UK Power Networks

Business plan (2015 to 2023)

Annex 13a: Regional Cost Justification

March 2014

“A reliable… an innovative… and the lowest price electricity distribution group.”

ukpowernetworks.co.uk

Contents

This annex has been updated to reflect UK Power Networks' March 2014 business plan. We have a tracked change version for the purpose of informing Ofgem of all revisions to the July 2013 business plan, should this be required.

1 Executive summary

For many people, London is one of the great cities of the world. It is the largest centre of population in the UK and increasingly recognised as the powerhouse of the British economy. It is the seat of Government and the chosen location of many prestigious national and international organisations. As well as being a major commercial centre, and one of the three major financial centres in the world, it is also the cultural hub for the UK and hugely influential across the English speaking world and beyond.

Whilst all DNOs take the stewardship of their electricity networks extremely seriously, the responsibility that comes with serving the people and institutions of London places a particular pressure on UK Power Networks. Partially in response to this, the London network has developed in a way which differentiates it from other networks in the UK.

Alongside this heightened level of responsibility, the London network is challenged in unique ways, for example:

- **Highest Electrical Load Density in Europe**: operating at the extremes of demand, greater than for other UK networks serving areas twenty times larger. In spite of this, London has the best fault performance in the UK and its customers face amongst the lowest distribution charges;
- **Highly Interconnected Network**: providing a much better capability to respond to faults and restore supplies, but at the expense of greater engineering complexity;
- **Mostly Underground Network:** delivering greater resilience than other networks, however when a fault does occur, there is always the need to excavate and reinstate the ground;
- **High Congestion with Other Underground Utilities:** competing with many other utilities and services, this forcing us to dig by hand, rather than by machine, and to lay our cables at a greater depth
- **Dense population requires substations to be located in Third Party buildings:** often underground, bringing problems of access when moving equipment into a basement location or in conducting electrical work in a working office or residential location;
- **Higher costs of resources:** our costs for labour and contractors have to recognise the high living costs in London and the South East in order to recruit and retain the best people, whether working directly for us or for one of our partners.

Whilst some of the above features have some benefits attached, such as the resilience of an all-underground network, they also result in additional costs which are largely unavoidable and exist purely as a consequence of the location of our network.

It should also be remembered that the ‘London’ (LPN) network only covers part of London, and around 20% of each of the South East (SPN) and Eastern (EPN) customers live within the M25.

This document provides the evidence and rationale supporting the following additional costs associated with UK Power Networks’ network location:

- Labour, pensions and contractor costs are approximately 21.3% higher in LPN, 8.4% higher in SPN and 2.5% higher in EPN relative to the average;
- Exceptional costs of operation, as a result of the unique constraints presented by London, add over £27m to the annual cost of operating the London Network (LPN).

Furthermore, it details our Central London Network strategy which is designed to ensure that our political and business customers in the heart of the city continue to receive a service which is as good as they might experience in any other world city - a crucial consideration in these times of globalisation and the increasing willingness for large organisations to move to the optimum location for their purpose.

2 Introduction

2.1 Context and Scope

This document sets out the additional costs faced by UK Power Networks as a result of operating in London and the South East. The scope includes:

- Analysis of regional labour cost differentials in London and the South East effecting UK power Networks DNOs, LPN, SPN and EPN;
- A description of the Central London Network strategy
- Quantification and evidence of specific costs unique to operating in London, the “London Factor” costs, over and above the Labour cost differentials; and
- Explanation of how these costs are incorporated in UK Power Networks business plans for ED1.

The original version of this document (Annex 13A: Regional Cost Justification) was submitted as part of the RIIO-ED1 business plan in July 2013.

In light of Ofgem’s RIIO ED1 Fast-track Assessment in November 2012, a number of revisions have been made to the document including:

- Adoption of Ofgem’s methodology for quantifying regional labour cost differentials;
- An update to the contents related to the Central London Network strategy and its associated benefits and costs
- Updated and revised calculation of the “London Factor” cost; and
- Further justification and rationale in some areas in the light of new and more accurate information.

We have also included a mapping of these exceptional costs to the appropriate cost categories so as to aid Ofgem in making appropriate adjustments, prior to cost assessment.

2.1.1 Regional labour cost differentials

As part of our examination of how the regions we operate within impact upon our expenditure, we have considered the implications of the higher cost of living in London and the South East. This is a well-recognised feature which feeds through directly into higher salary costs, but also provides further upward pressure on salary and benefits, as employers seek to recruit and retain staff.

An economic factor, such as this, is somewhat different to the other factors detailed in this annex, as firstly it can only be quantified through analysis of external data sources, and secondly it applies to all three of our networks, whilst the remainder of the document focuses on LPN only.

2.1.2 London Factor Costs

The challenge and responsibility for maintaining the electricity supply to London and surrounding area is proudly accepted by UK Power Networks. Unfortunately this comes at a price that would not feature in maintaining electricity supplies to any other City in the UK. This is the “London Factor” which is explained in depth in the following report.

The LPN area covers an area of 722 sq. km of London This area encompasses London’s chief financial district (which is one the world’s three most important financial centres, along with Tokyo and New York City), the UK centre of government, the seat of the Royal Family and home to over 7,500,000 Londoners. For the LPN electricity distribution network this brings unique challenges and costs:

- The maximum demand of 5,167 MW is higher than some Distribution Networks covering an area 20 times greater;
- It has the highest load density in Europe of 8 MW/km² and circa 2 million customers; and
- The network serves some very demanding key customers ranging from government departments to prestigious internationally known stores such as Harrods.

These particular challenges are the key driving forces of the London Factor costs described in this document.

2.1.3 London Factor Costs in the ED1 Business Plans

The London Factor costs and regional labour differentials are implicitly built into the costs of doing business in UK Power Network's DNO regions. This puts UK Power Networks at a potential disadvantage when benchmarking business plan costs against those of other DNOs. Therefore, Ofgem makes regional adjustments as part of it modelling of efficient costs in order to ensure companies are compared on a like-for-like basis.

Regional Labour and the London Factor costs are treated separately by Ofgem in benchmarking. To account for regional Labour differentials, a weighting (or regional labour cost indices) is applied to all Labour, Pensions and Contractor costs for all DNOs, thus equalising the labour costs before benchmarking.

The London Factor costs must first be identified within the business plans, before making an appropriate level of adjustment to the relevant parts of the business plan costs. In appendix A18 of this annex, we have provided an approximate mapping of the London Factor costs to the appropriate parts of the business plan cost submission. This is not an exact science as for many of the costs there is no 1:1 mapping to the reported business plan tables. Rather, they are built into the unit costs of performing certain defined activities.

UK Power Networks believes that the proposed allocations provide suitably accurate representation of the London Factor costs within each table for the purpose of benchmarking.

2.2 Document Outline

This Annex is set out as follows:

- **Section 3** sets out the rationale for higher labour and contractor rates in London and the South East and briefly describes our approach to accounting for these cost differentials in the business plan assessment;
- **Section 4** gives an overview of the total London Factor cost incurred by LPN and explains how these costs are distributed within the business plan cost tables;
- **Section 5** provides a description of the Central London Network strategy; and
- **Sections 6** to **13** provide an in-depth explanation and detailed evidence to support each element of the London Factor costs, specifically highlighting costs which are unique to London.

3 Regional Labour Costs

3.1 Background

As part of the last electricity distribution price-control review (DPCR5), Ofgem made adjustments to the operating expenditure for distribution companies operating in London in order to improve the comparability of cost data using in the cost assessment.

UK Power Networks obtained an adjustment of £33.3m (in 11-12 prices) to reflect the increased labour and contractor costs it faces, plus an urbanity allowance in respect of some of the higher costs of operating in a super-urban region. These adjustments were then applied in the form of reductions in the reported operating expenditure, prior to its use in the benchmarking.

Furthermore, Ofgem recognised that some other companies benefit from labour costs which are below the national average. Hence in the same way that it is reasonable to make downward adjustments for higher cost areas, prior to benchmarking, upward adjustments should be made for some companies reflecting the fact that their labour and contractor costs are lower than the national average. This is to ensure that the benchmarking takes account of the inbuilt cost advantage of operating in their regions.

Having examined recent regulatory precedent, both from DPCR5 and RIIO-GD1, UK Power Networks analysed regional labour costs and demonstrated unambiguously that UK Power Networks' 3 DNOs, but in particular its LPN network, is subject to higher salary costs than other DNOs simply as a result of its location.

3.2 Methodology for Quantifying Labour Cost Differentials

Ofgem's fast track assessment recognised that there are labour cost differentials between London, the South East and elsewhere in Great Britain and made adjustments for this in the benchmarking of DNO costs. UKPN accepts the labour cost indices and methodology applied by Ofgem in the fast track assessment benchmarking model; concluding that the outcome is representative of the additional labour costs faced in LPN, SPN and EPN.

This section briefly describes the methodology applied by Ofgem to adjust for these additional labour costs and outlines the key metrics applicable for UK Power Network's DNOs.

The benchmarking model applies labour indices calculated using the Office of National Statistics (ONS) Annual Survey of Hourly Earnings (ASHE). These indices, as shown in Table 1, represent the relative labour costs across the DNOs based on 5 years' (2008 – 2012) relative wages across three regions; London, South East and the rest of Great Britain. The three indices are the mapped to DNOs according to the proportion of regional population within each DNO.

These Indices show that labour, pensions and contractor costs are approximately 21.3% higher in LPN, 8.4% higher in SPN and 2.5% higher in EPN relative to the average.

Table 1: Regional Labour Cost Indices (source - Fast Track Assessment Benchmarking model)

DNO	Labour Cost Indices
ENWL	0.970
NPGN	0.970
NPGY	0.970
WMID	0.973
EMID	0.974
Swales	0.970
SWest	0.970
LPN	1.213
SPN	1.084
EPN	1.025
SPD	0.970
SPMW	0.970
SSEH	0.970
SSES	1.054

It is recognised that not all work needs to be delivered by locally-based resource subject to higher labour costs. Where possible, a company can seek to mitigate these regional factors by, for example, relocating parts of its operation to areas of the country with cheaper labour costs. Indeed, UK Power Networks has done this for many aspects of its administrative and back-office operations. However there will always be a proportion of the operation, in our case the direct activities and its immediate management, which needs to be based in the area being served. We would assert that the increased costs of this local operation is beyond management control and hence should be taken account of, when assessing UK Power Networks' efficiency.

UKPN accepts Ofgem's assumption that 89% of direct activities, 40% of indirect activity but no Business Support activity should be subject the regional labour cost adjustments. Individual work locality factors for each element of the business plan are shown in Table 2 below. For example, £1m Labour, Contractors and Pensions cost for direct activities is equivalent to ~ £730k in the "average" region (i.e. £1,000,000 *x* 89% locality factor ÷ 1.213).

Table 2: Proportion of work needed to be done locally (source - Fast Track Assessment Benchmarking model)

Cost Type	Proportion Local
Connections	89%
Diversions	89%
Reinforcements	89%
Transmission Connection Points	89%
ESQCR	89%
Asset replacement	89%
Refurbishment	89%
Civil works	89%
Operational IT & telecoms	89%
Legal & safety	89%
Quality of Service	89%
High value projects	89%
Non-core network investment	89%
Trouble call	89%
ONIs	89%
Severe weather 1 in 20	89%
Inspection & maintenance	89%
Tree cutting	89%
NOCs other	89%
Closely associated indirects	40%
Smart meters	89%
Business support	0%
Non-operational capex	40%

4 The London factor – additional costs

4.1 Summary

Table 3, below summarises those additional annual operating costs incurred by UK Power Networks which derive from its operations in London and that we have been able to quantify

For each of the quantifiable costs, section 4.2 below highlights the key drivers of the exceptional cost in London and specifies where these costs are incurred in terms of the business plan costs.

Table 3: Annual additional costs to LPN and SPN due to operating in London

Section	London Factor	Description of unique cost	LPN average cost (£m p.a.)	SPN average cost (£m p.a.)
3	Labour and contractor costs	Higher labour and contractor costs due to higher cost of living	7.0	3.5
5	Central London Network strategy	Additional costs of providing the enhanced service demanded by customers in Central London	11.2	0
6	Transport & Travelling	Congestion charging, exceptional parking and servicing costs and the cost of moving plant overnight to avoid heavy traffic.	0.6	0
7	Excavation	Exceptional lane rental, permitting and traffic management costs in London.	2.6	1.0
8	Operations	The extra cost of maintaining and repairing assets in the London environment; including primary and secondary substations and LV, HV and EHV cable systems.	8.4	5.5
9	Security	Network preparations and unplanned de-mobilisations associated with major events.	1.8	0.5
10	Properties	Increased insurance premiums incurred due to LPN's terrorism risk and indirect premiums incurred as a result of the higher cost of operation.	0.5	0.2
11	Tunnels	Inspection, maintenance and defect repair and charges for accessing tunnels owned by local authorities.	2.2	0
	TOTAL		33.3	10.7

UK Power Networks has taken innovative measures to keep these costs to a minimum. These mitigations are described in further detail in the relevant chapters of this document, for example:

- New technology adopted for Oil cable fault location: PFT training equipment
- Developing alternative technology to cable freezing but using non-intrusive Cable heating technology
- Engaging PCN to challenge all parking fines
- 11 Major event planner to chart all major events in all Regions that may affect supplies or UK Power Networks reputation
- Bringing in-house in the civil excavation works in the SPN area
- Adopt shift working to carry out street works outside "normal" working hours to offset the high charges imposed by Lane Rental charges
- Introduction of 24x7 shift working to improve the customer service in the Inner enhanced interconnected area of Westminster and The City of London
- Establishment of a heat recovery system for waste heat from transformers at Bankside Power Station substation for the Tate Modern gallery

4.2 Overview of London Factor Costs and Drivers

In this section, for each London Factor summarised above:

- The key London-specific cost drivers are highlighted;
- The cost is broken down into its constituent elements; and
- It is indicated how these costs are distributed in the Business Plan cost submission.

Note: A detailed matrix of costs mapped to business plan cost tables is supplied in Appendix A.18.

4.2.1 Section 5 - Central London strategy

The Government, commercial, cultural and other organisations which are based in Central London are a major contributor to the success of both the city and the UK more broadly. In the context of increased, globalisation it is important that we provide a level of service that is at least comparable with other world cities. Whilst by UK standards, the performance of the LPN network is extremely good; this is no longer the case when international comparisons are made.

Improving the level of provision in Central London is one of the key requests of our stakeholders, however it can only be achieved by a major change to our operations and targeted investment in our network assets. Key to this is the establishment of a 24x7 operational presence in the centre of London, enabling us to provide much improved response times to faults and the capacity to establish an inspection and maintenance regime to reduce the incidence of faults in the first place.

In addition, we propose to further invest in our network automation so as to improve the overall resilience of the network in Central London and our ability to respond to faults.

The key components of implementing this strategy are as follows:

Table 4: Summary of Central London strategy

Cost Element	Cost (£m p.a.)	Allocation in Business Plans
Fault response teams	3.80	Troublecall
Enhanced inspection and maintenance regimes for link boxes, substations and network sweeps	0.60	Inspection and maintenance
Indirect support to new operation, including supervision, design, planning, health & safety and customer liaison	2.50	CAIs: Network Design, Project Management, Engineering Management
Capital investment in automation and unit protection	4.30	Asset replacement, Operational IT&T
Total	11.20	

4.2.2 Section 6 - Transport & Travelling

The density of traffic in London and the associated lost time due to congestion has a significant impact on what would otherwise be productive time of our field teams. This is difficult to quantify, however £0.6m per annum of additional cost is described in this paper covering the specific costs associated with:

- Congestion Charging: London has one of the largest congestion charge zones in the world;
- Parking: the majority of the primary and secondary roads in the London area are covered by parking restrictions;
- Vehicle service costs: vehicle servicing rates are almost 45% higher in London than in the EPN area; and
- Overnight Plant delivery: plant and equipment often needs to be moved overnight to avoid heavy vehicles being stuck in traffic jams.

Table 5 Summary of exceptional costs (Transport and travelling)

Cost Element	Cost (£m p.a.)	Allocation in Business Plans
Congestion Charging	0.26	Streetworks separate assessment
Parking & Access	0.20	CAIs: Vehicles & Transport
Vehicle Costs	0.10	CAIs: Vehicles & Transport
Plant Delivery	0.07	CAIs: Stores
Total	0.63	

4.2.3 Section 7 - Excavation

With a predominantly underground network in an area heavily congested by other utilities, excavations are both frequent and complex in LPN. In a significant number of cases, this requires excavation of pavements or highways, with the higher associated reinstatement costs, and a frequent requirement for time-consuming hand-digging, rather than the use of machines.

Some constraints associated with this, such as delays due to Archaeological Artefacts and Environmental restrictions, are inherently difficult to quantify, however there are a number of significant and quantifiable exceptional costs including: lane rental, works permits and traffic management.

Table 6: Summary of exceptional costs (Excavation)

Cost Element	Cost (£m p.a.)	Allocation in Business Plans
Lane rental and charges	1.61	Streetworks separate assessment
Permits	0.57	Streetworks separate assessment
Traffic Management	0.45	Streetworks separate assessment
Total	2.63	

4.2.4 Operations

The inherent nature of the London Network, as well as exceptional levels of demand, makes operations costly for LPN. Figure 1 below summarised some of key drivers of higher costs.

Figure 1: Causes of high operating costs in London

Highest Electrical Load Density in Europe	Mostly Underground Network and High Congestion with Other Utilities	Substations in Third Party Buildings, Often Underground	Cables Alongside Railway Lines
Evening and Weekend Working for HV & EHV Faults Interconnected LV Network to enable high utilisation of transformers requires specialist treatment	High risk of damage by other Utilities Need for deeper excavation in congested roads Special cable materials which are difficult to work with	Difficulty in access involving third parties Expensive ventilation Specialist safety measures High flood risk and cost of flood damage	Limited access times Cost of long term work-around solutions Management and negotiation challenge with rail companies

Table 7: Summary of exceptional costs (Operations)

Cost Element	Cost (£m p.a.)	Allocation in Business Plans
Substation key holding service	0.11	Pro-rata across NOCs and EMCS
Substation ventilation	0.14	50% Civil Works, 50% I&M
Substation Confined Space service	0.19	40% Non-op Capex (small tools and equipment), 40% Op Training, 20% I&M
Substation flooding	0.50	NOCs: I&M
Unclaimed Cable damage	2.59	Pro-rata across some NOCs and CAIs – see detailed matrix
Pipe cutting	0.14	Pro-rata across some core – see detailed matrix
Link box inspections	0.38	NOCs: I&M
Substation Trip testing	0.25	NOCs: I&M
Excessive HV Fault cost	0.81	Pro-rata across some NOCs and CAIs – see detailed matrix

Substation access - additional cost of replacing Plant	0.71	Pro-rata across some core, NOCs and CAIs – see detailed matrix
Extensive evening and Weekend working	0.78	Pro-rata across some parts of each cost area – see detailed matrix
Excessive EHV Fault cost	0.52	Pro-rata across some core, NOCs and CAIs – see detailed matrix
Railway access	0.88	Pro-rata across some core, NOCs and CAIs – see detailed matrix
Underground primary substations	0.35	Pro-rata across some core, NOCs and CAIs – see detailed matrix
Total	8.35	

4.2.5 Security

In the lead up to the frequent major events in London (such as festivals, sports events, government affairs and royal occasions) UK Power Networks conducts precautionary work to:

- Mitigate against the impact of network faults;
- Increase security;
- Coordinate operations with event planners; and
- Increase resources available to deal with emergencies.

In addition to the cost of this preparatory work, LPN bears the cost of de-mobilising then re-mobilising business-as-usual work at short notice.

Table 8: Summary of exceptional costs (Security)

Cost Element	Cost (£ p.a.)	Allocation in Business Plans
Above Network preparations	1.65	Pro-rata across some core, NOCs and CAIs – see detailed matrix
Unplanned de-mobilisations	0.13	Pro-rata across some core, NOCs and CAIs – see detailed matrix
Total	1.78	

4.2.6 Properties and Insurance

Insurance of UK Power Networks properties and assets in London are measurably higher than outside of London for two reasons:

- Increased direct insurance premiums due to LPN's location; and
- Increased indirect premiums based on higher costs to operate in London.

In particular, operational and non-operational buildings in London incur higher premiums due to the increased risk of Terrorism. Property damage insurance is also higher due to the reinstatement values of the assets in LPN's area.

Table 9: Summary of exceptional costs (Property and insurance)

Cost Element	Cost (£m p.a.)	Allocation in Business Plans
Terrorism insurance	0.43	Business Support - Insurance separate assessment

London Factor for Building insurance	0.03	As above
Total	0.46	

4.2.7 Tunnels

LPN has a large network of deep tunnels containing EHV cables between grid and Primary substations, as well as 11kV, communications and protection circuits. Tunnels have enabled expansion and reinforcement of the network to meet increasing demands despite the congestion under London's footpaths and roads; however they do bring about some additional costs, related to:

- Ventilation to make the environment safe for staff;
- Compliance with confined space working regulations;
- Dealing with flooding; and
- Payments to local authorities for the use of their cable pipe subways

Table 10: Summary of exceptional costs (Tunnels)

Cost Element	Cost (£m p.a.)	Allocation in Business Plans
Inspection, maintenance and defect repair	1.68	Pro-rata across some core, NOCs and CAIs – see detailed matrix
Equipment in the London Subway system	0.13	– As above
Specialist Engineering inspections	0.03	– As above
Inspection and maintenance costs for tunnels under construction	0.37	– As above
Total	2.21	

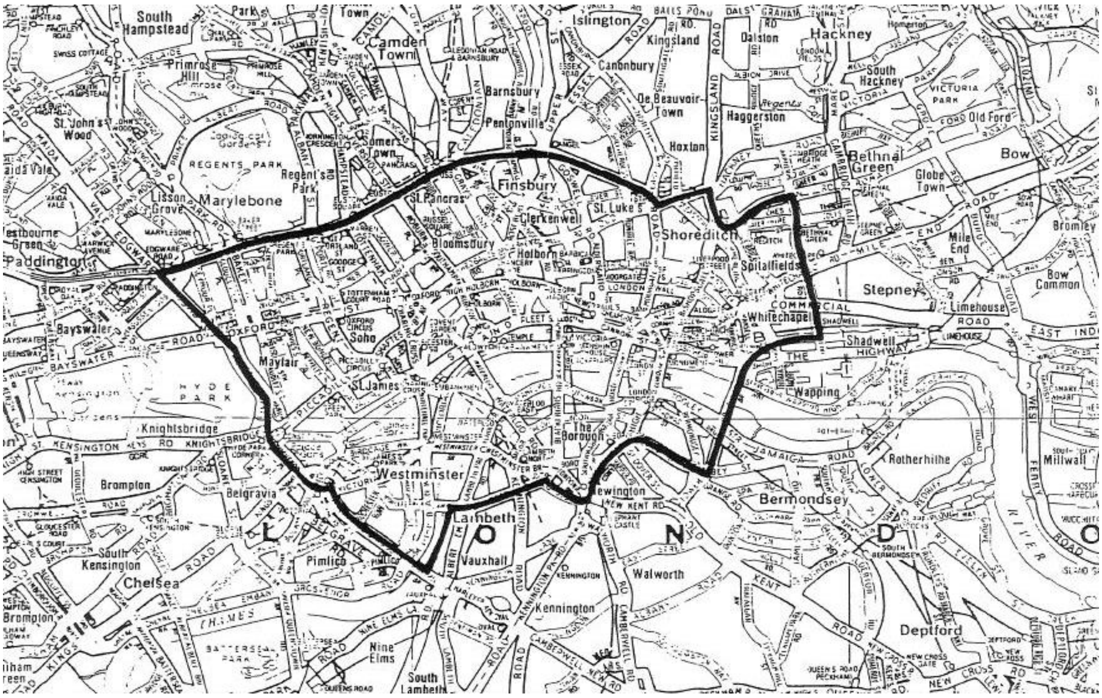
5 Central London strategy

5.1 Background

The Central London Area comprises circa 160,000 customers of the 2.3 million on the LPN network. Central and London government, the royal palaces, Houses of Parliament and 10 Downing Street are all customers of UK Power Networks in this Area. They are joined by many significant commercial and cultural organisations, which have a profound influence on both the UK economy and life in the Capital.

By reference to the Office for National Statistics, the value of business disruption to these customers is some 19 times the national average – note: ONS regional data taken for Inner London West area, which includes both the City of London and Westminster City Council.

Figure 2: The Central London Area



For some time these customers have been treated as if they are the same as any other UK Power Networks customer. In response to feedback from key stakeholders in The City and West End, we have developed the Central London Network Strategy, which will deliver enhanced service levels to customers in this area.

These enhancements to service levels reflect the high-value of the business done and the competitive threat from other nations that would like to attract that business - and the value it adds. This is illustrated further in table 10 which contrasts fault performance between a number of major cities:

Table 11: Comparison of network performance for key competitors to London

	Hong Kong	Osaka	Sydney CBD	New York	Central London
HV CIs	9.83	2.97	5.48	0.18	6.43

LV CIs	4.83	0.10	3.07	1.90	12.56
Total CIs	14.66	3.07	8.55	2.08	18.99
HV CMLs	0.27	0.91	8.42	11.85	4.54
LV CMLs	0.10	0.21	9.58	6.98	33.10
Total CMLs	0.37	1.12	18.00	18.83	37.64

5.2 The Central London Network strategy

The strategy identifies a number of asset and other operational changes that are necessary to deliver the increased level of service warranted, including improvements to operational response to faults, enhanced inspection and maintenance activities and targeted capital investment. These operational enhancements in particular could not be achieved without the establishment of a central London presence.

The objective of this team is to design and build an enhanced Network providing the highest level of security in order to secure high customer satisfaction ratings whilst rapidly responding to faults .

This new team, based at one of our central London Primary Substations will have a full complement of Field and Technical staff on 24x7 shift working, 365 days a year, as well as shift staff responsible for LV control, Safety, Customer Liaison, Design, Planning and Clerical support.

Office and depot accommodation is being developed in Shorts Gardens (Covent Garden) so that staff will always be available in the heart of London to respond to incidents within 30 minutes. For all faults, a Customer Liaison Manager will be sent with the field teams to provide customer care follow up, tracking and management & resolution of all outstanding customer issues associated with the incident even where power has been restored.

In addition, changes are also required in the inspections and maintenance routines to deliver the levels of service demanded by these customers. These changes relate to the proactive fixing of faults on the mesh network which have yet to manifest themselves in a customer outage but do increase the risk of outage if unresolved. We also propose to increase the inspection of link boxes and secondary sub-stations which are beyond their expected lives and hence could provide a cause of additional interruptions.

Finally, we plan to introduce further remote control on the meshed network to achieve the response times demanded by customers.

Table 12 below summarises the costs of providing this service.

Table 12: Additional Costs for Enhanced Service in Central London Area

Cost Category	Cost per year
Direct Opex	£4.4m
Direct Capex	£4.3m
Indirect Costs	£2.5m
Total	£11.2m

5.3 Specific changes proposed for Central London

There are a number of characteristics of both the design of the London network and the challenges of operating in the centre of the city that drive the need for a different approach to our operations. Key amongst these is the following:

- **Drive Times:** Traffic speeds in London are notorious, and get progressively slower approaching and entering the central business district. This significantly impacts the time for us to respond to a fault from one of our existing depots, which are based in the suburbs where land is cheaper and access easier. In response to this we have concluded that there is no option but to establish a full-time operational presence in Central London.

- **Distance from work:** The cost of housing means most of our engineers and other staff live a reasonable distance out from the centre of London. This, combined with the slow drive times in London, has a significant impact on our response times, out of hours, where we need to utilise "on-call" engineers.
- **Restrictions on working during daytime hours:** The combination of traffic management arrangements, environmental regulations and access restrictions means that a significant amount of activity on the network has to be conducted out-of-hours, either overnight or at weekends. When taken alongside the issues of 'on-call' staff travelling distances to respond to outages, this reinforces our view of the necessity that our new Central London depot should operate on a shifted 24x7basis ;
- **Network design necessitates 2 man teams:** The LPN network incorporates a "link box" that contains junctions within the network. These link boxes frequently needed to be lifted as part of repairing a fault, but their weight means that two people are needed for such lifting. In addition, network components in the London network are frequently in confined spaces. This has two impacts:
    - It drives us to have two man teams for most operational areas; and
    - It compounds the response time issues for on-call staff, as both members of a team have to meet up before they can address a fault.
- **Meshed networks:** The London network has a "meshed" design. This increases resilience as there are multiple paths that power can flow for delivery to a customer; however, it also masks faults, as all of those paths need to fail before the fault becomes apparent. We have instigated "network sweeps" to detect these "hidden" faults, allowing us to repair the faults in an economic and planned manner, and to maintain network resilience.
- **Network Age:** Many of the components that make up the London network are at or beyond their design lives. Whilst these could be replaced with new components, we can extend their lives (whilst maintaining reliability) by increasing the frequency with which they are inspected. This makes sense both from a cost and safety perspective, as well as from a view of the practicality of replacing those components.

The specific interventions required to address these issues are described further in the following table:

Table 13: Detailed proposals for the Central London operation

Intervention	Description	Cost Elements	Additional Cost p.a. (£m)
Rapid Response Teams	Dedicated shift teams for 24hour working. These deliver faster response to network faults (reducing CML), as well as reduced network holes (reduced CI and CML)	Additional 2 person teams are required for 24 hour shift working as follows: • 12 Jointer teams • 12 Gang teams (cover civil works) • 12 x Support Staff In addition, a further 4 x 2 person jointer teams are required to cover standard operating hours (07.00 to 23.00. (Note: this includes the costs of backfilling of existing LPN staff who have been transferred to work in Central London)	3.8
Maintenance of Interconnected Networks	Proactive investigation of network condition and status to identify and rectify faults that have not yet led to outages	This requires a further 5 x 2 person jointer teams.	0.4
Increased Inspection of link boxes	Move to annual inspections of link boxes, rather than on a	There are 3,456 installed link boxes in the Central London area. Previously we would have inspected these on a 4-	0.1

	4 yearly cycle	year cycle (i.e. 864 per year). We now propose to move to an annual inspection cycle, which equates to an additional 2,592 inspections a year at a UCI of £37 per linkbox	
Increased Inspection of Secondary Sub-stations	Move to annual inspections of secondary sub-stations, rather than on a 2.5 year cycle.	There are 4,014 distribution substations in the Central London area. Previously we would have inspected these on a three-year cycle (i.e. 1,338 per year). We now propose an annual inspection cycle which equates to an additional 2,676 inspections a year at a UCI of £47 per substation	0.1
Indirect costs in support of the Central London operation	Additional locally-based staff and facilities costs within the Central London depot to support field operations	Supervision (senior authorised personnel) - £1.1m Engineering management and clerical - £0.3m Customer liaison - £0.4m Safety/cable watch - £0.1m Stores/logistics - £0.4m Parking for operational vehicles - £0.2m	2.5
Total Opex			£6.9m
Increased Automation	Installing remote control of Air Circuit Breakers in the interconnected network	Capital investment in the network to extend the ability to remotely control switchgear to minimise the impact of a fault	1.2
Unit Protection on HV	Convert feeder groups to unit protection	Capital investment in the network to enable greater resilience and improved restoration times under fault conditions	3.1
Total Capex			£4.3m
TOTEX TOTAL			£11.2m

We estimate that these initiatives will deliver a number of benefits, notably:

- **Increased Reliability:** These measures are at the heart of our strategy to improve the reliability of our central London networks - as will be observed in reduced customer interruptions and customer minutes lost.
- **Improved safety:** Given the aging nature of our network, the increased inspections we propose will improve the safety of our network - for our staff and the public. This is consistent with our statutory duties.
- **Greater value to customers:** The increased maintenance focus will enable us to extend the life of many of our network assets and thus temper the need for major capital investment to replace assets.

5.4 Costs and benefits

The forecast benefits of implementing this strategy is a 50% improvement on performance , equating to a reduction of 12,800 customer interruptions per annum, and 1,920,000 customer minutes lost per annum. Based on a population of 160,000 customers, this is equivalent to 8 CI per 100 customers and 12CML per customer.

We have estimated the "value" of each CML in London based on GVA data as published by the ONS. GVA per customer is significantly (19x) higher in Central London than for the generality of Great Britain:

	Central London				GB as a whole			
Year	GVA (£m)	Customers	Value of mins lost (10 hour day)	Value of mins lost (24 hour day)	GVA (£m)	Customers	Value of mins lost (10 hour day)	Value of mins lost (24 hour day)
2008	129,574	162,000	£3.65/min	£1.52/min	1,251,612	28,500,000	£0.20/min	£0.08/min
2009	127,281	162,000	£3.59/min	£1.49/min	1,229,749	28,500,000	£0.20/min	£0.08/min
2010	132,907	162,000	£3.75/min	£1.56/min	1,272,680	28,500,000	£0.20/min	£0.08/min
2011	136,911	162,000	£3.86/min	£1.61/min	1,304,828	28,500,000	£0.21/min	£0.09/min
2012	139,906	162,000	£3.94/min	£1.64/min	1,327,198	28,500,000	£0.21/min	£0.09/min

Utilising this information, the following table illustrates the "value" to the UK economy of each equivalent Customer Minute Lost in Central London, based on a population of 162,000 customers and 2012 GVA data.

CMLs saved	Value (£m) of 10 hour days (at £3.94/min)	Value (£m) of 24 hour days (at £1.64/min)
2	1.3	0.5
4	2.6	1.1
6	3.8	1.6
8	5.1	2.1
10	6.4	2.7
12	7.7	3.2
14	8.9	3.7
16	10.2	4.3
18	11.5	4.8
20	12.8	5.3

Based on a saving of 12 CMLs, the value of this is c.£7.7m/annum.

In line with this benefit, we are justified in including the £6.9m of operational costs identified in table 12. The additional £4.3m of proposed capital expenditure is documented in our Asset Stewardship Report for Central London

See link to Asset Stewardship Report

Further discussion of the costs and benefits are provided through the CBA which has been created and is documented in appendix 13c.

6 Transport & travelling

6.1 Background

At the National Joint Utilities Group (NJUG) London Street works Forum on 18th March 2013 it was reported that Garrett Emmerson, Chief Operating Officer had stated:

- London's strategic roads are on average 40% more densely trafficked than roads in other UK conurbations
- London has around 20% of the UK congestion, costing London's economy at least £2bn a year
- In 2009/10, 38% of this is was caused by road and street works and cost London's economy around £750m

As we needs inspect, maintain and repair faults on the underground electrical network, it is unavoidable that a large number of specialist vehicles need to be used by our field teams, engineers and contractors to carry out these essential works. A considerable amount of time is therefore spent stuck in traffic jams whilst travelling to and from our worksites leading to a great deal of unproductive time.

6.1.1 Transport for London report

The following extract from Travel in London Report 4 published by Transport for London in 2011 gives an overview of the traffic speeds in London's road network:

"On London's road network recent data suggest that the established historic trend towards increasing levels of traffic congestion in London may have been halted. Newly-available data from in-vehicle satellite navigation systems, not available for before 2006, suggest that overall traffic speeds have been stable over the past three years. This applies equally to central, Inner and Outer London. Indicators of excess delay or congestion, also derived from this source, suggest a stable overall picture, with some evidence of improvement (i.e. reducing congestion), particularly in Outer London and on the TLRN, over the most recent three years.

The average Greater London traffic speed in 2010/11 was 28.6 kilometres per hour (17.7mph), and the average excess delay, according to GPS data, was 0.8 minutes per kilometre (1.3 min/mile). TfL's primary indicator of journey time reliability for road traffic suggests that between 88 and 90 per cent of road journeys in the Capital are accomplished reliably – compared to a target of 89 per cent for this measure. However, it is not yet possible to discern a clear directional trend in this measure over the two years of data that are currently available".

Unfortunately, by the very nature of our works in carrying out excavations in the footpaths and roadway, we add to the traffic congestion by restricting traffic at the worksites. An indication of the restrictions on traffic and hence the impact on the ability for travel in the City of London on a daily and weekend basis is shown in Appendix A.1

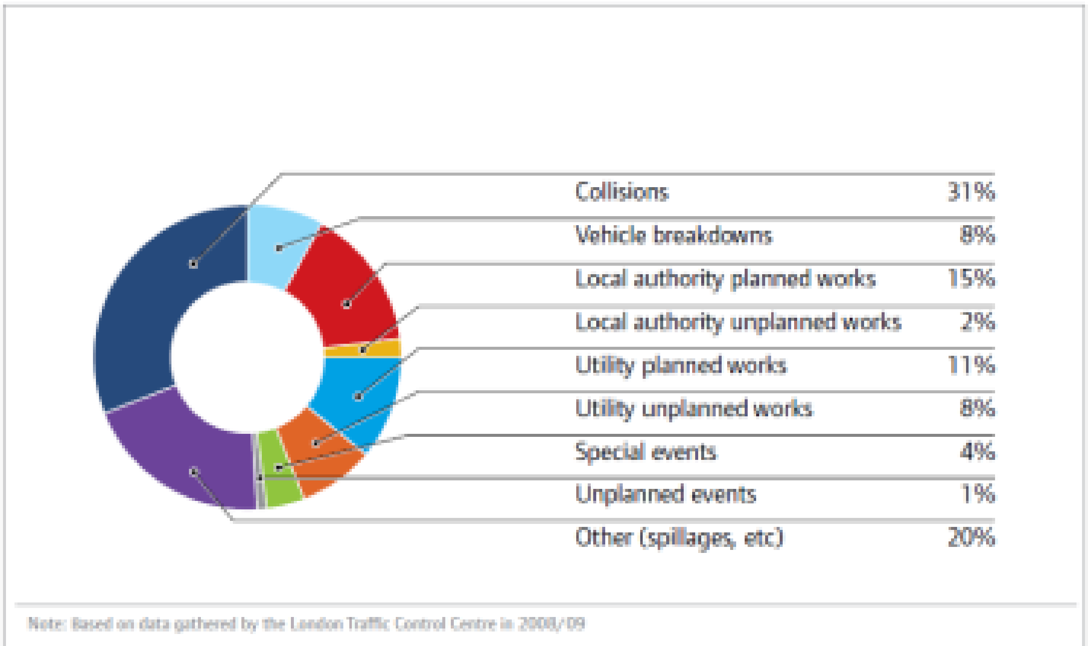
6.1.2 The Mayor's transport strategy for London

The following is an extract from The Mayors Transport strategy for London:

"Poor reliability and predictability of journey times means those who use the road network have to allow significantly longer for their journeys to ensure they reach their destination on time. Improving the reliability of journey times on the road network (even if average delays increase due to rising traffic volumes or other factors) is of significant benefit to motorists, freight operators and other users of the road network. It enables them to predict better how long a journey may take, allowing for efficient and economic planning of social and commercial activities and to reduce the total amount of time they would otherwise need to allow making their journey."

The vast majority of our field teams rely on their vehicles to carry out their day to day responsibilities; therefore reliability of journey times is essential if we are to meet our Customer Service targets. It is therefore comforting to know that the Mayor of London takes this issue very seriously in his Transport Strategy for London.

Figure 3: Cause of unusual congestion by proportion of duration



6.2 Congestion charging

The London congestion charge is a fee charged on most motor vehicles operating within the Congestion Charge Zone (CCZ) in central London between 07:00 and 18:00 Monday to Friday. It is not charged at weekends, public holidays or between Christmas Day and New Year's Day.

The charge, which was introduced in 2003, is one of the largest congestion charge zones in the world. The charge aims to reduce congestion, and to raise investment funds for London's transport system.

The standard charge is £10 per day, for each non-exempt vehicle that travels within the zone and £9 per day for pre-registered vehicles. A penalty charge of between £60 and £187 is levied for non-payment. Enforcement is primarily based on automatic number plate recognition and Transport for London (TfL) is responsible for the charge.

Figure 4: Congestion charging area map

The UK Power Networks vehicle fleet is not exempt from congestion charging therefore all of our vehicles that are likely to travel in or though the Congestion Charge area are pre-registered and a monthly invoice is submitted to UK Power Networks by TfL.

The current congestion charges for the pre-registered UKPN vehicles are displayed in Table 14 below:

Table 14: TFL Congestion charges for the pre-registered UK Power Networks vehicles

Monthly TfL charge	Total Cost
Apr-12	£19,693
May-12	£17,582
Jun-12	£18,303
Jul-12	£19,557
Aug-12	£18,343
Sep-12	£16,029
Oct-12	£16,589
Nov-12	£16,586
Dec-12	£19,226
Jan-13	£20,139
Feb-13	£11,277
Mar-13	£23,363
Total	£216,687

In addition, there are a number of private vehicles owned by field engineers, managers etc. used for work purposes, but which can not be pre-registered by UK Power Networks, as that is the responsibility of the respective owners. Our Transport section also has the costs of dedicated staff to manage the systems.

The annual cost to UK Power Networks for vehicles to travel in the London Congestion Charging zone is £260,000.

6.3 Parking & site access

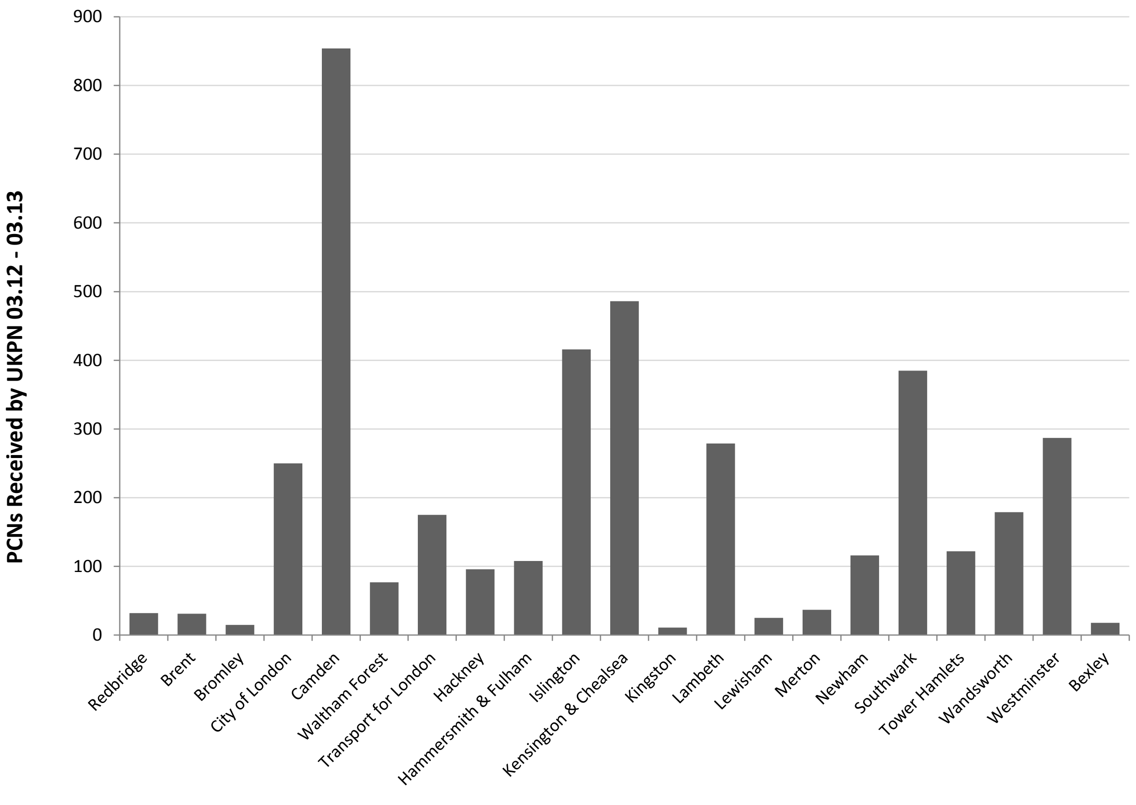
The majority of the primary and secondary roads in the London area are covered by parking restrictions in the form of single and double Yellow lines, prohibited Red Routes, Bus Lanes, Cycle lanes, Disabled Vehicle bays, Motorcycle bays, “Boris Bike” parking areas and resident Controlled Parking Zones (CPZ). In the main tourist areas this is supplemented with Bus & coach stands as well as Taxis ranks.

Wherever possible, staff are requested to use parking meters and to reclaim the expenses but parking is usually limited to a maximum of 4 hours and can vary in cost from £0.90/hour in the outer London Boroughs to £4.40/hour in the City and Westminster. Use of public transport is encouraged for visits that do not require tools, equipment or PPE to be carried.

None of the UKPN vehicles have any exemption from the national or local parking regulations, even when attending to emergencies. It is not uncommon for engineers to be actively engaged in restoring supplies after a fault, only to find that their vehicle has been given a parking ticket, immobilised by a wheel clamp or to have been towed away to the nearest car pound. Records indicate that UK Power Networks’ vehicles get clamped and towed away on circa 100 occasions each year. In addition to the expense of the fixed penalty notice, ranging from £65 to £130, and a vehicle release fee of circa £130, there is also the delay to the restoration of supplies and the 4 to 6 hours of unproductive time of our staff travelling to and from the car pound to recover the vehicle.

The annual costs of vehicles being towed away and subsequently being recovered is £84,000.

Figure 5: Data on the Parking Penalty Charge fines received



It is very rare that unrestricted parking is available in the vicinity of our works so, wherever possible, for planned works, payments are made to the local authority to "bag off" parking meters and resident parking bays at a cost of between £40 and £120/day (in the City of London). Typically, 10 to 28 days' notice is required for this service to be arranged.

Some Local Authorities view parking fines as a lucrative source of income as is detailed in Appendices A.2 and A.3. Regular discussions take place with the various local authorities in an attempt to gain some form of exemption for our vehicles, however to date, with very limited success.

The costs of parking fines can be as high as £20,000/month and 3999 parking fines were received in the LPN area in the last year. In an effort to reduce this amount, UKPN have contracted a company called PCN Appeals Ltd to challenge each and every parking ticket with the appropriate Highway Authority in an attempt to get it cancelled or reduced in value. Their fees are 50% of any savings made though successful appeals.

This service has proved to be successful in reducing the overall parking fine charges paid by circa 44%.

The additional cost for the last 12 months of being able to park essential vehicles whilst operating on or near the network is £202,749.

6.4 Vehicle costs

UK Power Networks run a fleet of liveried vans, lorries, off road vehicles and specialist vehicles together with a number of private cars. A few years ago our own transport workshops were closed down and a contract was awarded to BT Fleet to service our vehicles from 17 of their service centres located throughout the UK Power Networks area. The hourly rates charged by BT vary in line with their labour and overhead rates applicable to the location of their service centres.

The vehicles in the LPN region are serviced by BT Fleet at their London rates of circa £65/hour. The vehicles in the EPN and SPN area use similar facilities provided by BT Fleet but are charged at a much lower hourly rate between £45/hour to £51/hour.

The increased cost of servicing the LPN vehicles at the higher London rates is circa £100,000/annum.

6.5 Plant delivery

To avoid the expense of retaining a heavy plant and cable stores in the London area, all plant and equipment are stored at our Heavy Plant stores at either Bury or Maidstone. To avoid heavy lorries getting stuck in traffic jams en-route to London, overnight transport is used to deliver new plant and equipment and take back redundant plant and equipment from a number of staging areas in the London area. In comparison, Plant & equipment delivery to the SPN and EPN areas takes place during the normal working day.

The additional cost of this facility for overnight delivery of plant and equipment is £71,000/annum.

7 Excavation

7.1 Footpaths & roads

As indicated in previous sections there is very little room left in the majority of footpaths for new UK Power Networks circuits or space for repairs and upgrades due to the plethora of plant and equipment that has been installed by other utilities. It is common to have to dig down underneath other utilities to get a clear route, often to depths of circa 1.5 to 2 metres.

Alternatively an excavation in the roadway is required. This has a detrimental effect on the progress of our works leading to extended opening durations with the attendant costs of lane rental and increased customer complaints.

7.1.1 Excavated material removal

Most inner London Local Authorities require excavated materials to be removed from site, on the same day, so as to reduce congestion on the footpaths. In other areas, where there is more space, excavated materials can be stored on site so the costs for “muck away” services are not required.

“Muck away” services are more expensive in London as haulage costs are higher for the same reasons alluded to above for materials. The tips are all on the outskirts (outside M25) and consequently one truck will do a lot less loads per day for the same fixed costs. An example of this is that a tipper truck in the City will do say 3 loads/day, whereas the same truck on a job outside M25 may do 10 loads/day. The result is that “muck-away” in London costs in excess of 50% more, than costs outside of the M25.

7.1.2 Weekend & evening working

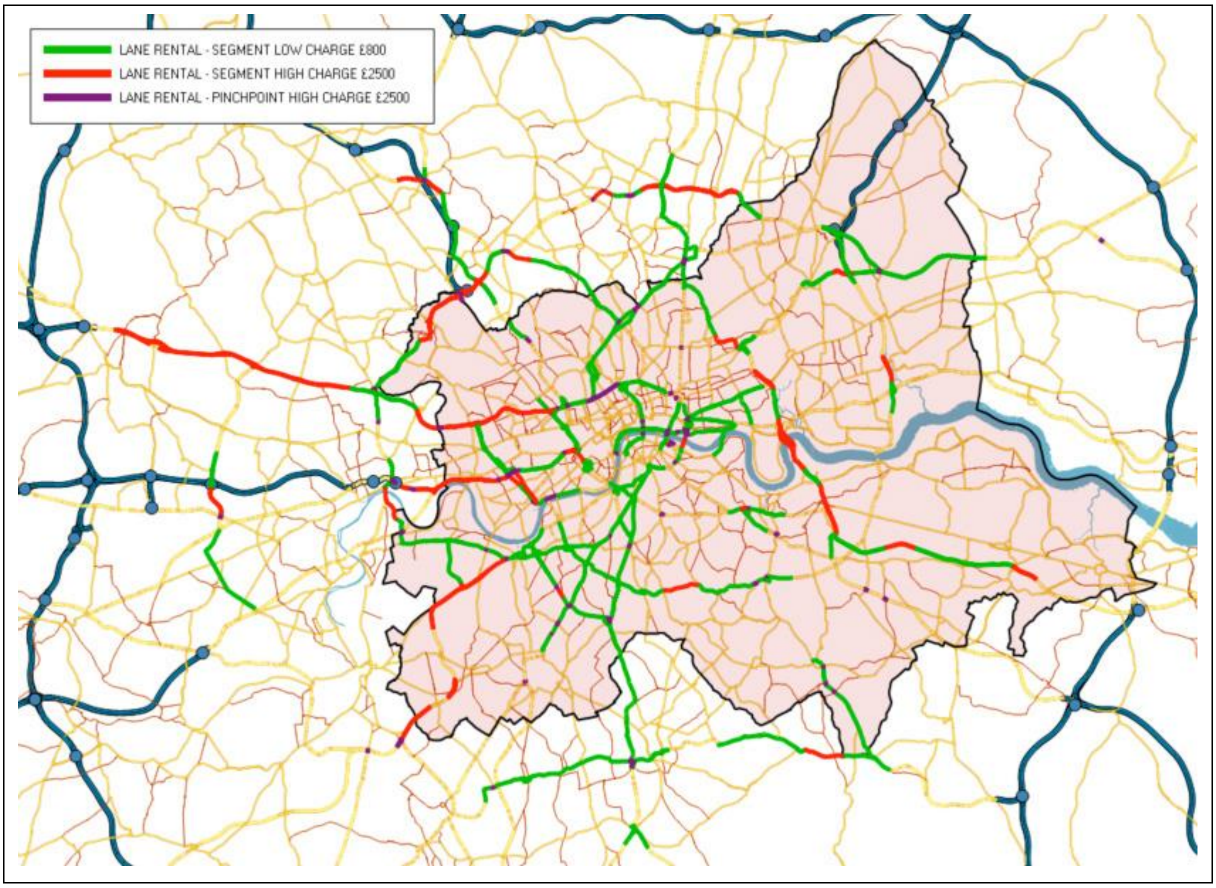
With the advent of Lane Rental, there is even more pressure on utility companies to complete work outside of “normal” working hours to minimise exposure to high charges, as well as to comply with Local authority requirement for plant movement and cranes to be used out of normal hours. This conflict with the European Working time legislation limiting working hours and has resulted in UK Power Networks having to change working patterns to a shift system in London so as to cover this new out of hours requirement. We anticipate this requirement extending as other highway authorities adopt lane rental.

7.1.3 Lane rental

Under Section 59 of the New Roads & Street Works Act (NRSWA) there is a duty placed on Highway Authorities to co-ordinate works of all kinds on the highway and UK Power Networks and other utility companies have a parallel duty to co-operate in this process under Section 60 of the NRSWA. The implementation in June 2012 by

Transport for London (TfL) of the Traffic Lane Rental Scheme (TLRS) aims to encourage Utility companies to minimise their encroachment on cycle ways and carriageways.

Figure 6: London Lane Rental categorisation



To do this, TfL charges the utility companies a daily fee of either £800 or £10,000, depending on the level of disruption, for obstructing public highways. This applies on 57% of the TfL road network or circa 2% of all London's roads.

The charges are also levied if, during the course of our works, we park our vehicles to unload equipment as well as when we provide pedestrian walkways and signage to protect pedestrians who need to walk in the carriageway. The charges apply from the time when the ground is broken until when the reinstatement is made and an application for "permit" needs to be made prior to commencement of works.

There are 674 lane rental locations crossing though 29 London Boroughs so this has a great financial impact on UK Power Networks when completing excavations for fault repairs, construction and reinforcement works. For emergency works the charges apply 24hours from the start of the works. The cost of Lane rental charges is recovered from the customer for any New Connection's works.

There are 674 lane rental locations crossing though 29 London Boroughs so this has a great financial impact on UKPN when completing excavations for fault repairs, construction and reinforcement works. For emergency works, the charges apply from 24 hours after the start of the works. Note: the cost of lane rental charges is recovered from the customer for any Connections works.

The cost of lane rental and permit charging for the first year of operation is £1,613,218.

As the present scheme is only a trial in a restricted number of areas in London, the costs are expected to rise considerably over the full implementation.

7.2 Permits

Since January 2010, 18 London councils and Transport for London (TfL), have operated, a Permit Scheme which granted Authorities powers to ensure consistency and facilitate better co-ordination of Road Works.

Prior to the Permit Scheme, local authorities had limited powers to control where, when and for how long roads were dug up - regardless of the chaos they caused. It was estimated there were around one million holes dug in London’s roads each year, with little or no regulation, and most utilities were only required to give short notice of with 90% of works being carried out with less than ten days’ notice to the highway authority. Each year, in Westminster alone seven and a half square miles of road are dug up, through c.28,000 excavations.

Since the inception of the scheme, Local Authorities have reported a reduction in the disruption caused by road works in central London because for the first time councils are able to control when road works are undertaken.

The cost of a Permit depends on the scale of the works and the street where they take place and ranges from £40 to £345 which is intended to cover the administrative cost of operating the scheme. By law, local authorities are not able to profit but just cover their costs.

If works that require a Permit take place without one, the Works Promoter may be issued with a Fixed Penalty Notice (FPN) of up to £500, and ordered to apply and pay for the Permit that they should have had in the first place. If a Works Promoter breaches the conditions of a Permit, they may be issued with a FPN of up to £120.

The use of a FPN avoids the need to go to court, meaning any punishment is swifter and less bureaucratic.

Region	Capital Program	Network Ops Capital	Network Ops faults	Total	Cost/km²
LPN	£55,678	£102,409	£424,760	£582,847	£807
EPN	£25,666	£7,180	£225,596	£258,442	£13
SPN	£20,909	£16,163	£90,761	£127,833	£15
– Total:	£102,252	£125,752	£741,117	£969,121	

LPN equivalent cost at SPN rate /km²	– £11,083	
London Factor Cost	– £571,763	

The additional cost for operating under the London rates for Permits is £571,763.

7.3 Traffic management

Local Authorities are increasing their demands that UK Power Networks install some form of traffic management when working in the highway or even in the footpath when pedestrians are diverted out into the roadway. This takes time to get agreement on the scheme with the Local Authority and adds considerably to the costs of the work.

Table 15 below summarises the amount of Traffic Management schemes we have been requested to put in place.

Table 15: Traffic Management Schemes

Region	Stop Go Boards	Contra-flow	Convoy Working	Give & Take	Lane Closure	Multi way sign	Priority Working	Road closure	2 way signals	Total
EPN	286	1	2	8	101	553	31	377	1692	3151
LPN	18	2	0	6	233	49	79	166	103	697

SPN	68	1	2	7	89	282	51	181	785	1514

From the above table is can be seen that there is an additional cost of £450,000 to operate in the LPN area due to the demands of the Local Authority for UK Power Networks to install traffic managing schemes as excavation sites

7.4 Environmental restrictions on street works

The Control of Pollution Act 1974 allows the London Councils to set times during which works can be carried out and the methods of work to be used. Contractors and Utility companies need to apply for prior approval for their works by completing a Section 61 application.

For The City of London and Westminster Council, these requirements extend to the following works:

- Erection, construction, alteration, repair and maintenance of buildings, structures or roads
- Breaking up, opening or boring under the road or adjacent land in connection with the construction, inspection, maintenance or removal of works
- Demolitions or dredging work
- Any work of engineering constructions

Hours of permitted working are:

- Monday to Friday – 8am to 6pm
- Saturday – 8am to 1pm
- Sunday and Public Holidays – no working

These restrictions apply for our planned construction and reinforcements work which unfortunately does not align well with the Lane Rental aims which is to have work completed outside “normal” working times.

It is not unusual for the local Environmental Enforcement Officers to close down our out of hour emergency works as a result of one or more complaints from residents. This then causes us to have to reschedule the essential works and to suffer unproductive time as a result of the cessation of out-of-hours works.

We presently don’t have systems in place to capture costs associated with delays due to Environmental restrictions so the London Factor Costs are unquantifiable

7.5 Archaeological artefacts in City of London

Archaeological remains and ancient monuments are important evidence of the City of London’s past and its role as a commercial and trading centre reflecting past land use, society and occupation as well as social and economic change. The remains have intrinsic value as well as contributing to the wider landscape of the City, its hinterland and trading connections.

Figure 7: City wall, Goring Street

The development of the City of London through the Roman, Saxon and medieval periods to the present day is contained in visible and buried monuments and archaeological remains. The almost continuous occupation of the City has led to the build-up and development of a complex and in some areas, deep archaeological layer. In many areas, monuments such as the Roman and medieval City wall are conserved as part of a development.

Elsewhere, they are buried below existing building basements, streets and open spaces, or subsumed into later buildings. For much of the City's history, surviving archaeological remains are the only source of information; and for later periods, archaeology complements surviving documentary records.

Scheduled Monument Consent is required for works affecting a scheduled ancient monument or it's setting, and is obtained from the Department for Culture, Media and Sport. As expected this consent process can be very protracted lasting many months or even years and the discovery of archaeological artefacts at one of our work sites usually leads to a complete cessation of works for an indeterminate period.

We presently don't have systems in place to capture costs associated with delays due to Archaeological Artefacts so the London Factor Costs are unquantifiable.

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8 Operations

8.1 Background

UK Power Networks takes its supplies of electricity from National Grid, predominately at 132kV, from a number of strategically placed Grid Supply points in and around LPN, EPN & SPN. The electricity is then transformed down in our Grid and Primary Substations to reach our larger customers at HV (11kV or 6.6kV) or domestic and smaller commercial customers at low voltage.

UKPN has a number of Fault Response and Repair teams and engineers who are responsible for providing an emergency service, attending to losses of supply and locating and repairing the faults as quickly as possible to ensure the minimum Customer Minutes Lost (CML's). In addition there are field teams and engineers who are responsible for the design and construction of new networks, reinforcement of the existing networks and the on-going maintenance of all the plant and equipment.

The majority of LV cable jointing is carried out with the cables live using insulated tools and safe live jointing techniques, but work on the HV and EHV plant and equipment is always carried out with the plant and equipment dead isolated and earthed to make it safe. Due to the high electrical loading in London it is not always possible to carry out work during "normal" working hours so it has to be undertaken when the load permits, usually at evenings and weekends, which increases the costs but minimises the possibility of disturbance to our customers.

Unlike electrical distribution networks in SPN and EPN the distribution network in London is 99.99% underground therefore there are no comparatively "easy" overhead line works as all faults, construction or reinforcement works require extensive groundwork. The London network has grown considerably over the years and there is a mixture of direct buried or pit and ducted cables. The majority of cables are in the footpath but as the congestion of utility assets in the footpath grows, increasingly the only "spare" space is in the roadways. Our cables are buried at circa 450mm deep for Low Voltage cables and circa 650mm deep for High voltage cables. The depth increases when laid in the roadway.

The older types of Low Voltage (LV) & High Voltage (HV) cables are Oil impregnated Paper insulated; lead covered with steel or tape armour (PILCSWA). This type of cable is traditionally very robust but as the lead sheath provides the waterproof covering it can be susceptible to ground movement, traffic vibration or tree routes. Cables traditionally come in lengths of 250m and cable joints are needed to join lengths of cables together and to provide services to customers via branch or crutch joints.

Figure 8: Older Cable

Cable joints were traditionally lead-sleeved, filled with hot poured bitumastic compound. Once exposed in a footpath or roadway excavation these type of lead sleeved joints can be broken down and remade adding flexibility to future jointing operations. The ground works are then backfilled and reinstated and the cables will then probably remain undisturbed for the rest of their serviceable life of circa 50 to 60 years.

Once cracked the lead covering of the cable or joint will let in moisture from the surrounding ground causing a flashover, usually leading to loss of supplies and one or more excavations will be needed to locate and repair the fault.

The more modern types of cables have Polyvinyl Chloride (PVC) or Cross Linked Polyethylene (XLPE) insulation. The cables can be either laid direct in the soil or installed in ducts but they do not generally have the steel wire outer covering making them more vulnerable to damage. This type of construction makes these cables much more flexible and less susceptible to moisture ingress.

Figure 9: Modern Cables

Different methods of jointing have been developed for these cables using cold pour resins and or heat shrink tubing. Unfortunately, once set the resin joints are not able to be broken down so these type of joints need to be cut out of the network to accommodate future cable jointing, so larger excavations are required.

Table 16: Comparison of underground cables lengths between UK Power Network Regions

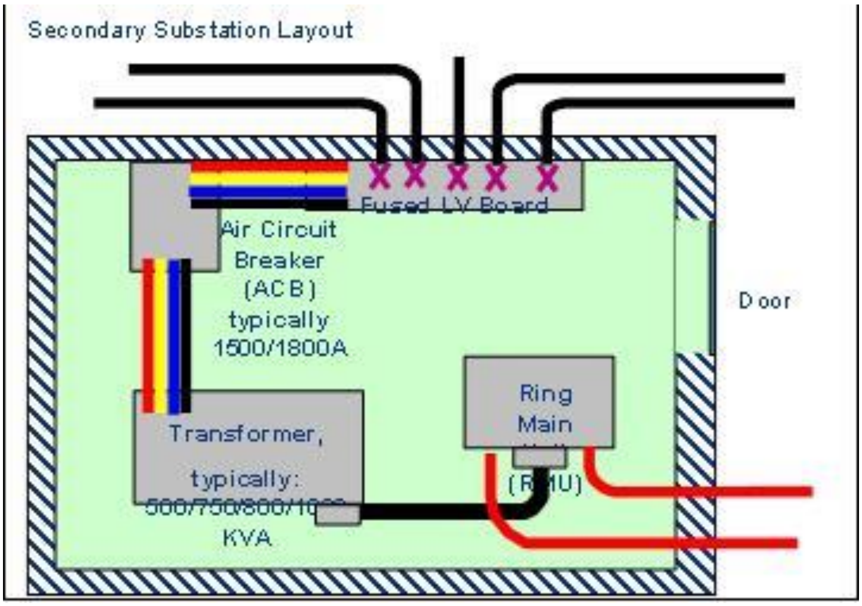
Type of cable system	LPN Route length (km)	EPN Route length (km)	SPN Route length (km)
Low Voltage Cables	22,705	39,892	26,056
High Voltage Cables (6.6-11kV)	12,107	19,562	12,031
Extra High Voltage cables (>11kV)	1,760	2,627	1,725

Once cables have been installed underground it is not possible to carry out inspections or maintenance apart from at the termination points in building, substations or LV underground link boxes.

8.2 Secondary substations

There are circa 14,000 secondary substations in the LPN area that transform the high voltage 6.6kv or 11kV electricity down to low voltage that can be used by domestic and commercial customers. A typical substation is approximately 3 metres wide by 3 metres long and contains HV switchgear, a transformer and some LV switchgear and distribution board. The LV cables from the Distribution board then radiate out from the Substation along the local streets and footpaths.

Table 17: Typical plant layout of a Secondary Substation



Field teams and engineers require 24x7 unrestricted access to these substations to carry out routine inspection and maintenance, as well as emergency response during power cuts. In the suburbs these substations are usually free standing in a brick building or GRP enclosure in open areas, easily accessible and visible without parking or restrictions on access.

As land is at a premium in the LPN area; the closer you get to the West End or The City of London the rarer it becomes for a substation to be visible from the street as they are usually hidden away in underground car parks, basements of offices, shops and flats or in large holes in the road or footpath completely out of site. This makes accessing the substations more difficult as often there are protracted discussions with security staff or managing agents. Quite frequently access is not possible as the majority of buildings are unoccupied out of hours.

Furthermore, it is not unusual to find that building works are undertaken in the premise and new walls have been constructed or doors added through which our staff don't have access.

Figure 10: Substation in Suburban area with good access

8.2.1 Substation access: key holding service

To mitigate some of the access problems in buildings where external and internal doors leading to our substations are locked, UKPN employs a team of 3 staff who are responsible for maintaining a set of keys to each building in a secure key safe located in the nearest Primary Substation to the premises.

This service is carried out in conjunction with the managing agents or key holders of the buildings containing our substations and the team make regular checks of the access at each and every building to ensure the access arrangements are up to date. Presently there are keys held at 32 primary substations for 1150 buildings in the LPN area.

Figure 11: Restricted access Substation access at basement level

Drawings and descriptions of the routes though the building are documented and made available on our Network Control systems so that those engineering staff responding to an emergency can gain access to the substation , potentially in the darkness resulting from a power cut..

Alternatively this team fit dual locking facilities to doors with customers' padlocks or locks alongside UK Power Networks padlocks or locks. They can also fit a key safe to the outside of the customers building containing a set of the customers' access keys

The provision of this service which is unique to the LPN area and costs £105,000/annum to ensure the minimum of delays in getting access to our Substations to restore supplies.

8.2.2 Substation ventilation

With normal substations, placed above ground, the ventilation to remove waste heat from the transformer(s) is usually provided by low level cool air louvers in the outside wall of the substation and high level louvers on the opposite outside wall to provide high level hot air exhaust.

When the substation is underground or in areas where there is no ventilation, as is typical in the West End and City of London, then UK Power Networks needs to install forced ventilation systems to remove the waste hot air.

Without forced ventilation the temperatures of the transformer can soon rise to more than 100°C which is detrimental to the life of the transformer and can lead to failures of other plant and equipment in the substation with subsequent loss of supply. It is also unsafe to expect our staff to work in such high temperatures.

A typical forced ventilation system would have high and low level ducting running maybe 2 floors up to ground level to bring in cool air and extract the hot air with main and standby fans to provide air movement. The systems would be thermostatically controlled but in some of our heavily loaded substations the system is running 24x7 to maintain a stable temperature. Any opening into the substation would be fitted with some form of fire protective device to shut of the air supply in case of a fire in the substation.

In new build substations the provision of the air handling systems is made by the developers but in a number of cases UK Power Networks retrofit ventilation systems to older Substations as load increases. There is an on-going inspection, maintenance and replacement program for substation ventilation systems as with continuous running of the fans the fan motors only last a relatively short number of years before they require replacement.

The added cost to UK Power Networks in the LPN region to inspect maintain and replace the ventilation equipment is £ 141,000/annum

8.2.3 Substation access: confined spaces

In the City and West End circa 1,100 substations have been declared as Confined Spaces i.e. "Any space of an enclosed nature where there is a risk of death or serious injury from hazardous substances or dangerous conditions (e.g. lack of oxygen, gases, fumes etc.)". The substations are underground with restricted access involving a vertical ladder or pavement flap. If an engineer were to fall ill or have an accident and be immobilised in one of these confined space substations then the only way out would be to winch the casualty up to the surface.

All operational staff that could possibly enter one of these substations is required to have periodic confined space training, be authorised to work in confined spaces and to wear and operate the appropriate PPE and equipment, including:

- Full PPE: Safety boots, FR coveralls, gloves, high visibility jacket, helmet, eye protection
- Full body harness
- Gas detector
- Torch
- Fall Arrest device

For the Category C sites additional safety equipment is required:

- movement detector
- 2 way underground compatible radio
- Emergency MSA breathing apparatus

Our specialist confined space contractors are available on standby for a £150 callout fee and £100/ hour in case a confined space substation requires access by our field staff in emergency conditions for fault restoration etc.

A top man is required to be stationed above ground with access to the appropriate safety equipment and be in communication with the working party underground.

Table 18: Description of the Confined Space Categories

	Access & Egress Characteristics	Typical Locations
Type A	Accessed by stairway. Egress in an emergency is relatively straight forward and quick.	Underground substations and Plant Rooms Areas where heating boiler present.
Type B	Accessed by vertical ladders, step irons or steep steps e.g. greater than an average stairway. Recovery of an injured casualty is likely to be difficult.	Underground substations, Cable Pits, Air Receivers and Plant Rooms Oil Pits, Vessels inc. conservator tanks Areas with height restrictions or obstructions such as cables or plant
Type C	Number of access/egress points. Accessed by vertical ladders or step irons or by other means. Work may be some distance from egress point and at depth where communication becomes difficult. Recovery of an injured casualty is likely to be difficult.	Tunnels Ducts, Culverts.

For all new substations our designers try wherever possible to site the new Substations in easy access areas but there is very little that can be done to alter the access arrangements for existing substations.

There are very few confined space substations in the EPN and SPN Regions so the additional costs factors in the LPN Region for Confined space working are:

Confined Space Tasks	Cost
Training and refresher training of 200+ operations staff (3 year cycle)	£76,666
Purchase, testing and inspection of safety equipment	£73,333
Cost of Specialist contractors to attend site to ensure UKPN staff safety	£45,000
Total	£194,999
The overall costs of providing this Confined Space service in LPN is £195,000	

8.2.4 Substation flooding: Pump out contaminated water

As UK Power Networks have a considerable number of substations below ground level, they are very susceptible to flooding either from ground water or from burst water mains.

Unfortunately once the water gets into our substations and has picked up dirt, oil, grease and any pollutants it has to be classified as “contaminated” water, and we are not permitted to discharge it down a drain or manhole without it being filtered or treated.

Figure 12: Tanker and Filter unit at Bishops Bridge Road flooded Substation

Under environmental legislation, we are required to use a filter bag on the end of the pump hose for small amounts of water like a flooded joint hole. For larger volumes of water, we need to hire in a portable water filtration system or one or more tankers to suck up the water and to then take the water to a licenced Waste disposal. Sometimes the tankers have to drive as far as Southampton to discharge their contaminated water, thereby adding greatly to the cost.

Figure 13: Flooded Substation at Bishops Bridge Road

We use specialist contractors to look after our flooding issues including the hire of appropriate tankers, plant and equipment and disposal of the contaminated water.

The contractors will also clean up the residue left in the substations after the flood waters have been cleared up.

The costs of engaging these specialist contacts to deal with the LPN flooded substations is £500,000/annum

8.3 LV cable systems

8.3.1 Cable depths

All utility assets in the footpath and road should be laid in accordance with "NJUG Guide to the position and colour coding of Underground Utility apparatus". This is a guideline only and is for ideal conditions with maybe one pipe or cable from each utility in the footpath. It is very rare in London to find anything like the NJUG "ideal" conditions. So it's usually a case of first in gets the best position and any Utility following on has to make the best use of the space that is left.

The "normal" depth for UK Power Networks LV cables is circa 450mm in the footpath and circa 650mm in the roadway, if there is an un-obstructed route, which is rare in the Westminster and City of London areas due to congestion of other utilities. At the moment there are circa 15 different telecommunications companies that are eligible to lay their green plastic ducts in the roads and footpaths of Westminster, but at a much shallower depth than the electricity cables. So whenever UK Power Networks needs to lay new cables or to expose existing cables there are invariably one or more pipes from a variety of telecommunication companies in the way.

8.3.2 Damaged cables

Due to the large amount of utility equipment in the ground in close proximity to UK Power Networks LPN LV and HV cables there is a greater opportunity for cable damages by other utilities. This can be demonstrated in the following:

Table 19: Comparison of the number of damaged cables in each UK Power Network region

Region	No. of Damaged LV cables	No. of Damaged HV cables	No. of Damaged EHV cables	Geographic Area of each Region (km²)
LPN	2,814	571	51	722
EPN	4103	1788	183	20,300
SPN	2,345	1,678	109	8,327

When one considers its size, it is plain to see that LPN suffers by far the greater number of cable damages/km² due to its more congested footpaths and roadways and greater volumes of street works by other Utilities and their contractors

Table 20: Normalised number of damaged cables in London by km²

Region	No. of Damaged LV cables/km²	No. of Damaged HV cables/km²	No. of Damaged EHV cables/km²
LPN	3.898	0.791	0.071
EPN	0.202	0.088	0.009
SPN	0.282	0.202	0.015

Whilst some utility contractors own up to cable damages when they occur, far too often the damage, however slight, is not reported and the excavation is backfilled, only to fail at some stage in the future leaving UK Power Networks to pick up the cost of excavation and repairs, as well as the extra CI's and CML's. These unrecovered costs amount to circa £2.98M on a gross cost of £27.8M

In order to understand if the LPN area has higher unrecovered costs on damaged cables taking into account the much smaller Regional Area than SPN and EPN, the following table shows that London has significantly higher unrecovered costs / km² as a result of the unwillingness of other Utilities and their contractors to admit to cable damage in the London area.

Table 21: Normalised cost of Damaged Cables in London

Region	Geographical Area (km²)	Gross cost of Cable Damages	Cost of damage /km²	Unrecovered costs of cable damage	Unrecovered costs of cable damage /km²
LPN	722	£27,800,000	£38,504	£2,980,000	£4,127
EPN	20,300	£44,860,000	£2,210	£4,530,000	£223
SPN	8,327	£31,000,000	£3,723	£4,500,000	£540

Taking the unrecovered cost/km² of the EPN cable damage in EPN away from the LPN unrecovered cost/km² of cable damage gives the normalised cost for the 722km² in London amounts to £2,589,823

8.3.3 Pipes and ducts

The LV cables can either be laid direct in the ground or pulled in either 3" or 4" earthenware ducts or in 125mm plastic double walled black pipes which can be broken or cut away relatively easily for future works. Historically in some areas of the West End and The City steel pipes were used. Steel pipes give very good resilience to mechanical damage from other utilities but when access is needed to reinforce or connect to these cables it is very time consuming to identify and cut sufficient steel pipes away to permit the works to be carried out.

Steel pipes are unique to the West End and City of London. To enable routine works to be carried out on a daily basis, two dedicated "pipe cutting" teams are needed. These teams cut into the pipes, in most cases with the cables live, using specialist tools and have a great deal of training and expertise.

The cost to the LPN area to maintain these 2 x 2 person metal pipe cutting teams is £140,000

8.3.4 Fused Radial LV Networks

The majority of LV networks in the UK Power Networks area are "fused radial". That means that the LV circuits are fused in the local substations usually with 300A or 400A fuses and then each cable then runs radially out from the Substation along the road via one or more Linkboxes. The cables eventually come to an open point in an underground Link box or a "pot end" at the end of the cables.

These cables are only fed from one end and if there is a fault on the cable the fuse(s) blow in the local substation and all customers connected to that fuse remain off supply until our Emergency crews attend to fix the fault and replace the fuse. The disadvantage of the fused radial network is that each transformer only supplies the load it is connected to, so some transformers will be highly loaded and others may be lightly loaded. The balance of load may vary between times of day or season depending on the type of load connected to that transformer.

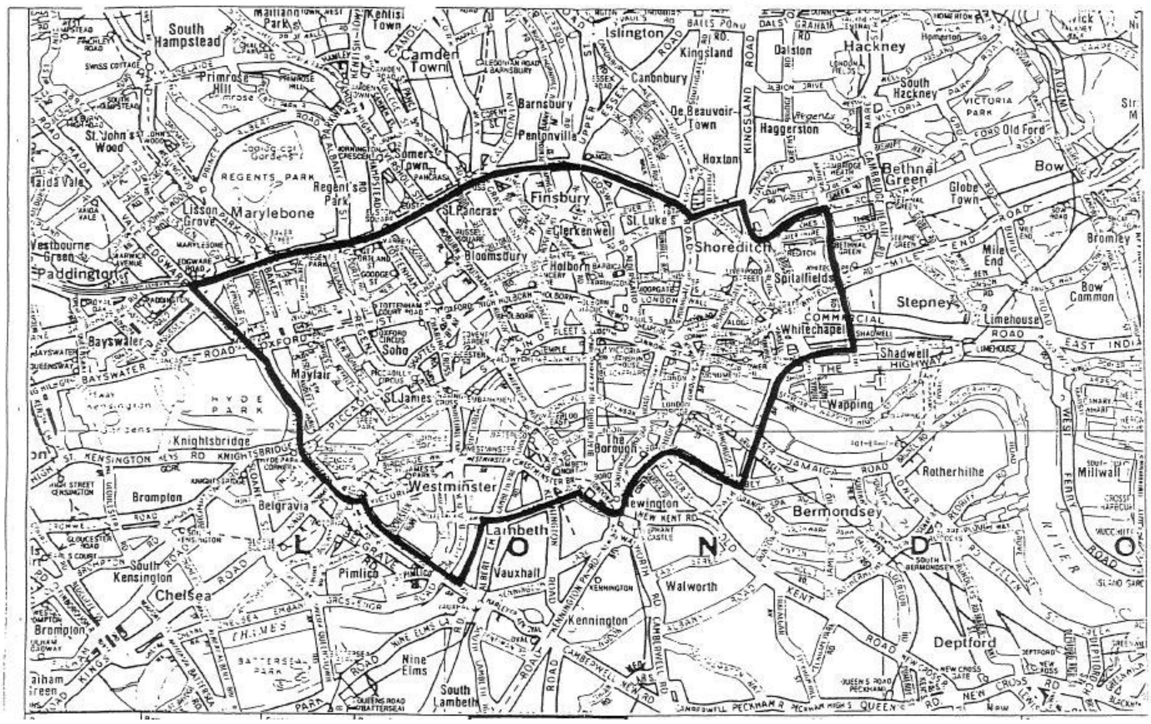
In the event of an HV fault on a fused radial network all substations fed by the faulted HV feeder lose supply until the Control Engineers carry out remote switching to isolate the faulty section of HV cable and switch back supplies to the substations from alternative HV cables. This invariably takes less than 3 minutes to achieve.

8.3.5 Interconnected LV Networks

In the more congested highly loaded areas of London, mainly in the West End and the City, the fused radial network is not so beneficial. More capacity is needed in the LV cables so an "Interconnected network" is used where most LV cables are fed from both ends. A number of Substations that are geographically close to each other form an "LV Block" with about 3 MW of transformer capacity. As all of the LV cables are connected together, the entire load in the Block is shared equally amongst all of the Transformers, so the interconnected systems allows for a very high utilisation of transformer capacity. Usually each cable is fused at 500A due to the higher loadings and adjacent Blocks are connected together via Fringe fuses to provide further support of the load and to assist in maintaining supplies in the event of an HV fault. A number of Blocks that are connected together in this way is called an LV Group.

In the event of an HV fault on an interconnected network all substations in that Group fed by the faulted HV feeder lose supply, but as each LV Block is electrically connected to the adjacent LV Blocks via Fringe Fuses, the supply is maintained. The Control Engineers carry out remote switching to isolate the faulty section of HV cable and switch back supplies to the Group of substations from alternative HV cables. Therefore customers fed from an interconnected LV network do not usually experience a supply loss in the event of an HV fault.

Figure 14: LV Interconnected area in London



The interconnected network is relatively small and is restricted to the highly loaded area of the West End and The City as outlined on the diagram above.

8.3.6 Link boxes

As previously indicated, each LV cable is usually connected to one of more “Link boxes”. These are basically a large underground connection box about 1m long by 0.65m wide where either 2 or 4 LV cables are connected together. Each link box is covered by a concrete pavement cover that can be removed by special lifting keys. There is a system of copper links or fuses that can be inserted or removed in the Link Box to change the way each cable is connected to each of the other cables. So if there is no link or fuse inserted in for a particular cable that is an “open point”.

The older style link boxes are made of cast iron filled with hot poured bitumen. If the link box overheats in service the compound heats up and the level rises sometimes to a level that make the link box inoperable.

The newer types of link boxes have an insulated plastic case with a cold pour resin that sets hard. This will not melt or distort with the heating effect of an overload.

All linking and fusing operations are carried out with the cables and Link boxes live, using specialist insulated tools and a great deal of training and experience.

Figure 15: Serviceable link box with Links and a fuse being inserted

All UK Power Networks Regions use 2 way and 4 way underground link boxes.

In the LPN area there are a total of 47,000 link boxes, of which:

- 36,000 are in the fused radial areas and are inspected circa every 8 years
- 11,000 are in the interconnected areas and are inspected every 4 years

This 8 year inspection frequency aligns with all of the link boxes in the EPN and SPN areas.

The inspection procedure ensures that the equipment is operating satisfactory and that all fuses and fringe fuses are checked. There is also a check for water ingress, rubbish, signs of overheating or indications of a flashover due to a fault.

As indicated above, the fringe fuses carry the load in the event of an HV fault and occasionally they blow due to overload. After every HV fault these fringe fuses must be checked as, if they have blown, the LV Blocks may not have adequate support to maintain supplies to customers following a subsequent HV fault in the area.

Figure 16: A Link box that has suffered a flashover due to a fault.

The inspection and maintenance of the LPN interconnected area link boxes has 5 x 2 man dedicated field teams which is a unique cost to London. The cost of these teams is £ 385,000/annum

8.3.7 Trip testing

As indicated previously, in the event of an HV fault the Substations in the interconnected areas rely on reverse power flow from the adjacent LV blocks to maintain supplies to the customers connected to the affected KV Block.

In order for this facility to work successfully there are protective "Reverse Power Relays" fitted in each Interconnected Substation which are designed to trip the circuit breakers under certain fault conditions.

Figure 17: One of the items of HV switchgear that is "Trip tested"

As with all protective devices installed on an electrical distribution network it is essential to prove that they are working correctly otherwise a mal-operation of the protection could cause additional customer interruptions or damage to plant and equipment.

For the circa 4100 substations in the central London interconnected area there is a 2 yearly inspection program where our technical staff visit each substation and carry out a “trip test” to ensure that the appropriate circuit breakers operate correctly.

This trip testing is unique to the LPN area as none of the other Regions have an interconnected HV & LV system and costs £250,000/annum

8.4 HV Cable systems

For the majority of outer London the HV network is run on an “open ring” basis with a fused radial LV network. The majority of the HV switchgear in the secondary substations is remote controlled that can be operated by the Control Engineers at the Network Control Centre in Ipswich. In the event of an HV fault the HV feeder goes dead, the control Engineers use remote monitoring equipment to determine which part of the network is faulty and then operate the HV switchgear remotely to restore the supplies. This normally takes less than 3 minutes during which time up to 2000 customers may be off supply.

The load in the City and West end is very high, in fact at 23MW/km² it’s the highest load density in Europe. To supply these high profile customers UK Power Networks use an “open ring” HV network with an LV Interconnected network which is more appropriate to provide a greater degree of resilience in times of HV faults.

The load is formed into 3 MW “groups” which are fed via a single HV feeder but back-feeds are available from adjacent groups in the event of an HV fault. This type of network is more complicated to design, build, operate and maintain but it is very effective and provides excellent reliability in maintaining supplies to customers in the event of an HV fault.

8.4.1 High Voltage cables

8.4.1.1 Paper Insulated Lead covered HV Cables

The majority of our older High Voltage cable networks (6,600volt and 11,000volt) are traditional paper insulated, lead covered, steel wire armoured cables (PILCSWA) with bitumastic lead filled joints and have given good service since their installation in the 1960’s.

These cables can have either a copper or aluminium stranded conductor. Just like the LV cables, if their waterproof lead covering is damaged then the cables may suffer from water ingress and ultimately fail.

Joints between lengths of cable are traditionally sweated ferrules covered with a lead sleeve and then filled with a hot bitumastic compound. An earthenware shell is then placed around the joint to provide mechanical protection.

Table 22: Paper Insulated Lead covered cable details

Cable Construction

A. Aluminium or Copper conductors – 3 x stranded sector shaped on 70mm^2 cable and above, round conductors below 70mm^2.
- Large range of conductor sizes on the network 16-300mm^2 with an overall diameter range between 40.3 - 71.6mm

B. Layers of paper insulation impregnated with mineral oil compound
C. Figs. 1 & 2 Additional (belt) insulation layer
D. Lead sheath, covered with bitumen coated paper and hessian layers, as a bedding for the armour wires
E. Steel wire armours
F. Bitumen coated hessian tape serving (oversheath)
G. Fig 3 Shows a screened cabe with a conductive layer applied over each core.

8.4.1.2 Cross Linked Polyethylene (XLPE) HV Cables

Over the last 20 years, modern XLPE insulated cables have been installed. These "Triplex" type cables are either copper or aluminium stranded conductors with a red PVC outer covering to indicate that they are High Voltage.

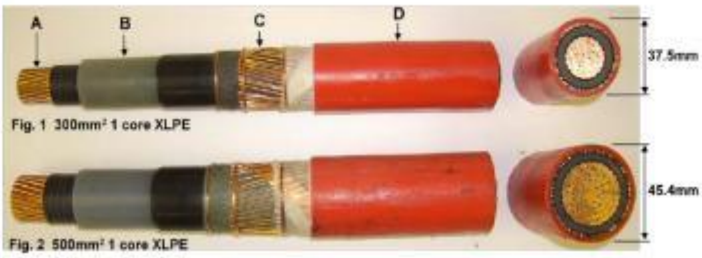
They are supplied in single core format with circa 1000m on a drum or in a "triplex" formation with 3 single core cables loosely wound together to form a 3 core cables with typically 250-300m on a drum.

Joints between lengths of cable are via nut and bolt type fittings with heat shrink covering to keep them watertight.

Table 23: XLPE cable details

Cable Construction

A. Copper conductor – stranded round 300 & 500mm^2
B. XLPE insulation – thickness 3.4mm
C. Copper wire earth screen - 35mm^2 CSA on both sizes of cable
D. Red MDPE oversheath



When work needs to be carried out on an HV cable it needs to be made dead, isolated and then earthed and appropriate safety documents issued by the Engineer. The typical areas for HV faults are cracks around the lead joint due to expansion and contraction after many thousands of heating and cooling cycles, or mechanical damage to the waterproof covering due to damage by third parties.

Figure 18: Drums of HV Triplex Cable

Once the fault is located and assuming that the cable is at a normal depth, it is a relatively simple operation to excavate the footpath or roadway to expose the faulty cable, cut out the faulted joint or damaged portion of the cable and to joint in a short length circa 3 to 5m of new cable with 2 new straight joints.

When some of the older 33kV and 66kV circuits are taken out of service they can be re used at 11kV but the disadvantage is that they were traditionally laid much deeper so any faults on these circuits require more extensive excavations and are therefore much more expensive.

To give an indication of the variability of HV cable repairs and the amount of work necessary the following examples of HV cable faults are provided:

8.4.1.3 Glaucus Street 11kV Cable fault

The example shown is an 11kV circuit where the 11kV feeders from Glaucus St utilise a section of old 33kV cables.

Four large joint holes had to be excavated in the roadway circa 3 m deep to initially determine the position of the fault and then to find a section of cable that was not damp and in serviceable condition.

There was ingress of contaminated water to a depth of 1.5m from the adjacent canal and 18,000 litre capacity tankers had to be continually be used to pump hazardous material out of the excavations. Each tanker could clear a joint hole twice before it needed to be taken away and emptied.

Due to the water, the paper insulation in the cable was damp to a point approximate 20 m each way from the position of the fault so approximately 40 metres of excavation at 3m deep had to be excavated to install the cables between joint holes.

40m of 33kV cable was jointed in to replace the faulty section. 33kV joints were required due to the water ingress into the joint bays.

Figure 19: Composite views of the excavations and joint bays at Glaucus St.

Figure 20: The extreme conditions of one of the HV joint holes

Table 24: Glaucus Street HV fault costs

Glaucus St HV fault	Cost (£k)
Labour	13.8
Materials	2.7
Contractors	3.3
Total	19.8

8.4.1.4 Appold Street 11kV Cable fault

An 11kV cable joint faulted in a pit that had a number of other HV circuits running through it. Unfortunately it was a main feeder route out of the nearby Finsbury Market Primary Substation and the other HV cables in the congested cable pit suffered from collateral damage from the initial explosion.

Our engineers had difficulty in getting close enough to visibly inspect the damage as it was feared that one of more of the other cables could fault at any time resulting in a serious situation if the Engineer was in close proximity.

Figure 21: The mass of 60 HV cables (red lines) in the vicinity of the fault outside Finsbury market primary substation

Due to the high loads it was not possible switch out all of the HV cables in the pit without affecting supplies to a very large area of the City of London. Sandbags and other forms of protection were applied and a mini excavator was used to take out some of the ground either side of the pit to expose the cables for a damage assessment

To avoid hand digging and to ensure the safety of staff, a Vacuum excavator and Air Knife was employed at a cost of approximately £1000 a day. This avoided the need for the cables to be moved as well as allowing the operator to be positioned some distance away if the cables should fault.

Figure 22: Vacuum excavator being used

Subsequently it was found that 8 other adjacent HV cables had suffered some form of damage and careful planning was needed to ensure customers were not disconnected as these were taken out of service for repair. The biggest challenge was in the identification of the damaged cables due to the presence 60 other HV cables in and around the fault position. This situation is unique to LPN as there are no Grid or Primary substations with the same density of cables in those regions.

The whole program of investigation and fault repairs took approximately 5 weeks with 24x7 working.

Figure 23: HV Cables exposed behind the fault

Figure 24: Cable congestion at the fault position

8.4.2 Excessive cost of High voltage faults

London suffers circa 500 HV faults each year and in most cases the repair works can be completed for approximately £8,400, which compares favourably with the costs of HV fault repairs in the EPN and SPN regions.

However as can be seen from the two examples of HV fault repairs above, in those many occasions when the conditions are not so favourable then the costs and duration of the fault repairs are going to be greatly increased.

It is estimated that the increased cost of HV fault repairs in London, as a result of technical or environmental constraints, costs £810,000/annum

8.5 High voltage plant changes

As indicated previously, many of the Substations in the West End and The City of London are underground, often 2 or 3 levels down. A transformer weighs upwards of 3 tonnes so in order to replace the plant and equipment a plant access route is required that can take the weight of the plant and equipment as well as any lifting and handing apparatus required to carry out the move. For a buried substation this usually means a buried plant access hatch in the road or footpath sometimes 2 metres + in depth.

Figure 25: Plant moving over the top of Westminster Abbey by crane

Substations have been in place for many years and new buildings may have been constructed all around them compromising the plant access, so a very large crane may be needed to lift the plant and equipment over the building. It is not unusual to find that new walls have been constructed, or ducts and pipework installed across the ceilings of basement passages that were designated as plant access routes.

Equally, what used to be a service corridor may now be a major access route with decoration, floor coverings etc. It is not unusual to find that the building's managing agents or owners don't even know that a substation exists in their basement, so structures have been built directly on top of the plant access hatch that will need to be removed and replaced after the works have been completed.

Figure 26: Preparation of plant access though a bookshop in Great Marlborough St SW1

To replace the plant and equipment many discussions are needed with the building owner to clear a route for the old plant and equipment to be taken out and for the new plant and equipment to be taken in.

Hence, a simple plant move that would take a few hours in an above ground substation may take:

- extensive negotiations with the landlords;
- preparation and agreement of lifting plans, method statements and risk assessments;
- preparation for the plant access route, including the protection or removal of carpets, flooring and decorations;
- involvement of loss adjustors if trading has to stop or high quality surfaces have to be removed;
- large excavations for the plant access hatch and removal of spoil;
- use of large and expensive lifting and handling equipment;

- suspension of residents parking or parking meters to allow parking of our vehicles and equipment;
- permits and permissions for the use of cranes which is often only permitted at weekends;
- arrangement of road closures or installation of traffic management schemes;
- assembling of a team of staff and specialist contractors, often out of hours, to complete the plant movement

Figure 27: Royal Lancaster Hotel plant replacement

Once the plant move has been completed the property then has to be resorted to its original condition, including resealing of the waterproof plant hatch, backfilling and reinstating the excavations, relaying any disturbed surfaces like carpets or marble flooring and deep cleaning so that the landlord can return the building to normal operations.

The above activities need to be compressed considerably when plant fails and needs emergency replacement, often using temporary lighting throughout the job, although the fact that the property is off-supply often leads to quicker decision making by the Landlords to facilitate building works to gain access for the plant and equipment.

For a number of the prestigious buildings in London we can't just issue a statutory notice that we are going to disconnect supply for a plant change as that would involve the building closing down and so we work with the customer to provide generation and continuity of supply. As can be seen from the photo below, this can often result in multiple generators being supplied and connected up via hundreds of meters of temporary LV cabling.

Figure 28: Penta Hotel - generation required for transformer change

A study has been made of 73 plant replacement projects in the inner London area in the last year which had an overall cost of £757,478. The breakdown of the exceptional costs as a result of the restricted access, ground-works etc., out of hours working requirement etc. is are as follows:

Table 25: Additional costs of plant moving in London

Work item	Number of sites affected	Overall exceptional costs (£k)
Traffic Management	19	49.0
Manual Handling	23	70.1
Excavation in the carriageway	26	94.6
Out of hours working at time & a half	31	20.8
Out of hours working at double time	27	29.3
Total:		263.8

The exceptional costs account for circa 34% of the total costs and these would not occur if these plant replacement projects were in the SPN or EPN regions. Extrapolating this additional uplift in costs to the total costs incurred in a typical year (average of the last 2 years of annual spend), this would amount to additional annual costs of £714,000 in London.

The additional costs to enable plant and equipment to be changed in restricted access secondary substations are £714,000/annum.

8.6 EHV cable systems

8.6.1 Background

The Extra High Voltage (EHV) network in London comprises cables at 22kV, 33kV, 66kV and 132kV. The constructions of the older variants of these cables at the lower voltages are traditionally solid cables i.e. Oil impregnated paper insulated conductors with a lead outer sheath and steel wire armoured (PILCSWA) to provide mechanical protection from damage.

For the higher voltages (66kV & 132kV), the design of these cables may change so that they have oil impregnated paper insulation surrounded with either a lead or corrugated aluminium sheath. The complete cable is then pressurised with either oil or dry nitrogen gas to provide additional insulation and to fill any voids in the paper insulation. Oil tanks or nitrogen cylinders are located at strategic points along the route.

The circuits are often laid with 3 separate cables, one per phase as opposed to the 3 phase 3 core cables for each circuit at lower voltages. These circuits are laid with a minimum covering of circa 1.5m in a trench circa 1.5m wide, but historically the older circuits can be found to be laid at depths of up 6m.

Figure 29: Lead sheath cracked on an oil filled cable

These types of oil or gas filled EHV cables were strongly favoured pre-privatisation and so in London, UK Power Networks has inherited the longest route kilometres of oil and gas cables in the UK. Unfortunately many of these cables reaching an age when they are prone to leaks, which are very time consuming and costly to locate and repair. Replacement 132kV oil filled cable has to be specially made at a cost of circa £300/m with a delivery time of circa 12 months.

A typical joint bay for the 3 separate 132kV cables is circa 7.5m long, 2m wide and circa 2m deep with a concrete base constructed prior to cable jointing.

Table 26 EHV Cable comparison between UK Power Network Regions

Type of EHV cable system	LPN Route length (km)	EPN Route length (km)	SPN Route length (km)
33kV Oil filled cables	305	619	470
33kV Gas filled cables	17	0	7
66kV Non Pressurised	121	0	0
66kV Oil filled cables	291	0	0
66kV Gas filled cables	16	0	0
132kV Non Pressurised	203	57	101
132kV Oil filled cables	215	194	239
132kV Gas filled cables	72	0	44
Total km:	1760	2627	1725

8.6.2 EHV circuit outages

Due to the high loads on the EHV network in London a lot of essential maintenance and repair work has to be completed out of hours. Typically maintenance is carried out during the summer months when the heating load is not connected. However, in London, on many of our Grid and Primary Substations, we experience summer peaks that are even higher than the winter peaks as a result of air conditioning. This then has a detrimental effect on our ability to take circuits out for maintenance without putting the load on the rest of the network in jeopardy.

So for many of our EHV engineers and field staff, a lot of their time is spent switching out circuits from say midnight on Friday night and then carrying out essential work during the weekend to get the circuits back on load before the Monday morning peak load.

As can be seen from some of the descriptions of EHV Oil and Gas cable faults which follow, we have only a short window over the weekend in which to switch out the circuit, carry out the cable freeze to try and find the oil leak and then to get the cable back into a serviceable condition before Monday morning.

Knowing if a Grid or Primary substation feeds mainly a domestic load or a commercial load dictates if the circuits can be released for work during the day, evening or weekend. In general, circuits feeding commercial loads can be made available evenings and weekends and circuits feeding domestic loads can be made available for work during the day, but need to be restored before the evening peak and cannot be taken out of service at weekends.

We are required to run our electrical networks to be “firm” in the event of the loss of one items of equipment which means that if we lose an EHV feeder due to a fault, supplies can be maintained by reconfiguring the network. If we then suffer a second loss of a critical circuit then it is very likely that load would be lost as there would not be anywhere for the load to be picked up forming an adjacent substation. This situation is then called “Out of Firm”

The City Load is only firm for a maintenance outage at the weekends – hence the city is maintained at the weekends. City Load is out of firm “Monday to Friday” for a second circuit outage for a 12 hour period each day.

These constraints make the scheduling of the essential annual maintenance plan extremely challenging, taking into account the work load, resources available and the forecast load, which could then change due to un-seasonal weather conditions.

An analysis of the overtime for the EHV field staff and engineers indicates that the majority of their overtime is dictated by the availability of circuits. This load related London Factor work amounted to an extra cost of £784,712 in 2012.

These circumstances are not unique to the London area as there are some heavily loaded circuits in EPN and SPN but in those regions they are the exception and not the norm.

8.6.3 XLPE transition joints

Newer circuits are constructed from XLPE that removes all of the issues with leaking oil or gas and these types of cables have proven to be very reliable since their introduction. However it is not always feasible to joint in a length of XLPE cable into an existing Oil or Gas circuit that has suffered a fault or is past its economic life.

Figure 30: XLPE 3 core EHV cable

A Gas transition joint only exists at the moment at 132kV and is only available for single core cables and is 3 m long and 1m diameter. Three of these are needed for each circuit, so an exceedingly large excavation is required. A 66kV gas transition joint is not manufactured.

There are lots of types of oil transition joints to XLPE cable manufactured at all voltages, but our experience of these joints is that they are subject to regular failures.

Figure 31: Oil transition joint being prepared at Dartford cable fire

If transition joints are used to joint in a section of XLPE cable, then the oil or gas circuit still needs to be maintained along the route. Therefore, either Oil or gas pipes invariably need to be laid alongside the new XLPE cable to maintain the continuity of the oil or gas supplies to the remainder of the pressurised cable. On occasions we have had to lay up to 1km of pipeline to maintain the oil flow along a circuit.

8.6.4 Cable oil leaks

The benefits of reliable Oil cables have to be offset as they begin to age and we witness an increasing frequency of oil leaks. Oil tanks are placed at strategic locations along the routes to feed the cable and maintain a constant pressure of oil. Alarms are located at these positions to detect when oil pressure drops, indicating a possible leak.

Figure 32: A Cable freeze in progress on a shallow cable route

The LPN network includes approximately 2,200km of Fluid filled cables with over 1480 fluid filled sections in the London area. These are low pressure cables dating back to the 1930s. These cables are extremely reliable and an electrical fault is exceedingly rare, as long as positive oil pressure is maintained. However the joints are the weakest point of any circuit and we are finding that oil leaks are becoming more frequent. A significant amount of money is being invested in replacement of these EHV circuits in ED1 but this will be a long process and in the meantime the existing assets will need to be kept in serviceable condition with regular repairs and maintenance throughout their remaining life. We currently pump approximately 184,000 Litres of cable fluid into our cable systems each year and have developed cutting edge methods of cable leak detection and fault location. Nonetheless when an oil cable develops a leak it requires accurate location, excavation and then repair before the oil can have a detrimental effect on the environment.

Cable Freezing can be used which utilises liquid nitrogen applied directly around the cable to freeze the oil in the cable. By monitoring the pressure drop at each end of the circuit, an indication can be given of the leak location. As can be imagined, the use of liquid nitrogen can very hazardous, expensive, time consuming and can have a detrimental effect on the future life of the cable.

UKPN are developing a similar technique which utilises heating tapes to apply heat the cable, and hence the oil, which will be flowing towards the leak. The use of a Thermovision camera or temperature gauges detects the heat flow. Unlike the freezing technique that requires the cable to “de frost” for circa 24 hours before being re-energised. The heating method takes considerably less time than freezing the cable as well as having no detrimental effect on the cable which can be switched back immediately after testing.

8.6.5 New technology for leak location

Figure 33: Vehicle mounted PFT Leak location equipment

Our latest technology is to use a PFT Leak Location system that operates by detecting a Perfluorocarbon tracer added to the oil that evaporates, when it leaks from a suitable tagged leaking cable section at the point of leak. A specially equipped detector van drives along the route and detects minute quantities of the PFT gas in the atmosphere to pinpoint the leak. We have an 80% success rate with this equipment but unfortunately the deeper the cable, the less effective this method is.

As indicated previously a number of our EHV cables are at a “standard” depth of circa 1.5 metres and are reasonably accessible for PFT detection, location, excavation and electrical repair works. However there are a number of cables routes that were laid between 3 to 7 metres deep, so any error in pinpointing the exact position of the leak leads to a significant amount of extra excavation, time and costs.

8.6.6 EHV cable fault examples

The following table give an indication of the annual volumes of the EHV cable faults across all 3 UK Power Networks Regions:

Table 27: EHV Cable Faults by Region

Region	Geographical Area (km²)	Route length of EHV cables (km)	No of EHV cable faults: 66/33/22kV	No of EHV cable faults: 132kV
LPN	722km²	1760km	17	5
EPN	20,300 km²	2627km	119	25
SPN	8,327 km²	1725km	45	4

It is very rare that an EHV cable fault in the LPN leads to customers being off supply due to the redundancy and protective systems built into the network.

There is a budget cost for each EHV fault which allows for “normal” ground work conditions circa 1.5 m deep but as indicated previously, due to the nature of the depth of EHV cables and utility congestion in the roads and footpaths, some such faults result in extreme costs.

EHV cables in the EPN and SPN Regions have always been known to be run at this normal depth and often their circuits run in green-field land or open spaces where access is not a problem and excavations can be undertaken without uncovering other utilities and space constraints.

All excavations over c.2m deep need to have the ground supported to prevent it caving in. Either timber or sheet steel poling boards are used with bespoke timber struts or steel trench frames being used as the excavation depth increases. Once the excavation gets down to circa 3 metres deep structural calculations and design work needs to be completed by specialist staff to ensure the structure is safe to work in and around.

For “normal” Oil and gas filled cable repairs in outer London and EPN and SPN where the cables are circa 1.5m deep and there are fewer constraints on excavation and other utility obstruction, the average cost of a repair would be circa £30,000. However (as can be seen from the examples illustrated below) the depth of cables and the subterranean congestion in London can cause the costs to rise dramatically.

The additional costs of repairing EHV cable faults in the LPN Region that are very deep and in congested footpaths are £520,000

The following pages provide examples of the extent of the works associated with some recent EHV cable faults in the London area where there were very deep excavations and long lengths of cables replaced under difficult and expensive conditions.

8.6.6.1 Backhill to Fisher Street No. 4 33Kv Circuit

This fault was an oil leak in a heading 7m deep. The leak was on a 33kV cable in the middle of a heading and so 2 very deep excavations were needed at each end of the heading to prove where the leak was. The end result was that the faulty cable had to be cut and capped each side of the heading and then pulled out from the pipe. 100m of oil filled cable had to be installed and 2 oil filled joints completed. As the cable was 7m deep the PFT leak location technique was not effective so a number of cable freezes had to be completed which is a very time consuming and expensive process.

The photo depicts one of the joint holes.

Figure 34: 7m deep Shaft to access Backhill to Fisher St Oil filled cable

Figure 35: EHV cable fault repairs Backhill to Fisher St

Figure 36: 7m deep joint bay Backhill to Fisher St Oil filled cable

The repairs to this circuit took 8 weeks:

Table 28 Back Hill EHV Circuit fault repair costs

Back Hill to Fisher St No. 4	Cost (£k)
Labour	14.1
Materials	2.9
Contractors	137.0
Other	0.2
Total	154.2

Note: Contractors cost includes materials supplied by the contractor

8.6.6.2 Lisson Grove 66kV Oil circuit repair

On the Lisson Grove circuit, a 66kV oil joint exploded due to oil starvation due to a fast oil leak. The cable was originally installed in 1931.

Due to the high loading on the circuit it was only available for fault location at weekends. The 5 ended circuit needed to be switched out, starting at midnight on a Friday night. It then needed to be left to cool down for a few hours.

Cable freezing was used to try to pinpoint the location of the leak with the cost of the liquid nitrogen alone running to more than £4,000. The freezing equipment was fitted on Saturday morning and the tests completed over the weekend. The freezing equipment was removed on Sunday and the circuit allowed to thaw ready for its return to service. This process was repeated 6 times over 6 weekends before a final fault position was found.

The only repair possible was to overlay 150m of 33kv 3core oil filled cable and to install 2 new Oil filled joints.

The teams worked 24x7 to get the work completed and as a result there were a number of environmental issues with local residents.

Due to utility congestion along the route the only clear line was along the very busy main road where traffic management schemes had to be implemented. The excavation was in the road and took approximately 12 weeks to locate and complete repairs.

Figure 37: Road Excavation Lisson Grove

Figure 38: Road closure required for delivery of replacement cable

Table 29: Lisson Grove EHV Cable fault costs

Lisson Grove 66kV repair	Cost (£k)
Labour	95.2
Materials	9.7
Contractors	356.8
Other	0.1
Total	461.8

Note: Contractors costs include materials supplied by the contractor

8.6.6.3 Eltham to Sydenham 132kv Gas Circuit fault repair

This circuit comprised 3 single core 132kv Gas filled cables and the fault was due to a failure of the Gas transition joint. This required the excavation of one very large joint hole of circa 25m long by 3m wide by 2m deep.

The work was complicated by constant running water that needed to be pump away. 24x7 site security was needed as it was on a public thoroughfare and welfare facilities were required on site with crew room, Toilets, storage etc.

The total time to carry out the work was circa 3 months from start to finish as a new joint had to be manufactured.

As there are very few EHV cable jointers in the county that can work on these types of joints, the manufacturer had to carry out a training course before repairs could be completed.

Figure 39: Original Gas joint failure

Figure 40: Berry Hill Joint Bay

Figure 41: New Cable route circa 2m deep

Figure 42: New Cable route circa 2m deep

Table 30: Eltham to Sydenham EHV Cable fault repair costs

Eltham to Sydenham No. 1	Cost (£k)
Labour	44.0
Materials	32.2
Contractors	189.1
Total	265.3

Note: Contractors costs include materials supplied by the contractor

8.7 Railway access difficulties

To avoid undergrounding of cables, there used to be a policy, pre-privatisation, to run cables alongside railway lines either on hangers alongside the track, under or over bridges or in concrete troughs. This method had the advantages of being relatively cheap way to install cables without a significant amount of excavation.

Nowadays it is proving increasingly difficult to get trackside possession access to carry out our any inspections and repairs to the cables and this is usually limited to the 3-4 hours in the early morning when the tracks are de-energised and trains are not running.

There are charges by Network Rail to provide the required safety cover lookout persons as well as the frequent mobilising and de-mobilising of our staff over a number of consecutive nights to complete the work. At times it is next to impossible to get track possession access due to train movements and so UK Power Networks have to bear the additional costs of a work-around solution whilst a legal agreement for access is negotiated. It is not uncommon for such a negotiation to take years to conclude.

The cost of track possession and restricted access to HV & EHV cable systems alongside or bridging over Railway property is £877,000

8.7.1 Ranelagh Bridge EHV Cable Oil leak

Ranelagh Bridge provides a specific example of the cost of delays caused by lack of access to the track. There was an oil cable leak on a cable circuit in a steel trough crossing Ranelagh Railway Bridge in Paddington.

The bridge crosses 12 tracks of the London Underground and Great Western mainline and the Rail Authorities insisted that access could only be permitted on one day each year; Christmas Day.

Figure 43: Ranelagh Railway Bridge

The circuit was eventually replaced in the footpath of a bridge crossing the railway tracks but the original leaking cable was stuck in the trough and was unable to be removed during the restricted access times.

Since then the oil has continued to leak and to date the cost of the clean-up operation, including scaffolding and oil lines and tanks with a specialist contractor engaged to regularly collect the residual oil has risen to £697,000.

These costs continued to rise until the next 1 day access period on Christmas day 2013. Had this circuit been in a more accessible situation, the clean-up and recovery cost would be circa £50,000.

Figure 44: Leaking oil cable crossing Ranelagh Bridge

8.7.2 HV Supplies to Excel Olympic Venue

In 2002 an 11kV circuit supplying the Excel exhibition centre developed a fault which was subsequently located underneath the Docklands Light Railway (DLR) track near Custom House station. The faulty cable was capped on either side of the blockage and left isolated. Fortunately the cable was in a bank of ducts under the railway tracks however these were found to be blocked when attempts were made to pull out the faulty cable. An attempt was made using CCTV to check these pipes to determine the cause and location of the blockage.

A scheme was developed to directional drill under the track to replace the damaged duct route and a deep shaft was excavated either side of track to start off the directional drilling rig. Unfortunately some track ballast kept sliding into the shaft excavations so the work was halted due to possibility of undermining the track.

The legal team spent a number of years negotiating with the rail authorities for a new under track crossing however, the situation became further complicated as the new Crossrail route was designed to run alongside the DLR tracks over the HV cable route. Excel was then subsequently named as an Olympic Venue which assisted in the agreement of the new easement, however the new under -track crossing needed to be phased in with the Crossrail works, which was not going to happen before the Olympics.

As a result, an alternative proposal had to be executed involving the excavation and laying of a new 440m HV cable route along a footpath parallel with the track, at an estimated cost of £145,781. In addition to the circa 10 years of frustrated excavations, abortive planning and legal works, the estimated cost overall of this HV fault, which, from an engineering perspective, was relatively straightforward was circa £250,000 instead of a more normal cost of circa £20,000

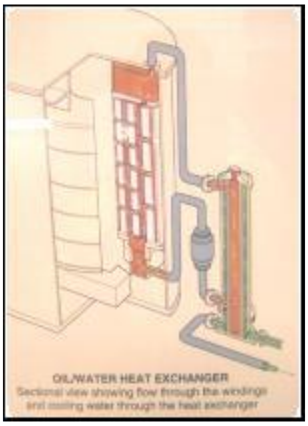
8.8 Underground primary substations

As indicated previously, the amount of land that is available for UK Power Networks to construct new Primary substations is very limited so the footprint of the Substation is a small as practicably possible. Whilst it is good for developers and local Authorities to only have to release a small amount of land, this leads to a significant amount of on-going issues for Operations, Inspection, Maintenance and repairs at these sites.

A typical EPN and SPN Primary will usually be in single storey building, perhaps raised above ground level to do away with the need for a confined space working cable basement. It will be on a large site and have enough land around it to park a number of Lorries, vans and private vehicles and maybe space for one or more containers to contain spares and materials.

However in central London it is very rare for a Primary Substation to have any parking facilities and usually the plant and equipment is split over 2 or 3 floors. In a number of cases everything is completely underground perhaps in the 3rd or 4th level of basement of an office building, block of flats or under a pedestrian walkway etc.

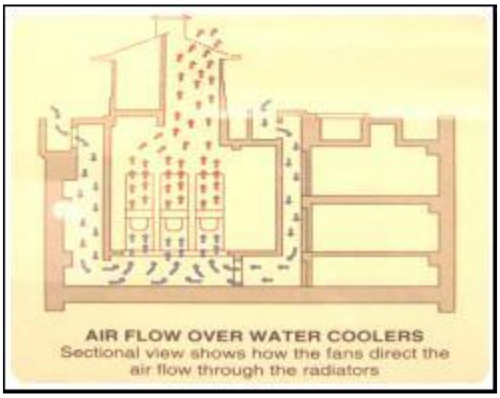
Figure 45: Transformer Oil to Water Heat exchanger



With an above ground Primary substation there is very little need for ventilation equipment or water pumps as natural ventilation is available and ground water is not much of a problem. With a totally underground substation all areas require forced ventilation, and it is common for the cable basement to be below the water table thus requiring measures to ensure that the plant and equipment is protected.

Hence, main and standby pumping systems are needed as well as main and standby ventilation systems with sophisticated controls to shut down the ventilation system in the event of a fire to contain any fire suppression gas. Over-ride ventilation systems are also required to vent any basement areas after the gas has discharged as the Gas is heavier than air and will naturally migrate to the lowest level of the site creating a dangerous situation for any personal entering after the fire suppression system has operated.

Figure 46: Ventilation systems for a below ground Primary transformer.



An above ground substation usually has the transformers at ground level and the hot oil passes to an adjacent cooler bank using predominately natural ventilation backed up by fans.

With a totally underground Primary Substation, the hot oil in the transformer still needs to be cooled however the additional pipework and radiators containing thousands of litres of inflammable oil is a significant risk, so the oil that is contained within the blast proof transformer bay is fed into a heat exchanger fitted to the transformer so that water can be used to take the heat away from the transformer to radiators external to the transformer bay. Dual heat exchangers and dual pumps and pipework are fitted to ensure sufficient cooling facilities are available should one of the pumps or heat exchangers fail.

This complex cooling system requires a lot more maintenance than is required for the above ground types of cooling systems. The fans and pumps have a relatively short life of a couple of years as they are in service almost continuously.

Figure 47: 11kV cables in a Substation cable basement

When UKPN staff attend site for routine inspection and maintenance or, to respond to faults or incidents, additional staff are needed to be deployed for the manual handling of spares, plant & equipment up and down a number of flight of stairs as it is very rare that there are goods lifts installed. Often a crane has to be hired to lower the heavier items to the lower levels though a plant access hatch.

The cable basements at these sites are declared "Confined Spaces" so only appropriately trained and equipped staff can be deployed to carry out any works. Due to the small space in the cable basement and up to 60 panels of HV switchgear, there is a considerable amount of HV cables criss-crossing the cable basement, on the floor, walls or mounted on cable trays, racks and brackets, so access and working in congested cable basement takes longer to avoid damage to nearby cables.

The additional cost to UK Power Networks to operate, inspect and maintain the large number of complex underground and or restricted space Primary Substations is circa £345,000/annum.

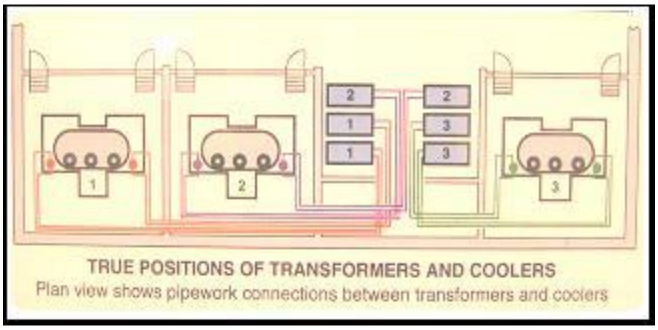
8.8.1 Leicester Square underground primary substation

Leicester Square underground Primary Substation was one of the first totally underground substations constructed in the early 1990's and the only evidence of its existence is the theatre ticket office which was constructed to disguise the outlet grills on its roof for the waste heat from the cooling fans. The entire site is buried up to 3 levels down under Leicester Square. Millions of Londoners and tourists that visit the Square are totally unaware of the subterranean infrastructure that lies under their feet.

Figure 48: Personal access hatch at Leicester Square Substation

The only access to the site is via a hydraulically operated pavement flap and access for vehicles is very difficult due to the large numbers of pedestrians. There is a similar hydraulically operated Plant access hatch and emergency exit on site.

Figure 49: Oil to water cooling system at Leicester Square Substation



There are 6 oil-to-water heat exchangers installed at this site together with 12 large diameter fans to provide the cooling air to the hot water in the radiators. The site is has now been running for 20+ years continuously with a very high load on the 3 x 132/11kV transformers so the maintenance of the plant and equipment is becoming quite labour intensive.

8.8.2 Bankside power station primary substation

This site once contained a large oil fired power station which closed in the late 1970s. UK Power Networks has a major Grid and Primary Substation on the site which it shares with the Tate Modern Art Gallery. A complete refurbishment of the substation has just been completed resulting in the site having the longest single HV switchboard in Europe with 100+ 11kV switch panels.

During the design stage, advantage was taken of our experience with Oil to Water cooling systems to design and construct a system to recover the waste heat from the boilers and supply the low grade heat to the adjacent Tate Modern to pre-heat their water. From each of the 6 primary transformers there are 12 cooling towers with 24 fans all interlinked with 120+ valves and pumps by hundreds of metres of lagged large metal piping. The piping then goes to a Tate Modern Interface where they take the heat to be plumbed into their domestic heating system. As this is the first known trial of this type of heat recovery system in the UK no charge is made to the Tate Modern for the supply of the heat, but they did make a contribution to the design, development and installation costs.

See Appendix A.16 for additional photos of the Bankside Tate Modern heat recovery system.

Figure 50: Cooling systems and pipework on the roof of Bankside Substation

9 Security

9.1 Security issues of a major city

London is in the headlines most days as a result of the multitude of events, meetings, demonstrations, local and national governmental day to day business, royal visits and other stories that may be of interest to the public. It is not uncommon for a network fault in London affecting relatively few high profile customers to be of media interest and occasions will be discussed in the Houses of Parliament in some form or other.

Our operational staff need access to virtually all of the most important buildings in London where we have substations and equipment e.g. in Royal Palaces and Apartments, Downing Street, The Houses of Parliament, MP's office buildings at Portcullis House, Government, MOD & Security organisation buildings, Tower of London, Embassies, Commercial and Financial headquarters building, and Emergency Services control centres.

Our staff often require high levels of security vetting and passes to secure areas so there are restrictions on who UKPN can deploy in these high security areas and a great deal of time is taken up in obtaining consents and permissions for routine access and work to be carried out which often has to be completed out-of-hours.

In the lead up to and during the Olympics we worked very closely with the Security services and the Centre for the Protection of National Infrastructure and based our mitigation strategy on their advice. UKPN contracted for security guards to be in position 24x7 at a number of Critical "Olympic" Grids and Primaries. The remainder of the Grids and Primaries were checked on a regular basis by mobile patrols. In addition mobile CCT and intruder detection systems were deployed as well as installing a complete new suite of electronic locks on all doors.

9.2 Major events

The UK Power Networks media team register all major public events that are due to take place within our area to gauge any possible impact it may have on our operation or to invoke special measures for the operation and control of our network in relation to the event and surrounding areas. Often these events are attended by national and international heads of state, government ministers, the famous and not so famous and the event may be watched by thousands if not hundreds of thousands of spectators on the streets of London, as well as national and international multi-media broadcasting service.

The threat of disruption to any major event from national and international terrorist and or militant organisations is a very real issue for the security services. We work closely with the security services who often require pits, manholes, substations, tunnels and any other plant and equipment in the event area to be physically inspected for explosive devices one or more times before the event.

In addition, depending on the priority of the events we may:

- Arrange meetings with the event organisers, broadcasters, security services etc. to co-ordinate our works
- Change the running arrangements of the distribution network;
- Perform additional testing and maintenance on critical plant and equipment;
- Physically check all supplies at the event locations;
- Check for "touch voltages" for items of street furniture along the route where spectators gather;
- Place additional security personnel or protection on Critical Grids and Primaries;
- Set up a major incident room with a media team presence;
- Obtain security clearance and passes for relevant staff on site;
- Close down any excavations in the vicinity of the event and along the route;

- Locate staff in Primary and secondary substations and place extra staff and materials on standby nearby to cater for system emergencies;
- Issue standby communication equipment.

This precautionary work invariably has to be completed at UK Power Networks cost and to indicate the magnitude of these costs, the table below gives shows the expenditure on a number of recent events:

Table 31: Major Event typical costs for Networks security

Typical Events	Additional security cost to UKPN (£k)
Priority 1, e.g. Royal Jubilee events	23.5
Priority 2, e.g. funeral of Rt. Hon. Margaret Thatcher's, G8 conference	18.3
Priority 3, e.g. Chelsea Flower Show, FA Cup final	6.4
Priority 4, e.g. State Opening of Parliament, CBI Annual Dinner	4.3
Priority 5, e.g. London Marathon, Chinese New Year celebrations	2.3

9.2.1 Network Preparation for Major events

The following table shows the relative numbers of major events in the LPN area compared to our other regions. We have formulated a well-rehearsed approach to the staging of these events and the mitigation measures which we consider appropriate.

See Appendix A.5 for the Network preparation matrix for Major Public Events

Table 32: Number of Major events by Region

Event Priority	Event description	Media Coverage	LPN: No. of events	EPN: No. of events	SPN: No. of events
1	Royal Wedding/ Funeral/ Jubilee/ Coronation etc.	National & International press coverage for > 6 months in advance. Global broadcasting.	2	0	1
2	World Cup in UK Power Networks area, G8 "type" Conference	National Press coverage for > 6 months. International media interest (>3 months). National /International broadcasting.	11	0	0
3	Remembrance Day Parade, Opening of Parliament, Budget Day, Utility Awards	Regional long term negative publicity (> 1 month) or national short term negative publicity (< 1 month)	66	7	3
4	Queen & DoE visits, Cup Final /Wimbledon Tennis, Party political conferences, Rugby International	Regional/Sector specific coverage for > 1 month. Possible recordings broadcast	74	21	6
5	"Minor" Royal Family Visit Oxford & Cambridge Boat Race Lord Mayors parade, London Marathon	Local or very specific coverage (e.g. industry magazine)	378	34	61
		Total	556	62	61

Note: Table 30 excludes the additional numbers that can result from a major event or festival, such as the Olympics. In 2012, we faced an additional 25 Priority 1 "Olympic" events in LPN and 1 Priority 1 "Olympic" events in EPN.

From the matrix shown in Appendix 5 the approximate costs for each major event has been calculated based on the number of hours involvement for field staff, engineers and managers for each of the 5 Priorities of events.

The following table shows the cost to each Region for hosting these major events. The sheer number of such events in LPN, when compared to the other two regions, has been used to identify the differential in cost faced by UKPN, when compared to other DNOs.

Event Priority	Typical cost/event (£k)	LPN Cost (£k)	EPN Cost (£k)	SPN Costs (£k)	Uplift in LPN vs. EPN
1	23.5	47.0	-	-	47.0
2	18.3	201.3	-	-	201.3
3	6.4	416.0	44.8	19.2	371.2
4	4.3	318.2	90.3	25.8	227.9
5	2.3	883.2	80.5	142.6	802.7
Total		1,865.7	215.6	187.6	1650.1

The additional Network preparations for the significant number of major events in London cost UK Power Networks £1,650,100/year.

Note: this figure excludes the additional events associated with the 2012 Olympic Games

9.2.2 Re-scheduling of planned works due to Major Events

Whilst the above events are in progress we still have to maintain business as normal to our customers so it is often necessary to have to reschedule our planned works in the area and divert staff away from the congested roads. Often the routes to be taken by heads of state etc. are only released a few days before the event and we then have to close down our work along the route.

A good example of this was the multi-way HV cable route being excavated along the carriageway in Lower Thames Street near Southwark Bridge. Lane restrictions were in place for a significant number of weeks to allow the works to continue when we were instructed by The City of London at short notice to completely close down our works for the G8 conference as the heads of state motorcade was to go along that stretch of road.

The site was completely cleared for a number of days at considerable expense to UK Power Networks and then work re commenced. A few weeks later the site had to be completed shutdown again as it was on the route for the London Marathon.

With all of the above major events in the LPN area it is quite routine for minimal notice to be given of the need for to demobilise and shut downs work, apply temporary reinstatement as required and clear the site for the event, with the reverse reactivation of works after the event.

Unplanned de-mobilisations and subsequent re-mobilisations, as a result of external instructions from the authorities cost UK Power Networks circa £125,000/annum

10 Properties and Insurance

10.1 Background

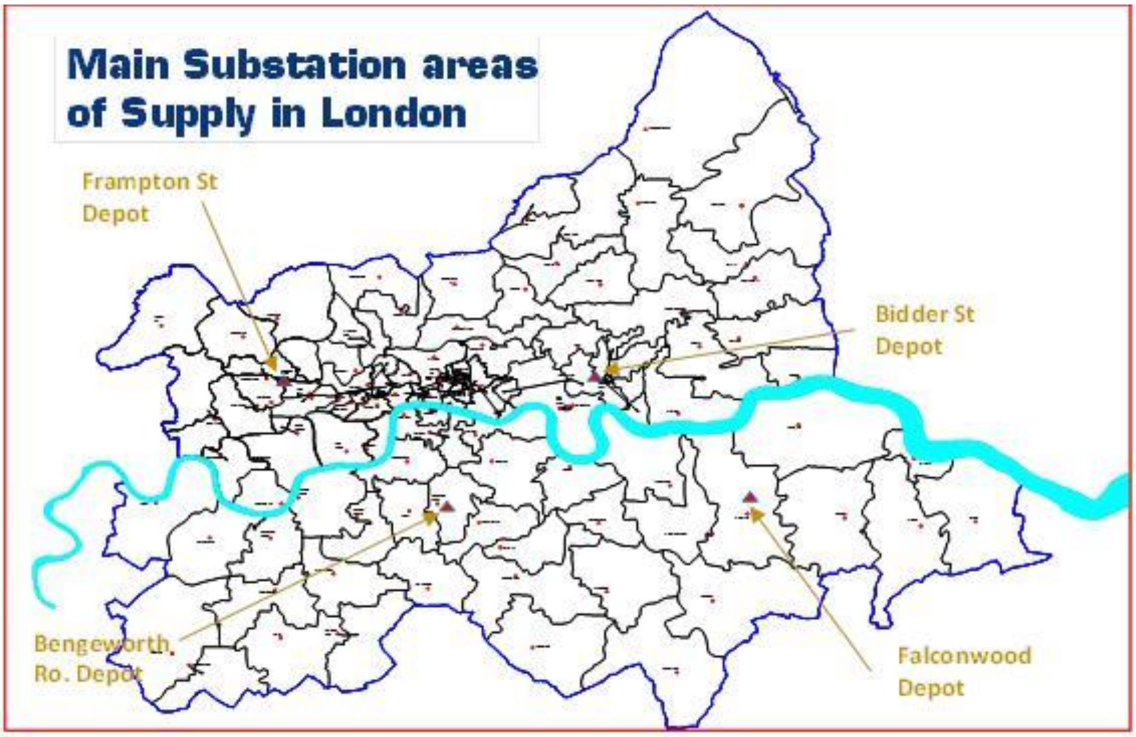
We operate in London and it is essential that we have the operational infrastructure of offices, depots and stores etc. so that our field teams and engineers have the necessary support and facilities in reasonable proximity to the areas that they work in. With the average reported traffic speeds in London of little more than 10mph, it is obvious that vehicle journeys should be kept to the minimum to avoid unproductive time.

There are many Grid and Primary Substations in London but unlike our counterparts in EPN and SPN it is very rare for such a substation to have space for vehicle parking, materials storage and any form of accommodation.

Most of the inner London operational sites have a very small footprint with the majority of plant and equipment placed underground, so there are little or no parking facilities available. To try to reduce the costs of renting suitable accommodation, on occasions use has been made of some smaller operational sites. The larger operational sites were often placed in what are now residential areas and on occasions these facilities have had to be withdrawn following objections from residents due to the noise etc. resulting from their 24x7 use.

10.2 Operational buildings

Figure 51: LPN Depots



As can be seen from the map of LPN above, UKPN operate from just 4 main depots strategically placed with relatively good transport and travelling connections. Three of these locations are in Grid sites to reduce costs.

Each of these sites has facilities for vehicle parking, plant and equipment storage & back office accommodation. The Bengeworth Road depot is the only heavy plant drop off point for the whole of London. Our logistics function operates an overnight service from the Heavy Plant stores at Bury or Maidstone to deliver new transformers, switchgear etc. and take back redundant plant for refurbishment or scrapping.

For the Olympics and in anticipation of additional congestion on London's road system, we established 4 sub depots where fault response and repair teams could be based and have a small stock of materials etc. Three of these locations are still being used as it was found that they improved our response times and gave greater flexibility.

10.3 Insurance of Property and Assets

There are two aspects to the Insurance of UKPN properties and assets:

- Increased direct insurance premiums that we incur because of LPN's location.
- Increased indirect premiums that we incur because of the higher cost to operate in London

10.3.1 Terrorism Insurance Premiums

This is due mainly to the risk rate that insurers apply to premiums that LPN pays for Terrorism insurance. Terrorism risk rates are determined by geographical zones and the government backed insurer (Pool Reinsurance Co. Ltd.) that UK Power Networks have historically used define four zones (A-D) where:

- Zone A relates to Central London
- Zone B relates to Inner London and select Central Business Districts (CBD's) in major cities (See Appendix manual identifying the limited CBDs of cities)
- Zone C relates to rest of England
- Zone D relates to rest of Great Britain

Zones A & B attract a premium rate of 0.03% per £Million of property assets insured

Zones C & D attract a premium rate of 0.006%

The regulated businesses of UK Power Networks insure combined property assets in the region of £6bn, however that LPN falls entirely within zones A and B. Tables 31 and 32 show the differential costs that result from this.

Table 33: Terrorism Insurance costs: Operational Grid & Primary Substations

Region	Insured Value	No of Grids & Primaries	Insurance loading	Terrorism insurance premium
LPN	£1,766,630,000	159	0.0300%	£529,989
EPN	£2,633,795,000	619	0.0060%	£158,028
SPN	£1,556,335,000	320	0.0060%	£93,380
Total:	£5,956,760,000	1,098		£781,397

If the LPN Grids and Primaries were insured at the Zone C&D rates this would bring the costs down to £105,998.

Table 34: Terrorism Insurance costs: Offices & Depots

Region	Insured Value	No of buildings & Depots	Insurance loading	Terrorism insurance premium
LPN	£27,628,960	8	0.0300%	£8,288.69
EPN	£71,333,917	30	0.0060%	£4,280.04

SPN	£48,459,040	23	0.0060%	£2,907.54
Total:	£147,421,917	61		£15,476.27

The"replacement" value of the Offices and Depots is relatively low at £147.4M when compared to the values of the operational sites so the terrorism insurance premiums is only £15.4K overall. However if the 0.006% EPN insurance loading could be applied in LPN, this would reduce the costs by £6.6K.

Due to these very high costs, UKPN has opted to move away from the Government backed Terrorism insurer. In doing so, we now have a limited amount of Terrorism insurance cover that also has more exclusions in its coverage. This alternative to Pool Reinsurance Co. Ltd insurance still has a differing risk rate for geographical zones in the UK, but has cheaper premiums; however UK Power Networks now bears the risk of claims for the first £5M.

The equivalent additional London Factor for Terrorism insurance of the Operational and Non-operational Buildings is £429,021.

10.3.2 Indirect Premiums

This is predominantly Property Damage insurance and results from the reinstatement values of the assets in LPN's area. An insurance assessor that was engaged last year confirmed that on balance the cost of insurance for our equipment in London was somewhere in the region of 10% higher than the national average when taking into account the additional costs that arise firstly from the specific characteristics of the assets used e.g. larger, and more/different equipment required to fit the urbanised constraints and secondly the additional constraints on construction e.g. increased costs due to planning, design, more complex civil engineering work, restrictions on working, higher labour and contractor costs and congestion etc.

Table 35: Building Insurance costs: Offices and depots

Region	Operational Grids & primaries insured Value	Offices & Depots Insured Value	Total Insured value	Insurance premium
LPN	£ 1,766,630,000	£27,628,960	£1,794,258,960	£352,576
EPN	£ 2,633,795,000	£71,333,917	£2,705,128,917	£531,563
SPN	£ 1,556,335,000	£48,459,040	£1,604,794,040	£315,345
Total	£ 5,956,760,000	£147,421,917	£6,104,181,917	£ 1,199,484

The total costs of the Regulated building insurance is £1,199,484

All buildings are valued with a regional factor, which takes into account the increased building costs for that area (with London Postal districts being one of the highest at approximately 13% above the UK average) these figures are regularly published by the BCIS(Buildings Cost Information Service) thorough the RICS (Royal Institute of Chartered Surveyors). The allowance used for increased Plant & Equipment costs in London was approximately 10%; hence we have overall a 10% increased London weighting.

Taking into consideration the higher replacement costs for London properties and plant, as indicated by the independent Insurance Assessor, without this increased insurance loading there would be a saving of approximately £32,200.

Therefore the additional "London Factor" for Building insurance of the Operational and Non-operational site is £32,200.

11 Tunnels

11.1 Background

After London Underground (150kM) and Thames Water, UK Power Networks has the 3rd longest collection of accessible tunnel routes in London. Our 35 tunnels total circa 40kM in length with at least 4 tunnels crossing under the Thames.

Figure 52: Tunnel, Shaft Olympic Park

Due to the increasing congestion under London's footpaths and roads it became increasingly difficult to plan and construct new primary cable routes to cater for the increasing demand for electricity in the capital. The answer was to construct a deep tunnel system to contain our new EHV cables between grid and Primary substations. This also has the advantage that future reinforcement can be relatively easily accommodated and the same tunnels can be used to contain 11kV circuits as well as communications and protection circuits.

The tunnels are typically c.2.4m diameter and are accessed via a number of vertical shafts of up to 10m in diameter and 30m deep. The shafts serve as an entrance and exit for the HV and EHV cables as well as personal access, and ventilation.

The EHV cables are often buried in the base of the tunnel covered in a weak mix concrete to dissipate the heat whilst the HV cables are usually suspended on hangers or brackets along the roof or sides of the tunnel. Joints are avoided so, where possible, long lengths of cables are specially made so that joints are external to the tunnel.

A tunnel environment is often damp or wet so it's not a very good environment for fixed wiring for lighting or power. Fixed lighting is often limited to the tunnel shafts and any work that takes place in the tunnels needs temporary lighting and power to be run in before work commences.

Figure 53: Millennium Cable Tunnel Inspection

11.2 Tunnel Inspection & Maintenance

The older tunnels are not fitted with any forced ventilation and we have found from experience that when the cables become loaded the fabric of the tunnel gets hot, and any surface mounted cables expand and snake about on their brackets or cable trays. The air temperatures can rise as high as 55°C. At these temperatures the cables are not under stress but it is not safe for staff to work in the tunnels under these conditions, thus making any faults more difficult to repair

Figure 54: Movement of cables due to high ambient temperature

Before the Olympic Games a survey was made of the Millennium cable tunnel running from West Ham to the O2 Olympic Venue and high temperatures of circa 50°C were found. As a result temporary ventilation was installed to lower the temperature in case repairs were needed during the Games. Work is presently underway to install permanent ventilation equipment.

The newer tunnels are fitted with head houses that contain powerful fans to force air though the tunnels with fans at one end blowing the air and the fans at the other end sucking out the hot air to atmosphere. This greatly reduces the ambient temperature in the tunnels and is linked to sophisticated control monitor equipment.

Figure 55: Tunnel Ventilation control equipment, Olympic Tunnel.

This equipment is remotely monitored and can be used to show the air flows and fan speed settings as well as providing alarms for mall-operation, fire detection and intruders.

With adequate ventilation equipment installed, the tunnels can be used more intensively as additional cables can then be installed into the tunnels without a detrimental effect on the tunnel temperatures.

Whilst being a very valuable asset the tunnel systems are costly to maintain as confined space working regulations need to be complied with and specialist training and equipment needs to be provided. ‘Top men’ are needed at each tunnel shafts along with the appropriate rescue equipment. Radio communications via a “leaky feeder” are required between the top men and the crew working underground and a range of safety equipment needs to be carried by each member of the confined space qualified team in the tunnel.

UK Power Networks have a number of staff and engineers, trained to operate in confined spaces, but in general all of the inspection and maintenance services are contracted out to a specialist company.

11.3 Tunnel defect repairs

The biggest issue in operating tunnels is combating the ingress of water. When tunnels become flooded or partially flooded, any metalwork rusts and the tunnel fabric, cables, plant & equipment starts to deteriorate rapidly. Hence, the main aim of the inspection and maintenance regime is to make an early detection of water ingress and to fix it before it becomes a problem.

Prior to the Olympics all tunnels that contained cables supplying an Olympic venue or Olympic facility were given an extra round of inspections. It was found that 2 of these tunnels were in a flooded condition. In places they were flooded completely to the roof which would cause serious problems if there were to be a cable fault in the tunnels as the flooding would have prevented repairs being carried out. It was found that in both cases the cause was a simple matter of a drain pipe being blocked or broken, both by 3rd parties. These examples are shown below:

11.3.1 Millennium Tunnel: West Ham to the O2 flooding.

The cause of this flooding was due to the ground levels being changed around the shaft entrance at the O2 and in the process the outlet drain pipe had been obstructed. Unfortunately it was never determined who had carried out this work causing damage to the drain pipe. The tunnel from West Ham passes under the River Thames and at its lowest point it became flooded to the roof so it was impassable from end to end. This also affected the air flow so a dramatic rise in temperature was noticed in parts of the tunnel with the air temperature rising to circa 50°C.

Once the drainage problem had been rectified it was a matter of continuous pumping for a number of days to reduce the flooding level at the lowest point of the tunnel.

Figure 56: Millennium cable tunnel under the River Thames towards the flooding

Figure 57: After effects of flooding on tunnel control equipment

11.3.2 Duke St/Leicester Square/ Carnaby Street Tunnel flooding

When rising water was noticed in the Carnaby Street section of this tunnel it took some time to determine that the cause was a broken drainage pipe outside the Primary Substation. It was suspected that the pipe had been broken during other utility works but the company responsible could not be determined.

The only means to rectify the problem was to engage specialist contractors to break though the reinforced concrete wall of the substation and to construct a heading approximately 3 metres long and 2 metres high from within the Substation, out under the street, to intercept the drain pipe at the point at which it had been broken.

This work took circa 2 weeks to be completed at a cost of £37,405 and in addition our tunnel infrastructure needed to be repaired at a cost of £10,824.

The cost of inspection, maintenance and repair of defects in our tunnel network is £1,679,778

See Appendix A.8 for additional details by tunnel

11.3.3 Tunnels: Health issues

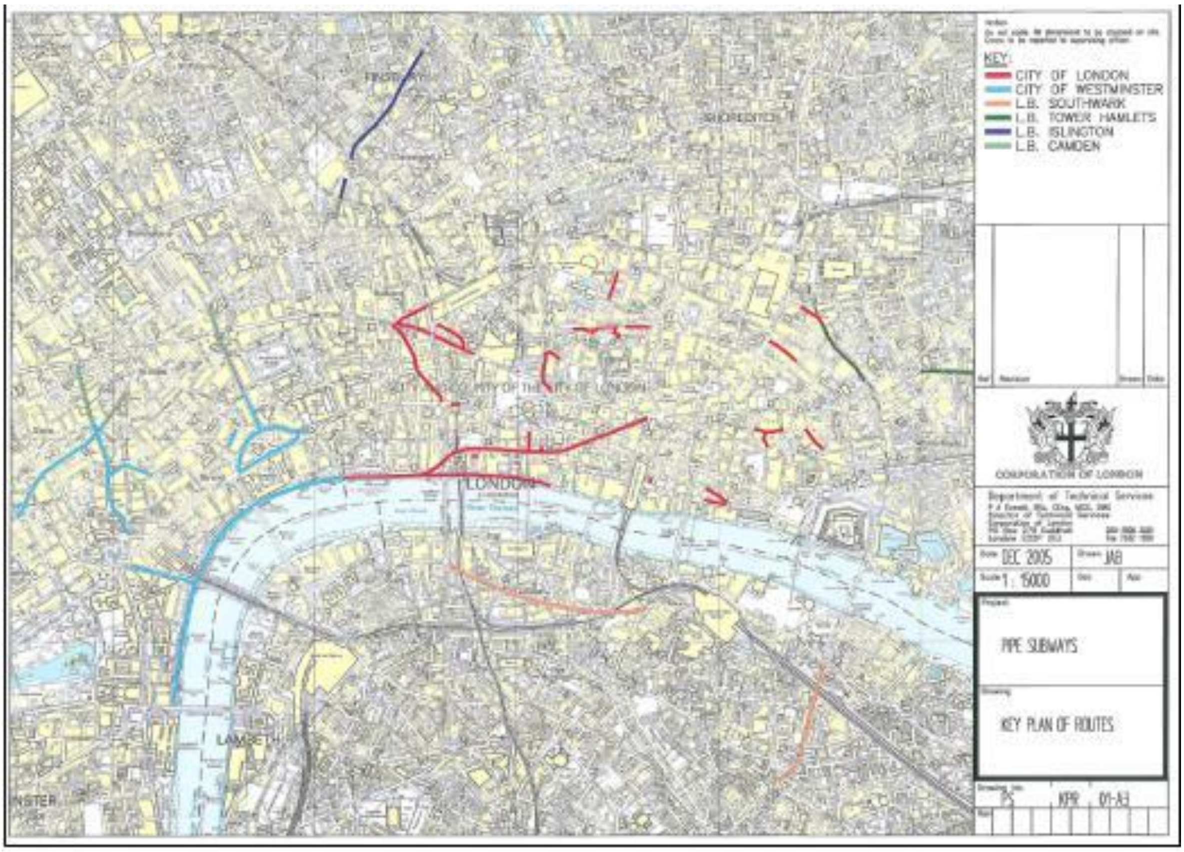
The warm, damp environment in cable tunnels is ideal for the breeding of water-borne diseases, so frequent testing of water samples is taken. Traces of Weils disease have been detected in the Millennium tunnel and Legionnaires disease in the Longford St to Backhill tunnel.

All staff that work in tunnels wear disposable masks as a matter of routine but the application of disinfectant to the tunnel systems is a frequent occurrence. Preventative works were put in place to eradicate traces of the disease by specialist staff wearing appropriate PPE.

Figure 58: Specialist contractor in air tight suit

11.3.4 Cable Pipe Subways

Figure 59: Pipe Subway system in the City & West End



In the West End there is a system of underground utility subways that run under the main streets with sub-tunnels connecting the basements of the major buildings. The tunnels are owned and maintained by:

- Westminster City Council
- London Borough of Camden
- London Borough of Tower Hamlets
- London Borough of Islington
- London Borough of Southwark
- City of London Corporation

The tunnels contain Gas, Water, Electricity and communication utility pipes and cables. The entrances and exits from these subway systems are locked via gratings in the centre islands of the roads, usually at the main junctions. Most of the tunnels are circa 2.4 m in diameter and are relatively shallow running parallel with the main roads, but in some places they descend to circa 30 metres to avoid the shallow cut London underground tube tunnels. The tunnels are equipped with lighting and natural ventilation

Figure 60: Houndsditch Subway

UK Power Networks have an extensive network of HV and LV cables in these subways and access is strictly controlled by a permit system. Confined space working procedures are applied, so any teams that UK Power Networks deploy in these tunnels need to be authorised for confined space working. The Local Authorities make an access charge for every visit we make which also covers their maintenance and repair programs.

The annual 'rental' cost for having equipment in the London Subway system is £127,212.
The cost of carrying out an annual inspection of the entire 19,685m Subway system to check on the UK Power Network Assets is £25,936

11.3.5 Tunnels under construction

There are presently 3 new tunnels under construction to provide reinforcement of EHV supplies to the City and West End. Most of these tunnels are being built to the new specification with head houses at each end to provide forced air cooling, fire alarms and other controls.

Table 36: Tunnels under construction

Tunnel Route	Length with forced ventilation	Ventilation equipment	Estimated Completion
Wellclose Square to Finsbury Market	2.6km	Tunnel Only	June 2013
New Cross to Wellclose Square	3.0km	Tunnel Only	Start of 2015
New Cross to Finsbury Market	5.6km Two Fans in Finsbury Market Shaft	Three Fans in Wellclose Square Shaft (control equipment in small surface head house) Two Fans in New Cross Shaft (Control equipment in small surface head house)	End of 2015
Willesden to Taylor's Lane	1.3km	Two fans in Willesden Shaft (Control equipment in equipment room in shaft – SCADA and TCMS in surface control room)	Sept. 2013

These additional tunnels will increase the annual Inspection and Maintenance costs of the LPN tunnel network by circa £375,000.

12 Appendices

A.1 TFL City of London Highway Activity maps

Figure 61: Highway Activity typical weekday

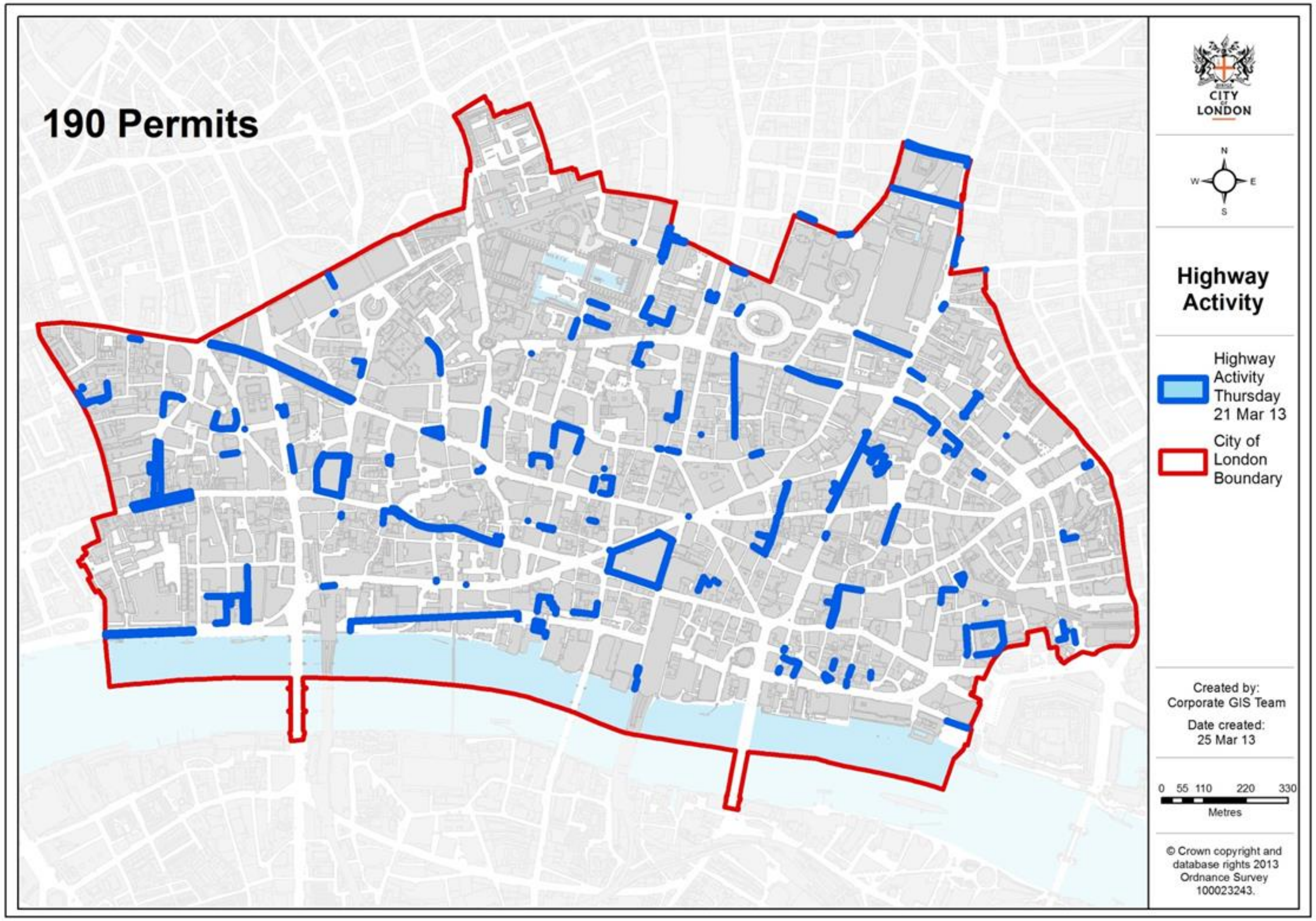
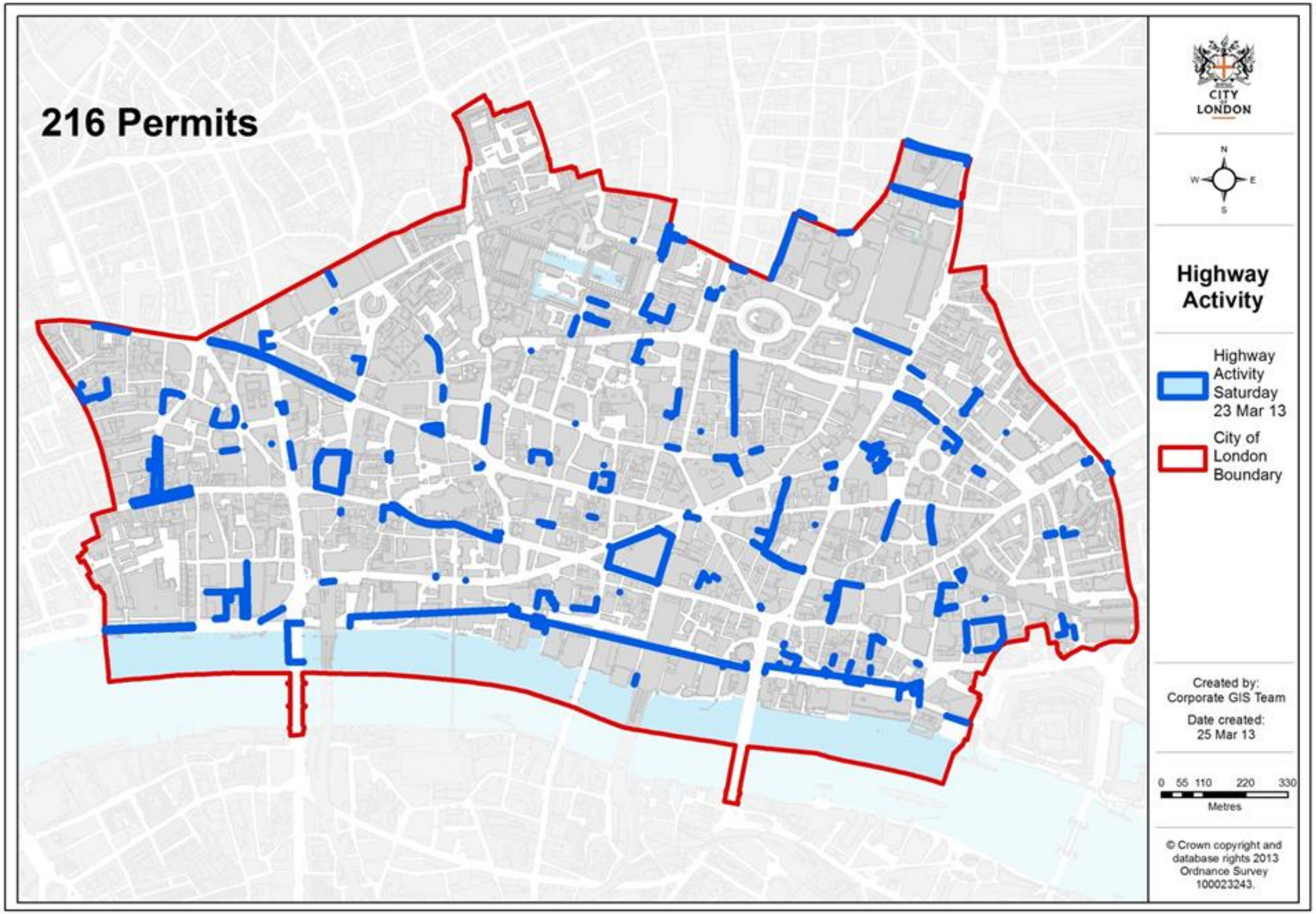


Figure 62: Highway Activity Typical weekend



A.2 Parking meter suspension charges and notice periods

AUTHORITY	COST	ADMIN FEE	NOTICE REQUIRED
Barking & Dagenham	£12.50 per bay per day	£50	
Barnet	£60 per bay per day	None	6 Working Days
Bexley	£15 per bay per day		4 Working Days
Brent	£25 per bay per day	£95	8 Working Days
Bromley	£25 per bay per week		6 Calendar Days
Camden	£34.59 per bay per day	£55	18 Calendar Days (£200 late notice fee)
City of London	£120 £22 £12 or £10 per bay per day		6 Working Days
Croydon	£35 per bay per day in Central CPZ other bays £24 bay per day	£30	6 Working Days
Ealing	£30 for the 1st residential bay on 1st day then £10 per bay per day	None	8 Working Days
Greenwich	£55 per bay on 1st day & £20 per bay per day for P&D bays or £5 per day for all other types		8 Working day for Permit & Shared bays 3 Working days for other types
Hackney	(Band 1) £14 per bay per day for up to 3 days and £21 on 4th day onwards (Band 2) £13 per bay per day	<4 days: £130 4+ days: £195	8 Working Days
Hammersmith & Fulham	£35 per bay per day	£35	15 Calendar Days
Haringey	£12 per bay per day	£50	9 Calendar Days
Hounslow	1 x Bay £45 & £15 for additional bays for 1st day, subsequent days will be £15 per bay per day	None	11 Working Days
Islington	£160 for 1st day the £25 per bay per day		16 Calendar Days
Kensington & Chelsea	£44 per bay per day up to 5 days. 5 days + £66 per bay per day		6 Working Days
Lambeth	£40 per bay per day	£60	11 Working Days
Lewisham	£30 for P&D Bays – No charge for resident bays	£50	6 Calendar Days
Merton	£42 per bay per week		5 Working Days
Newham	£21 £20 or £16 per bay per day depending on area	£25	10 Working Days
Redbridge	£20 per bay per day	Cheque Payment	8 Working Days
Richmond upon Thames	£30 £19 £8 per day depending on Road category	£90	7 Working Days
Southwark	£25 per bay per day		7Calendar Days
TFL	Red Route Dispensations £48 for 1st day and £24 subsequent days – Bay Suspensions on Red Routes £35 per bay per day		12 Working Days

AUTHORITY	COST	ADMIN FEE	NOTICE REQUIRED
Tower Hamlets	Zone A & C £75 for 1st day and £25 per additional bay per day Zone B & D £65 for 1st day and £15 per additional bay per day		5 Working Days
Waltham Forest	£50 per bay for 1st day the £10 per bay per day thereafter	£50	28 Calendar Days
Wandsworth	£26 per bay on 1st day and subsequent bays £21 per bay		5 Working Days
Westminster	£41 per bay per week NJUG		10 Working Days

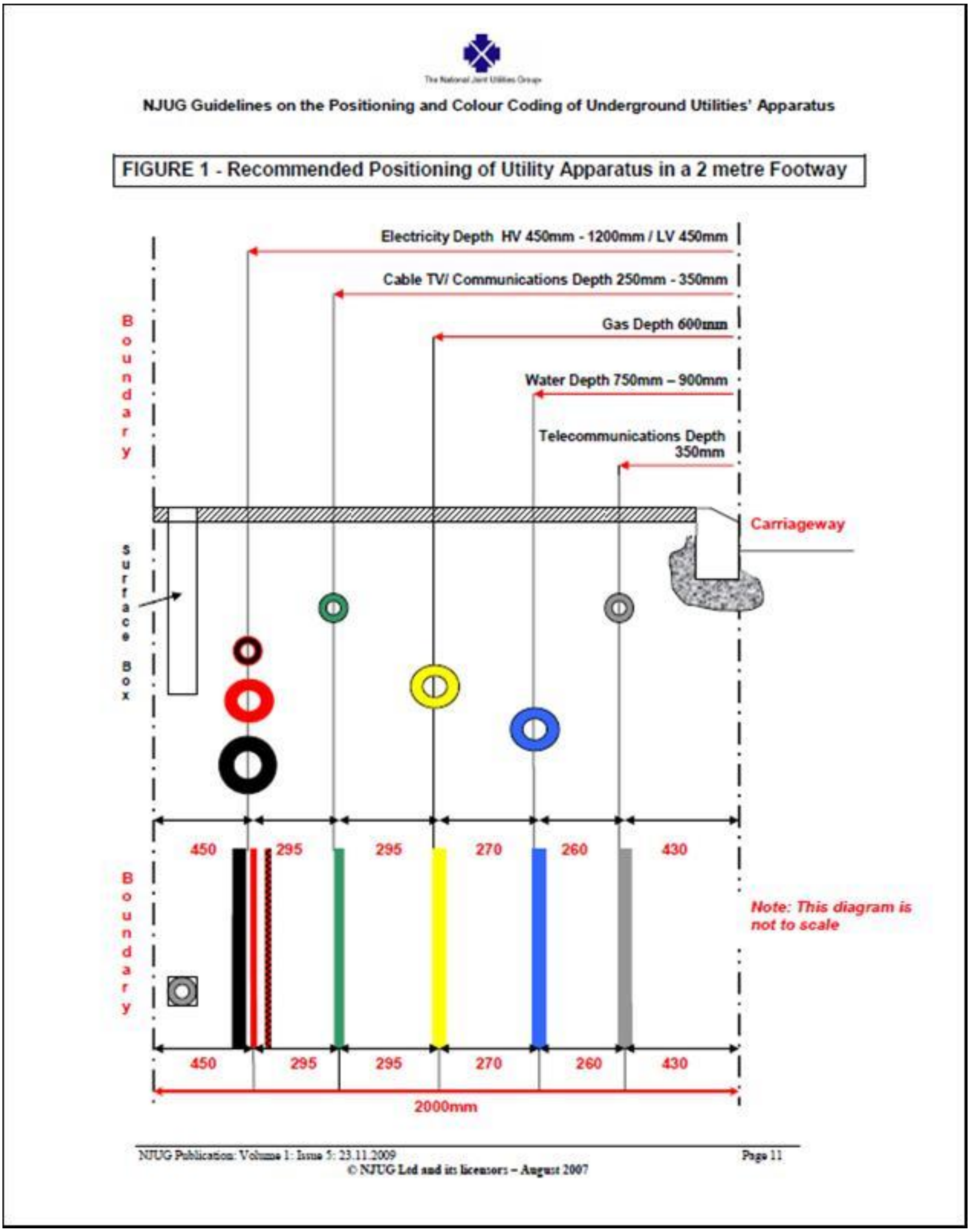
A.3 Penalty Charge notices in LPN

	Average cost / fine:	£65

Borough	PCNs Received #	Value of PCN's £
Camden	854	55,510
Kensington & Chelsea	486	31,590
Islington	416	27,040
Southwark	385	25,025
Westminster	287	18,655
Lambeth	279	18,135
City of London	250	16,250
Wandsworth	179	11,635
Transport for London	175	11,375
Tower Hamlets	122	7,930
Newham	116	7,540
Hammersmith & Fulham	108	7,020
Hackney	96	6,240
Waltham Forest	77	5,005
Merton	37	2,405
Redbridge	32	2,080
Brent	31	2,015
Lewisham	25	1,625
Bexley	18	1,170
Bromley	15	975
Kingston	11	715
Other	0	0
Total	3999	259,935

Savings achieved by PCN Appeals Ltd:	44%	114,371
Amount owing by UK Power Networks after successful appeals:		145,564
Savings payable to PCN Appeals Ltd as fees:	50%	57,186
Overall cost to UKPN (£/annum):		202,749

A.4 NJUG Footpath Utility layout



A.5 Network preparation matrix for Major Public Events

UK Power Networks: Network preparation matrix for Major Public Events — To be read in conjunction with Major Public Events procedure NDP 00004

Note: The matrix below has been prepared to compare future Major Public Events against the network preparations that were made for the Olympics — Updated: 22nd March 13 — Date:

	Local Event →				Global coverage	COMPARISON
Media Coverage:	Local or very specific coverage (e.g. industry magazine)	Regional/Sector specific coverage for < 1 month. Possible recordings broadcast	Regional long term negative publicity (> 1 month) or national short term negative publicity (< 1 month)	National Press coverage for > 6 months. International media interest (<6 months). National / international broadcasting	National & international press coverage for > 6 months in advance. Global broadcasting	
Priority Level:	5	4	3	2	1	1
Indication of No. of events/year (excl. Olympic events for 2012)	EPN: 34, SPN: 51, LPN: 378	EPN: 21, SPN: 6, LPN: 74	EPN: 7, SPN: 3, LPN: 66	EPN: 0, SPN: 0, LPN: 11	EPN: 0, SPN: 1, LPN: 2	LPN: 27
Senior Managerial Involvement	Area Manager	Area Manager	Regional Manager	Director	CEO + Director	CEO + Director
Area Event Project Manager involved	No	No	No	Yes	Yes	Yes
Typical Events:	"Minor" Royal Family Visit Oxford & Cambridge Boat Race Lord Mayors parade London Marathon	Queen & DoE visits Cup Final / Wimbledon Tennis Party political conferences Rugby International	Remembrance Day Parade, Opening of Parliament Budget Day Utility Awards	World Cup in UKPN area G8 "type" Conference	Royal Wedding / Funeral / Jubilee / Coronation etc	London 2012 Olympics
Network Activity						
Common Activities to all voltages						
Restrict planned shutdowns to ensure reception of TV coverage	No	No	No	No	Yes	Yes
Clear up outstanding faults on "Event Network"	Yes	Yes	Yes	Yes	Yes	Yes
Liaison with Event organisers/Local Authorities/Police etc	Yes	Yes	Yes	Yes	Yes	Yes
Daily Conference calls with Senior Management	No	No	No	Yes	Yes	Yes
Determine & Document "Event network"	No	Yes	Yes	Yes	Yes	Yes
Engineers on duty at or nearby events for all or part of the event(s)	No	No	No	Yes	Yes	Yes
Restrict access to ENMAC Control system	No	No	No	No	Yes	Yes
Lockdown of some or all of the BAU IT Systems	No	No	No	No	Yes	Yes
Lockdown of HV & EHV "Event networks"	No	No	No	Yes	Yes	Yes
Open excavations closed in the vicinity of congested areas/key routes	Yes	Yes	Yes	Yes	Yes	Yes
Security checking of UKPN Personnel & Contractors accessing event(s)	No	No	No	Yes	Yes	Yes
Security Sweeps of associated S/Ss & Primaries	No	No	No	Yes	Yes	Yes
Strategic Spares available on site or readily available	No	No	No	Yes	Yes	Yes
LV						
Emergency generation to be on site or readily available for LV customers	No	Yes	Yes	Yes	Yes	Yes
Link Box inspection along event congested routes	No	No	Yes	Yes	Yes	Yes
Load Monitoring of event supplies for critical LV customers	No	Yes	Yes	Yes	Yes	Yes
Network Sweeps for blown fuses etc in associated interconnected area(s)	No	No	Yes	Yes	Yes	Yes
Service cut out inspections of event venues, replace fuses if req	No	No	No	Yes	Yes	Yes
Service cut out inspections of transport interchanges near events	No	No	No	No	Yes	Yes
Touch voltage testing of PILs etc in event congested areas	No	No	No	No	Yes	Yes
HV						
Confidence switching of HV feeders supplying event(s)	No	No	No	Yes	Yes	Yes
Daily inspection of associated S/Ss	No	No	No	Yes	Yes	Yes
Fit Lock-in Security locks on local S/Ss	No	No	No	Yes	Yes	Yes
HV Normal Open Points to be moved if necessary	No	No	Yes	Yes	Yes	Yes
On line Partial Discharge mapping of associated HV circuits	No	No	No	No	Yes	Yes
Pre-event inspection of associated S/Ss	No	No	No	Yes	Yes	Yes
RTU Commissioning on associated circuits	No	No	Yes	Yes	Yes	Yes
RTU installation on critical circuits if not already in place	No	No	No	Yes	Yes	Yes
EHV						
Contingency supply restoration plans readily prepared	No	No	No	Yes	Yes	Yes
Daily visit to associated Grids and Primaries	No	No	No	Yes	Yes	Yes
Determine if necessary to change run. arrangements at key Primary(s)	No	No	No	No	Yes	Yes
Manned selected Grids and Primaries for key periods for any C(?) threats	No	No	No	No	Yes	Yes
Pilot cable testing for associated circuits	No	No	No	No	No	Yes
Primary protection testing of associated circuits	No	No	No	No	No	Yes
Protection setting re-calculation of associated circuits	No	No	No	No	No	Yes
Strategic Spares available on site or readily available	Note: Apart from fuses etc. for events of <48 hours duration there is no advantage in keeping major items of spare plant and equipment on site. The event will have been completed before spares can be utilised.					
LV (Underground) Network	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	On site	On site
LV (Overhead) Network	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	Existing stocks
HV (Underground) Network	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	On site
HV (Overhead) Network	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	Existing stocks
EHV (Underground) Network	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	On site
EHV (Overhead) Network	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	Use existing available stocks	Existing stocks

A.6 Civil Works contract price differential

NAMP No.	Work Description	Volume of work in LPN	Value of work aty LPN contractor rates	Value of same work at EPN contractor rates	Cost differential
02.01.07	Service fault underground repair	2,557	£2,787,205.67	£2,222,009.25	£565,196.42
02.01.19	other plant (LV etc)	6	£10,544.34	£6,834.10	£3,710.24
02.01.21	132/33kV cable fault repairs (not oil filled)	63	£473,325.97	£316,204.59	£157,121.38
02.01.24	11kv Cable fault repair	815	£1,611,386.19	£1,606,643.42	£4,742.77
02.01.27	LV Cable fault repairs	4,991	£5,812,485.43	£7,266,818.84	-£1,454,333.41
02.01.28	Blown LV Fuses at substation	199	£99,983.21	£258,798.51	-£158,815.30
02.01.29	Flickering Supplies	30	£31,035.12	£42,231.34	-£11,196.22
02.01.39	Street Lighting Fault Replacement	3,332	£2,355,069.86	£2,256,769.50	£98,300.36
02.01.42	No Loss of Supply - Miscellaneous Faults	115	£88,445.46	£78,981.51	£9,463.95
02.01.48	High Earth Loop Impedance (HELI)	127	£143,843.38		£143,843.38
02.05.08	Cable pit maintain	1	£1,336.44		£1,336.44
02.05.10	Gas cable - cylinder change	4	£17,585.25		£17,585.25
02.06.02	Repair Oil Leak	150	£1,052,833.51		£1,052,833.51
02.06.03	Defect repair gas	24	£147,286.53		£147,286.53
02.06.09	Replace minor oil plant + sheath testing	1	£1,336.44		£1,336.44
02.08.08	Pilot Cable Repairs	49	£219,494.82		£219,494.82
02.23.02	Maintain TC Forced Ventilation	4	£7,744.16		£7,744.16
02.28.06	Cable maintenance (tele) - gas cable routine at	20	£81,041.73		£81,041.73
02.28.07	UKPN circuit faults	6	£25,496.61		£25,496.61
02.33.09	Tunnel non compliance rectification work	1	£668.22		£668.22
02.36.01	Remove redundant LV services	943	£544,438.13	£431,141.49	£113,296.64
02.50.15	Faulted cut-out replacement	47	£17,804.54	£21,149.72	-£3,345.18
02.50.17	Replace Faulted Link Box	2	£3,178.65	£2,136.26	£1,042.39
					£0.00
					£0.00
02.50.20	Capital Replacement & Refurbishment of FFC J	26	£208,991.78	£0.00	£208,991.78
02.50.21	Capital Replacement of faulted RMU	3	£1,822.70	£2,440.02	-£617.32
02.51.01	Substation earthing reinstatement following the	1	£2,672.88	£698.63	£1,974.26
03.01.01	Cable Fault Damage	1,419	£942,438.93	£726,076.15	£216,362.78
03.02.01	st. ltg. discons / recons / knockdowns / transfe	315	£215,850.60	£138,572.11	£77,278.49
03.03.03	Connections - divert plant, mains and services (	941	£1,233,140.78	£0.00	£1,233,140.78
03.03.06	Provision for 18% of NRSWA schemes	97	£133,739.27	£0.00	£133,739.27
03.04.01	Connections - Service Alterations - Costs	1	£137.18	£288.20	-£151.02
Total		16,290	£18,272,363.78	£15,377,793.62	£2,894,570.16

A.7 Backhill to Fisher Street No. 4 Circuit.

A.8 Cable Tunnel Expenditure

	Tunnel locations	Older tunnel spec.	Newer Tunnel spec	Under Construction	Tunnel Length (m)	OPEX Defects	OPEX Inspection	OPEX Maintenance	OPEX TOTAL	CAPEX TOTAL	Total by Tunnel
1	Aberdean Place	Yes			27	£0	174.42	£12,420	£12,595	£326	£12,921
2	Bankside to Gt Guildford St		Yes		140	£0	£ 904.40	£0	£904	£0	£904
3	Barking-Thamesmead	Yes			771.4	£11,903	£4,983	£0	£16,886	£870	£17,756
4	Battersea A-Chelsea Embankment	Yes			433.8	£0	£2,913	£7,706	£10,619	£762	£11,381
5	Battersea B - Grosvenor rd	Yes			602.8	£0	£3,894	£7,706	£11,600	£1,251	£12,851
6	Battersea South-by main gate	Yes			100	£0	£646	£0	£646	£0	£646
7	City rd to Back hill to Farringdon rd (COLT)		Yes		1383	£13,328	£22,419	£13,397	£49,144	£10,023	£59,167
8	Bankside to Farringdon rd (COLT EXT)		Yes		2000	£24,356	£125,311	£215,312	£364,979	£0	£364,979
9	City Rd internal tunnel	Yes			238.5	£0	£1,540.71	£0	£1,541	£762	£2,302
10	City Rd-Beech St	Yes			1147	£0	£7,410	£12,208	£19,618	£50,187	£69,806
11	Coram St - Hunter St	Yes			118	£0	£762	£0	£762	£163	£925
12	Crayford River Tunnel	Yes			80	£0	£517	£0	£517	£0	£517
13	Deptford - Stowage	Yes			201.11	£0	£1,402	£0	£1,402	£0	£1,402
14	Deptford 22Kv	Yes			114.6	£0	740.31	£0	£740	£0	£740
15	Deptford Power Station	Yes			237.1	£0	£2,272	£0	£2,272	£925	£3,197
16	Deptford River Tunnel	Yes			579	£0	£3,740	£0	£3,740	£816	£4,556
17	Duke st - Leicester Sq - Carnaby	Yes			2398	£8,781	£15,491	£13,409	£37,681	£5,346	£43,027
18	Finsbury Market Internal	Yes			223.6	£0	£1,444	£0	£1,444	£2,285	£3,729
19	Finsbury Market to City Road			yes	?	£0	£0	£0	£0	£0	£0
20	Holloway - Islington	Yes			260	£1,989	£1,680	£0	£3,668	£326	£3,995
21	Lodge Rd 66KV	Yes			355.17	£0	£2,461	£0	£2,461	£2,067	£4,528
22	Millwall Dock	Yes			133	£0	£859	£0	£859	£16,972	£17,832
23	New Cross 66KV	Yes			136	£0	£878	£0	£878	£5,078	£5,956
24	New Cross Varcoe Rd	Yes			145	£0	£808	£0	£808	£0	£808
25	Olympia	Yes			186.7	£0	£1,206	£0	£1,206	£32,073	£33,279
26	Olympic Tunnel (LLV) W.Ham - Hackney		Yes		5520.5	£118,231	£35,662	£324,597	£478,490	£0	£478,490
27	Roding River	Yes			165	£0	£1,066	£0	£1,066	£1,361	£2,427
28	Seacoal Lane	Yes			87.4	£0	£565	£0	£565	£163	£728
29	St Johns Wood - Back Hill	Yes			5058	£0	£32,675	£0	£32,675	£31,169	£63,844
30	Wallis Rd - Cadogan Place	Yes			78	£0	£504	£8,875	£9,379	£490	£9,868
31	Welclose Sq to Finsbury Market			yes	?	£0	£0	£0	£0	£0	£0
32	West Ham - O2- Brunswick Wharf	Yes			1760	£0	£22,199	£120,626	£142,825	£23,872	£166,697
33	Willesden - Fulham	Yes			5978	£23,217	£38,618	£14,870	£76,704	£7,507	£84,212
34	Willesdon to St Johns Wood			yes	?	£0	£0	£0	£0	£0	£0
35	Wimbledon- Wandsworth- Pimlico	Yes			9440	£1,774	£0	£83,246	£85,021	£28,183	£113,203
36	All Tunnels					£13,129	£0	£0	£13,129	£0	£13,129
37	Spares					£0	£0	£0	£0	£69,977	£69,977
									£0	£0	£0
									£0	£0	£0
									£0	£0	£0
									£0	£0	£0
				Sub Totals	39,930.68	£216,707	£335,745	£834,372	£1,386,824	£292,954	£1,679,778

The above "Older Specification" tunnels have predominately natural ventilation, minimal alarms and un-sophisticated control equipment, so maintenance costs are relatively low. But will increase as more cables are installed and ventilation systems upgraded

The above "Newer" tunnels have forced ventilation, Temperature and fire sensors, security equipment and sophisticated remote control equipment, so maintenance costs are higher than the Older Tunnels

The above Tunnels under Construction will have forced ventilation, Temperature and fire sensors, security equipment and sophisticated remote control equipment, so maintenance costs will be higher than the

A.9 Contractors London Cost premium Activities

The reasons for the premium cost of utility operations in London versus the rest of Great Britain are summarised in the following table:

1.0 Difficult Work Surfaces	
1.1	Predominance of hard surfaces (roads and footpaths) difficult to dig in to, e.g. Footpath construction is often the same as roads Some footpaths are built over old roads – deeper hard dig Small proportion of unpaved/soft dig
1.2	Restaurants and pavement cafe's (can delay planned operations)
1.3	Parking of vehicles over access points e.g. on pavements, increasing number of aborted jobs
1.4	More fancy and expensive work surfaces e.g. York stone, granite paving or setts.
1.5	Pavement vaults
2.0 Restricted Vehicle Access	
2.1	High percentage of pedestrianized zones – no vehicle access
2.2	High proportion of commercial outlets, including 24 hour working, resulting in need to provide alternative access and minimal opportunity to carry out work without disruption or mitigation
2.3	Restrictions from having to provide constant access to works in narrow streets or one way systems
2.4	High percentage of parking restrictions from red routes and double yellow lines
2.5	General lack of parking impacting everyone from surveyors to gangs to post site work assessors
3.0 Planning Process	
3.1	Time consuming process (with high administration costs) to arrange for: □ parking bay & road closures □ bus stop suspensions □ traffic light removals
3.2	Limited planning time available for emergency works resulting in high number of aborts
4.0 Traffic impacts	
4.1	Accidents, traffic and gridlock more prevalent in London than elsewhere in the UK
4.2	Delay and congestion in London Streets resulting in longer travel time and higher fuel costs
5.0 Local Authority and TfL requirements	
5.1	Unique council restrictions for City of London & Westminster
5.2	London Permit Scheme for notification of road works
5.3	Congestion charging, both the direct cost of the charges and the administration of the registration scheme

5.4	Lane rental system with charges of £2,500 or £800 per day on TfL controlled roads
5.5	Fixed penalty notices and the HA appearing to use as a source of income
5.6	Section 74 fines, particularly coupled with HA challenge on duration of road works, giving increased risk of over-run fines
5.7	Suspension of parking and resident bays to facilitate works
5.8	– Section 62 notices and contraints on noise / trafic etc.
5.9	Low emission zone requirements for commercial vehicles
5.1	Specific requirements for construction vehicles on London projects / Authorities (e.g. cycle friendly)
5.11	Requirement for more robust separation of pedestrians, to deal with heavy pedestrian flows
6.0 Public and End Customer base	
6.1	Difficulty in planning and scheduling work due to demanding and “expert” customer base
6.2	Complaints culture - higher expectations and more aggressive
6.3	Heavy „load“ on utility networks and consequential costs associated with outage
6.4	Difficult to contact customer base - high percentage of flats
7.0 Seat of Parliament & foreign embassies	
7.1	Government property – restricted access, high security, lack of detail
7.2	MOD property – restricted access, high security, lack of detail
7.3	Parades, riots, marches & demonstrations
7.4	Access to Diplomatic property
8.0 Seat of Monarchy	
8.1	Royal property, parks etc. all with special requirements and high security needs
8.2	Public days, events and road closures
8.3	Royal restrictions and official visits
8.4	Special Branch & Scotland Yard restrictions
9.0 Staffing	
9.1	High churn on staff & operatives especially in the city due to alternative employment options
9.2	Difficult working conditions e.g. hard surfaces and work into deep manholes requiring special skills
9.3	High gang churn, sickness and absenteeism
9.4	Low proportion of staff actually live in central London so increased travel times and delays on emergency attendance
9.5	General reluctance of operatives to work in the more demanding area of central London
9.6	Lack of availability of local labour and difficulties in recruiting labour for London work

9.7	Higher wage bill
10.0 Materials	
10.1	Material costs in London, higher than the rest of the country
10.2	Costs of material deliveries to inner London sites
10.3	Competition for material delivery due to other construction activities leading to delays and disruption.
10.4	Use of rapid setting materials as unable to wait until conventional materials harden
10.5	No local tips in central London requiring long and slow journeys to remove spoil from the worksite
11.0 Violence / theft / terrorism / harassment	
11.1	Harassment from public
11.2	No go areas of violence - double up teams in certain areas
11.3	Theft from sites
11.4	Bomb scares and police activity
12.0 Asset and ground conditions	
12.1	Older network of assets
12.2	Higher proportion of corrosive soils, causing pitting and structural weaknesses
12.3	London soils are more susceptible to movement (causing stress, strain or pull on pipes and joints)
12.4	Slow moving, often heavy traffic put stresses on buried pipes
12.5	London underground tunnels, cabling and ventilation shafts restrict ground available to work in
12.6	Larger assets in London requiring larger excavations to access them
12.7	Deeper assets in London requiring deeper excavations to access them
12.8	Restricted access to basement electricity sites and higher maintenance costs
13.0 Utility congestion	
13.1	Results in increased administration and aborted works
13.2	Higher incidence of third party damage due to the higher density of services and other assets
13.3	More care needed in excavation resulting in a higher proportion of hand dig
13.4	Frequent use of concrete as backfill material on previous work, resulting in difficulty excavating
13.5	Limited accurate knowledge of what else is in the ground
13.6	More contractors working in the fixed area.
14.0 Other	
14.1	Effect of large projects, demand for resources. (Olympics, Crossrail, Tideway, HS2 etc.)
14.2	Tourism

14.3	Limited site storage space - need for additional deliveries and service requirements
14.4	Tree preservation orders requiring revised on site planning
14.5	Higher premises costs
14.6	Higher insurance costs
14.7	More costs associated with security access clearance for individuals
14.8	Higher cost of office and depot accommodation

A.10 Damage Cable Analysis

	LPN			EPN			SPN		
	Incidents: Damage Repairs	Incidents: Asset Replacements	TOTAL	EPN Damage Repairs	Incidents: Asset Replacements	TOTAL	SPN Damage Repairs	Incidents: Asset Replacements	TOTAL
Damage Incidents	2012	2012	2012	2012	2012	2012	2012	2012	2012
LV Services Damages (excluding cut out incidents)									
Overhead Asset Repair	**-**	**-**	**-**	**1,592**	**19**	**1,611**	**935**	**10**	**945**
LV Services Damages (excluding cut out incidents)									
Underground Asset Repair	**2,126**	**1**	**2,127**	**4,182**	**5**	**4,187**	**2,560**	**41**	**2,601**
LV Network Damages									
UG Cables (Non CONSAC) - Asset Repair	2,480	79	2,559	3,715	26	3,741	1,891	108	1,999
UG Cables (CONSAC) - Asset Repair	14	-	14	22	-	22	2	-	2
OH Lines - Asset Repair	-	-	-	1,377	1	1,378	763	7	770
All Other Switchgear, Plant & Equipment - Asset Repair	237	4	241	183	157	340	48	296	344
	2,731	**83**	**2,814**	**5,297**	**184**	**5,481**	**2,704**	**411**	**3,115**
HV Network (11 kV & 20 kV) Damages									
UG Cables - Asset Repair	313	26	339	784	8	792	673	42	715
OH Lines - Asset Repair	-	-	-	1,079	4	1,083	657	6	663
Pole Mounted Switchgear Circuit Breakers - Asset Repair	-	-	-	10	-	10	-	-	-
Pole Mounted Switchgear (All Types ex CB) Asset Repair	-	-	-	133	1	134	3	-	3
Pole Mounted Transformers - Asset Repair	-	-	-	174	-	174	74	-	74
All Other Plant and Equipment (inc GM transformers) - Asset Repair	231	1	232	985	11	996	865	98	963
	544	**27**	**571**	**3,165**	**24**	**3,189**	**2,272**	**146**	**2,418**
EHV Network (22 kV, 33 kV & 66 kV) Damages									
UG Cables (Pressure Assisted) - Asset Repair	6	-	6	6	-	6	-	-	-
UG Cables (Non Pressure Assisted) - Asset Repair	7	-	7	62	-	62	20	-	20
OH Lines - Asset Repair	-	-	-	36	-	36	22	1	23
All Other Plant and Equipment - Asset Repair	15	-	15	82	-	82	78	-	78
	28	**-**	**28**	**186**	**-**	**186**	**120**	**1**	**121**
132 kV Network Damages									
UG Cables (Pressure Assisted) - Asset Repair	1	-	1	2	-	2	-	-	-
UG Cables (Non Pressure Assisted) - Asset Repair	1	-	1	6	-	6	2	-	2
OH Lines - Asset Repair	-	-	-	7	-	7	7	-	7
All Other Plant and Equipment - Asset Repair	21	-	21	30	-	30	19	-	19
	23	**-**	**23**	**45**	**-**	**45**	**28**	**-**	**28**
	5,452.0	**111.0**	**5,563.0**	**12,875.0**	**213.0**	**13,088.0**	**7,683.7**	**599.3**	**8,283.0**

A.11 Pool Reinsurance Co. Ltd: Zones (part 1)

3.11 Definition of Zones

Zone A:

Central London

E1 E14	EC1 EC2	EC3 EC4	SE1	W1	WC1 WC2	SW1

Zone B:

(i) Inner London

BR1	HA9	NW1	SE3	SM4	TW8
BR3	IG1	NW2	SE4		TW9
	KT1	NW3	SE5	SW2	TW10
CRO	KT2	NW4	SE6	SW3	
CR4	KT3	NW5	SE7	SW4	W2
CR7		NW6	SE8	SW5	W3
CR9	N1	NW8	SE9	SW6	W4
	N2	NW9	SE10	SW7	W5
E2	N4	NW10	SE11	SW8	W6
E3	N5	NW11	SE12	SW9	W8
E5	N6		SE13	SW10	W9
E6	N7		SE14	SW11	W10
E7	N8		SE15	SW12	W11
E8	N10		SE16	SW13	W12
E9	N12		SE17	SW14	W14
E10	N14		SE19	SW15	
E11	N15		SE20	SW16	
E12	N16		SE21	SW17	
E13	N17		SE22	SW18	
E15	N18		SE23	SW19	
E16	N19		SE24	SW20	
E17	N22		SE25		
			SE26		
			SE27		

(ii) The Channel Tunnel

(iii) Central Business Districts

Aberdeen	AB1, AB2, AB9, AB10, AB11, AB12, AB13, AB14, AB15, AB16, AB21, AB22, AB23, AB24, AB25
Birmingham	B1 to B5
Bradford	BD1, BD2
Bristol	BS1, BS2, BS99

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A.12 Pool Re-Insurance Co. Ltd: Zones (part 2)

Cardiff	CF1, CF10, CF11, CF24
Crawley	RH10
Dundee	DD1
Edinburgh	EH1, EH2
Enfield	EN1
Glasgow	G1, G2
Hillingdon	UB10
Leeds	LS1, LS2, LS9
Leicester	LE1
Liverpool	L1, L2, L3, L5, L20
Manchester	M1 to M8 and M50
Milton Keynes	MK9
Newcastle upon Tyne	NE1, NE2, NE6, NE7, NE8, NE28, NE29
Nottingham	NG1
Reading	RG1
Sheffield	S1, S9
Slough	SL1
Swindon/Thamesdown	SN1

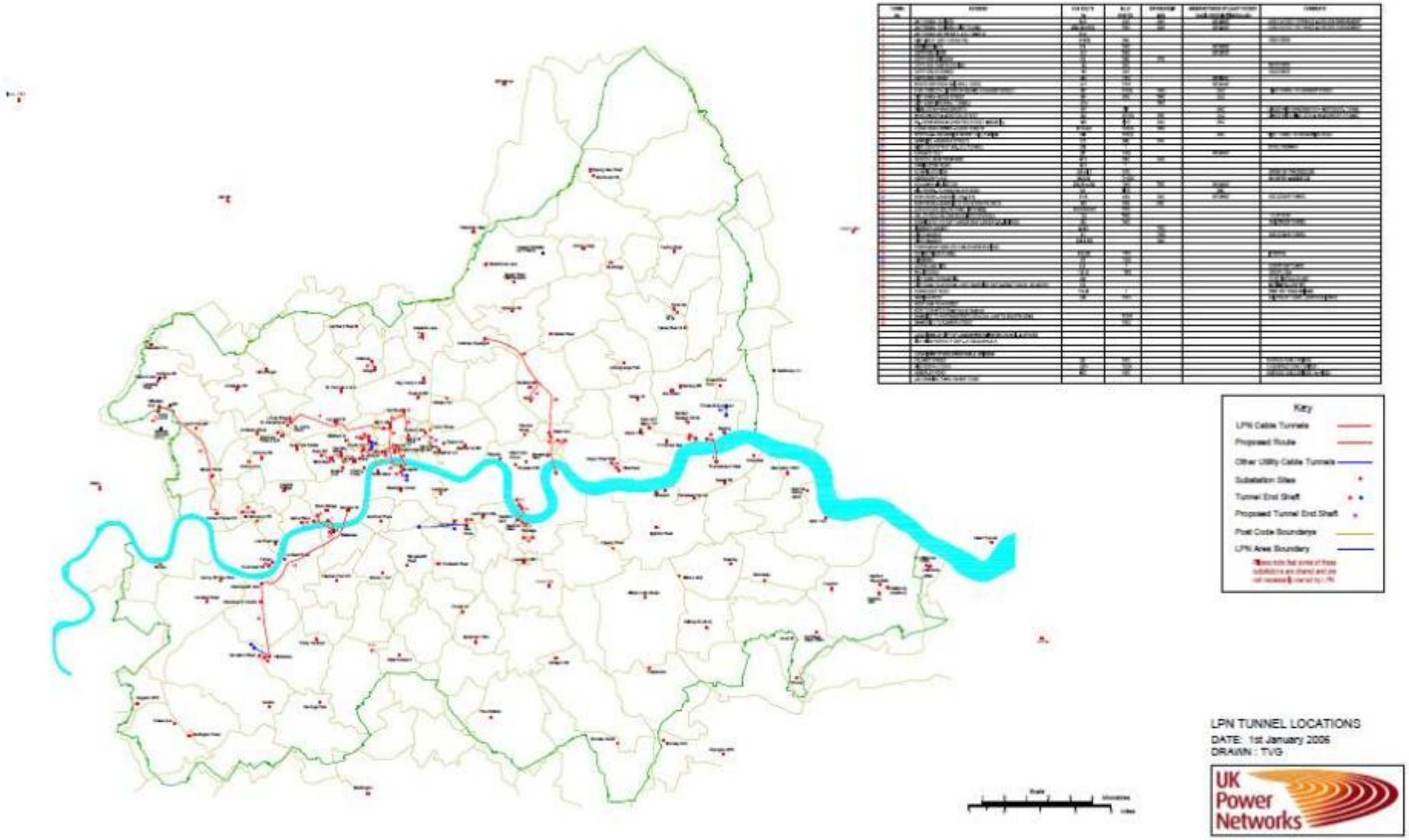
Zone C Rest of England (except Devon & Cornwall)

Zone D Rest of Great Britain

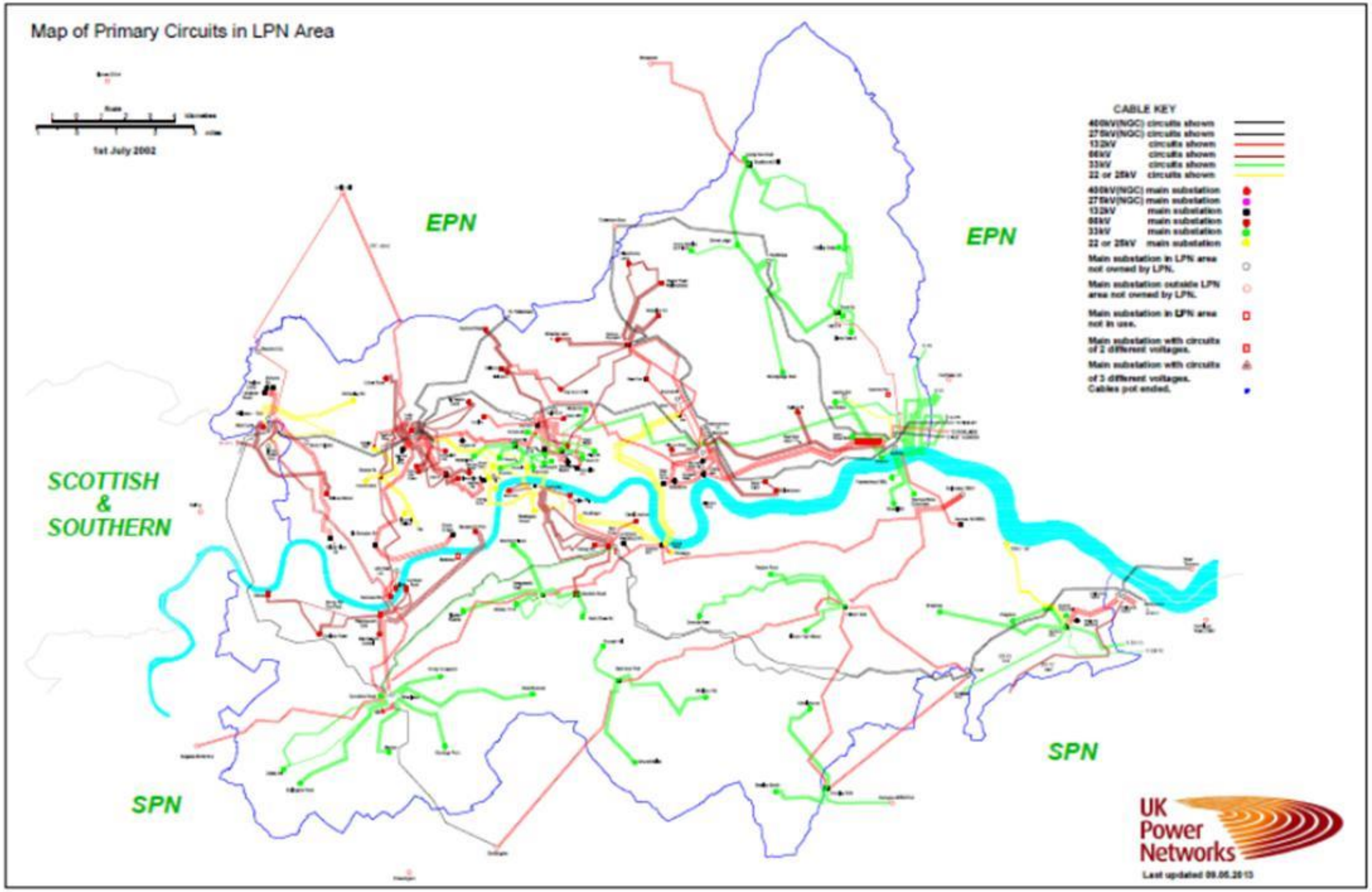
i.e. Scotland, Wales, Devon and Cornwall (except for postcodes for Aberdeen, Cardiff, Dundee, Edinburgh and Glasgow listed in Zone B above)

NB: Apart from any postcodes listed above, all Property within non geographical postcodes should be allocated to a zone in accordance with its geographical postcode location.

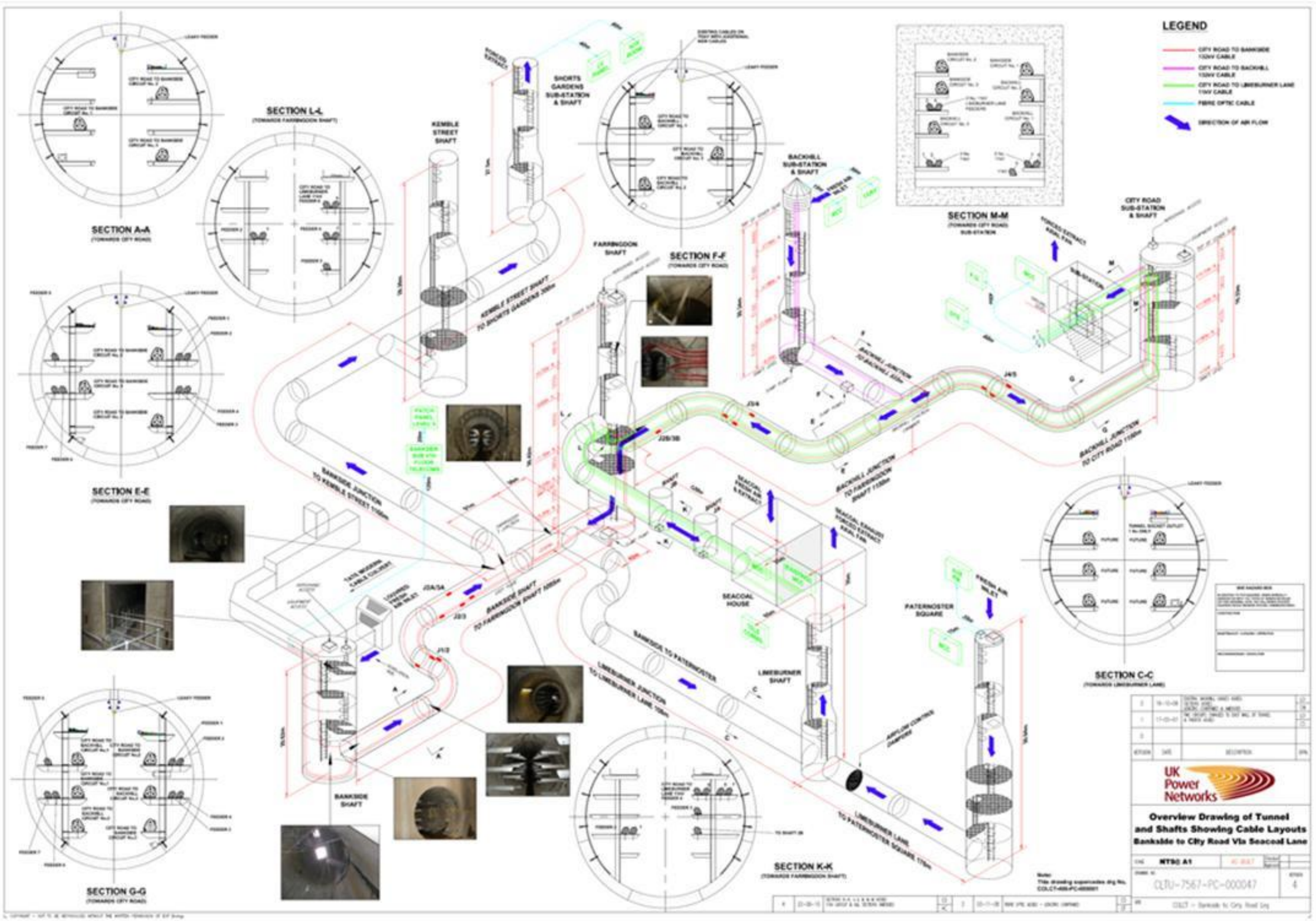
A.13 LPN Tunnel Drawing



A.14 EHV Cable drawing for LPN



A.15 City of London Tunnel Diagram



A.16 Bankside Power station Heat recovery system

Figure: 63 Cable Basement

Figure 64: Cooling towers on the roof of Bankside Substation

Figure 65: Valves and pipework for the heat recovery system

Figure 66: Heat recovery system control panel

A.17 Subways in West End & City of London

SUBWAYS COVERED BY THIS CODE OF PRACTICE

City of London	Middlesex Street Charterhouse Street St.Brides Street St.Andrews Street Shoe Lane Snow Hill Holborn Viaduct (Both North & South) St.Martin-Le-Grand London Wall Barbican Houndsditch Lloyds Avenue Fenchurch Avenue Monument Street Lower Thames Street Bush Lane Distaff Lane London Bridge (Tunnels through structure and North Chamber only) Ludgate Hill Queen Victoria Street Victoria Embankment (Part) Basinghall Avenue Peters Hill Puddle Dock Pauls Walk Brewers Hall Gardens
London Borough of Camden	Kingsway Southampton Row Rosebery Avenue Charing Cross Road Shaftesbury Avenue Kingsway Subway (part)
London Borough of Islington	Rosebery Avenue
London Borough of Southwark:	Southwark Street Tower Bridge Road
London Borough of Tower Hamlets	Commercial Road Middlesex Street
City of Westminster	Northumberland Avenue Victoria Embankment Garrick Street Tavistock Street Strand Aldwych Aldwych/Kingsway Kingsway Charing Cross Road/ St.Martin's Place Shaftesbury Avenue/ Cambridge Circus Regent Street Marble Arch Oxford Street Cranbourne Street Piccadilly

Continued

A.18 Allocation of London Factor Costs

This appendix shows how the London Factor Costs are distributed in the UK Power Networks ED1 business plan costs. An accompanying spreadsheet is attached which aligns with Ofgem's benchmarking modelling methodology.

Two different methods are applied for allocating London Factor Costs within the business plans:

- Manual; or
- Spread

The attached spreadsheet performs the necessary calculation, in order to calculate the amount (in £) of London Factor cost applicable to each element of the business plan.

Manual method:

50%

Some costs can be clearly attributed to one or more elements of the business plan. Where this is the case, cells are highlighted in Red as shown above with a % amount indicated. For example, Substation Ventilation is equally distributed between Civil Works (Core) and Inspections & Maintenance (NOCs).

Spread method:

1

Some London Factor Costs are implicitly built into the costs of doing work and are less easy to allocate directly to elements of the business plan. A pragmatic approach is to allocate these costs to all related activities proportionally, accordingly to the amount spent in on that activity in total.

				Network Investment Costs (RAV)																															
		Separate Assessment		Connections									Core Costs															Non Core NI	Non core						
Normalisation category	Specific activity	Streetworks	Insurance	Connections	LV network - demand	HV network - demand	EHV network - demand	132kV network - demand	LV network - generation	HV network - generation	EHV network - generation	132kV network - generation	Diversions	Reinforcement	General Reinforcement (excl. LCT)	LCT Reinforcement	Fault level Reinforcement	Transmission Connection Points	ESQCR	Asset Replacement	Refurbishment	Civil Works	Operational IT & Telecoms	Legal & Safety	QoS	High Value Projects - ex ante	High Value Projects - reopener		Flooding	BT21CN	Technical losses and other environmental	High impact Low Probability (HILP)	Critical National Infrastructure	Black Start	Rising Mains and Laterals
Transport and travelling	Parking & Access																																		
Transport and travelling	Vehicle Costs																																		
Transport and travelling	Plant Delivery																																		
Operations	Substation key holding service																																		
Operations	Substation ventilation																						50%												
Operations	Substation Confined Space service																																		
Operations	Substation flooding																																		
Operations	Unclaimed Cable damage																																		
Operations	Pipe cutting														1	1	1			1		1				1									
Operations	Link box inspections																																		
Operations	Substation Trip testing																																		
Operations	Excessive HV Fault cost																																		
Operations	Substation access - additional cost of replacing Plant														1	1	1			1	1	1				1									
Operations	Extensive evening and Weekend working				1	1	1	1	1	1	1	1	1				1			1		1				1									
Operations	Railway access														1		1			1						1									
Operations	Excessive EHV Fault cost														1		1			1		1													
Operations	Underground primary substations														1	1	1			1		1													
Central London	CL fault response																																		
Central London	CL enhanced I&M																																		
Central London	CL Indirect Support																																		
Central London	CL network investment																			1			1												
Resources	Labour and contractors														1	1	1			1		1	1												
Security	Major events and Unplanned de-mobilisations														1	1	1			1		1		1		1									
Tunnels	Tunnels																					1													
Separate Assessment																																			
Transport and travelling	Congestion Charging	100%																																	
Excavations	All	100%																																	
Property	All		100%																																

				Network Operating Costs (RAV)															Closely associated Indirects (RAV)											Smart Meters		
		Separate Assessment		Network Operating Costs															Closely associated Indirects											Smart Meters	iness Supp	Non Op Capex
Normalisation category	Specific activity	Streetworks	Insurance	Trouble Call (CV15a)	TC LV/HV overhead faults	LV underground faults	HV underground faults	EHV/132kV	LV Plant & Equipment	HV Plant & Equipment	Pressure assisted cables	Submarine cables	LV & HV Switching	ONIs (CV15b)	Severe Weather-Atypical	Inspections & Maintenance	Tree Cutting	NOC's other	TOTAL CAI	Network Design & Engineering	Project Management	Engineering Mgt & Clerical Support	System Mapping - Cartographical	Control Centre	Call Centre	Stores	Operational Training	Vehicles & Transport	Network Policy	Total Smart Meters	TOTAL BUSINESS SUPPORT	Non Op Capex
Transport and travelling	Parking & Access																											1				
Transport and travelling	Vehicle Costs																											1				
Transport and travelling	Plant Delivery																									1						
Operations	Substation key holding service					1	1	1	1	1	1			1		1						1										
Operations	Substation ventilation															50%																
Operations	Substation Confined Space service															20%											40%					40%
Operations	Substation flooding															100%																
Operations	Unclaimed Cable damage				1	1	1	1	1	1	1		1							1	1	1				1						
Operations	Pipe cutting																															
Operations	Link box inspections															1																
Operations	Substation Trip testing															1																
Operations	Excessive HV Fault cost						1			1			1			1				1	1	1				1						
Operations	Substation access - additional cost of replacing Plant				1	1	1	1	1	1	1		1			1				1	1	1				1						
Operations	Extensive evening and Weekend working				1	1	1	1	1	1	1		1			1				1	1	1		1								
Operations	Railway access						1	1	1	1	1		1			1				1	1	1										
Operations	Excessive EHV Fault cost							1					1			1				1	1	1					1					
Operations	Underground primary substations					1	1	1	1	1	1		1			1				1	1	1					1					
Central London	CL fault response					1	1		1	1			1																			
Central London	CL enhanced I&M															1																
Central London	CL Indirect Support																			1	1	1										
Central London	CL network investment																															
Resources	Labour and contractors					1	1	1	1	1	1		1	1		1				1	1	1										
Security	Major events and Unplanned de-mobilisations					1	1	1	1	1	1		1	1		1					1	1										
Tunnels	Tunnels															1				1	1	1										
Separate Assessment																																
Transport and travelling	Congestion Charging	100%																														
Excavations	All	100%																														
Property	All		100%																													