London Use case set up report

Pillar A+C

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SUMMARY SHEET

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Abstract.

This report describes the work under Pillar A of the Eliptic Project undertaken by Transport for London (TfL)t. The work will first investigate the technological, logistical and economic viability of using TfL's owned electrical network which serves the London Underground (LU) railway to power both overnight and in-service opportunity charging of electric busses operating scheduled service in the city. Should the initial feasibly study identify a suitable location a demonstration project will be undertaken to install, operate and monitor bus charging facilities powered by the LU electricity network.

This report describes the work to be undertaken on Pillar C of the Eliptic Project undertaken by Transport for London (TfL). The work will investigate the technological, logistical and economic viability of using TfL's owned electrical network which serves the London Underground (LU) railway to power both overnight and daytime charging of electric taxis, freight vehicles and the TfL support vehicle fleet all of which operate and ad hoc service throughout the city.

Key words:	Pillar A: Electric bus, opportunity charging, overnight charging, London Underground Pillar C: Keywords Electric vehicles, taxis, freight, overnight, daytime
Critical risks:	Pillar A: No suitable site identified, Insufficient spare capacity in the LU electricity network. Pillar C: Operational, legal and demand forecasting

DOCUMENT CHANGE LOG

Pillar A

Version	Date	Main area of changes	Organisation	Comments
0.1	21/10/15	First Draft	TfL	
0.2	27/10/15	Second Draft	TfL	
0.3	30/10/15	Third Draft	TfL	
0.4	5/11/15	Final Draft	TfL	
0.5	3/12/15	Review	UITP	
1	11/12/15	Revised report	TfL	

Pillar C

Version	Date	Main area of changes	Organisation	Comments
0.1	26/10/15	First draft	TfL	
0,2	27/19/15	Second Draft	TfL	
0.3	05/11/15	Final Draft	TfL	
0.4	11/02/16	Revised draft	TfL	
0.5	13/02/16	Commented draft	VDV/Berends	PreFinal version
0.6	25/02/16	Revised draft	TfL	
1	26/02/16	Final layout/revision	VDV/Berends	Final version

CONTRIBUTING PARTNERS

Company	Names	Company Info
Transport for London (TfL)	Mark Poulton, David Talbot	Public transport operator

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1. Executive Summary

Pillar A

This report describes a feasibility study designed to investigate the possibility of using the London Underground's (LU) private electricity network across the city to supply power to installations for the charging of extended range and/or fully electric buses operating scheduled services. It goes on to discuss a demonstration project designed to show successful connections to the LU network and how these connections could meet the needs of the bus operators while not adversely impacting on the safe and efficient operation of the underground rail system. It will also investigate the potential legal, contractual, planning and policy barriers to deploying such a system.

Pillar C

This report describes the rationale behind, planned activity in and intended outcomes of a use case to be undertaken by Transport for London (TfL) to investigate the possibility of using the London Underground (LU) owned private electricity network to support the rapid charging of a wide range of plug-in vehicles such as taxis, the TfL support vehicle fleet and the vehicles of other public and private sector users. This use case takes the form of a feasibility study and details of the work plan; risk management and scheduling are included.

2. Partner Contribution

TfL is leader of the London Use Case set up report. UITP has reviewed the document.

Company	Sections	Description of the partner contribution
TfL	Entire document	Leader of the document
UITP	Entire document	Review of the document
Rupprecht Consult	Entire document	Review of the document

3. Context conditions Pillar A

3.1. Economic, geographical and urban context of the Use Case

Transport for London manages London's bus (fig 1), tube system, Docklands Light Railway, over-ground railway and tram networks (fig 2). Of particular relevance to this use case this includes 11 underground railways lines covering 402km serving the 270 stations of the underground railway network using over 525 trains and approximately 700 bus routes, 79 bus stations, 78 bus depots and around 19500 bus stops served by approximately 8500 vehicles (operated by private companies).

Figure A 1[1]: Central London bus routes

[1] http://content.tfl.gov.uk/bus-route-maps/central-london-bus-map.pdf

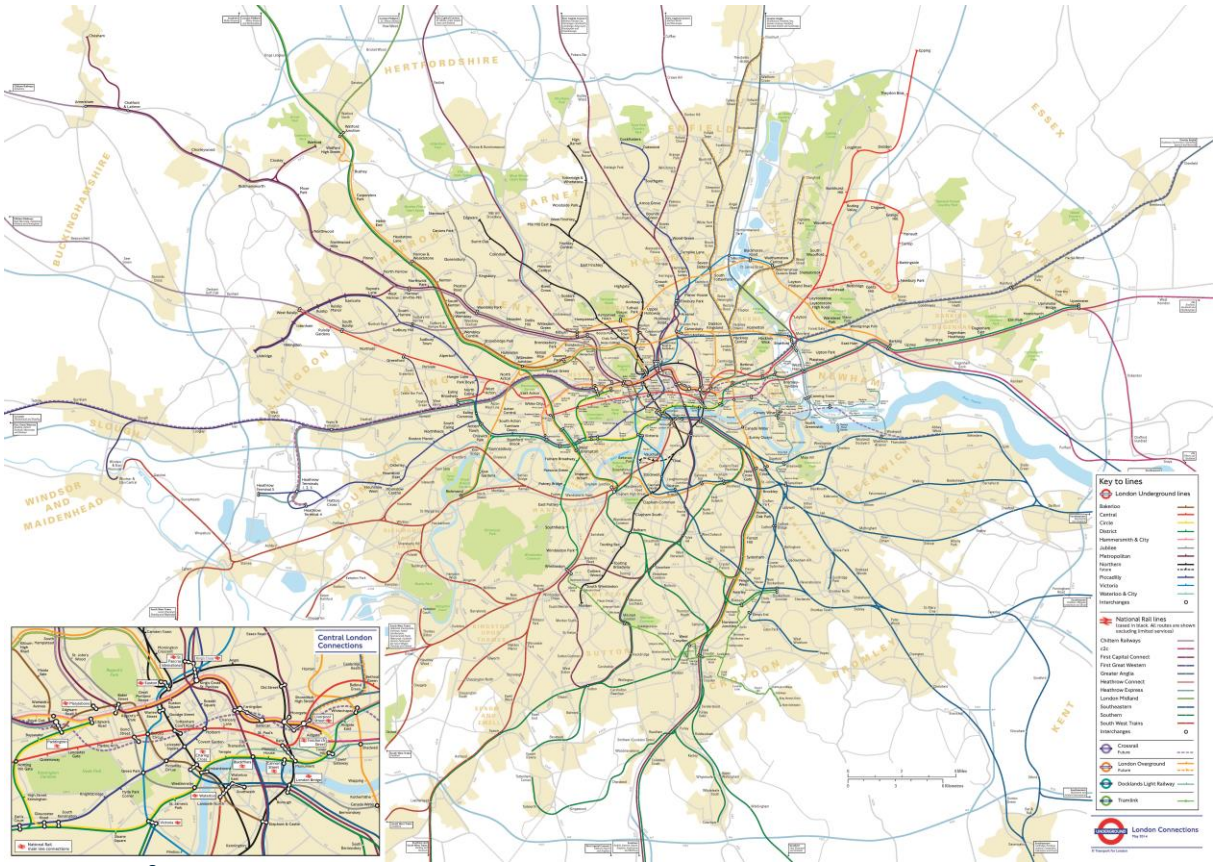


Figure A 2[2]: Underground and Overground railway lines in London

3.2. PT service context

London Underground (LU) normally runs between about 5am and midnight. Also an overnight underground services is planned which will operate on certain lines throughout Friday and Saturday nights providing a 24 hour a day service. While some bus routes only operate at certain times of day (typically 0500-0000 hours) night bus routes across the city means the network provides a 24hr a day service (fig 3). In total London buses deliver around 6.5 million passenger journeys on a typical week day throughout the city and between them all in total cover almost half a billion kilometers a year. The underground rail network carries around 3.1 million passengers on an average weekday.

[2] http://content.tfl.gov.uk/london-connections-map.pdf

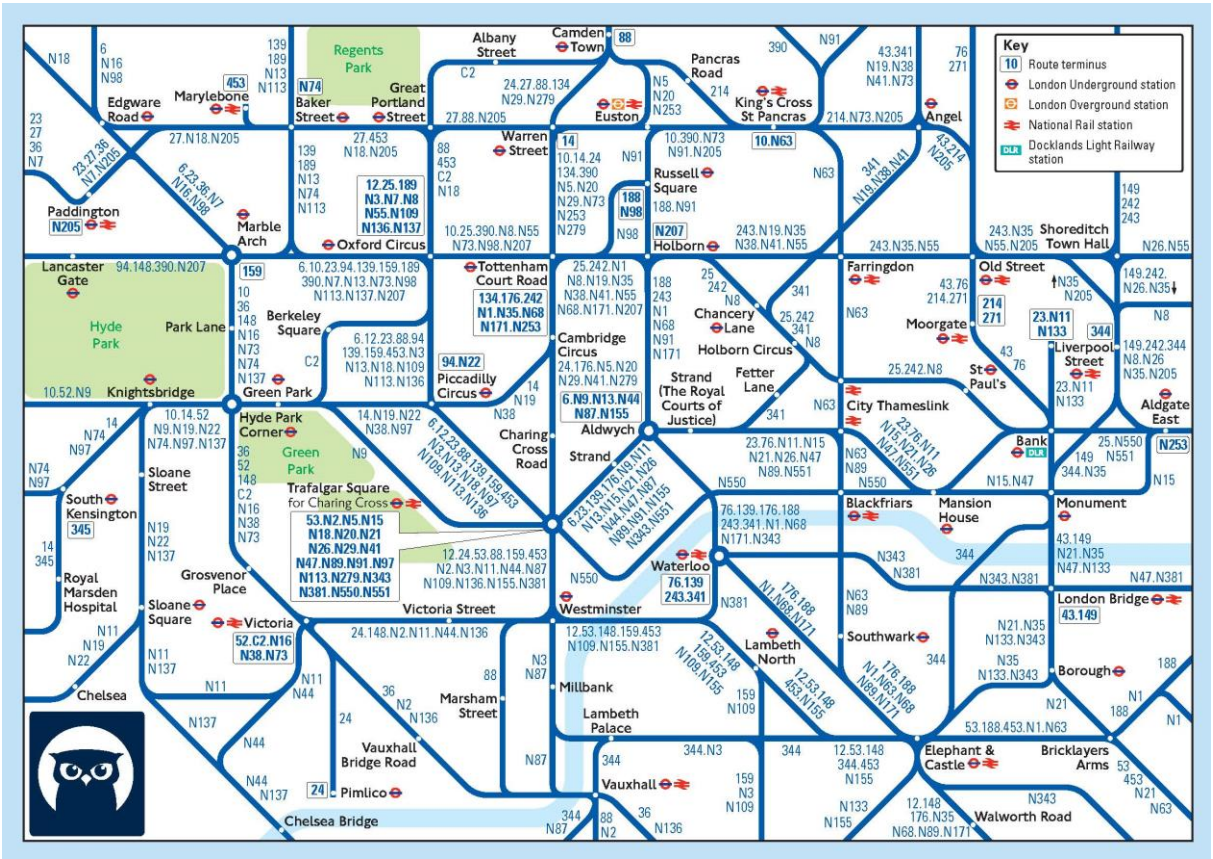


Figure A 3[3]: London night bus routes

3.3. Information about the Use Case

This use case will undertake an overarching investigation of both the London Underground electricity supply system and the London bus network to understand where suitable bus garages and other charging locations (which could include bus stations and bus stands where suitable) are in reasonable proximity to a point where a connection to the LU power network can be made. What constitutes reasonable proximity will vary from site to site depending on local geographic and infrastructure factors.

This feasibility study will include developing a detailed understanding of LU's ability to supply power, for example more available during the nightly shutdown of the majority of the underground rail network, at points close to suitable bus garages. This will then be compared to the detailed demand profile based on the routes suitable for electric plug in vehicles operated from those garages. It will also investigate the potential legal, contractual, planning and policy barriers to implementing the demonstration project and more general LU power network supported bus charging facilities.

[3] http://content.tfl.gov.uk/bus-route-maps/central-london-night-bus-map.pdf

Overnight charging, while ensuring vehicles are well charged for their first journey of the day, will not deliver sufficient power for all day operations. To address this issue the use case will also investigate the possibility of implementing opportunity charging systems at bus termini to provide top up charges through the day and how this can be supported from the LU power network. Delivering this with no adverse impact on the safe and efficient operations of London Underground will be one of the major challenges to be addressed.

Once the feasibility study has identified bus garages and routes with a suitable demand profile close to a viable connection to the LU power system the use case will move into a demonstration phase (possibly linked to the ZeEUS project). This is intended to include connection of charging infrastructure to LU power network and real time monitoring of demand from the buses operating on the chosen routes. These could be the approximately 1500 hybrid buses currently operating in London[4], a figure which is expected to rise to 1700, or 20% of the total fleet by the summer of 2016. Alternatively these could be drawn from the pure electric bus fleet. 17 such vehicles are currently operating on 4 routes across the city, a number which is growing all the time. For example 51 e-buses are planned to be operational on routes 507 (between Waterloo Station and Victoria Bus Station) and 521 between Waterloo and London Bridge stations by the summer of 2016.

[4] https://tfl.gov.uk/campaign/bus-investment

4. Objectives Pillar A

4.1. Objectives of the Use Case

The key overall objective of this use case is to understand how the TfL owned LU power network can be used to support the faster, more efficient and cheaper electrification of London buses. This will be delivered through undertaking a comprehensive feasibility study looking at both the supply of electricity from the LU power network and demand based on the vehicles operating from the chosen location and routes they serve.

Should this feasibility study identify locations where demand and available space for infrastructure provision coincides with suitable locations to connect to the LU power network the use case will move on to a demonstration project. During this second phase the practicality of connecting to the LU's power network will be confirmed and detailed analysis undertaken on demand for charging, availability of power from the LU network and the effectiveness and reliability of the installation in providing sufficient charge for normal operations of the bus routes involved.

4.2. Expected impacts

Expected impacts of the work are significant and wide ranging

- Lower costs of electrification of the London bus network
- Faster delivery of electrification across the London bus network
- Electrification possible in locations the national electricity Distribution Network could not serve
- Reduction in the environmental impacts of the bus network, for example lower CO2 and NOx & PM10 emissions.

4.3. Use Case KPIs

A 2.1, Feasibility study

- A2.1.1 Number of potentially viable sites identified (geographic and infrastructure validation, sites that meet the need of the buses and can be serviced by an LU connection.)
- A2.1.2 Number of power source choices validated and justified in terms of cost.
- A2.1.3 Mapping of the demand for bus charging infrastructure.
- A2.1.4 Possible charge capacity availability by location (combine with demand to understand the network we need to build)

- A2.1.5 Identify gaps in coverage of the feasible network and places where cover fails to meet demand.

A 2.2, Demonstration Project

- A2.2.1 Identify a location with demand, space for infrastructure and operations and sufficient accessible power supply.
- A2.2.2 Legal/planning/safety issues identified and mitigated at an early stage
- Not considered unforeseen delays in implementing the demonstration project.
- A2.2.3 Number of additional buses the demonstration system can charge and keep fully operational.
- A2.2.4 Develop a price model and means of charging users.

5. Risks Pillar A

Insufficient capacity in the London Underground electrical network to deliver the necessary amount of charging required for buses to meet their schedules

Political change, in particular the ongoing UK Government comprehensive spending review.

Unknown underground services encountered during installation of the demonstration project.

No suitable co-location of bus garages and other bus charging locations and LU power infrastructure identified

Legal, commercial and/or regulatory constraints on providing an electricity connection to (private) bus companies

6. Detailed description of the Use Case Pillar A

6.1. Description of expected use case features, establishing the link among use case conditions, objectives and background

London has one of the most complex bus systems in the world. It comprises 79 bus stations, 78 bus depots, 675 bus routes, and around 19500 bus stops. This network is served by approximately 9000 vehicles (operated by private companies) delivering around 6.5 million passenger journeys a day throughout the city. In central London buses are running 24hrs a day (fig. 3). All these services are operated by private sector business working under contract to Transport for London.

Currently around 1500 hybrid buses and 17 fully electric buses operate in service in London with more being brought into service regularly. Availability of charging infrastructure is one of the major constraints on further increases in these numbers. Presently power for electric vehicle recharging is supplied from the public electricity distribution network. In a growing city such as London this network is under intense pressure to supply ever increasing energy demands from all its users. Lead times for new connections to the electricity supply or the upgrading of existing ones can be long. In many areas of the city local electricity substations are operating close to their maximum capacity meaning upgrades to transformers are needed. These, high cost, upgrades are charged to the customer whose requirement triggered improvement work.

The use case will be comprised of two stages, first a feasibility study investigating both the LU power system and London bus network. This study will seek to identify suitable locations where suitable bus facilities are in close proximity to points where, theoretically, a connection to the LU power network could be constructed and also fully understand the capacity of the LU power network to support charging of electric vehicles anywhere in the city. For the purpose of identifying a demonstration site priority will be as far as possible given to a bus garage housing vehicles which serve the London ultra-low emissions zone (ULEZ) (Fig 4). The ULEZ is a key aspect of London's air quality improvement plans[5]. By 2020 all cars, motorcycles, vans, minibuses, buses, coaches and heavy goods vehicles (HGVs) will need to meet strict exhaust emission standards (ULEZ standards), or pay an additional daily charge, when travelling in in the zone. In practice for buses this means replacing diesel powered vehicles with ones employing some form of electrical power. This is expected to result in up to an extra 300 hydrogen fuel cell or fully electric buses

[5] https://tfl.gov.uk/modes/driving/ultra-low-emission-zone

coming into operation in central London between now and 2020[6]. This will mean ever growing demands for reliable and economical facilities both for overnight garage based and on route opportunity charging. This project will investigate alternative power supplies to charging facilities at locations where the regular electricity grid cannot meet demand.

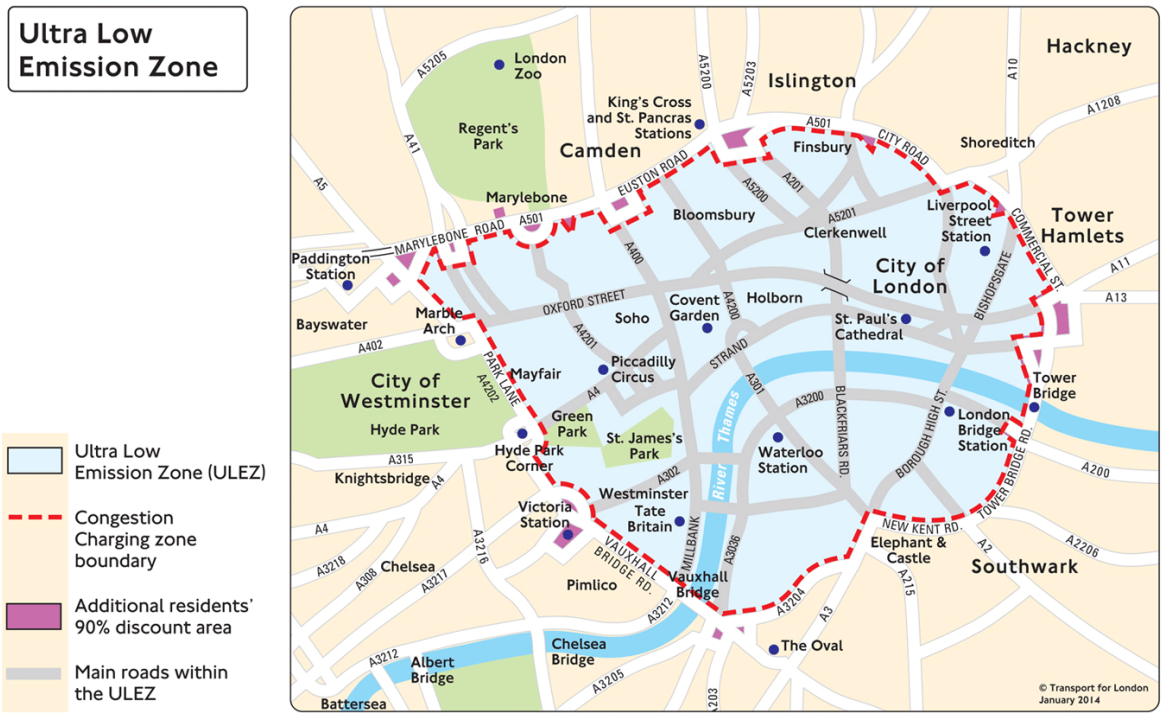


Figure A 4: London Ultra Low Emissions Zone[7]

The use case has already identified proximity of the connection to the possible charging point as a prime deciding factor in locating a demonstration project. In a highly developed urban area such as central London installing new cabling in the road is complicated, expensive, and disruptive and also carries a high risk of encountering problems such as previously unknown services delaying the excavation. GIS will be used to investigate potential cable routes between the LU power network and sites for installing charging infrastructure.

Bus garages in London have a variety of owners (TfL, other public sector organisations, and the private sector) and ownership arrangements (short term lease, long term lease, freehold). For the purposes of identifying a demonstration site and in order to simplify gaining access to garages and permission to undertake the demonstration project initial selection will focus on garages where TfL owns the freehold. If this does not yield suitable sites emphasis will shift to identifying sites in

[6] http://content.tfl.gov.uk/ulev-delivery-plan.pdf
[7] https://tfl.gov.uk/cdn/static/cms/images/ulez-map-cc-boundary.gif

public or private ownership in freehold ownership or where the current lease extends beyond the life of the ELIPTIC project.

Once a number of bus garages, suitable in terms of ownership and proximity to the LU power network have been identified, work will begin to understand the capacity of the LU power network to supply the necessary electricity. The current balance of power supply and demand at the substation or transformer room identified as the potential connection point will be modeled and monitored. The physical infrastructure at the substation or transformer room will also be investigated. At this stage any sites where the LU power network does not have at least 40kVA spare capacity at some point in the duty cycle (the minimum required to support one charging point) or where there is not an unused switch available in the substation / transformer room to make the connection will be dismissed from further consideration. This is considered the absolute minimum level of capacity and infrastructure which would possibly support a demonstration project. In practice once details of the demonstration installation are finalised this requirement may be raised.

Following on from the identification of one or two technically feasible demonstration sites the bus routes operating from these locations will be investigated. Preference will be given to sites operating single deck buses which serve routes entirely or partially within the London ultra-low emissions zone. Depending on the outcome of the site selection exercise one or two sites will be selected for a more detailed investigation of their suitability as a demonstration site. Construction and installation costs will be developed and planning applications needed considered. TfL currently plan to undertake one or two demonstrations, in the case of delivering two this would be one garage based overnight charging demonstration and one opportunity based demonstration based at a bus terminus serving a current or potential electric bus route.

Once a suitable location is identified a demonstration project will be undertaken to build and connect LU powered charging infrastructure and monitor how well the facility constructed can meet the operational needs of the bus routes it serves without adversely affecting the operation of the underground rail system. Exact specifications of the demonstration infrastructure installation will depend critically on the current and planned electric vehicle operations from the chosen location. As London bus services are provided by private sector operators a variety of both hybrid and fully electric vehicles are in operation across the city. The demonstration project will, as far as possible, be implemented technology neutral to the actual charging infrastructure connected. A supply will be established which can support whichever system is needed to charge the busses operating from the demonstration location.

6.2. Use Case constraints

Both the LU power network, which follows the routes of the LU rail network and the London bus network are existing networks and as can be seen from figures 1 and 3

are both very complex. While the power network is fixed in terms of geographic location bus routes vary over time, some are deleted, others added and others are altered as travel demand evolves. The first major constraint on the study is identifying suitable locations for installing and operating charging infrastructure within the current bus network which also coincide with accessible points to draw power from the LU power network.

Secondly the LU power network is an operational system which operates under a high level of demand which varies throughout the day and over the year. Generally the demands on the network are much lower overnight (00:00 - 05:00) compared to daytime. Any power drawn from it to provide electricity for charging buses will have taken in such a way so that it in no way degrades the safe and efficient operation of the underground rail network or has an adverse impact on power quality.

Thirdly the combination of the complex geography of the network and high proportion of double deck buses in use will pose unique challenges and constraints on delivering electric services which meet the performance of current diesel powered buses.

6.3. Use Case monitoring criteria

The use case will be monitored against the criteria listed below:

Table A 1: Planning Monitoring Criteria

no.	Planning Activity
1	Needs analysis
2	Technological parameters determination
3	Mapping/GIS
4	Modelling
5	Legal feasibility

6	Financial feasibility
7	Infrastructure performance specification
8	Procurement strategy (please describe if public tender or other)
12	Wiring/de-wiring technology design and planning
13	Charging infrastructure procurement
14	Infrastructure design and installation planning
15	Infrastructure installation
16	Infrastructure testing
17	Sub-station design and planning
19	Route selection
20	Installation of data recorder
21	Data collection according to the selected KPIs
21	Selection of evaluation process
22	Status of Delivery: Use case set up report

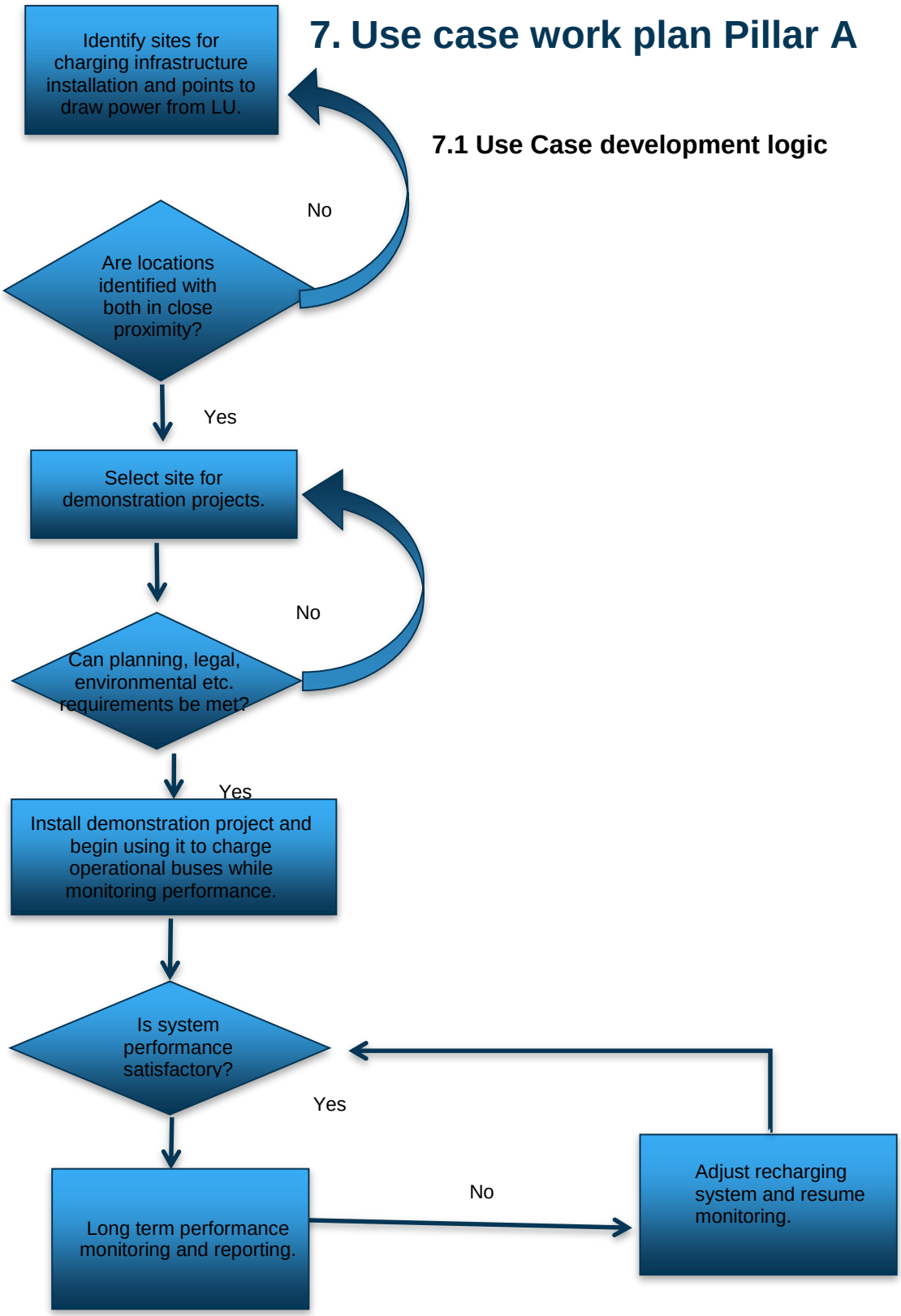
Table A 2: Delivery Monitoring Criteria

no.	Activity
1	Needs analysis
2	Technological parameters determination
3	Mapping/GIS

4	Modelling
5	Legal feasibility
6	Financial feasibility
7	Close monitoring of daily operation of vehicles
8	Close monitoring of charging infrastructure
11	Unexpected wiring/de-wiring technology operational issues, if relevant
12	Unexpected infrastructure operational issues, if relevant
13	Unexpected sub-station operational issues, if relevant
15	Unexpected other technical issues, if relevant
16	Regular operation of the data monitoring system
17	Data collection according to the selected KPIs
18	Local dissemination
19	Status of Delivery: Final use case report

7. Use case work plan Pillar A

7.1 Use Case development logic

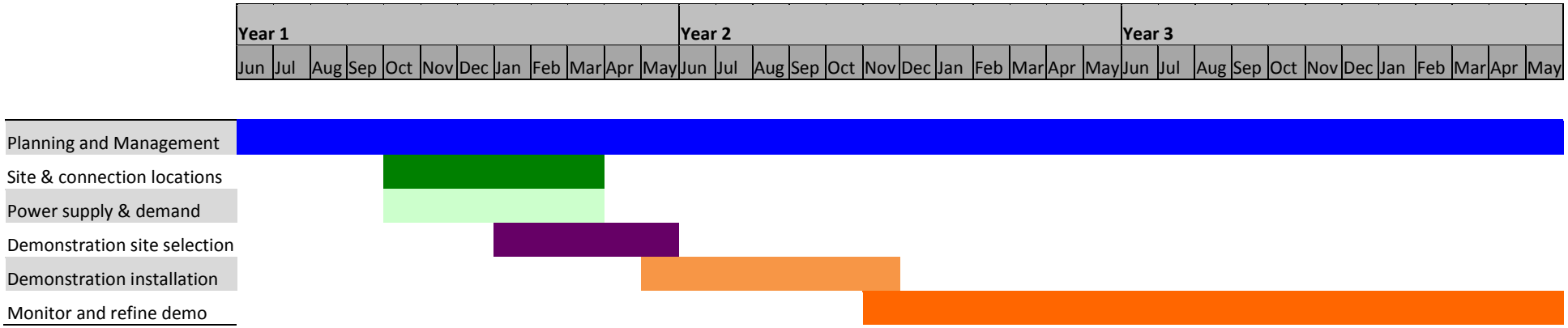


7.2 Work plan

Table A 3: Work plan

Number	Action	Total person months	Staff 1	Staff 2	Staff 3	Start-month	End-month
1	Project planning reporting and evaluation	(Staff time from WP 1)	Mark Poulton	David Talbot		1	36
2	Investigate geographic co-location of bus charging sites and LU power network access	1	Lisa Dipnarine	Will Fane-Gladwin	David Talbot	5	10
3	Investigate power supply and charging demand at co-located sites	2	Will Fane-Gladwin	Michael Scott-Robinson	Matthew Webb	5	10
4	Identify demonstration site and plan installation.	2	Lisa Dipnarine	Will Fane-Gladwin	David Talbot	8	12
5	Install demonstration project.	3	Michael Scott-Robinson	To be decided	To be decided	12	18
6	Monitoring performance of charging system and impacts on LU power network, system refinement	1	Michael Scott-Robinson	Tom Cunnington		18	36

7.3 Detailed Timeline



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 636012.

8 Expected results Pillar A

The first, feasibility study, stage of the use case will deliver a thorough understanding of the extent to which the LU power network can support the charging requirements of the London bus network. It will also give a better understanding of the charging requirements needed to be met to deliver high levels of electric bus services on a network as complex as exists in London

The second, demonstration phase, will provide proof the connections from the LU network to charging infrastructure can be made in a safe, reliable and cost effective way. Once the connections have been made it will confirm or allow correction of models of the charging infrastructure and capability needed to deliver services performing at least as efficiently and reliably as the current diesel buses do. It will also deliver an appraisal of the environmental benefits of the demonstration.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 636012.

9. Context conditions Pillar C

9.1. Economic, geographical and urban context of the Use Case

Transport for London manages London's bus, tube system, Docklands Light Railway, over-ground railway and tram networks. It is also responsible for the licensing of taxis and private hire vehicles. There are over 100,000 licenced taxi and private hire drivers in London between them delivering approximately 300,000 journeys per day. In addition to this TfL and other public sector organisations in London operate significant fleets of support vehicles of many types across the city.

As part of the implementation of the London Ultra Low Emission Zone (ULEZ, Fig 1), a key aspect of London's air quality improvement plans[8], by 2020 all cars (including taxis and private hire vehicles), motorcycles, vans, minibuses, buses, coaches and heavy goods vehicles (HGVs) operating in the zone will need to meet strict exhaust emission standards (ULEZ standards), or pay an additional daily charge, when travelling in in the zone. This is expected to drive the uptake of all forms of electric vehicles with a concomitant increase in demand for charging infrastructure.

This use case takes the form of a desk based study to understand the feasibility of using the LU power network to supply the electricity demands of charging infrastructure, particularly for locations where connections to the regular electricity grid would be prohibitively time consuming or costly. In this use case we will focus on understanding the capacity of the LU network to support the charging of public transport vehicles other than scheduled buses (for example taxis and private hire vehicles), TfL operational support vehicles and freight vehicles.

The capacity of the LU power network to support charging of scheduled buses is the subject of a separate study under pillar A. TfL plan to undertake the pillar C use case in final year of the Eliptic project to build on learning from both its own pillar A case study and possible demonstration project and other use cases undertaken in Eliptic around Europe.

[8] https://tfl.gov.uk/modes/driving/ultra-low-emission-zone

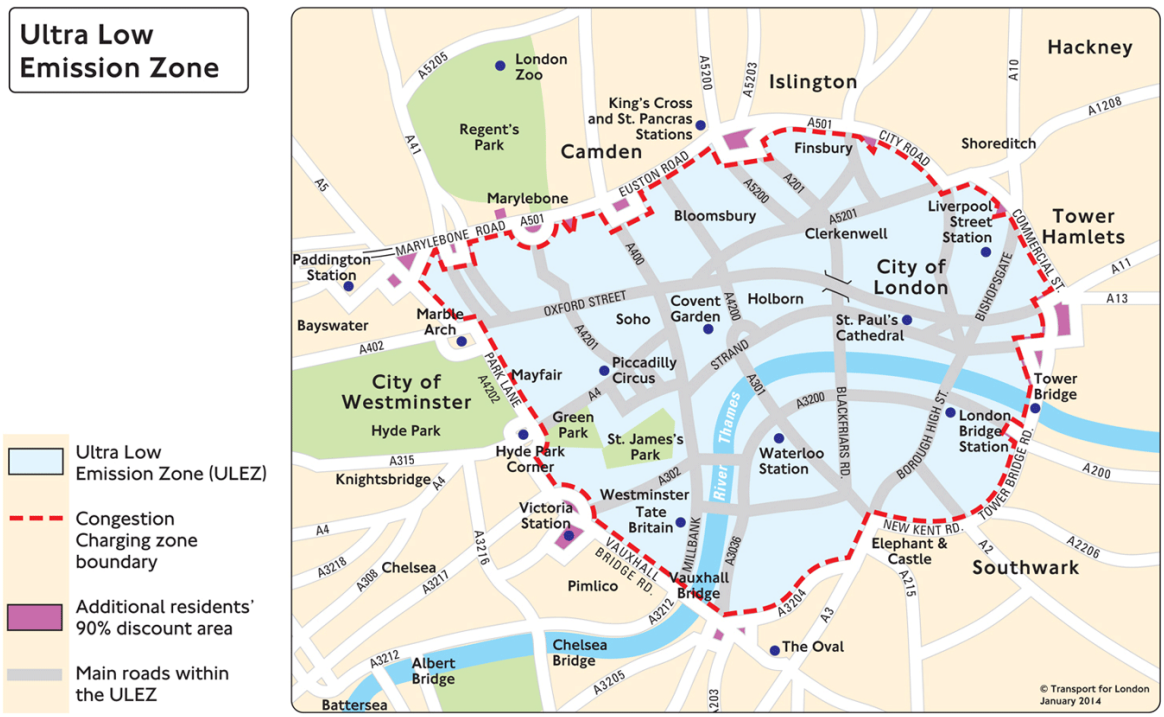


Figure C 5 - London Ultra Low Emission Zone

9.2. PT service context

London's passenger transport system is a complex mix of public and private sector service such as under and over ground rail, scheduled buses, licenced taxis, private hire vehicles and river based services. London has a very large fleet of taxis and private hire vehicles, accounting for 35% of the almost quarter of a million such vehicles in England[9]. In 2015 in London there are around 22,500 black taxis and 63,000 private hire vehicles[2], however private hire vehicle numbers are rising strongly as Uber grows in popularity.

While taxi trips only account for just over 1% of the approximately 24 million[10] passenger journeys (Fig. 2) undertaken in London on an average day, this still equates to approximately 300,000 trips a day in the city [11]. As a result around 30% of CO2 and NOx and 28% of PM10 emissions from TfL run or administered services in London are believed to come from taxis and private hire vehicles[12].

In advance of the implementation of the ULEZ from Jan 1st 2018 all new London taxis must be zero emission capable. This coupled to the 15 year age limit on of taxis operating in the city, supported by fiscal measures such as the UK Government's plug in vehicle[13] and taxi

[9] https://www.gov.uk/government/collections/taxi-statistics
[10] https://tfl.gov.uk/corporate/about-tfl/what-we-do
[11] http://content.tfl.gov.uk/travel-in-london-report-8.pdf
[12] http://content.tfl.gov.uk/tfl-health-safety-and-environment-report-2013-14.pdf
[13] https://www.gov.uk/plug-in-car-van-grants/overview

top up[14] grants, will lead to very strong growth in demand for a widespread, cost effective and efficient system of charging points throughout London. While it is expected most of this charging capacity will be supported from the publically-accessible electricity distribution network via the national grid, TfL recognise there may be locations around the city where such provision is not feasible on technical and or economic grounds. This use case will aim to deliver a detailed understanding of the capability of the LU power system to fill these gaps.

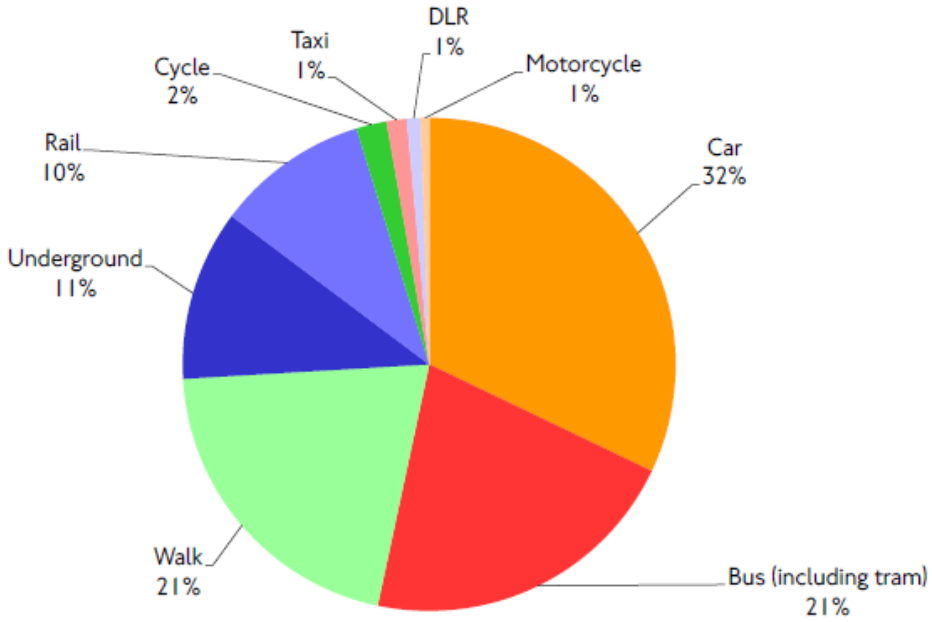


Figure C 6 - Transport Modal Share in London 20143

In addition to this growing demand from the taxi and private hire vehicles the Ultra-Low Emission Vehicle (ULEV) Delivery Plan[15] commits TfL to deploying 120 electric vehicles within its support fleet as part of the commitment to deploy 1,000 such vehicles across the whole Greater London Authority (GLA) fleet. While they are not directly involved in transporting passenger the TfL support fleet is a critical part of the London Public transport system.

9.3. Information about the Use Case

This use case takes the form of a desk based feasibility study into ways in which TfL's London Underground (LU) private electrical power network can be used to support the faster electrification of the taxi, private hire vehicle and commercial fleets operating in London by powering rapid charging hubs. It will investigate the practicalities of making connections from

14 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/382190/taxis-preliminary-guidance.pdf

15 http://content.tfl.gov.uk/ulev-delivery-plan.pdf

the LU power network to permanently located charging infrastructure and also investigate ways of delivering temporary facilities at major events and managing demand for power from the LU network through use of energy storage. It will also study the legal, policy, contractual and planning situation and issues around delivery of such a system.

10. Objectives Pillar C

10.1. Objectives of the Use Case

The overall objective of this use case is the delivery of a feasibility study into all aspects of the use of the LU power network to support the installation of fixed and transportable electric vehicle rapid recharging systems. The transportable system will allow for the provision of electric vehicle rapid charging at the major high profile but short duration events which take place in London throughout the year. Such a system will also allow for the market testing and demand evaluation of potential fixed recharging infrastructure, without rising installation of charging equipment which no one will use or of the wrong capacity for local needs. The study will also investigate the practicality of storing energy drawn from the underground network at times of low network demand during the overnight shutdown of underground services for use as required throughout the day regardless of the loading on the LU network.

Beyond the end of the project, if the use case proves the viability of one or both these approaches, it could lead to the faster installation and wider availability of charging infrastructure across London which, in turn, should drive faster and greater adoption of electric vehicles by the target user groups over the coming years.

10.2. Expected impacts

Whilst the use case is restricted to a feasibility study successful completion of its objectives and exploitation of its findings could have very significant impacts:

- Drive faster electrification of London taxi, private hire and other commercial vehicle fleets.
- Wider availability of electric vehicle rapid charging facilities.
- Electrification possible in locations the public electricity distribution network could not serve cost-effectively.
- Reduction in the environmental impacts of road transport across London, for example lower CO2, NOx and PM10 emissions.

10.3. Use Case KPIs

The KPIs to be collected for the London Use Case Pillar C are related to the KPI category ”Other parameters” only:

- C2.1 Number of viable charging site / mobile battery base locations identified and validated in terms of cost/benefit of using the LU power network.
- C2.2 Understand the use and charging profiles of the likely user base.
- C2.3 Develop a price model and means of charging users.
- C2.4 Total charge capacity identified as viable (fixed and transportable).

11. Risks Pillar C

The feasibility study identifies the following list of risks to take into account in the development of the study. In general the work under pillar C is considered low risk in that it is a fully funded study which only uses resources under the direct control of TfL

Description of risk	Proposed risk-mitigation measures
Lack of available capacity within TfL to undertake the study.	Ensure key staff are aware of the project requirements and timetables well in advance. Identify alternative expertise if necessary.
Political change, in particular the ongoing UK Government comprehensive spending review.	Monitor political developments and adapt the study accordingly if necessary.

Table C 1 - Risks and Mitigation

12. Detailed description of the Use Case Pillar C

12.1. Description of expected Use Case features, establishing the link among Use Case conditions, objectives and background

This use case takes the form of a feasibility study into the use of the LU electrical power network to support the installation of both fixed and transportable electric vehicle rapid recharging systems. It will also investigate ways of storing energy drawn from the underground network at times of low network demand for use as required throughout the day regardless of the loading on the LU network. It will aim to identify all the available points to connect charging systems to the LU power network and map how these relate to surface transport infrastructure such as taxi rest ranks and support vehicle depots.

The Ultra-Low Emission Vehicle Delivery Plan for London8 commits TfL to delivering 150 high speed charging points by the end of 2018 and 300 by the end of 2020. These will be a mix of 22kW fast charge stations and higher power rapid charge points. This feasibility study will investigate the LU power network to identify possible locations to draw power from and investigate the availability of collocated or nearby sites suitable for the installation of either/or vehicle charging facilities designed to allow rapid charging of any electric suitable vehicles other than buses and sites for charging transportable batteries which power mobile recharging solutions. As well as addressing technical factors the study will investigate the legal, contractual, planning and other policy related factor which may hinder or help the use of the LU network to recharge electric vehicles other than buses.

The study will also look at payment and cost factors needed to deliver a viable long term solution.

12.2. Use Case constraints

The LU power network is very complex and fixed in terms of geographic location. Location of potential sites to install charging infrastructure is also widely spread across the city and constrained by TfL's ownership of suitable locations.

The first major constraint on the study is identifying suitable locations for installing and operating charging infrastructure within the TfL estate which also coincide accessible points to draw power from the LU power network.

Secondly the LU power network is a system which operates under a high level of demand which varies throughout the day and over the year. Generally the demands on the network are much lower overnight (00:00 - 05:00) compared to daytime. Any power drawn from it to provide electricity for charging road vehicles will have to be taken so that it in no way degrades the safe and efficient operation of the underground rail network. Though it should be noted this constraint leads to one of the threads of the feasibility study, the investigation of the use of energy storage to harvest power from the LU network during times of low demand and make it available to electric vehicles on demand at any time of day or night.

Thirdly, any potential solutions identified by the use case must comply with a complex array of planning, policy, contractual and other legal matters if it is to a solution that can be employed in practice.

12.3. Use Case monitoring criteria

The use case will be monitored against the criteria listed in tables 1 and 2. As this use case is a desk based feasibility study the measures selected will, by and large, be an integral part of the study itself and final report on TfL's activity in the Eliptic project. Similar measures will also be used should the use case result in the installation of LU powered charging infrastructure being installed outside the Eliptic project.

No.	Activity
1	Needs analysis
2	Technological parameters determination
3	Mapping/GIS
4	Modelling
5	Legal feasibility
6	Financial feasibility
15	Data collection according to the selected KPIs
16	Selection of evaluation process
17	Status of Delivery: Use case set up report
18	Other

Table C 2 - Monitoring criteria, project planning

No.	Activity
1	Needs analysis
2	Technological parameters determination
3	Mapping/GIS
4	Modelling
5	Legal feasibility
6	Financial feasibility
14	Data collection according to the selected KPIs
15	Local dissemination
16	Status of Delivery: Final use case report
17	Other

Table C 3 - Monitoring criteria, project execution

13. Use case work plan Pillar C

13.1. Use Case development logic

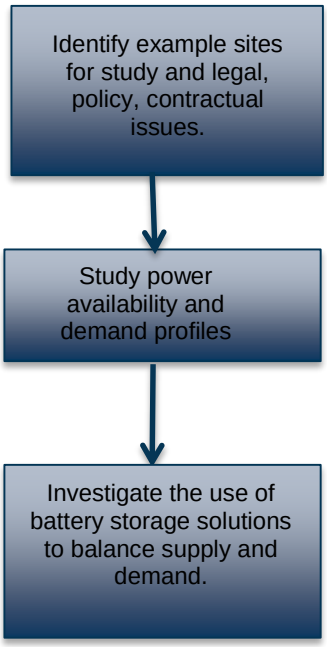


Figure C 7 - Scheme of the Use Case logical development

13.2. Work plan

The work plan showed below represents the main tasks and subtasks of the works of the London Pillar C Use Case.

No	Action	Total person months	Staff 1	Staff 2	Start-month	End-month
1	Project planning reporting and evaluation	0.25	European research coordinator	Principal technical specialist	18 (Nov16)	36 (May18)
2	Identification of example sites	0.75	Principal technical specialist	European research coordinator	24 (May17)	25 (Jun17)
3	Study legal, contractual and policy issues		Principal technical specialist	TfL Legal	24 (May17)	27 (Aug17)
4	Investigating likely demand, power availability and pricing models	1	Interface and networks engineer	Principal technical specialist	25 (Jun17)	26 (Jul17)

No	Action	Total person months	Staff 1	Staff 2	Start-month	End-month
5	Investigate battery solutions to provide temporary charging infrastructure and manage the demand made on the underground network.	1	Interface and networks engineer		25 (Jun17)	28 (Sep17)
	Total Months	3				

Table C 4 - Description of the tasks and partners involved in the work plan

13.3. Detailed timeline

A detailed timeline is shown in the following figure:

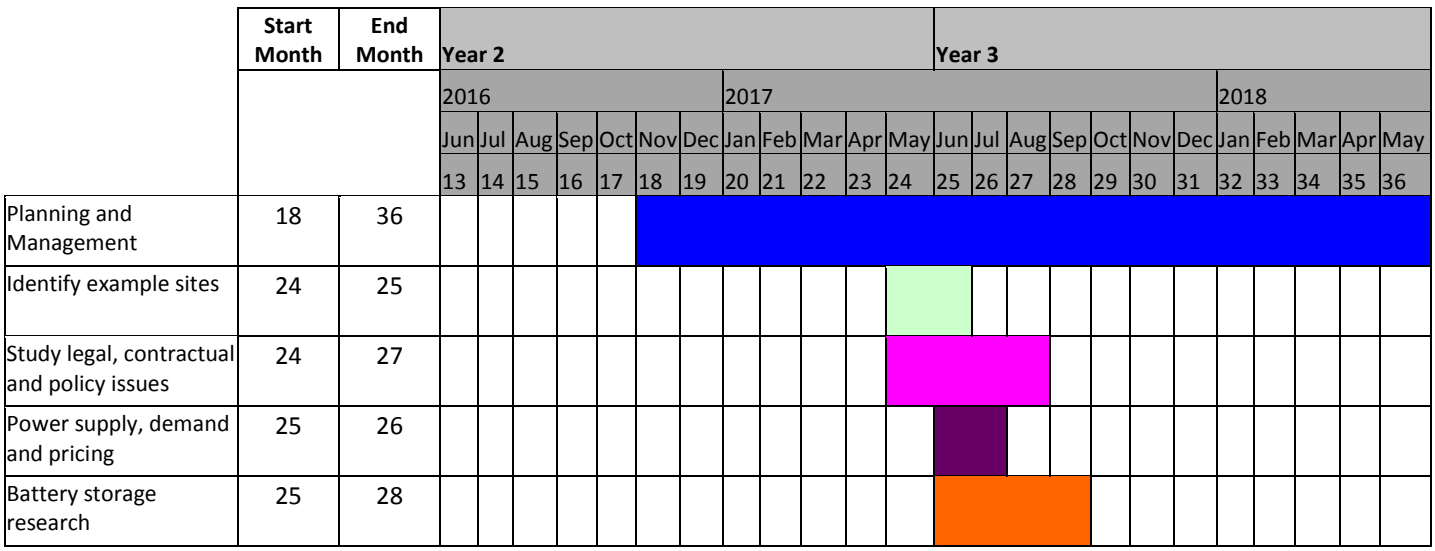


Figure C 8 - Detailed Timeline

14. Expected results Pillar C

This use case will deliver a strong understanding of the ability of the LU power network to support both the installation of charging points at TfL owned locations and transportable temporary recharging infrastructure and energy storage. Whist the activity taking place under Eliptic is limited to a desk based case study, exploiting the intended outcomes has the potential to have a major positive impact on the availability of electric vehicle charging infrastructure across London and consequently the speed of uptake of electric vehicles in the city.