cable routes from Willesden is problematic and an alternative solution from the new EPN Hendon substation is also being evaluated.

3.2 Asset Health

The forecast health indices (without intervention) for switchgear, transformers and gas pressure and fluid filled cables are tabulated below:

| HV Circuit breakers | | | | | | | | | | |
|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| BULWER ST | | 29 | 1 | | | | | 30 | | |
| FULHAM PALACE RD | | 60 | | | | | 60 | | | |
| GIBBONS RD | 14 | 18 | 7 | 29 | 18 | 12 | 20 | 54 | | |
| KIMBERLEY RD | 24 | | | | | 24 | | | | |
| TOWNMEAD | | 29 | | | | | 29 | | | |
| WILLESSEN BR 11kV | 1 | | | | | | 1 | | | |

| EHV Circuit breakers | | | | | | | | | | |
|----------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| ACTON LANE 22kV | | | | 4 | | | | | | 4 |
| NEASDON LUL 22kV | 2 | | | | | | 2 | | | |
| WILLESSEN BR 11kV | 1 | | | | | | 1 | | | |
| WILLESSEN BR 25kV | | | 2 | | | | | | | 2 |

| 66kV and 132kV circuit breakers | | | | | | | | | | |
|---------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| WILLESSEN GRID 66kV | | | 3 | 1 | | | | | | 4 |
| WILLESSEN GRID 132KV | 1 | 19 | | | | | 15 | 5 | | |
| SHOREDITCH 66KV | | 1 | | 5 | | | 1 | | | 5 |

| Primary Transformers | | | | | | | | | | |
|----------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| BULWER ST | | | 4 | | | | | | 4 | |
| KIMBERLEY RD | | 1 | 3 | | | | | 4 | | |
| TOWNMEAD | 1 | 2 | | | | 1 | | 2 | | |

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| Grid Transformers | | | | | | | | | | |
|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| FULHAM PALACE RD | 1 | 2 | | | | | 3 | | | |
| GIBBONS RD | | 3 | | | | | 1 | 2 | | |
| NEASDON LUL 22kV | | 2 | | | | | | 2 | | |
| NORTH POLE BR 25kV | | 1 | | | | | 1 | | | |
| WILLESSEN BR 11kV | | 2 | | | | | 1 | 1 | | |
| WILLESSEN BR 25kV | 1 | 1 | | | | | 2 | | | |

Table 4. Cable HI profile without intervention

| Asset ID | Section (Route) | Cable Section | Region | kV | HI in 2012 | HI in 2015 | HI in 2024 |
|--|-----------------|----------------------------------|--------|-----|------------|------------|------------|
| 2067982 WILLESSEN GRID 132KV-LEICESTER RD 33KV | | CABLE SECTION: 32983287-1-B-C | LPN | 132 | 2 | 2 | 3 |
| 2067956 WILLESSEN GRID 132KV-NEASDON LUL 22KV | | CABLE SECTION: 32980261-1-A | LPN | 132 | 2 | 3 | 3 |
| 2067985 WILLESSEN GRID 132KV-TAYLORS LANE | | CABLE SECTION: 3298TAYT-3-A | LPN | 132 | 2 | 3 | 3 |
| 2067957 WILLESSEN GRID 132KV-WILLESSEN BR 25KV | | CABLE SECTION: 32980299-1-A | LPN | 132 | 2 | 2 | 2 |
| 2067958 WILLESSEN GRID 132KV-WILLESSEN BR 25KV | | CABLE SECTION: 32980299-1-B | LPN | 132 | 2 | 2 | 2 |
| 2067959 WILLESSEN GRID 132KV-WILLESSEN BR 25KV | | CABLE SECTION: 32980299-2-A | LPN | 132 | 2 | 2 | 3 |
| 2067960 WILLESSEN GRID 132KV-WILLESSEN BR 25KV | | CABLE SECTION: 32980299-2-B | LPN | 132 | 2 | 2 | 2 |
| 2067948 WILLESSEN GRID 66KV-BULWER ST 11KV | | CABLE SECTION: 32970109-1-A | LPN | 66 | 2 | 2 | 2 |
| 2067952 WILLESSEN GRID 66KV-BULWER ST 11KV | | CABLE SECTION: 32970109-3-A | LPN | 66 | 2 | 2 | 2 |

3.3 Security of Supply and Load Index Analysis

Table 5. Load index (LI) profile without intervention

| Substation | Voltage kV | Load Index | |
|--------------------|---------------|------------|------|
| | | 2015 | 2023 |
| Bulwer Street | 66/11 | 3 | 5 |
| Fulham Palace Road | 132/11 | 1 | 2 |
| Gibbons Road | 132/11 | 1 | 1 |
| Kimberley Road | 132/33 | 4 | 5 |
| Townmead Road | 66/11 | 1 | 1 |

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Table 6. P2/6 Assessment Table

| Sub-station | P2/6 | Type of substation | Secondary Voltage | Firm Capacity (MW) | Transfer (MW) | P. F. | Winter 12/13 Summer 2012 (M W) | Winter 13/14 Summer 2013 (M W) | Winter 14/15 Summer 2014 (M W) | Winter 15/16 Summer 2015 (M W) | Winter 16/17 Summer 2016 (M W) | Winter 17/18 Summer 2017 (M W) | Winter 18/19 Summer 2018 (M W) | Winter 19/20 Summer 2019 (M W) | Winter 20/21 Summer 2020 (M W) | Winter 21/22 Summer 2021 (M W) | Winter 22/23 Summer 2022 (M W) |
|-----------------------|------|--------------------|-------------------|--------------------|---------------|-------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| Fulham Palace 'C' | YES | | 11kV | 152.60 | 19.61 | 0.97 | 102.73 | 103.39 | 104.49 | 105.67 | 106.66 | 107.78 | 108.97 | 110.21 | 111.49 | 113.20 | 114.90 |
| Fulham Palace 'C' | YES | | 11kV | 123.65 | | 0.92 | 93.97 | 94.57 | 95.56 | 96.62 | 97.52 | 98.53 | 99.61 | 100.73 | 101.89 | 103.43 | 104.97 |
| Gibbons Road | YES | | 11kV | 147.80 | 4.51 | 0.97 | 83.49 | 83.85 | 84.43 | 85.04 | 85.56 | 86.14 | 86.74 | 87.35 | 87.98 | 88.78 | 89.60 |
| Gibbons Road | YES | | 11kV | 124.99 | 5.79 | 0.93 | 64.84 | 65.10 | 65.53 | 66.00 | 66.38 | 66.81 | 67.26 | 67.72 | 68.20 | 68.79 | 69.41 |
| Neasden 22kV LUL T1 | YES | Customer | 22kV | 35.44 | | 0.96 | 5.20 | 5.89 | 5.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Neasden 22kV LUL T1 | YES | Customer | 22kV | 27.60 | | 0.92 | 5.30 | 5.99 | 5.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| North Pole 25kV BR | NO | Customer | 25kV | 0.00 | | 0.96 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 |
| North Pole 25kV BR | NO | Customer | 25kV | 0.00 | | 0.92 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Willesden 11kV BR | YES | Customer | 11kV | 20.00 | | 0.96 | 8.76 | 8.76 | 8.76 | 8.76 | 8.76 | 8.76 | 8.76 | 8.76 | 8.76 | 8.76 | 8.76 |
| Willesden 11kV BR | YES | Customer | 11kV | 20.00 | | 0.92 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 | 8.74 |
| Willesden 25kV BR | YES | Customer | 25kV | 35.00 | | 0.96 | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 | 10.18 |
| Willesden 25kV BR | YES | Customer | 25kV | 35.00 | | 0.92 | 9.34 | 9.34 | 9.34 | 9.34 | 9.34 | 9.34 | 9.34 | 9.34 | 9.34 | 9.34 | 9.34 |
| Willesden Grid 132kV | YES | | 132kV | 553.00 | | 0.96 | 197.93 | 199.51 | 201.07 | 196.84 | 198.23 | 199.81 | 201.47 | 203.18 | 204.96 | 207.28 | 209.61 |
| Willesden Grid 132kV | YES | | 132kV | 488.40 | | 0.96 | 174.98 | 176.48 | 177.84 | 173.32 | 174.55 | 175.94 | 177.41 | 178.92 | 180.49 | 182.54 | 184.60 |
| Acton Lane 22kV LE | NO | NG | 22kV | 0.00 | | 0.97 | 55.33 | 55.68 | 56.29 | 56.95 | 57.51 | 58.15 | 58.82 | 59.50 | 60.22 | 61.00 | 62.17 |
| Acton Lane 22kV LE | NO | NG | 22kV | 0.00 | | 0.92 | 38.48 | 38.69 | 39.07 | 39.48 | 39.82 | 40.21 | 40.62 | 41.04 | 41.48 | 42.08 | 42.88 |
| Acton Lane 22kV LUL | YES | Customer | 22kV | 19.40 | | 0.98 | 8.54 | 8.54 | 8.54 | 8.54 | 8.54 | 8.54 | 8.54 | 8.54 | 8.54 | 8.54 | 8.54 |
| Acton Lane 22kV LUL | YES | Customer | 22kV | 19.40 | | 0.92 | 8.50 | 8.50 | 8.50 | 8.50 | 8.50 | 8.50 | 8.50 | 8.50 | 8.50 | 8.50 | 8.50 |
| Brentham New 22kV LUL | NO | Customer | | 0.00 | | 0.96 | 9.16 | 9.16 | 9.16 | 9.16 | 9.16 | 9.16 | 9.16 | 9.16 | 9.16 | 9.16 | 9.16 |
| Brentham New 22kV LUL | NO | Customer | | 0.00 | | 0.92 | 7.62 | 7.62 | 7.62 | 7.62 | 7.62 | 7.62 | 7.62 | 7.62 | 7.62 | 7.62 | 7.62 |
| Bulwer Street | YES | | 11kV | 56.75 | 13.82 | 0.97 | 40.42 | 40.87 | 41.61 | 42.38 | 43.03 | 43.76 | 44.52 | 45.31 | 46.12 | 47.16 | 48.20 |
| Bulwer Street | YES | | 11kV | 42.75 | 13.16 | 0.95 | 40.08 | 40.52 | 41.22 | 41.96 | 42.58 | 43.28 | 44.02 | 44.78 | 45.56 | 46.55 | 47.55 |
| Greenford New LUL | NO | Customer | | 0.00 | | 0.96 | 6.29 | 6.29 | 6.29 | 6.29 | 6.29 | 6.29 | 6.29 | 6.29 | 6.29 | 6.29 | 6.29 |
| Greenford New LUL | NO | Customer | | 0.00 | | 0.92 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 | 5.30 |
| Kimberley | YES | | 11kV | 43.70 | 17.88 | 0.97 | 43.30 | 43.63 | 44.20 | 44.83 | 45.36 | 45.95 | 46.58 | 47.23 | 47.90 | 48.82 | 49.74 |
| Kimberley | YES | | 11kV | 38.17 | | 0.91 | 28.35 | 28.56 | 28.91 | 29.30 | 29.63 | 30.01 | 30.40 | 30.81 | 31.23 | 31.80 | 32.38 |
| Park Royal Royal LUL | NO | Customer | | 0.00 | | 0.96 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 |
| Park Royal Royal LUL | NO | Customer | | 0.00 | | 0.92 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 |
| Townmead | NO | | 11kV | 32.49 | 6.45 | 0.98 | 34.52 | 34.85 | 35.39 | 35.95 | 36.41 | 36.95 | 37.51 | 38.10 | 38.71 | 39.49 | 40.27 |
| Townmead | YES | | 11kV | 24.20 | 3.82 | 0.95 | 23.46 | 23.68 | 24.03 | 24.40 | 24.70 | 25.06 | 25.43 | 25.81 | 26.21 | 26.73 | 27.24 |
| Willesden Grid 66 kV | YES | | 66kV | 425.10 | | 0.96 | 127.61 | 128.70 | 130.51 | 132.44 | 134.05 | 135.88 | 137.81 | 139.80 | 141.87 | 144.56 | 147.26 |
| Willesden Grid 66 kV | YES | | 66kV | 376.70 | | 0.96 | 94.22 | 95.03 | 96.35 | 97.76 | 98.93 | 100.26 | 101.67 | 103.12 | 104.62 | 106.57 | 108.52 |

Table 7. P2/6 Assessment Table

Notes:

The table identifies a capacity shortfall at Townmead Road over the winter peak 2017/18. This is to be resolved by the approved reinforcement scheme 2644 for the installation of a 3rd 22.5MVA transformer forecast for commissioning in 2014.

The single transformer London Underground and Network Rail supply points at North Pole, Brentham, Greenford and Park Royal are highlighted as 'out of firm'. These 'sole user' sites are outside the scope of P2/6 with security of supply maintained by interconnection across the Customer's networks.

A Modification Application was submitted to National Grid in September 2012 for the installation of a 4th 275/132KV SGT to secure against an (n-2) condition when the substation demand exceeds 300MW.

Willesden

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

3.4 Operational and technical restrictions

There are no known issues.

3.5 National Grid

Willesden 132kV: As detailed in Section 2 a Modification Application for a 4th Willesden 275/132kV SGT has been submitted to National Grid for commissioning Q3 2016. The scope of work includes installation of a 2nd bus coupler and section switch to create a 4 node substation.

Acton Lane 22kV: This 1965 vintage switchboard is programmed for asset replacement towards the end of ED1. The exact timing will be determined by National Grid (owner) in consultation with the users UK Power Networks and SSE.

It is understood that SSE's medium term objective is to migrate their primary supplies from 22kV to 66kV. Should this occur, LPN would become the sole User and National Grid are expected to request LPN to adopt the fully depreciated switchboard and 4x90MVA 66/22kV transformers.

3.6 Network Constraints

There is no circuit diversity for the tunnel circuits to:

Fulham Palace Substation - 3x132kV cables installed in CBS (cement based sand)
Gibbons Road - 3x132kV XLPE cables installed on cable brackets
White City – 132kV cables installed on brackets

To reduce the consequences of a high impact low probability (HILP) event the cables to Gibbons Road and White City are to be installed either side of the tunnel to reduce the likelihood of consequential damage.

The Fulham Palace cables are installed in CBS which offers significant physical protection and reduces the risk of induced damage between circuits.

4 Recommended Strategy

The network strategy for this area is designed to ensure:

- Continued adherence to the security of supply criteria defined in Engineering Recommendation P2/6
- Maintaining reliable network operation by asset replacement, or refurbishment, of poorly performing equipment identified through asset condition monitoring (HI) techniques

Whenever possible the asset replacement and reinforcement works are to be co-ordinated to achieve an efficient economic solution.

Willesden

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

4.1 Proposed Interventions

Table 8. Summary of Proposed Interventions

| Substation | Driver | Commissioning Year | Scope of works | New Firm capacity |
|--------------------|-------------------|--------------------|---|----------------------------------|
| Acton Lane 22kV | Asset replacement | 2022 - 2024 | Replace existing bulk oil circuit breakers | No change |
| Gibbons Road | Asset Replacement | 2021 | Replace 11kV Sections 3,4 & 5 | No change |
| Bulwer Street | Asset Replacement | 2020 | Replace Grid Transformers GT2 and GT3 | No change |
| Willesden 132kV | Asset Replacement | 2022 | Refurbish switchgear | No change |
| Kimberly Road | Reinforcement | 2023 | Install 2x15MVA transformers | 64.5MVA (winter) |
| Bulwer Street 11kV | Reinforcement | 2019 | Permanent 11kV transfers to White City | No change |
| Willesden 132kV | Reinforcement | 2017 | Install 4 th SGT and associated bus coupler and section switch | (n-1) = 720MVA (n-2) = 480MVA |

Table 9. Proposed Interventions

Acton Lane 22kV Asset Replacement:

Condition assessment of this F Palin VTR/VDP switchboard predicts that replacement will be required towards the end of ED1. Partial replacement is impractical due to the integral construction of the existing equipment and the exact project timing will therefore need to be jointly agreed by all users, LPN, National Grid and SSE. It is expected that National Grid will project manage the replacement with LPN responsible for the cost of the 4 Kimberly Road feeder panels with the 3 London Underground Ltd panels recharged to the Customer (LUL).

Gibbons Road 11kV Switchboard Replacement

Gibbons Road is a complex 87 panel switchboard divided into 7 sections.

Sections 1, 2, 6 and 7 are equipped with 1200amp AEI QF461 switches. Sections 3, 4 and 5 are equipped with HSSL VMVD panels installed in 2001 and rated at 2000amps. It is proposed to asset replace the 54 HSSL panels and reconfiguring connections to achieve a unified 2000amp switchboard (8 less panels will be required).

Bulwer Street Transformer Replacement

Based on existing health index data Grid Transformer 3 is forecast to become HI4 by 2023 with the remaining units reaching either HI3 or HI4. In order to deliver a phased asset replacement programme, it is proposed to replace 2 transformers with equivalently rated (15MVA) units by 2023 with the remaining two transformers programmed for ED2.

Kimberly Road

The substation is forecast to become LI5 by the end of ED1. Due to the local network configuration of the interconnected feeder groups there is only limited scope to increase the 11kV transfer capacity to adjacent substations and it is therefore proposed to install an additional 2x15MVA 22/11kV transformers and associated 2x 5.3km 22kV underground circuits and an 11kV switchboard extension.

Willesden

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Bulwer Street 11kV Transfers to White City

It is proposed to permanently transfer an 11kV Group to the new White City substation to provide capacity headroom, release spare panels for future reinforcement of existing groups and reduced reliance on post fault transfer to maintain P2/6 compliance. The transfer would also mitigate against customer interruptions should an (n-2) condition occur during the long outage duration asset replacement of GT2 and GT3 transformers (see below). The 11kV reconfiguration is to be programmed consecutively with the commissioning of the new White City substation.

Willesden 132kV 4th SGT

A 4th SGT will be required to cater for an (n-2) condition when the aggregated demand exceeds 300MW and Willesden 132kV substation becomes reclassified as Class E under ER P2/6. There is uncertainty surrounding future demand levels due to different reinforcement options for London Underground's Neasden and the timing of the White City development. A Modification Application has been submitted for the additional SGT to commission Q3 2016 however, both LPN and National Grid are aware of the need to monitor the demand levels and the proposed connection date may require amendment to coincide with Customer requirements. In order to connect the addition transformer it will be necessary to install a Section 2 bus coupler and a reserve busbar section switch to create a 4 node substation.

4.2 Costs and Phasing

Table 10. Proposed ED1 Interventions

| Cat. | Reference | Description | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 |
|------|--------------|--|---------|---------|---------|---------|---------|---------|-----------|-----------|---------|---------|
| A | 1.48.02.7784 | Willesden B.R. 25kV - Replace 33kV Switchgear | 0 | 0 | 0 | 101,387 | 169,751 | 0 | 0 | 0 | 0 | 0 |
| A | 1.48.11.2535 | Acton Lane 22kV Circuit Breaker Replacement (NG*) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 63,790 | 164,710 |
| A | 1.50.01.8499 | Gibbons Road 11kV: Asset replace AEI QF Switchgear | 0 | 0 | 0 | 0 | 0 | 75,000 | 93,000 | 1,531,656 | 0 | 0 |
| A | 1.51.03.8498 | Bulwer Street: Replace Transformers GT2 & GT3 | 0 | 0 | 0 | 9 | 129,614 | 662,470 | 673,152 | 0 | 0 | 0 |
| A | 1.55.02.7777 | Willesden Grid 132kV - Refurb 132kV Switchgear | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 471,184 | 0 |
| R | 1.33.01.8492 | Kimberley Rd 22/11kV - ITC (add 2x15MVA) | 0 | 0 | 0 | 0 | 0 | 82,442 | 1,236,629 | 2,967,909 | 412,210 | 247,326 |
| R | 1.34.02.8497 | Bulwer Street: 11kV Load Transfers to White City | 0 | 0 | 0 | 25,000 | 305,000 | 169,237 | 0 | 0 | 0 | 0 |
| R | 1.36.01.2660 | Willesden 132kV GSP - 4th SGT (240MVA) (N-2) | 0 | 0 | 0 | 588,274 | 147,068 | 0 | 0 | 0 | 0 | 0 |

Willesden

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5 Forecast HI & LI Post Intervention

| HV Circuit breakers | | | | | | | | | | |
|---------------------|---------|---------|---------|---------|---------|------------------------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 with Intervention | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| BULWER ST | | 29 | 1 | | | | | 30 | | |
| FULHAM PALACE RD | | 60 | | | | | 60 | | | |
| GIBBONS RD | 14 | 18 | 7 | 29 | 18 | 12 | 20 | 54 | | |
| KIMBERLEY RD | 24 | | | | | 24 | | | | |
| TOWNMEAD | | 29 | | | | | 29 | | | |
| WILLESDEN BR 11kV | 1 | | | | | | 1 | | | |

| EHV Circuit breakers | | | | | | | | | | |
|----------------------|---------|---------|---------|---------|---------|------------------------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 with Intervention | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| ACTON LANE 22kV | | | | 4 | | | | | | 4 |
| NEASDON LUL 22kV | 2 | | | | | | 2 | | | |
| WILLESDEN BR 11kV | 1 | | | | | | 1 | | | |
| WILLESDEN BR 25kV | | | 2 | | | | | | | 2 |

| 66kV and 132kV circuit breakers | | | | | | | | | | |
|---------------------------------|---------|---------|---------|---------|---------|------------------------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 with Intervention | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| WILLESDEN GRID 66kV | 4 | | | | | | 4 | | | |
| WILLESDEN GRID 132KV | | | 1 | 19 | | | 20 | | | |

| Primary Transformers | | | | | | | | | | |
|----------------------|---------|---------|---------|---------|---------|------------------------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 with Intervention | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| BULWER ST | | | 4 | | | 2 | | 1 | 1 | |
| KIMBERLEY RD | | 1 | 3 | | | | | 4 | | |
| TOWNMEAD | 1 | 2 | | | | 1 | 2 | | | |

Willesden

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| Grid Transformers | | | | | | | | | | |
|--------------------|---------|---------|---------|---------|---------|------------------------|---------|---------|---------|---------|
| Substation | 2015 | | | | | 2023 with Intervention | | | | |
| | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 | No. HI1 | No. HI2 | No. HI3 | No. HI4 | No. HI5 |
| FULHAM PALACE RD | 1 | 2 | | | | 3 | | | | |
| GIBBONS RD | | 3 | | | | 1 | 2 | | | |
| NEASDON LUL 22kV | | 2 | | | | | 2 | | | |
| NORTH POLE BR 25kV | | 1 | | | | 1 | | | | |
| WILLESDEN BR 11kV | | 2 | | | | 1 | 1 | | | |
| WILLESDEN BR 25kV | 1 | 1 | | | | 2 | | | | |

Table 11. Load Index Profile post intervention

| Substation | Voltage kV | Load Index | |
|--------------------|---------------|------------|------|
| | | 2015 | 2023 |
| Bulwer Street | 66/11 | 3 | 1 |
| Fulham Palace Road | 132/11 | 1 | 2 |
| Gibbons Road | 132/11 | 1 | 1 |
| Kimberley Road | 132/33 | 4 | 1 |
| Townmead Road | 66/11 | 1 | 1 |
| White City | 132/11 | n/a | 1 |

Willesden

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

6 Alternative Strategies

With the exception of the new main substation, no major re-design of the Willesden networks are proposed during ED1 with the recommended strategy formulated to maintain the operational integrity and cater for the forecast new demand at White City and the lower probability of increased demand at LUL Neasden. The following alternative options have been considered:

6.1 Acton Lane 22kV Asset Replacement

The alternative to replacement would be refurbishment. Although installed circa 1965, the F Palin VTR36 and VDP36BO bulk oil switchgear has a high reliability which, linked to a low number of operations per year, could allow an 'operational life extension' without compromising network reliability.

Regular condition monitoring is therefore to be carried out in conjunction with National Grid and SSE which, when linked to SSE's medium term plan to vacate the switch room, could result in refurbishment becoming the recommended strategy with replacement parts becoming available from the existing and future (ex-SSE) spare panels.

The National Grid owned 4x 90MVA 66/22kV transformers are also expected to require asset replacement within the next 10 years. If LPN becomes the sole users of the site the demand would reduce to circa 70MVA by 2023 allowing replacement with smaller rated transformers reconfigured from the 132kV busbars thereby rationalising ownership boundaries.

6.2 Willesden 132kV 4th SGT

The Modification application for a 4th SGT requested a Q3 2016 connection date based on the demand data detailed in Table 15 below. However, both the Neasden and White City developments are outside the control of UK Power Networks and the option of deferring the connection date was rejected in favour of assuming the status quo at Neasden (30MW) and an initial commissioning demand of 10MW at White City in 2016.

Willesden 132kV Demand Summary

| | winter | 12/13 | 13/14 | 14/15 | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 |
|-------------------------------|--------|------------|------------|------------|------------|------------|------------|------------|------------|
| Winter PLE | summer | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Leicester Road (EPN) | | 50 | 56 | 60 | 65 | 70 | 73 | 78 | 79 |
| Network Rail Nth Pole | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Network Rail 11kV + 25kV | | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| Neasden LUL T1 | | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Fulham Palace | | 106 | 109 | 112 | 115 | 118 | 120 | 121 | 123 |
| Gibbons Road | | 86 | 88 | 90 | 93 | 95 | 97 | 98 | 100 |
| White City (future) | | | | | | 10 | 30 | 50 | 52 |
| ECO Earls Court | | | | | | | | 8 | 15 |
| Total Demand | | 292 | 303 | 312 | 323 | 343 | 370 | 405 | 419 |
| Transfer allowance | | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| P2/6 assessment demand | | 274 | 285 | 294 | 305 | 325 | 352 | 387 | 401 |

7 References

| References | Description |
|------------|-------------|
|------------|-------------|

Willesden

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

| | |
|-------------|--|
| Reference 1 | Planning Load Estimates 13 th February 2013 |
| Reference 2 | LPN Standard Running Arrangements (SRA's) 2013 |
| Reference 3 | Asset Condition Report June 2013 |
| Reference 4 | NAMP Table J 19 ^h February 2014 |
| Reference 5 | Borough Local Development Plans (various) |
| | |

7.1 Appendices

| Appendix | Description |
|------------|--|
| Appendix A | Geographical diagram |
| Appendix B | Single Line Diagram – Existing 132kV Network |
| Appendix C | Single Line Diagram – Existing 66kV Network |
| Appendix D | P2/6 Analysis Table |

7.2 Document History

| Version | Date of Issue | Author | Details |
|---------|---------------|---------|--|
| 1.0-1.1 | 18/01/13 | C Winch | Amended and re-issued following document review |
| 1.2 | 03/06/13 | C Winch | Final v1 |
| 1.3 | 23/06/13 | S Mould | Updated with 5 th June NAMP, EPN HI List 2013 data v0.4 and latest LI information |
| 1.4-1.5 | 25/03/14 | C Winch | Updated and reformatted |

Willesden

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

8 Document Approvals

Recommended by:

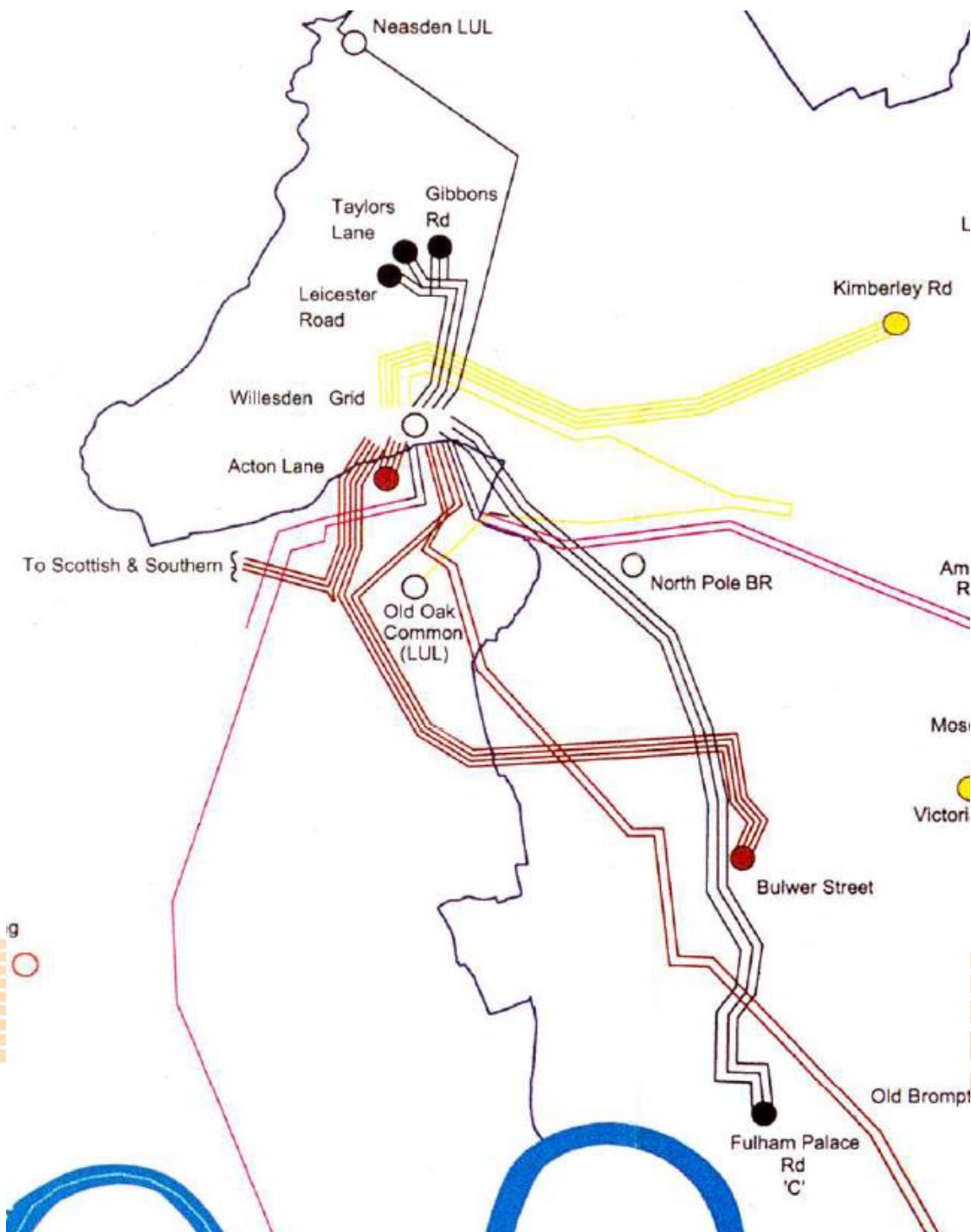
| Name | Role | Signature | Date |
|---------|---|-----------|------|
| C Winch | Infrastructure Planner | | |
| S Motte | IDP Coordinator LPN | | |
| C Winch | Infrastructure Planning Manager - South | | |

Approval by:

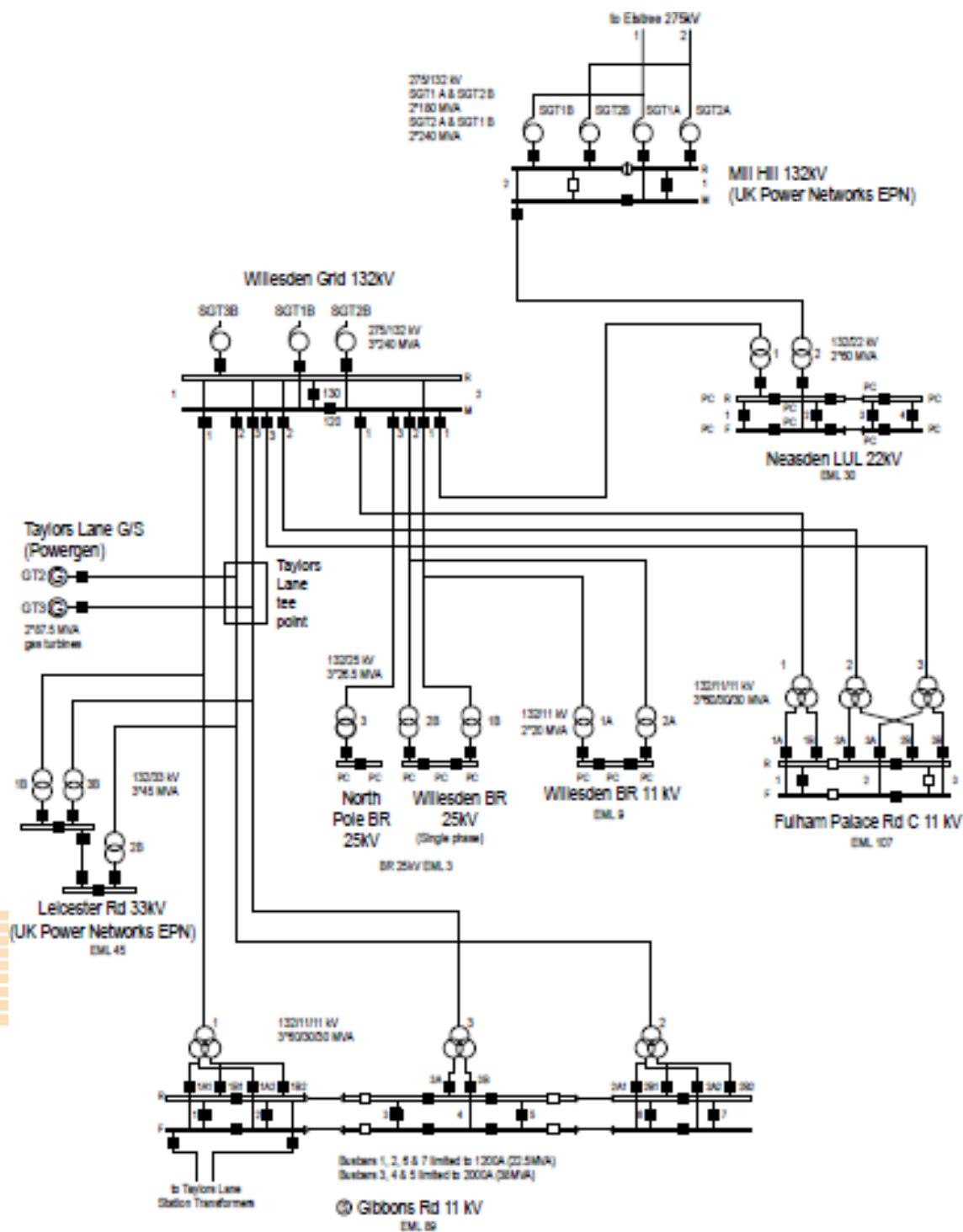
| Name | Role | Signature | Date |
|----------|------------------------------|-----------|------|
| R Kemp | Head of System Development | | |
| B Hatton | Director of Asset Management | | |

Willesden

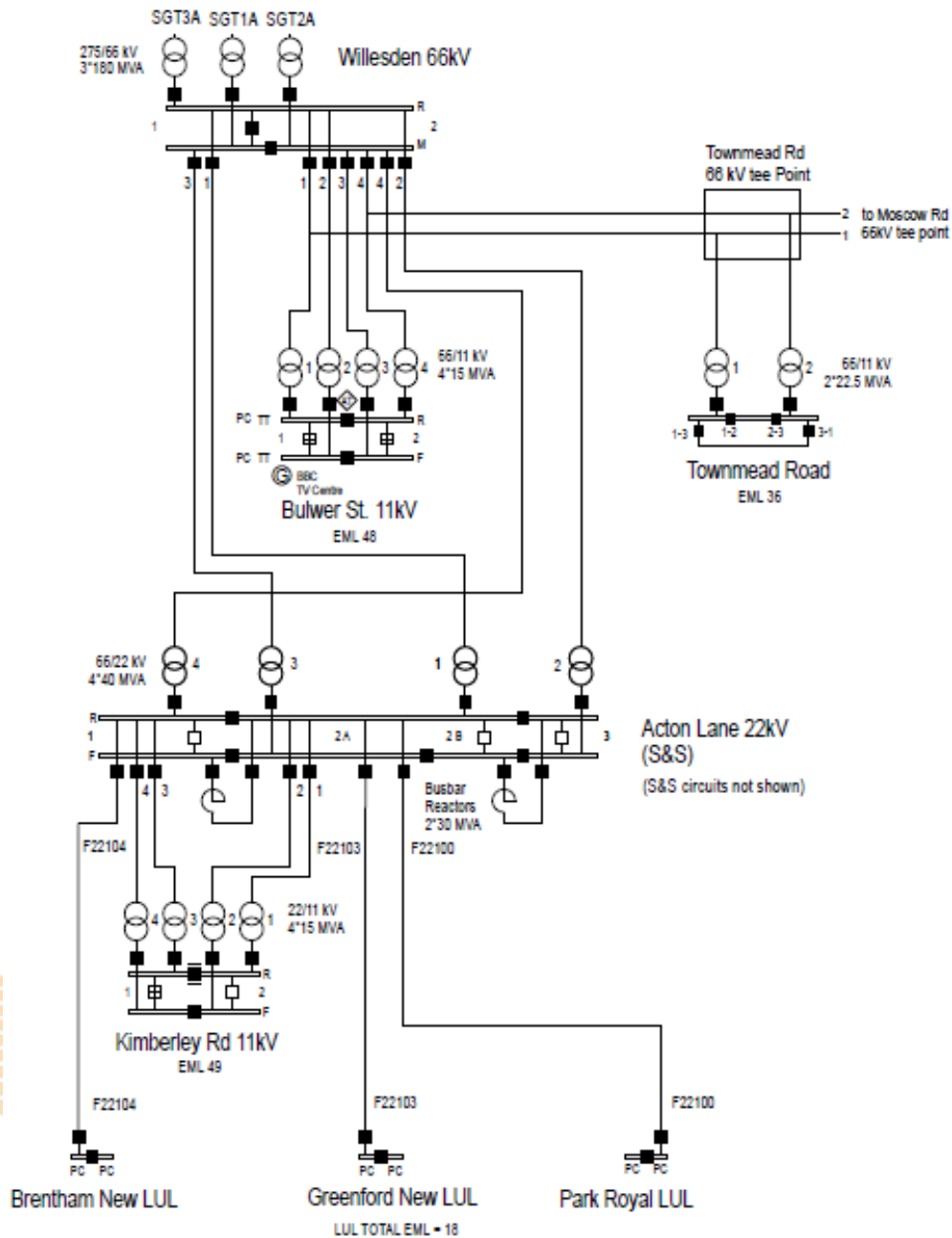
APPENDIX A: GEOGRAPHICAL DIAGRAM



APPENDIX B: SINGLE LINE DIAGRAM – EXISTING 132KV NETWORK



APPENDIX C: SINGLE LINE DIAGRAM – EXISTING 66KV NETWORK



Regional Development Plan

Willesden

