WSP | PARSONS BRINCKERHOFF

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# ELECTRIC VEHICLE CHARGING STUDY

## *A REVIEW OF OPTIONS FOR CHARGING AT HOMES WITHOUT OFF-STREET PARKING*

A Consortium of London Boroughs and Transport for London – including Hackney, Haringey, Kensington & Chelsea, Brent, Greenwich, Merton and Hounslow

***FINAL REPORT***

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# EXECUTIVE SUMMARY

The objectives of this study are to examine the options for the provision of electric vehicle (EV) charging to residents living in London with no access to off-street parking, and provide a robust assessment of the different solutions.

A comprehensive long list of the possible options was developed through a combination of desktop research, reviews of best practice and new developments internationally, stakeholder consultation and brainstorming amongst our technical specialists.

Consultation with key stakeholders has proven a key aspect of this study in arriving at a set of options that are practical and deliverable from a variety of perspectives. It has also provided invaluable insights into each prospective option and London's electric vehicle ecosystem.

Shortlisted options were identified through a long-list sifting process. Streets were then selected to serve as case studies for generic street types, including: a terraced street (Inner), semi-detached street (Inner/Outer), mixed land use street (Central/Inner) and a street lined with flats/apartments (Central).

Taking at random a specific house in each case study, we assessed in-situ the effectiveness of each charging option, the findings of which go on to inform the detailed options appraisal.

Based on the findings of the case studies, feedback from stakeholders and further research undertaken for each of the short listed options, detailed multi-criteria assessments were completed for each option.

The wide ranging assessments against many different factors found that on balance there was not much separating each option. As the case studies demonstrated, the suitability of each option varies to a large degree on highly localised factors. As well as the behavioural traits of the prospective buyer, and in some case also the attitudes of prospective EVCP hosts or operators.

Scenarios were developed to provide an indication of what the future charging infrastructure mix might look like for residents without off-street parking.

In the short term, 2015-17, we forecast that initially the more established and readily available options will predominate.

In the medium term, 2018-20, we anticipate a shift towards the more versatile socket networks.

In the low end estimates this is tempered by possible barriers to more widespread uptake (i.e. technical limitations with more street lights than anticipated, or slower integration within vehicles).

In the high end scenario, where delivery issues to do not hamper the socket network model, their cost effectiveness and versatility would limit the attractiveness and viability of higher cost alternatives, like the parallel network option, which may instead serve very specific locations only.

A positive outcome is that in both the High and Low end scenarios we see the proportion of prospective buyers for whom no satisfactory solution is available rapidly diminish, from nearly 70% in 2015 to 10-25% by 2017, and 0-7% by 2020.

The forecasts assume that as other alternatives become available, the use of options such Source London and Parallel Networks becomes less appealing, or less essential, for residential charging, either because the alternative solutions may be nearer to their homes, cheaper, or more readily available.

Though it is important to note that in reality they are likely to adapt and evolve in line with emerging models, technologies and market rates, in which case we would anticipate their proportions of market share would adjust accordingly.

In time for example the parallel network option might adopt the socket technology rather than more costly conventional EVCPs, with the two options merging in effect.

This study has found that there is unlikely to be a one-size fits all solution for providing charging facilities to residents without off-street parking, or at least not in the short to medium term.

The problem is complex and requires consideration of a wide range of factors, including the effectiveness of the charging technology, charging model and its deliverability.

Each option has pro's and con's, and specific issues and limitations to overcome. The different challenges and issues can be categorised in three key areas:

- Business models/ Market Acceptance
- Charging Infrastructure and Technological Challenges
- Charging Locations and Access

Whilst this study has chiefly approached the assessment of options at an aggregate level for London, some consideration was also given to how the effectiveness and deliverability of options might vary by street type and spatially.

In Central and some Inner London Boroughs we would anticipate the full range of charging options being available, with Source London points being more concentrated, but also with more non-resident demand and car club vehicles occupying them during the daytime. We would also anticipate there being more opportunities for Parallel Network bays, as prospective EV buyers may be more concentrated, and with less likelihood of having off-street parking.

In Outer and some Inner London Boroughs, Source London and Parallel Network points may be sparser, with fewer prospective buyers clustered in close proximity and with no access to off-street parking.

Socket networks could be equally applicable in both areas, but potentially to slightly different formats. In Outer London their provision in off-street car parks and employers car parks may be more prevalent, as well as clusters of residential streets without off-street parking. In Central and some Inner London Boroughs sockets may be more prevalent as part of the general streetscene, in streetlights, on masts, on walls or in floor-boxes, as well as off-street car parks where available.

Trailing cables seem more likely to feature in Outer London Boroughs were they permitted, as they are likely to be reliant on the resident being able to park immediately outside their home and within reach of the cable.

Remote charging via Rapid charging stations could be widely available, though may be better suited to more Outer London Boroughs, where vehicles are used more regularly and do more miles.

To take forwards the findings of this study, the key issues and outstanding questions associated with the shortlisted options should be addressed, with a view to informing subsequent decision making on infrastructure investment, policy making and strategy development.

SECTION 1

# INTRODUCTION AND CONTEXT

# 1 INTRODUCTION AND CONTEXT

## 1.1 Aims and Objectives

1.1.1 The objectives of this study are to examine the options for the provision of electric vehicle (EV) charging to residents living in London with no access to off-street parking.

1.1.2 The study aims to provide a robust assessment of the feasibility and suitability of different technological solutions, including legal, safety and practical considerations.

1.1.3 The objective of this report is to provide practical recommendations for enabling residents without off-street parking to charge their EVs, with a focus on solutions deliverable in the short to medium term.

## 1.2 Context

1.2.1 After a slow start, hindered by the recession and subsequent slow recovery, the limited number of models on the market, their high purchase cost, and a general uneasiness about their range and supporting infrastructure – EV sales are now beginning to grow rapidly.

1.2.2 There are now over 20 plug-in models available on the market. SMMT data shows EVs and plug-in hybrid EVs (PHEVs) saw the greatest year on year growth of all sectors in the automotive sector, rising 181% and 1,101% respectively on September 2013. Plug-in hybrids have also shown the largest growth in year to date registrations, rising 454% to 4,303. Whilst this growth is from a very low base, but nonetheless the rate of growth is significant.

1.2.3 To date it has been largely possible to satisfy the charging requirements of EVs through public charge point networks and domestic charge points. However as growth picks up, the scope for providing on-street EV charge points (EVCPs) in line with demand will become more challenging.

1.2.4 Two-thirds[1] of households in London do not have access to off-street parking, which can result in less than desirable charging practices, or simply serve to discourage the uptake of EVs, a key element in the strategy for tackling local emissions and poor air quality.

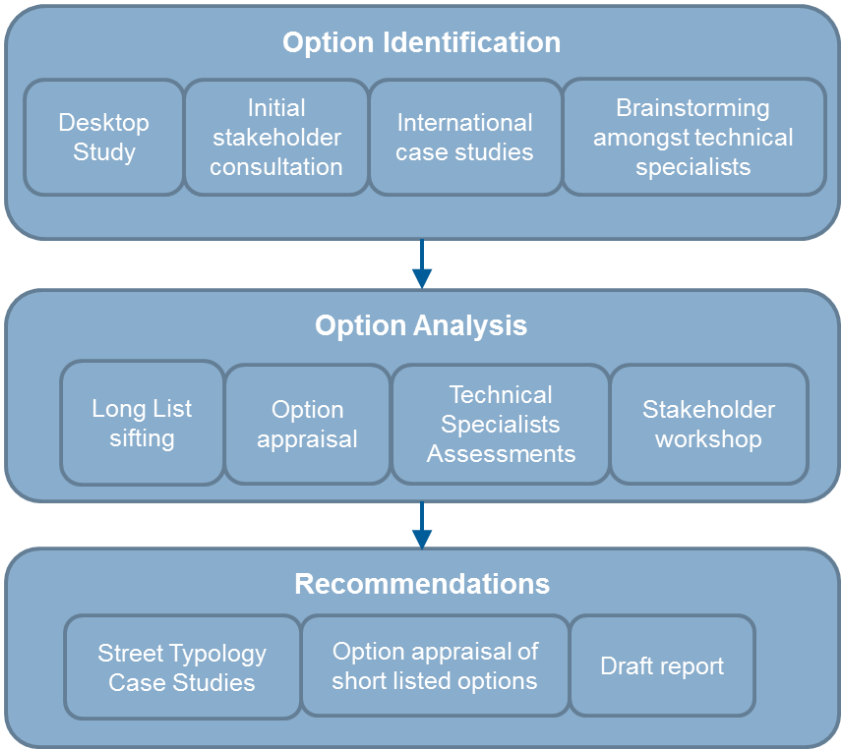
[1] *Feasibility Study into Electric Vehicle Uptake and the Impacts of Associated Infrastructure (TfL, 2015)*

SECTION 2

# METHODOLOGY

## 2 APPROACH

2.1.1 The section sets out the study's methodology. The figure below summarises the overall process.




### 2.2 Options Identification

2.2.1 We began by collating a comprehensive long list of the possible options to enable the charging of EVs at residences without off-street parking.

2.2.2 This was developed through a combination of desktop based research, a review of best practice, new developments internationally and a brainstorming exercise internally amongst our technical specialists experienced in EV planning.

2.2.3 It was also informed through further discussions with the client team at the inception meeting, and the initial stakeholder interviews.

2.2.4 The intention of the long list and option identification stage was to ensure all possible options were accounted for, and arrive at a comprehensive list. In doing so we also generated useful research and findings to feed into the subsequent options analysis.

### 2.3 Options Analysis

2.3.1 We then undertook a high level sift through the Long List of options to derive a short list of the options to assess further, the intention being to filter out any entirely unsuitable or unfeasible options prior to a more detailed assessment.

2.3.2 The criteria against which the options were assessed included:

- **Effectiveness** as charging solutions, and their general suitability as part of the streetscene; and
- **Deliverability**, including whether they could be implemented at a sufficient scale in the short to medium term, defined as 2015-17 and 2018-20 respectively.

2.3.3 Following an initial long list sifting exercise to arrive at a shortlist, a stakeholder workshop was convened to

present the emerging findings and proposed shortlist of schemes to be taken forwards.

2.3.4 The workshop discussions provided invaluable input to the process, bringing together a wide range of perspectives and interests. Following which the approved shortlist of scheme was taken forwards for more detailed analysis.

2.3.5 We worked with the client team to identify locations to serve as case studies. Each then served as worked examples for the shortlisted options. The intention being to work through some of the particular challenges associated with differing street typologies, including what could be regarded as typical terraced streets, semi-detached streets, mixed use streets and streets flanked by flats/apartments – all with no off-street parking, or very limited off-street parking.

2.3.6 The streets select also accounted for the challenges posed by different types of parking restrictions, conservation area status, and proximity or otherwise from key attractors, existing Source London points etc.

2.3.7 By working through each case study in-situ we were able to then complete a multi criteria appraisal table, building on earlier desktop research, international case studies and stakeholder interviews.

2.3.8 As part of the options appraisal we undertook an internal design workshop to work through the practical and technical challenges associated with each option, drawing on WSP| Parsons Brinckerhoff's multi-disciplinary expertise, including expert advice in EVCPs, street lighting, pavement engineering and parking, to provide a high level steer on technical matters, as well as the transport planning advice from the core team.

## 2.4 Recommendations

2.4.1 Based on the assessment of the issues for each option, we then determined their suitability, taking into account of a wide range of assessment criteria:

Effectiveness

- Usability
- Availability
- Cost to User
- Convenience of Charging Apparatus
- Access - dependency on access to specific bay
- Legibility as part of wider infrastructure
  Impact on Parking Supply
- Streetscene impacts
- Fit with Car Clubs
- Risks – Health & Safety and Legalities
- Proportion of market catered for - scope for wider roll-out

Deliverability

- Costs - installation, operation and maintenance
- Technological Constraints/ Challenges, risks of obsolescence
- Commercial Viability/ Acceptability, Business Models

- Revenue Implications/ Generation Potential
- Borough Resource Requirements
- Impact on Electricity Network

## 2.5 Stakeholder Consultation

2.5.1 Effective consultation with key stakeholders has proven a key aspect of this study. As not only is it critical in arriving at a set of options that are practical, effective and deliverable from a variety of perspectives. It has also provided invaluable insights and very particular experience to inform all stages of the study.

2.5.2 Key stakeholders were identified in conjunction with the client team, including:

- **London Boroughs** (including transport planning officers, and where appropriate parking, street lighting and/or legal officers):
  - Central - Westminster
  - Inner - Hackney
  - Outer - Hounslow
- **Transport Authorities/ Government Departments:**
  - Transport for London (TfL)
  - Office for Low Emission Vehicles (OLEV)
- **Charge Point suppliers/ Network operators**:
  - IER/Bolloré (formerly Source London);
  - UKSEV – EV Charge Point Industry Representative Group;
  - Ubitricity – New EVCP technology supplier
- **EV OEMs:**
  - Society of Motor Manufacturers and Traders (SMMT) –Industry Representative;
- **Electricity Suppliers:**
  - UK Power Networks;
- **EV Users**:
  - Local resident purchasing an EV
- **EV related Operators**
  - DriveNow UK
  - Zipcar
  - E-Car Club

2.5.3 We made initial contact by phone or email, introduced them to the aims of the study, and sought their views on any additional options to add to long list, before working through each option with them and discussing their views of the pro's and con's of each.

2.5.4 Of these stakeholder were successful in conducting full interviews with all but IER/Bolloré and SMMT, and 13 attended the subsequent stakeholder workshop (see appendices for further information).

SECTION 3

# OPTION IDENTIFICATION

# 3 OPTIONS IDENTIFICATION

## 3.1 Long Listing

3.1.1 A long list of possible charging solutions was developed following an extensive desktop research exercise, which sought to assemble all plausible options for further consideration through this study. These included charging options that were either in use or under development elsewhere in the UK or internationally, as well as emerging technologies.

3.1.2 A number of conceptual options were also included, which in principle might be deliverable. This approach seeks to ensure that the assessment is comprehensive and cognisant of all possible solutions when identifying the optimal options.

***Table 1 Options Long List***

| Options identification – a continuum of charging provision | Secondary options or characteristics |
|---|---|
| On-street charging near home - charging post | A.) Commercially as part of IERs Source London Network |
| | B.) Parallel Network - Independent supplier and operator facilitated by Council or other 3rd Party |
| On-street charging near home - taking supply from existing street furniture (i.e. Street lights) | C.) Retro-fitting or replacing existing electrical street furniture – including Ubitricity, or Pop-up power / Power bollards |
| Permit on-street charging near home – cable charging from home | D.) Secured matting |
| | E.) Duct-and-chamber |
| On-street charging near home – alternative technologies | F.) Inductive charging |
| | G.) Portable chargers |
| On-street charging within a reasonable distance of home – alternative technologies | H.) Rapid Charger Stations |
| | I.) Battery swap |
| Seek alternatives to on-street charging outside houses | J.) Dropped Kerbs, Shared Parking Apps, nearby 3rd party sites (e.g. public or private car parks) and secure lease arrangements, night time use of business car parks, shared use with Loading Bays |
| Discourage on-street charging outside houses | K.) Discourage on-street charging outside houses –encourage charging at destinations instead (i.e. do-minimum) |

3.1.3 The long list of options as set out in Table 1 takes the form of a continuum of charging solutions, which range from more conventional on-street charging solutions, through to more innovative options and more remote charging locations, and ultimately through to more compromised possible solutions.

3.1.4 At the bottom of the continuum would be the conclusion that no suitable solutions are available, so requiring on-street charging to be discouraged as an expectation.

3.1.5 Distinctions can be drawn between Options A-B, which are more fundamentally delivery mechanisms, and are assumed to use conventional EVCPs, and Options C-F which include different charging technologies or formats.

3.1.6 The rest of this section goes on to briefly introduce each of the options. Each is then assessed further in the following chapter.

On-street charging near home - charging post

**A.) Source London Network:** a conventional EVCP installed on street, within reasonable proximity of the users home, which would also function as part of the wider publicly accessible Source London network.

**B.) Parallel Network:** a conventional EVCP installed within reasonable proximity to the users home, and operated by a 3rd Party, unlike Source London this parallel network would likely be residents only, but entail initial a significant financial commitment from the resident to cover the initial capital costs:

On-street charging near home - taking supply from existing street furniture (i.e. Street lights)

**C.) Socket Networks:** sockets retrofitted to lamp-posts and other everyday street furniture.

Permit on-street charging near home – cable charging from home

**D.) Secured matting**: a low tech solution, which could enable users to plug in via domestic connection and trail their charging cable over a public footway.

**E.) Duct-and-chamber**: charging cables securely channelled beneath the public footway within a covered chamber, and fed through a lockable flap at the kerbside.

On-street charging near home – alternative technologies

**F.) Inductive charging:** wireless charging via electromagnetic induction pads embedded within the road and fixed to the bottom of the vehicle.

**G.) Portable chargers**: a portable battery recharging unit which can be wheeled up alongside the EV and left charge overnight.

On-street charging within a reasonable distance of home – alternative technologies

**H.) Rapid Charger Stations**: 43-50kw chargers configured and operated in a similar way to conventional petrol stations.

**I.) Battery swap stations**: replaces spent batteries with fully charged ones, operating in a similar way to conventional petrol stations.

Seek alternatives to on-street charging outside houses

**J.) Dropped Kerbs, Shared Parking Apps, nearby 3rd party sites, either:**

- Introduce additional off-street parking by paving over a garden and adding a dropped kerb, and accessing a conventional domestic charger.
- Utilise a third party (e.g. public or private car parks) and an EVCP via platforms such as JustPark or lease arrangements with businesses.
- Permit the shared use of Loading Bays overnight where fitted with EVCPs.

Discourage on-street charging outside houses

**K.) Discourage on-street charging outside houses:** If no solutions can be found for a particular location which are felt to be acceptable to the Borough and Transport for London, or that would be acceptable to the user, it may be necessary to instead adopt a formal policy position whereby charging is actively encouraged at destinations instead of on-street at home, alongside alternatives to car ownership, such as low emission car club membership.

## 3.2 International Case Studies

3.2.1 The long list has been informed by case study reviews of the developments underway or schemes in place at a number of leading cities globally when it comes to EV charging provision.

3.2.2 Whilst it is important to recognise that each is subject to its own unique set of regulatory, political and practical constraints, they nonetheless provide useful insights for what has worked elsewhere, and has in places contributed to greater EV uptake than achieved to date in London and the UK.

3.2.3 The case studies undertaken for this study included:

- Berlin
- Oslo
- Amsterdam
- Paris

## 3.1 Berlin

Local and national context

3.1.2 With aims for 15,000 EVs and 1,400 EVCPs across the city by the end of this year, Berlin is leading the EV revolution in Germany. In a city where only half of households own a car, sustainable transport already plays a key role in the urban infrastructure, and so creates favourable conditions for encouraging the uptake of EVs. By 2030 Berlin also aims to source 100% of its electricity supply from renewable energy.

3.1.3 On a national level, Germany has been tackling electromobility since 2008, and legislation to support EV growth has included: tax exemptions; transferable license plates; company car taxation; parking privileges and access to bus lanes.

3.1.4 At present there is also draft legislation seeking to standardise the connections provided by all new charging stations to include a uniform CCS (Combined Charging System) model that offers quick DC charging functionality. This will mean that EV users can rely on a charging station being compatible with their car, and do not encounter some present difficulties between different charging connectors provided by different EV manufacturers.[2]

3.1.5 The draft legislation also requires that charging stations report back to a central government database so that the status of the country's charging network is up-to-date and increasingly reliable as providers carry out more regular maintenance of charging equipment to strengthen the reputation of their product.

***Figure 1 the CCS connector which may become a mandatory requirement of all new charging stations in Germany***

3.1.6 Locally, the state of Berlin also implements a number of processes to improve the functionality of EVs, including a conceptualised map of public charging infrastructure and a uniform platform for collecting information and data. Leading by example, the State's authorities are also converting their fleet of vehicles to all-electric models.

3.1.7 Other pilot schemes include the E-City Logistics project which illustrated that EVs can be effectively used commercially as delivery vehicles. Their lower noise levels mean that deliverable hours can be extended to off-peak and night time, avoiding peak traffic.

[2] https://transportevolved.com/2015/01/20/germanys-new-draft-legislation-electric-car-charging-model-follow/

Ubitricity

3.1.8 Berlin-based Ubitricity are pioneering a charging socket device that would in principle enable charge points to become ubiquitous, both on-street and off-street, and so enable users to charge where they already park.

3.1.9 A key attraction of the Ubitricity 'socket network' model is the greatly reduced capital cost. The socket devices cost around $600 (£389[3]) each, which is around 90% lower than conventional on-street charge points. The cost savings are achieved by removing the metering technology from the charge points themselves, and instead integrating it within the charging cable carried by the user, avoiding the need to replicate it within each point. *(Further technical information is provided in the following chapter).*


3.1.10 Trials began in Berlin and Munich in 2012. The Berlin trials are focussed on street light charging, whilst the Munich trials are focused around charging provision for EV taxis using sockets in a wider variety of formats.

3.1.11 20 sockets were installed as of spring 2015, which is set to increase to 50 by summer 2015 and 100 by the end of 2015. The trials have encountered a number of delays through the planning process, and objections from alternative EVCP suppliers complaining of uncompetitive practices, which Ubitricity ultimately overcame by installing the trial sockets at their own expense.

3.1.12 At the time of writing around 200 of the sockets have been installed globally, in association with one of their shareholders, energy firm EDF.

EV Car Sharing Schemes

3.1.13 Berlin is also home to a large scale EV only car sharing scheme, Multicity. This includes 350 Citroen C-Zero EVs, available widely across the city centre area. The vehicles can be accessed using an electronic membership card, in a similar format to the better known Autolib car sharing scheme in Paris. The charging infrastructure is powered by 100% renewable electricity.

[3] *As of 17th February 2015*

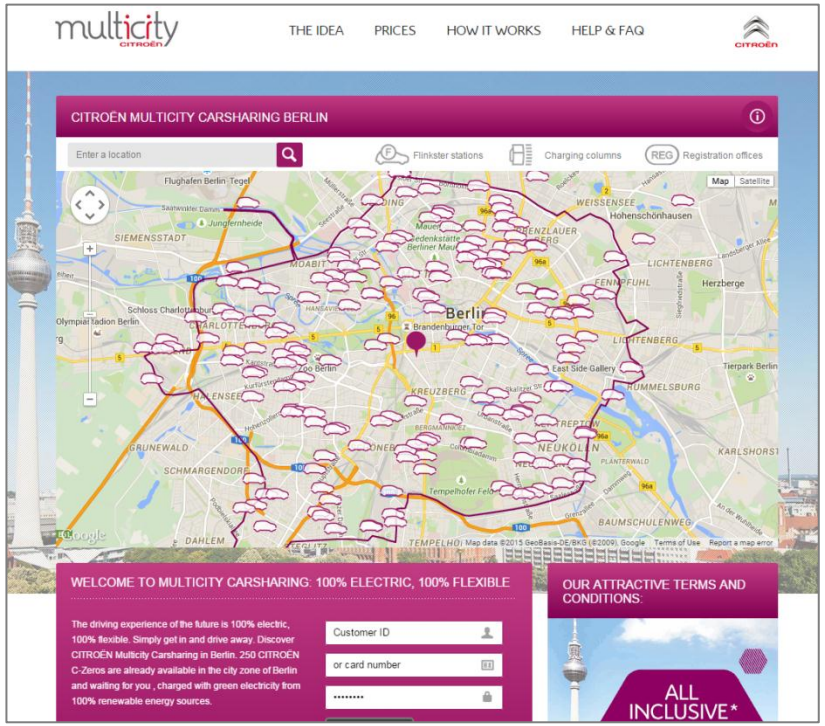



***Figure 2 Berlin Multicity EV Car Sharing Scheme Web Page***

3.1.14 Berlin also has a DriveNow scheme, a joint venture of BMW and Sixt. As of January 2014 it had 200,000 active users in Germany, with a fleet including electric Mini and BMW vehicles.

## 3.2 Oslo

Norwegian EV Market

3.2.2 Norway boasts the most EVs per capita anywhere in the world. In 2014, 1 in every 100 passenger cars on the road was a plug-in vehicle, and a market share of 3.1%.

3.2.3 Market share increases to almost 15% when electric cars, vans, plug-in hybrids (PHEV) and imported EVs are considered together[4]. In April 2014, Tesla's Model-S broke Norway's record for the most car registrations in a single month (1,493)[5].

3.2.4 The growth in Norway's EV market can be attributed to the success of a number of incentives provided by the government. These include: free EV use of bus lanes; tax and VAT exemptions; waived road and ferry toll charges and free municipal parking. For the EV user, these benefits are supplemented by lower insurance costs and free charge point access. Estimates suggest these subsidies could equate to savings of £5,000 per year.

3.2.5 Significant purchase tax incentives are also available, bringing the cost premium to only around €1,000 more than a conventional car. Surveys undertaken by the Norwegian Electric Vehicle Association were found to reinforce the importance of local measures in adding to the daily driving experience.

3.2.6 However, even with these measures in place for a number of years, sales did not increase until more

[4] http://www.hybridcars.com/top-6-plug-in-vehicle-adopting-countries-2014/4/
[5] *http://cleantechnica.com/2014/04/04/7-tesla-norway-facts-will-blow-away/*

conventional models from well-known manufacturers were available

3.2.7 The EV market is supported by a growing charge point network that, in early 2014, included 4,642 charging points across 1,298 charging stations, an increase of 25% on the previous year.

3.2.8 It is worth noting that Norway's near 100% reliance on hydropower makes the success of its EV growth even more significant as they are supplied by electricity from a renewable and sustainable source.

3.2.9 The success of EVs in Norway also stems from Nobil, a free-to-use and publically accessible database on EVCPs across the country[6]. The database collects information and distributes it in an effort to raise awareness on the availability of charging infrastructure, supporting existing EV users and encouraging new users.

***Figure 3 EVs are permitted to use bus lanes in Oslo***

[6] *http://www.nobil.no/*

Oslo

3.2.10 The focus of Norway's success is Oslo, with the highest concentration of EVs anywhere in the world [7] - almost 50% of the country's registered EVs[8]. The city was aiming for 900 public charging stations by the close of 2014, and supplemented by private charging facilities, a number of which received subsidised grants from the City of Oslo.

3.2.11 One of the major incentives is the use of bus lanes, particularly along the busy western corridor into Oslo. This is evidenced by the significant number of registrations in the suburbs around Oslo. Akershus, to the west of Oslo, is the county with the highest number of EVs registered, at 3,245. A local newspaper recently organised a "race" between a conventional car and an EV using the bus lanes. On a typical commute taking 1.5 hours, the EV arrived 45 minutes earlier than the conventional car. However the growth in EVs has been successful to the extent that it is now jeopardising this incentive, with the bus lanes becoming congested with EV traffic and slowing bus services[9].

3.2.12 This success of EVs is heavily reliant on the government subsidies that are in place, and are currently due to be withdrawn by 2018, or once 50,000 vehicles have been registered – which could be achieved this year[10].

3.2.13 The City of Oslo's procurement framework now only allows for replacement of municipal vehicles with electric vehicles. The City has a target that its car fleet

[7] *http://www.europeanenergyreview.eu/site/pagina.php?id=4268*
[8] *http://cityclimateleadershipawards.com/2014-project-oslo-evs/*
[9] *Myklebust (2013) - http://e-mobility-nsr.eu/fileadmin/user_upload/downloads/info-pool/EVs_in_bus_lane_Benjamin_Myklebust_ZERO_EVS27.pdf*
[10] *http://www.theguardian.com/environment/2014/jan/29/norway-electric-cars-sale*

will be zero emission by 2015, and has concluded a purchasing agreement for 1,000 vehicles.

Incentives in place to address barriers

3.2.14 A wide range of measures are in place to address the cost barriers, including both the running costs and capital costs. The Norwegian Government has focused incentives on pure EVs for the most part, the only exception being free parking and charging which has also been available to PHEVs.

3.2.15 In terms of the running costs, significant savings can be made from toll exemptions and free parking. There is also a significant saving on the refuelling costs relative to conventional vehicles.

Access to infrastructure

3.2.16 As yet, there is no national strategy on infrastructure, although the Government agency Transnova is in the process of developing a strategy.

3.2.17 In 2009, the Norwegian Government set up a 50 million NOK (c. £5.6 million) fund, where municipalities and companies could apply for grants to cover the installation costs up to 30,000 NOK (£3,380) per charging point. This resulted in 1800 charging points being installed.

3.2.18 The City of Oslo has been particularly active. The locations of the charging points within the city have largely been determined by requests from EV drivers. The City has also funded EVCPs for shared apartment buildings and businesses.

3.2.19 Across Norway public EVCPs are free to use and easily accessible, using a common key type provided by Norwegian Electric.

3.2.20 Fast charging is being developed by private companies, although there has been some level of public investment. Originally fast charging was free, but most providers now charge a subscription fee.

3.2.21 As yet the different providers do not facilitate access to each other's stations. However the national government has mandated that fast charging providers must provide reasonably priced charging to any non-member who requires it.

## 3.3 Amsterdam

3.3.1 The installation of charging stations in Amsterdam began in earnest in 2011. By 2012, 100 charging stations had been installed, and quickly grew to 650 in 2013. EVCPs were projected to reach 2,000 by the end of this year[11]. With a surge in activity in 2014, EV usage nearly doubled and the city has now committed to 4,000 charging points by 2018.

3.3.2 The number of electric vehicles in the Netherlands has increased from around 7,500 in January 2013 to 36,000 by end of March 2014, with councils becoming increasingly active when it comes to their policies regarding electric vehicles.

[11] http://viajeoplus.eu/wp-content/uploads/sites/4/2014/07/WP6-Amsterdam-EV-Charging.pdf

*Figure 4 Amsterdam elektrisch' charge point*

3.3.3 The strategic installation of public EVCPs forms part of the Amsterdam Metropolitan Area Electric project, which aims for the coordinated delivery of EV infrastructure across the city, instigating use in both public and private industry.

3.3.4 During the initial phases of promoting electromobility, EV users were offered free access to charge points, free parking and placed at the head of parking bay waiting lists – a significant perk given the high demand for parking spaces in Amsterdam, where it normally takes a year to get a permit[12].

*Figure 5 Tesla airport shuttle scheme, Amsterdam*


3.3.5 Amsterdam's Schiphol airport has recently introduced an electric taxi service. A fleet of 167 Tesla Model-S EVs shuttle passengers to and from the airport, to help compensate for the carbon emissions caused by the airport. Alongside the airports fleet of electric buses and free-to-use long-stay EV parking bays, the e-taxi service is a major factor in ensuring that Schiphol is one of the world's most sustainable airports[13].

Provision of parking benefits for electric vehicles

3.3.6 In the majority of the municipalities in Holland EVCPs are located in public spaces and in the municipalities.

3.3.7 In 51%[14] of cases Municipal Councils allow EV drivers to trail cables from their domestic chargers over the public footway, or allowing an extension of the house connection. This policy is felt to have had a significant

[12] *Introducing E-Mobility: Emergent Strategies for an Emergent Technology, e-mobility NSR (July 2014)*

[13] http://www.autoblog.com/2014/10/20/schiphol-airport-167-tesla-model-s-taxis-official/

[14] *Introducing E-Mobility: Emergent Strategies for an Emergent Technology, e-mobility NSR (July 2014)*

positive effect on EV take up, though interestingly no significant effect on PHEV purchases.

3.3.8 In addition, the Dutch Government's "Green Deal" programme includes a component with 'The New Motion', where for every electric vehicle that enters the market, the project commits to installing an intelligent charging point at home or work, based on an assessment of the client's particular requirements.

Access to infrastructure

3.3.9 One key feature of the Dutch infrastructure is that it is easy for all EV drivers to access the public infrastructure. The market has developed so that there are infrastructure providers (who install and operate the equipment) and service providers (who provide subscriptions to the users of charging points). All of these bodies, as well as E-Laad Foundation and the national government have worked together to ensure the interoperability of the infrastructure, so that any subscriber of any service provider can use any charging point.

3.3.10 Home charging has also been supported, with some local municipalities giving grants of up to €1,000 towards the installation of home charging points. Furthermore, some EVs were sold with one or more charging stations included, mostly free of charge including installation at home or office locations.

3.3.11 In Amsterdam EV owners are able to jump the queue for a parking permit. In some areas of Amsterdam, the waiting time for a parking permit can be up to 4 years. The City will also grant up to €1,000 towards the cost of a charging point in a public parking space.

3.3.12 In Amsterdam an EV-only car rental club "Car2Go" was launched in November 2011, with 300 Daimler SmartforTwo BEVs. There is no subscription fee to pay, instead, members pay only for the time they have used the vehicle for. EV charging is free to members and members are incentivised to plug the vehicle in, as they receive free minutes. By March 2013, more than 7,000 people had registered, and there are as many as 5,000 separate rentals a week.

## 3.4 Paris

3.4.1 In Paris the all EV car sharing scheme Autolib EV car club scheme was first launched in late 2011. The scheme is a public-private partnership between a large French industrial group, Bolloré, the City of Paris and surrounding cities.

3.4.2 The Autolib has been hugely popular, with a membership of around 155,000 by summer 2014, 3,000 'Bluecars' and around 5,000 EVCPs, averaging over 10,000 rentals a day.

3.4.3 The scheme covers 63 town council areas in and around Paris, and has been largely funded privately by Bolloré, though with significant contributions for the City of Paris towards EVCPs and the allocation of parking bays, estimated to be in the region of €35m.

*Figure 6 Paris Autolib EV Car Club Scheme*

3.4.4 The Autolib EVCP and Bluecars are distributed in clustered car sharing hubs, and predominantly focused around key attractors and destinations. The distribution is such however that the user can never be further than a quarter of a mile away from their nearest hub.

3.4.5 The scheme also permits privately owned EVs to charge within the dedicated charging bays, though there are some restrictions to the charging hours permitted.

## 3.5 Key Findings

3.5.1 **Oslo** is the world's leading exemplar city when it comes to proactive promotion of EV uptake, evidenced by the exceptionally high market shares of EVs (3.1%) and PHEVS (12%).

- Demand Responsive EVCP provision near the home
- Use of bus lanes
- Free use of EVCPs
- Prioritised parking permits
- Single access key type nationally

3.5.2 **Amsterdam** has seen a surge in EV ownership since 2014, with EV usage nearly doubling. The City has committed to 4,000 charging points by 2018.

- Co-ordinated delivery of EVCPs across the city
- Fast tracked parking permits for EV buyers
- Grants to install EVCPs on demand at home or work, including non-public locations
- Permission to charge by trailing cables over footways

3.5.3 **Berlin** is at the centre of innovative new approaches to reducing barriers to a more all-pervasive charging infrastructure.

- Trial socket networks
- Large scale EV only car sharing schemes and supporting EVCP network

3.5.4 **Paris** famously is home to the popular Autolib EV car club scheme.

- Widespread availability of EVCPs established through the Autolib network
- EVs are normalised across the city

SECTION 4

# OPTIONS ASSESSMENTS - LONG LIST

# 4 OPTIONS ASSESSMENTS – LONG LIST

## 4.1 Source London

4.1.1 Source London is the existing commercial network of publicly accessible EVCPs, established in 2011 by Transport for London, and bringing together points previously operating at a Borough level. The network includes a consortium of public and private sector organisations (including SSE, Asda, Heathrow Airport, Enterprise Rent-a-Car etc.).

4.1.2 There are currently more than 1,300 charge points in the network. Some EVCPs are located on-street while others are found in car parks, such as supermarkets and shopping centres.

*Figure 8 Source London Points*

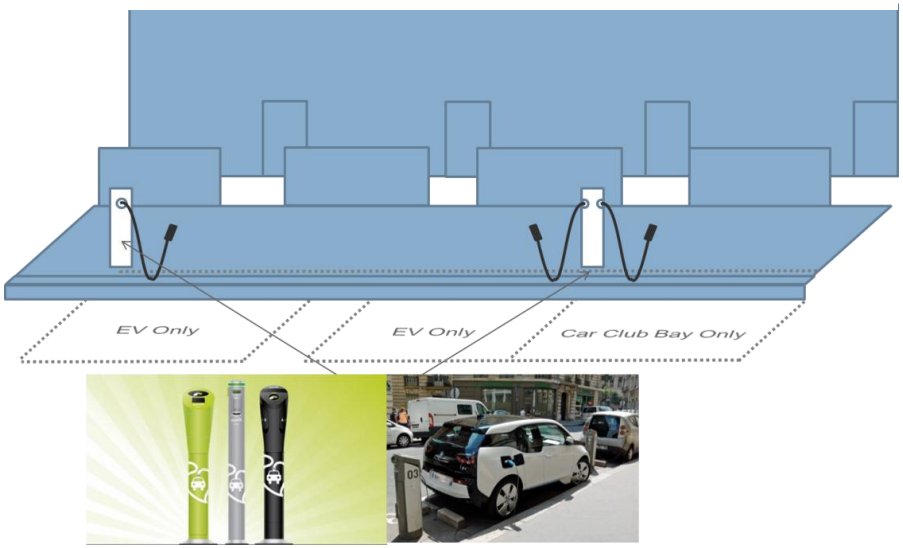



*Figure 7 Proximity of Source London Points*

4.1.3 There are a number of different types of charge points in the network, with the majority double-headed 3kWh and 7kWh connections, which charge your car from 0-75% in 6 or 3 hours respectively. They are accessible to any member of the Source London scheme (£5 membership until 30/09/2015).

4.1.4 In September 2014 the network was contracted out to IER, a subsidiary of the French industrial group Bolloré, which operates a base of 3,000 charging points across Paris, including the high profile Autolib EV car club scheme in Paris.

4.1.5 After rapid growth Source London has encountered a number of difficulties. The network is complicated by there being sixty-six different partner organisations in the scheme, and six different charge point designs.

4.1.6 A high proportion of the points (~30%[15]) are known to be faulty or obsolete.

4.1.7 IER's rebranded Bluepoint London's ambition is to increase the number of EVCPs to 6,000 by 2018, as well as launching an EV car club. Since being awarded the network IER have audited the EVCP network and concluded the network is in too poor a state to proceed with the initial plans to roll out the EV car club later in 2015.

4.1.8 IER has since been in negotiations with London Boroughs (25 of the 33 London Boroughs belong to Source), over a variation order to their contracts with Source. Mr Arnaud of IER said the company was having "constructive discussions" with the partners on the project and was close to formalising a new agreement with some local authorities. It is understood two possibilities have been explored:

1) **Full ownership** – IER will own the points, and hold a 99 year lease the on-street and off-street parking bays, with a minimum break period of 4 years, or 8 years for any new bays. They will also take responsibility for the maintenance, electricity costs and manage the supplier relationships. An annual fee of around £900 per bay would be paid, varying by location, plus a pro-rata year end profits for the Boroughs share of the network.
2) **Partial Ownership** - The Borough continues to own the asset, procure and supply the point (paid for by OLEV via the Borough, and purchased from a supplier i.e. Chargemaster, Pod Point etc.), manage the contract with the supplier, including maintenance and administration, and get reimbursed by IER for its use. IER would take control of charge point maintenance and set up round-the-clock support for the network.

4.1.9 At the time of writing it is understood 4 of the 25 London Boroughs have signed the variation orders - all to the Full Ownership model.

4.1.10 At present drivers pay just £5 a year to Source London and, in return, receive free parking and free charging. However it is understood Bluepoint's plan may seek to levy a fee of up to £5 an hour to park and charge in the area corresponding to Zone 1 of the London transport network.

<u>Prospects as a solution for on-street residential charging</u>

4.1.11 In some respects the natural solution would be for prospective EV buyers to simply register with IER, who would liaise with the applicable London Borough and make an application for OLEV funding. Then install the point in proximity of the resident, if a point was not already available in the vicinity.

4.1.12 However in reality as a commercial entity, with no responsibility for fulfilling such requests, IER would

[15] *LTT 28 November 2014*

likely wish to consider a number of factors, including the wider viability of a particular location before committing to installing and maintaining an unplanned additional EVCP.

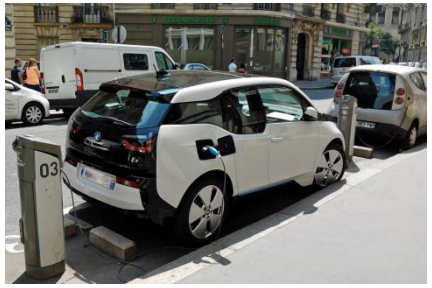
Location

4.1.13 It is understood that IER will seek to focus its deployment of EVCPs in clusters of 4 or more around attractors/destinations. In some cases it may be that this is within a reasonable proximity of the prospective buyer, but probably only in the minority of cases.

Availability

4.1.14 As a publicly accessible network, their availability to the resident would be dependent on the day-to-day usage of the network.

*Figure 9 Private EV charging at an Autolib EVCP in Paris*



4.1.15 In Paris the AutoLib can be booked and used by private EV owners, but at relatively high cost compared to domestic electricity rates, and limited to a maximum of 4 hour stays between 8pm and 8am, which effectively prohibits them from being used for the over-night charging typically required by residents.

***Case Study - Paris Autolib: Private EV owner usage***

- Bays can be booked and used by private EV owners
- Annual Subscription 15€ / 1st year, 0€ thereafter
- 1€ / hour charge
- Limited to 4 hour stay between 8pm and 8am - effectively prohibits over-night charging
- Users can reserve a space for a maximum of 90 minutes
- Penalty charge incurred if users don't use a reserved bay and fail to cancel the booking in time.

4.1.16 In the Paris Autolib car club users can reserve a vehicle in advance, though not more than 30 minutes beforehand: The Autolib' website, rental station screens and two smartphone apps provide real time updates as to where the nearest available car is, and allow the user to book it. The same systems, plus a touchscreen in the BlueCar itself, allow the user to locate a vacant Autolib' parking space near their destination, and to reserve it for a maximum of 90 minutes. If the user is delayed an alternative space can be identified and booked.

Price

4.1.17 It is understood IER's business model for the Source London points is based on comparatively expensive charges for use their bays (up to £5 per hour), geared more towards visitors and occasional users than regular users or commuters. Though it should be noted that IER have not formally confirmed their pricing structures at the time of writing, nor did they take part in

the stakeholder interviews, and this information is based on indirect research.

**Pros**

- **Augments the existing EVCP network**
- **Legibility** – delivers a single consistent network with a common access protocols, branding and information platforms.
- **Commercially viable model**, operated privately and following model established in Paris.
- **Comparatively deliverable** – uses conventional EVCP technologies
- **Economies of scales** in terms of maintenance and back office functions
- Own and operate model **minimises maintenance risks and burden on Boroughs**

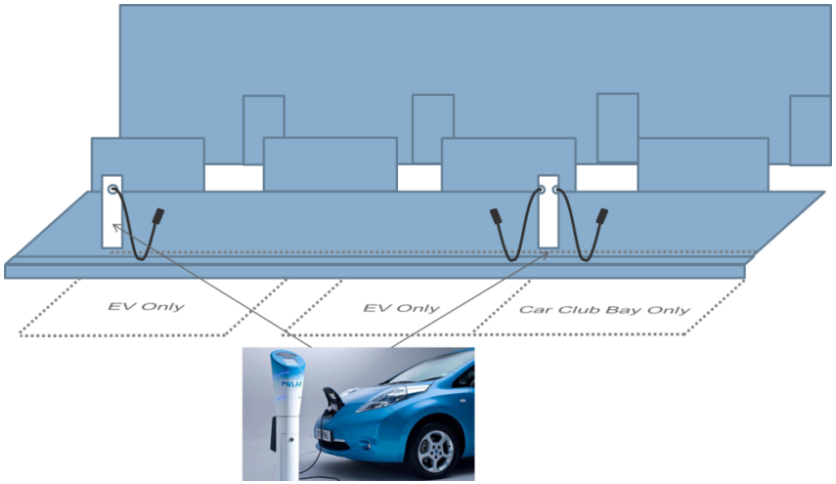
**Cons**

- Commercial imperatives mean the roll-out of EVCPs will likely need to consider a number of factors, including **viability of a location** before committing to installing and maintaining an unplanned additional EVCP. As such the model is likely to be plan-led rather than demand-led
- We understand deployment of EVCPs is likely to focus on clusters of EVCPs near attractors – **unlikely to install near residents homes**
- **High usage charges** are likely to limit the prospects for wide-scale use by residents and car clubs. It's understood IER's business model is based on comparatively expensive charges for using their bays, geared more towards visitors and occasional users than regular users or commuters.
- **Requirement for public accessibility** reduces the scope for bays to be routinely available for use by a particular resident. The resident would be dependent on the day-to-day usage of the network to be able to park near their home.

## 4.2 Parallel Network Bays

4.2.1 An alternative model to the Source London public network would be for a third party supplier and operator to establish a parallel network of EVCPs, but with otherwise conventional charge point technologies.

*Figure 10 Parallel Network Points*



4.2.2 This network could take on the role of providing on-street charging for residents, as a complimentary network to Source London, geared towards residents rather than visitors and tourists. It would be important for it to have to a very different role to that of Source London, to avoid unnecessarily duplicating infrastructure, back office functions, and potentially creating a confusing charging infrastructure for end users.

4.2.3 One such role is providing on-street chargers in locations which would otherwise not be catered for by Source, and providing charge points principally for use overnight by residents on a regular basis

4.2.4 Such a model would probably need to be demand responsive, and following a request from a resident.

***Figure 11 Proximity of Parallel Network Points***


4.2.5 The model would probably entail a Borough leasing the highway to an operator who would manage the EVCP network, either supplying points themselves or procured via the Council from an approved supplier.

4.2.6 Such a model is currently under development at the City of Westminster, and is due to be trialled this summer.

***Case Study – Westminster's Residents Only Parallel Network Model***

- Residents sign agreement for EVCP, inclusive of electricity usage, £3k per year agreement for 3 years to pay off the cost of the point.
- Model would be for 3 residents to share a point – could be upgraded to double headed points/ double bays latterly.
- EV only bay restrictions can be paired with residential permit parking
- WCC would lease highway to the operator who would manage the EVCP network, and the Council would take a share of profits.
- Point can be removed after 3 years if necessary – will be paid off.

4.2.7 The Westminster model being trialled provides one example of the type of format a parallel network approach might take. In practice it may be that different factors and weightings would be applied depending on the particular location and context of a scheme.

**Pros**

- **Residents only - geared to resident usage**, well suited to catering for overnight charging, which is more efficient, lower cost to the resident and in line with typical user demands.
- **Demand responsive** – unlike the Source London network, the approach can be demand-led, in response applications from residents.
- **Good fit with CPZ permit restrictions** – access to the bay can be limited to a particular resident parking zone, as well as EVs only.
- **Scope to install points closer to residents**
- Own and operate model **minimises maintenance risks and burden on Boroughs**
- In principle **car clubs could also operate from the charge points** if terms could be agreed.

**Cons**

- **Commercial viability** – in the case of the Westminster model, terms have been agreed with a supplier and operator, and a financier, which subject to this summer's trials, indicate a workable business model for this option can be reached. However Westminster is potentially more conducive to this model than elsewhere; it encounters high demand for EVCPs from residents, with a lengthy waiting list for EVCPs, high levels of in-commuting by EVs into the City, which then occupy publicly available charge points much of the day, and limited off-street parking available for residents. It is also a very wealthy Borough with high average incomes and comparatively low cost elasticity's. A resident's only model reduces the pool of prospective users and therefore the likely scope for revenue to an operator. The upfront capital investment initially borne by the financier and low returns on investment are likely to limit the appeal to private sector providers in places.
- **Requires clustered demand for EVCPs** – in order to spread the costs of installation and ensure sufficient usage, 3 resident applications are required. For this to work the applicants would need to live in reasonable proximity to each other, so they each feel it is convenient and merits the high investment costs. As such this is perhaps an option more suited to Central/inner London hotspots, at least until the cost of EVCPs comes down.
- **Political acceptability** – there is a risk that the bays would be perceived as being effectively for private use by individuals, which in an area of high parking stress would be controversial, and potentially seen as elitist. The Westminster model's approach neatly overcomes this to an extent by requiring that the point be shared by 3 users. In practice this is likely to be more than adequate for the users, for whom charging twice a week is likely to provide them all the charge they need for the short average trip lengths common to London. Then the remainder of the time they must find a resident's parking space like everyone else.
- **High upfront user costs** may dissuade mainstream cost conscious adopters, particularly as availability cannot be

guaranteed. As the points are on the public highway, even as EV only bays, paired with residents only permit zone restrictions, if a 4th resident within that permit zone chose to buy an EV, in principle they could also use the EVCP paid for by the 3 initial applicants. One approach might be to enable residents to reserve the bays for particular time slots, to allow for each of the 3 vehicles to charge overnight at least twice a week.

- **Borough resources and willing** – the appetite amongst Borough teams to forge a new series of agreements with providers, develop the necessary planning policy and oversee the network may be limited in places, with resource constraints and fatigue after the challenges of the Source London process.
- **Interoperability and legibility with Source London** – signing will need to be clear that they are residents only EVCPs and not for general use.

## 4.3 Socket Networks (taking supply from existing street furniture)

4.3.1 An innovative solution which enables users to plug into existing electrical infrastructure, such as streetlights via a simple socket using an 'intelligent charging cable'.

***Figure 12 Ubitricity 'Streetlight Socket'***


4.3.2 The sockets themselves are simple and low cost, but importantly are configured so as to remain inert until activated by a registered intelligent charging cable.

4.3.3 The intelligent charging cable includes a meter and communication device, and works by signalling to data control centres, and requesting authorisation to unlock the charge spot. It then transmits data on usage to the energy provider directly, which feeds into monthly billing, itemised like a phone bill, but instead reporting charge point serial numbers and locations.

*Figure 13 Ubitricity 'Intelligent Charging Cable'*

4.3.4 If the signal is poor the user can access charge points a limited number of times using 'offline authorisation', before the cable would then be locked and need to be reconnected, at which point it would transmit usage not already communicated. Ubitricity only envisaged this happening if a cable was kept in a locker in an underground car park for example, or in a very remote rural area, and advised is was not a significant problem they had encountered in their trials to date.

4.3.5 A key attraction of a 'socket network' model is the greatly reduced capital cost. The socket devices cost around $600 (£389[16]) each, around 90% lower than conventional on-street charge points. The cost savings are achieved by removing the metering technology from the charge points themselves, and instead integrating it within the charging cable carried by the user, avoiding the need to replicate it within each point

4.3.6 The socket network model is based on providing a 'trickle charge' – a low power AC single phase connection at 3kw per hour rate.

4.3.7 Ubitricity advised that in principle it would be achievable to have a charging socket on every streetlight, as they can regulate how much power is put through each via a central management room. One approach being considered is to offer users either a flexible tariff, which is cheaper and when necessary provides lower charging levels, alongside a premium rate service for users who require a faster or fuller charge.

Ubitricity Business Model

4.3.8 Ubitricity see the intelligent charging cable as a means of maximising the opportunities to charge. The low cost of the sockets and comparatively low demands on the grid mean in principle the sockets can be rolled out widely, and reach where drivers already park.

4.3.9 By relaying back to the host electricity supplier how much charge has been drawn, and facilitating payment directly to the DNO, so that the host is effectively cut out of the loop, and won't be charged for the additional electricity drawn, or have to process any billing arrangements the Ubitricity model greatly simplifies the process as a business model, and significantly reduces the functionality required of the host charge point.

4.3.10 Their initial proposition was that the intelligent charging cable meter was built into the vehicle, rather than incorporated within the cable. However whilst vehicle manufacturers apparently liked the concept, they were not willing to add further cost and commit to a particular charging protocol whilst so much uncertainly remained, but could be readily adopted as the industry matures.

[16] *As of 17th February 2015*

Streetlight Requirements

4.3.11 Ubitricity suggested that 1-2% of streetlights in Berlin could be immediately converted for charging with the addition of socket – it was explained that reasons for posts not being suitable are typically:

- **Positioning** – some are on the wrong side of the footway
- **Single Switchability**- in some cases streetlights are powered through a parallel connection to the main grid, which is centrally controlled and only powered up over-night when the lights are in use.
- **Column dimensions** – the column needs to be large enough to accommodate the socket and case – current models require posts inner diameter to be at least 140mm.

4.3.12 According to Ubitricity, of these factors the most significant is single Switchability, as this can apply to entire blocks or city regions, though if necessary streetlights could still be refitted to connect a steering device and socket more cost effectively than a conventional EVCPs.

4.3.13 Further to these factors, WSP|Parsons Brinckerhoff's in-house streetlight experts advised that whether the streetlight is STAT fed (part of the DNO mains) or private network fed would also have a significant bearing.

4.3.14 In the case of STAT fed networks, the mains connection and sub-station would typically have more than enough capacity to enable sockets to be added, and provide the trickle charge power required for a number of posts. Private network fed streetlights can be more problematic, and may include less robust cabling and sub-station connections, which may necessitate digging up and relaying long expanses of cables, or upgrading substations, to deliver the minimum acceptable 2.5-3kw charge.

Access to Streetlights – requirements for parking restrictions

4.3.15 The longer term model for a socket and intelligent charging based model would, as Ubitricity see it, be to install sockets en-masse so they were readily available where people already park, and so lessen the need for restrictive parking practices. But initially where the density of sockets is low, at least some bays would need to be designated as EV charging only bays, as is the case in the Berlin trial.

Interoperability with other charging networks

4.3.16 There has been a mixed reaction to Ubitricity model from rival EVCP networks in Germany, with some seeing them as a threat. Though they are working with some EVCP networks to ensure billing can be aggregated so users receive a single monthly bill. The intelligent charging cable can also 'remain silent' and be used for non-Ubitricity EVCPs.

Security Issues/ Risk of Black Market Charging Cables

4.3.17 Ubitricity had not encountered any issues in terms of charging cables being stolen or replicated, and advised the cables could be deactivated if reported stolen, much a like a mobile phone or bank card. They felt it would be very difficult for the cables to replicated, and also advised sockets had very little in-built intelligence,

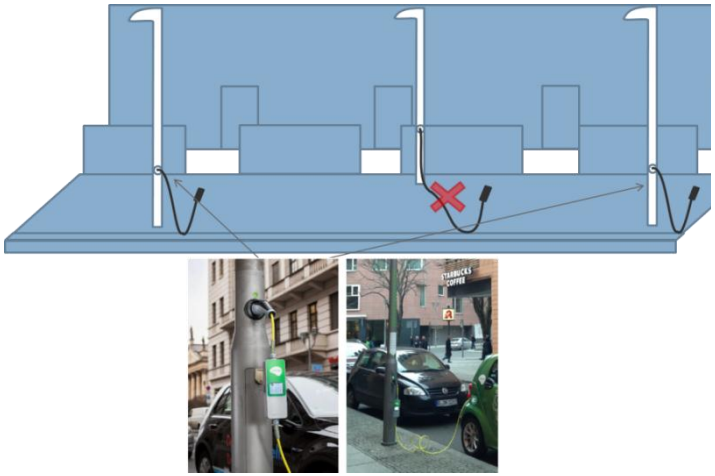
but could only be unlocked by their cables – and were patented at an EU level and not easy to replicate.

Socket Deployment

4.3.18 The sockets are highly versatile and could be deployed to provide on-street charging in a variety of formats, including, as illustrated in the figures below.

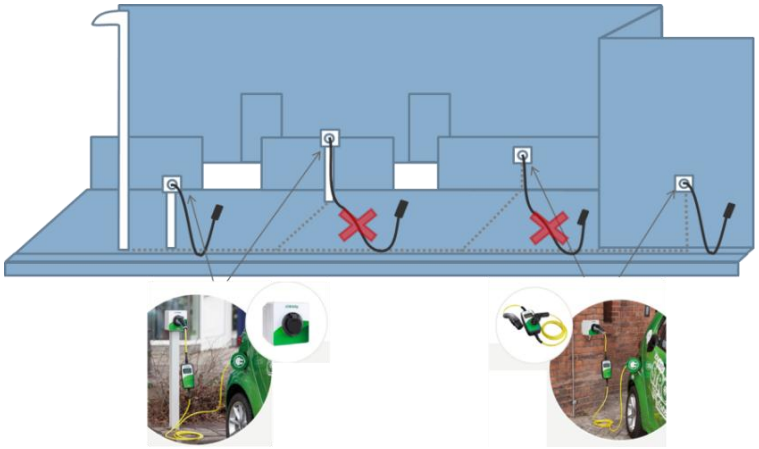
4.3.19 Figure 14 demonstrates the **streetlight based socket**, but highlights that a critical factor would be where the lamp column itself is located on the street. A lamp column set back from the kerb would result in the cable trailing across the public footway and present a trip hazard.

***Figure 14 Streetlight Sockets***



4.3.20 Figure 15 demonstrates how the sockets might otherwise be mounted, either on masts, or wall-mounted. As with the street lights these would need to be kerbside, rather than set back on the footway to avoid the trailing cable presenting a trip hazard.

***Figure 15 Sockets on masts or wall-mounted***

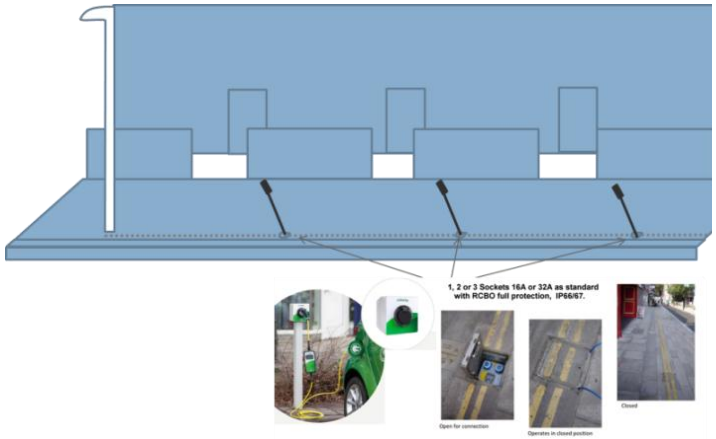


4.3.21 The approaches set out above are based on the trials currently underway in Berlin and Munich. A number of different approaches have also been considered to explore how best the technology might be exploited in a London specific context.

4.3.22 One such approach is illustrated in Figure 16, which proposes housing the sockets in flip lid floor boxes set within the footway. There are already examples across London where electrical supply units are stored this way. In principle this would enable the sockets to have minimal impact on the streetscene, and be installed

immediately adjacent to the kerbside to minimise the distance of the trailing cables.

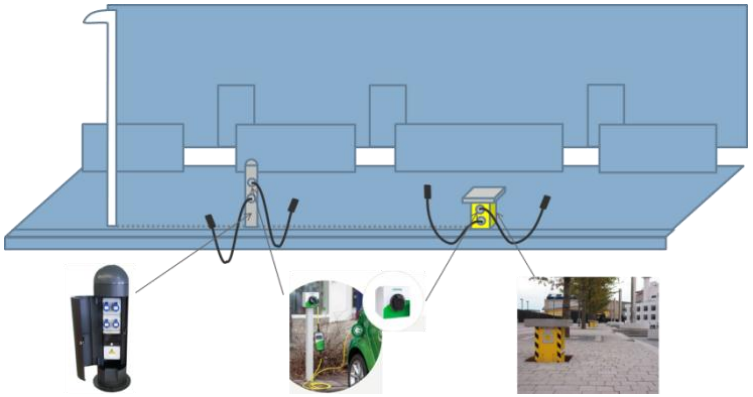
*Figure 16 Sockets housed in flip-lid floor boxes (Crouchers)*




4.3.23 This approach would though require an access key to unlock the flip lid to be made available to the public, and whilst they can often be purchased freely at hardware stores, are not commonly possessed.

4.3.24 It would also entail the user bending down to floor level, which may be uncomfortable or undesirable to some. There is also a risk that the lid might be left open by the user, and present a trip hazard, or risk a vehicle parking on the kerbside and dipping a tyre in it. This is no different to the risk posed by utilities companies reading water meters etc., but would be the general public rather than an individual operating under the auspices of an approved organisation.

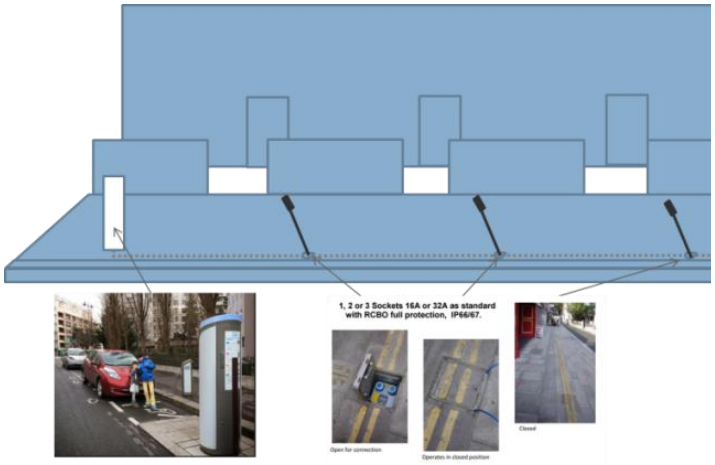
*Figure 17 Sockets housed in bollards or pop-up power units*



4.3.25 A further means of deploying the sockets would be to utilise bollards or pop-up power units, such as those shown in the figure above. These would add significantly to the cost of the socket though, and may pose limitations on where they could be installed, as greater depth is required, but may be appropriate in particularly sensitive locations.

4.3.26 In principle a further option might also be for an equivalent of the floor boxes approach to be paired with a single charge point access hub – see Figure 18.

*Figure 18 Local Hub Unit and Sockets housed in flip-lid floor boxes (Crouchers)*




4.3.27 The Paris Autolib features charge points clustered around hub points, which effectively serve as points at which to hire out vehicles on the adjacent cluster of charge points. In theory a single intelligent charge point communications meter and user interface, could then serve string of linked sockets or points concealed in flip lid floor boxes or alike along a street. The hub interfaces might then be distributed at the frequency of parking meters, conveniently nearby and visible, but not unnecessarily duplicating infrastructure.

**Pros**

- **Innovative and low cost solution**, around 10% the cost of conventional points.
- **Versatile** – scope to be installed in a wide range of settings and formats, and suitable for up scaling as demand increases, being low cost low impact on the streetscene. They also enable third party sites, such as employer car parks and secured public car parks to provide a charging facility, with minimal installation requirements and payment handled by their existing energy supplier.
- **Simple payment model means** the user is connected directly to DNO, streamlining the business model and removing the need for an intermediary party to collect payments etc.
- **Car Clubs** could operate from sockets
- The low cost sockets and trickle charge model **potentially removes the need for EV only bays** as sockets proliferate.
- In the medium to longer term the intelligent charging cable technology **can be integrated into vehicles**.

**Cons**

- **Availability of suitable street furniture** (i.e. lamp columns), located at the kerbside, with suitable connections to enable vehicle charging. Only around 1-2% of streetlights in Berlin were estimated to be immediately usable, although in many instances the costs of installing a new lamppost or strengthening the electrical connection plus the socket are lower than a conventional EVCP.
- **Market Acceptance** is a critical factor. The Ubitricity technology is due to be launched as a commercial proposition later this year in Germany, but is currently still at the trial phase.

It will require acceptance from multiple stakeholders, including the DNOs, Boroughs, TfL and other charge point suppliers. It will also need to win the confidence of prospective hosts that all additional electricity costs are paid for by the EV user.

- **Trickle charging** entails a low power AC single phase connection, at 3kw per hour rate, or whatever charge is available after light the street lamp, normally to a minimum of 2.5kw per hour. Whilst in practice this adequate for most users requirements when used for overnight charging, for some users this might not be sufficient, or that may be their perception.
- **Accessibility** –initially at least it will be necessary to designate EV only charging bays where the sockets are provided. Unlike other EVCPs however they would only be accessible to users with the intelligent charging cable.
- **Technological risks** – Ubitricity are still a start-up, and new iterations of the sockets and cables are under continual development. Equally the technology has been developed for the German market, so may require further testing and development before launching in London, although a socket was recently installed in the London Borough of Hounslow's offices, the first in the UK.
- **Lessens scope for capturing future revenues** – the business model is such that payments for the electricity are made directly to the DNO, which potentially limits the scope to capture it as additional revenue for the Borough or Transport for London, although longer term there may be an option to charge a premium for access or use of EV enabled bays.
- **Sensitivities to replacing street lights** – if a streetlight was found to be unsuitable and there was no alternative nearby, it may be politically unacceptable to replace a column if it was in good working order or had only recently been installed. Also in some places Boroughs have entered into long term PFI arrangements, which may complicate the process.
- **Concern amongst street light operatives** – street lighting teams are naturally concerned about any risks to lighting provision, and can be resistant to proposals which require holes to be drilled in the columns, and risk weakening their structural integrity.
- **Some sub-options require the public to open lids in footways** to reach sockets, which presents a risk that covers could be left open and present a trip hazard or damage parking vehicles.
- **Users must own an intelligent charging cable**, which cost around £400, though they are also compatible with conventional EVCP posts.
- **EDF are a stakeholder** in the company, which could lead to conflicts of interest with other DNOs.
- **Interoperability and legibility** – the network would need to work alongside Source London to avoid creating a confusing charging environment, though the intelligent charging cable can 'remain silent' and be used for non-Ubitricity EVCPs.

## 4.4 On-street charging near home – cable charging from home: Secured Matting

4.4.1 A low tech and cost effective solution would be to permit residents to trail cables from a home charging unit and over the public footway to their vehicle, covered by safe and secured rubber matting.

4.4.2 Secured matting is regularly used in public spaces and areas of high footfall to cover wires on a temporary/semi-permanent basis.

4.4.3 It would need to be textured to provide grip in wet conditions, waterproof, and brightly coloured to alert partially sighted people to its presence. It would also need to strong enough to bear vehicle loads should they mount the footway to park, but matting is available which meets this specification.

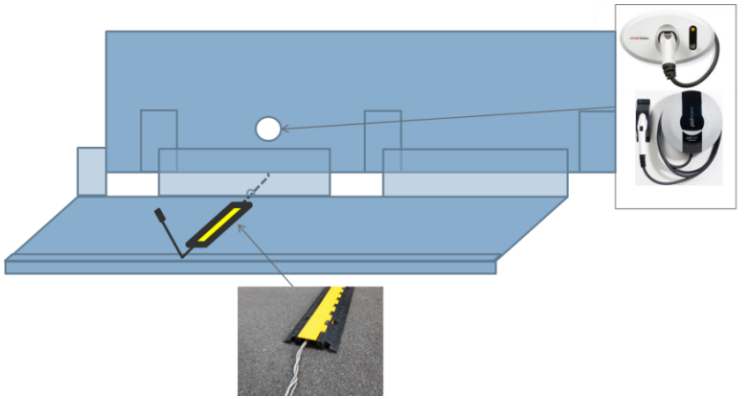
4.4.4 The matting could be bespoke to cover the full extent of the exposed wire, with a lockable portal at the kerb-end out of which the cable exits.

4.4.5 A bolt could be drilled into the kerb to enable the matting to be secured overnight.

Council Liabilities and exposure to legal claims

4.4.6 There is no definitive legal view concerning the legalities of permitting trailing cables over the footway, and to what extent councils may retain liability, as legislation simply was not drafted with consideration to such a requirement in mind. As such there have been differing interpretations across the country, though many have adopted the position that they cannot formally endorse permitting trailing cables as a policy.

***Figure 19 Secured Matting over trailing cables from a wall mounted domestic charger***



4.4.7 In terms of footway maintenance and Council responsibilities, our in-house pavement experts advised that the '**Network Maintenance Manual**' is what typically governs standards by which public footways should be maintained. **Section 3.2.3** of the manual notes that:

*"Defects on footways and cycle tracks affect safety, maintenance and serviceability. Compensation claims may result from defects that have not been repaired. Therefore, a pro-active rather than a re-active approach is needed, to identify defects before they become hazardous.*

*Conditions that are likely to prevent the achievement of the performance requirements include: steps/ridges on footways that are unacceptable.( over 20mm) or Ramps/Edges are too steep 1:10."*

4.4.8 So any matting would need to be no taller than 20mm and should have tapered edges down to about 5mm – which is achievable to carry standard charging cables.

4.4.9 10 Amp EV cables are 2mm in diameter, 32 Amp EV cables are 5mm in diameter, so both should fit within 20mm tall matting.

***Figure 20 Example of commonly available heavy duty safety matting for electrical cables***

4.4.10 This is seconded by a review of a personal injury solicitors advice[17] on what constitute grounds for a claim, which suggests the threshold for what constitutes a trip hazard in terms of pavement defects is 1 inch (25.4mm);

*"When making a compensation claim against the council for a pavement trip, the defect that has caused the accident must be at least 1inch. For example, if you have tripped due to a raised paving slab, the raised area must at least 1inch above the normal level of the pavement. If you have tripped due to a pot hole on the pavement, the pot hole must be at least 1 inch deep. Although a defect which is less than 1inch can cause accidents which result in significant injuries, it is very unlikely you would be able to make a successful pavement trip compensation claim. Cases have been considered by judges but have been unsuccessful, with one judge stating that "a pavement is not to be judged by the standards of a bowling green".*

4.4.11 The personal injury solicitors also note that:

*"Under section 58 of the Highways Act 1980 the council may have a defence to a pavement accident claim if they can prove they have a good system in place to inspect the pavement that has caused the accident, and they have carried out these inspections on a regular basis. A personal injury solicitor would look to challenge this defence on the basis that the system put in place by the local authority is either inadequate or has not been enforced properly."*

4.4.12 **The Highways Act 1980 and the New Roads and Street Works Act 1991** applies in pedestrian areas and roads, and sets out certain procedures which need to be followed and precautions which need to be taken, concern for example the lighting of scaffolds and waste skips, reinstatement of footpaths etc.

4.4.13 This legislation emphasises the need to take account of vulnerable groups. It is important to seek advice from the local authority.

4.4.14 Other relevant guidance includes '**Health & Safety Executive (HSE) Protecting the public - Your next move - Slips, trips and falls within pedestrian areas'**

*Section 65.) "Slips, trips and falls are a frequent source of injury to members of the public. Inadequate*

[17] http://www.councilclaims.co.uk/pavement-trip-compensation-claim/

*protection of holes, uneven surfaces, poor reinstatement, trailing leads and cables, spillage of oils, gravel etc are just some of the causes.*

*Section 66.) "The risks can be reduced in the following ways: avoid trailing cables (especially on stairways). Cover or fix any which need to cross pedestrian areas;*

*Section 83.) "Vulnerable groups such as the elderly, children and people with certain disabilities may need special attention. The disabled are especially at risk where construction work affects pedestrian routes, e.g. TV cable installation or scaffold erection on pavements. It is therefore important to; identify whether your work will affect a route which is regularly used by people with disabilities, do wheelchair users pass frequently, could blind or partially sighted people be at risk?*

4.4.15 One of the most notable pieces of legislation however is the **London Local Authorities and TfL Act 2013: Chapter 5. Section 5**, which enables London authorities to provide and operate charging apparatus for electrically powered motor vehicles on highways.[18]

4.4.16 The amendment primarily seeks to deliver the powers to provide "charging apparatus on highways for which they are responsible as highway authority". Under the clause the London authority may also grant other persons permission to provide or operate charging apparatus. The clause applies section 115D of the Highways Act 1980 which otherwise restricts these powers.

*(2) A London authority may grant a person permission to provide or operate charging apparatus for electrically powered motor vehicles— .*

*(b )on any highway for which they are responsible as highway authority.*

4.4.17 There are also provisions about liability in respect of injury:

*Nothing in this section— .*

*(a)is to be taken as authorising the creation of a nuisance or of a danger to users of a highway or a public off-street car park; or .*

*(b)(in relation to permissions granted under subsection (2)) is to be taken as imposing on a London authority by whom a permission has been granted any liability for injury, damage or loss resulting from the presence on a highway or public off-street car park of the charging apparatus to which the permission relates; or .*

*(c)is to be taken as imposing on a London authority any liability for injury, damage or loss resulting from the presence on a highway or public offstreet car park of a connecting cable; or .*

*(d)shall prejudice the right of a London authority to require an indemnity against any claim in respect of injury, damage or loss arising out of the grant of a permission granted under subsection (2),*

*but paragraph (d) is not to be taken as requiring any person to indemnify a London authority against any*

[18] *http://www.parliament.the-stationery-office.co.uk/pa/privbill/0708/017/017.pdf*

*claim in respect of injury, damage or loss which is attributable to the negligence of the London authority.*

4.4.18 Our reading of these provisions is that they are stating that Boroughs would not be open to liability claims for injuries associated with the charging apparatus on a highway which has been permitted by the Borough.

4.4.19 Significantly the next section goes onto place liabilities for injuries etc. on the person in charge of the EV.

*(8) For the purposes of determining, in any proceedings in a court of civiljurisdiction, who is liable for injury, damage or loss resulting from the presence on a highway or public off-street car park of a connecting cable at or near charging apparatus provided under this section, it shall be presumed that the person in charge of the relevant vehicle at the relevant time had responsibility for and control of the cable. .*

*(9)In subsection (8)— .*

*"the relevant vehicle" means the vehicle in respect of which the connecting cable was about to be, was being or had been used for charging;*

*"the relevant time" means the time when the liability arose.*

*(10)This section is without prejudice to section 162 of the 1980 Act (penalty for placing rope, etc. across highway). .*

*(11)In this section— .*

*"charging apparatus" includes any fixed equipment but excludes any connecting cable or wire which is not provided by the authority;*

*"connecting cable" means any cable or wire, whether provided by the authority or otherwise, used to connect the charging apparatus to a vehicle and that is not permanently attached to the charging apparatus;*

*"local Act walkway" and "walkway consent" have the same meanings as in section 115A of the 1980 Act;*

*"operate" in relation to charging apparatus for electronically powered motor vehicles includes supply or sell electricity by means of such charging apparatus;*

*"public off-street carpark" means a place, whether above or below ground and whether or not consisting of or including buildings, where off-street parking accommodation is made available to the public, whether or not for payment.*

4.4.20 Subsection 10 is notable as it reinforces that the clause which many have previously interpreted as being problematic to allowing EV users trail cables (**section 162 of the 1980 Highways Act**) is still valid (see below), though the legislation for the most part appears to provide adequate cover.

*162 Penalty for placing rope, etc. across highway.- A person who for any purpose places any rope, wire or other apparatus across a highway in such a manner as to be likely to cause danger to persons using the highway is, unless he proves that he had taken all necessary means to give adequate*

*warning of the danger, guilty of an offence and liable to a fine not exceeding [F1level 3 on the standard scale*

4.4.21 There does however appear to be some ambiguity over whether the amendment would cover trailing cables from charging points on residential premises (i.e. off the highway).

4.4.22 Whilst it is unlikely the intention of the amendment was to exclude this, what the wording covers specifically is to empower Boroughs and TfL to permit charge points to be installed on their public highways and off-street public car parks, removing any liabilities for injuries etc. related to the charging cables connected to those points.

4.4.23 As such it does not appear to explicitly remove, nor place, the liabilities associated with trailing cables from charge points beyond the public highway, with the Local Authority.

4.4.24 Our review of the various pieces of legislation, acts and guidance otherwise indicates that, for the most part, widely available external cable protectors should be adequate to conform to the recommendations stipulated.

Public Access to Reduced Liability Cover

4.4.25 A potential issue with the London Local Authorities and TfL 2013 Act placing all liabilities for trips, injuries etc. caused by charge point cables with the EV users, is that they may find themselves liable for significant costs, which would ordinarily be covered for Local Authorities by their public liability cover. As such it may be necessary, where trailing cables from domestic charge points, to enable the user to access public liability cover at a reduced rate, to cover them using home charging with the appropriate secured matting. We are not aware of any precedent for this however.

International Precedents

4.4.26 Elsewhere there are precedents for authorities formally permitting trailing cables, most notably in many of Dutch municipalities around Amsterdam.[19]

**Pros**

- **Low cost, low tech solution** which is readily deliverable
- **Enables payment to be captured domestically** through the use of their own domestic charge point.
- **Safe and durable matting is already available** and tested. Bespoke designs could also be specified if required, including a lockable portal at kerb-end. Matting could also be secured to the footway using a bolt in the kerb

**Cons**

- **Health and Safety risks** – the cable presents a trip hazard, and whilst secured matting is regularly used in public spaces and areas of high footfall to cover wires on a temporary basis, more routine long term applications are

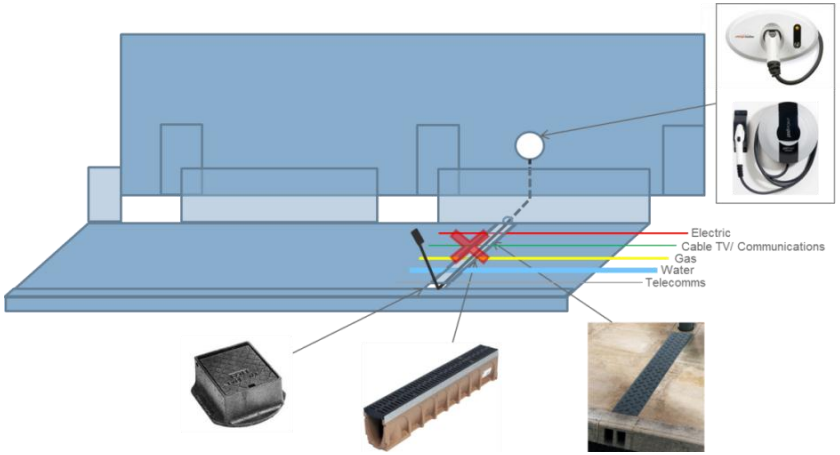
[19] *Introducing E-Mobility: Emergent Strategies for an Emergent Technology, e-mobility NSR (July 2014)*

not common, so represent something of an unknown.

- **Council liabilities and exposure to legal claims** - without an explicitly worded revision to priory legislation to remove any possible Local Authority of liabilities, the risk of prosecution remains. The London Local Authorities and TfL Act 2013: Chapter 5. Section 5 goes a long way towards alleviating Boroughs and TfL, and placing the liabilities on the individual EV user, but only specifically for charge points on public highways or off-street car parks.
- Potential **requirement for users to hold public liability cover** – were the wording amended or clarified as described above, and the liabilities definitively placed on the user, they may wish to take out public liability cover. This may prove hard to obtain or prohibitively expensive. One solution might be for users to be permitted to access at a discounted rate the Local Authorities own public liability cover.
- **Accessibility** is dependent on access to a bay immediately outside their home and within reach of the charging cable. In areas of parking stress this may prove challenging, and may necessitate providing an EV only charging bay, which can prove contentious. Also demarcating the bay as EV only would still not guarantee the specific user would have access as other EV users would be entitled to park there, although in this scenario there would not be a charging a facility available to them.
- **Politically sensitive** - There is a risk that the bays would be perceived as being effectively for private use by individuals, which in an area of high parking stress would be controversial, and potentially seen as elitist.
- **Aesthetic concerns** - matting outside every home on a street would present aesthetic concerns for their impact on the streetscene. They must be bright and standout by necessity to warm people of a potential trip hazard.

## 4.5 On-street charging near home – cable charging from home: Duct-and-Chamber

*Figure 21 Duct and chamber for trailing cables from a wall mounted domestic charger*




4.5.1 An alternative to approach to trailing a cable from a residents home charging unit and over the public footway, might be to enable them to pay for a duct and chamber to be installed in the footway, so the cable can be safely stowed away.

4.5.2 A lockable cover at the kerbside could be used to access the charger and reach to the EV.

**Pros**

- **Low cost, low tech solution** – approximately £350-400 per installation.
- **Cabling and trip hazards are largely removed**
- **Readily deliverable** – in principle they could be installed on a request basis much like a dropped kerb, whereby the residents covers the costs.
- **Enables payment to be captured domestically** through the residents on domestic charging unit and electricity provider.
- **Bespoke design could be specified**, including lockable flap at kerb-end and a non-slip finish, many parts to a very similar specification are already available.

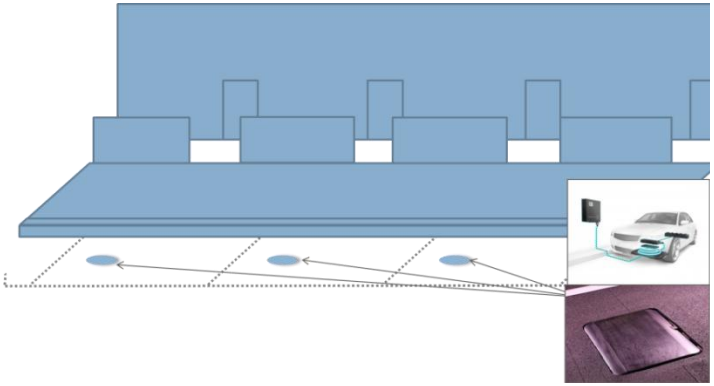
**Cons**

- **Access to utilities and services** – WSP| Parsons Brinckerhoff's in-house paving specialist's highlighted difficulties with duct and chambers which have to cross the footway at 90 degrees, as this means it will potentially obstruct access to the multitude of services running parallel to the carriageway. As such it is likely the chamber would need to be disturbed by utilities providers who require access, which can be as frequently as on an annual basis. This would probably entail a section of the chamber being dug up, and so require re-instatement at additional expense, either to the resident or the Council. The potential requirement for the chamber to be removed and reinstated on a frequent basis may also present difficulties to the resident if they were entirely reliant on charging via this approach, as they would then be subject to the streetworks teams timescales for reinstating the chamber.
- **Accessibility is dependent on access to a specific bay**, immediately outside their home, so the cable can reach. In areas of parking stress this may prove challenging, and may necessitate an EV only charging bay, which can prove contentious. Also, demarcating the bay as EV only would still not guarantee the specific user would have access as other EV users would be entitled to park there, although in this scenario there would not be charging a facility available to them.
- **Politically sensitive** - There is a risk that the bays would be perceived as being effectively for private use by individuals, which in an area of high parking stress would be controversial, and potentially seen as elitist.
- **Maintenance liabilities** – there is a risk that Councils would be required to maintain each of the ducts and chambers as part of routine maintenance. They may also find they have to take on back office roles, such as providing keys and replacement keys for the lockable covers.
- **Drainage** also needs to be considered

- **Some of the sub-options require the public to be able open lids in footways** to reach sockets, which presents a risk that covers could be left open and present a trip hazard or damage parking vehicles.

## 4.6 On-street charging near home – alternative technologies - Inductive Charging

*Figure 22 Inductive Charging Pads*



4.6.1 In principle inductive charging represents a very attractive charging solution, as it removes the risks and limitations posed by cabling.

4.6.2 The wireless system uses the principle of electromagnetic induction. A magnetic field generated by an alternating current in a primary coil (the charging pad) induces a current in a nearby secondary coil (the EV).

4.6.3 The charging pads can be embedded within parking bays, and could potentially be supplied and installed on an on-demand basis with contributions from residents, in a similar model to those described for parallel networks.

**Pros**

- **Minimises street scene impacts** – relative to conventional charging posts, or in terms of the aesthetic impact of trailing cables.
- **Removes trip hazards** – no cables, whereas even charge points immediately adjacent to the kerb still entail trailing cables over a short distance to the vehicle.
- **Utmost convenience to drivers**, no cable to plug in, or risk of not having the correct plug format for the socket.
- **Appeals to car club operator's** not to have any charging cables, can go missing or be used incorrectly, and generally present 'a friction' to prospective users.

**Cons**

- **Standardisation and interoperability** - Bespoke kit is required for each vehicle type, which does not come as standard on vehicles, meaning in the short to medium term the prospects of the technology to operate as part of a communal charging network are limited. Further standardisation of the positioning of the inductive coils across all the different vehicle types is required.
- **Timescales** - Unlikely to be viable solution in the short to medium term

- **Disruptive installation and maintenance** - Installing inductive charging points directly into the carriageway introduces added complications in terms of road works and lane closures
- **Reduced charging efficiency** - Some energy-transfer efficiency losses through inductive charging versus cable based charging.

## 4.7 Portable Chargers

4.7.1 With the introduction of energy storage solutions in a number of alternative energy projects, it is possible to consider electricity being delivered from a storage vehicle. There are already products designed and marketed for roadside recovery services, so it is possible to rescue a stranded EV driver.

4.7.2 Larger dedicated vehicles with greater than 100kWh capacity could provide a call out service to attend resident's vehicles and top up their charge overnight.

4.7.3 Web based booking facility and rapid charging technology could make charging available without the addition of any further street furniture, or the issues with parking discussed elsewhere in this report.

**Pros**

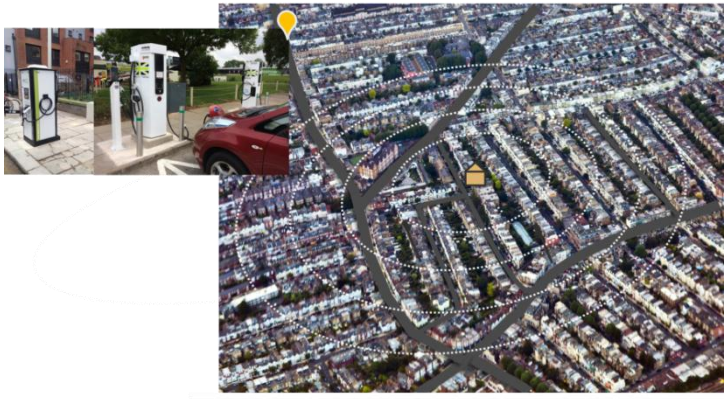
- **No street scene impacts** – no permanent features.
- **No location restriction** – charger comes to the vehicle.
- **Convenience to drivers** – equivalent of a valet service.

**Cons**

- **Capacity** – battery storage would be constrained by weight and volume.
- **Parking –** Although the vehicles can be parked anywhere, the service vehicle delivering the charge would be present an additional obstruction on the highway, if it cannot be parked kerbside.
- **Noise** – the regular delivery of this service overnight would potentially be a nuisance in residential areas.

## 4.8 On-street charging within a reasonable distance of home – Rapid Charge Stations

*Figure 23 Rapid chargers*



4.8.1 In principle Rapid Chargers could be installed to a similar format to that of petrol stations, on the basis that their recharging times are closer to those of ICEs (~20 minutes for 80%) than conventional EVCPs.

4.8.2 This model might be one option for homes which are not able to accommodate any form of on-street or domestic charger, particularly if they were paired with supermarkets or other amenities, so users could tie in routine trips to a rapid charger with other errands.

**Pros**

- **Convenience of more rapid charging appeals to many** - and perhaps increasingly so as uptake shifts from early adopters to the mass market, where users expectations are for less compromises relative to conventional vehicles, whether or not in practice they actually require rapid charging.
- **Lower density of points** – such a model could afford to be more selective on where infrastructure is located in some respects, as with petrol stations, because they're not limited to being within walking distance of an applicant's home, and could therefore be either on or off-street.
- **Readily deliverable** technology
- **Familiar refuelling behaviours** - the format is similar to how petrol stations are used in some respects, which may appeal to less ardent prospective EV buyers.
- **Remote charging could be integrated into other routines**, food shopping etc. For the majority of users in London a full charge 2-3 times a week would be sufficient.
- **Supports Car Clubs –** where rapid charging is more necessary, as in principle the vehicles will be in more constant use throughout the day. Floating car clubs in particular would benefit, where users are incentivised to return vehicles charged.
- **Part of a wider network role** – as well as potentially satisfying resident use, a rapid charging station network would also function as part of a wider charging infrastructure for non-residents.

**Cons**

- **Inconvenient to charge away from home** – whilst 20-30 minutes is significantly faster than conventional charging, it would still undeniably present some degree of inconvenience. It may not always be possible to build it into a routine stop, at for instance a super market or coffee shop, and at times would probably have to be a functional stop.
- **Availability** – Unlike petrol stations, with which many analogies can be drawn, an EV user couldn't necessarily expect to stop in on their way home and quickly recharge whilst doing shopping, without having booked specific slot in advance. For example if the user is running late and missed their pre-booked slot, they may have to wait 40 minutes or longer for the next. So they are less flexible than petrol stations in this respect.

- **Cost of rapid chargers** - Approximately £45,000 per unit, entails significant funding support.
- **Damaging to battery performance** - Regular use can prematurely shorten battery storage capacity.
- **Not all vehicles support Rapid Charge**

## 4.9 On-street charging within a reasonable distance of home – Battery Swap

4.9.1 Battery swap technology attracted a lot of attention and investment earlier in the 2010s, with BetterPlace investing significant sums launching trial networks in a handful of countries globally. However the operation filed for bankruptcy in 2013, and at that time the prospects for the technology looked more bleak.

*Figure 24 Battery Swap Stations*


4.9.2 Tesla recently (March 2015) appeared to revive the approach though, as they announced that they are continuing to investigate and develop this technology, with a view to incorporating it within its future models. So it appears there may be some future for the technology after all.

4.9.3 Battery swap technologies entail shortcutting the process of recharging the vehicles battery by simply removing it and replacing it with a fully charged replacement.

4.9.4 In principle this approach compares favourably with conventional ICE refuelling in terms of time to complete, unlike conventional charging or even rapid charging. They would likely operate on a similar type of distribution pattern and frequency to petrol stations.

**Pros**

- **Comparable recharging time to ICE refuelling**
- **Lower density of points, can be more selective on location** (though require relatively large off-street sites)
- **Format similar to Petrol stations**, familiar behaviour
- **Part of a wider network role**

**Cons**

- **Standardisation and interoperability** - to represent a mass market charging solution, a significant proportion of EV models will need to

be compatible with the battery swap mechanisms for a network to develop

- **Timescales** - Unlikely to be viable solution in the short to medium term
- **Cost of battery swap stations** – rumoured to be anything up to £750k to £1m, which clearly presents a significant obstacle to establishing a comprehensive network.
- **Commercial Models** - Requires a battery leasing type model and the necessary agreements amongst manufacturers and traders. The battery units represent very high value items, so necessitate strong assurances of technical effectiveness to ensure the EV is not left immobile.

### 4.10 Seek alternatives to on-street charging outside houses – Dropped Kerbs, Shared Parking Apps, 3rd Party Sites, Shared Use of Loading Bays

4.10.1 There are a number of alternative charging options, beyond the provision of on-street charge points as part of a wider communal network, which may in some cases be the most appropriate solution for a given user type and location.

4.10.2 In some circumstances it may be possible for the applicant to have a **dropped kerb** installed and simply create an off-street space, within the boundaries of their property, and therefore charge via a domestic charger (Figure 20).

4.10.3 It may also be possible to make more efficient use of existing off-street parking capacity, or **permit the shared use of on-street bays** dedicated for other uses (such as Loading Bays), where they have EVCPs and are predominantly used during working hours (also Figure 20).

***Figure 25 Dropped Kerb with driveway and domestic charger, Shared use Loading Bay and overnight EV only parking bay***

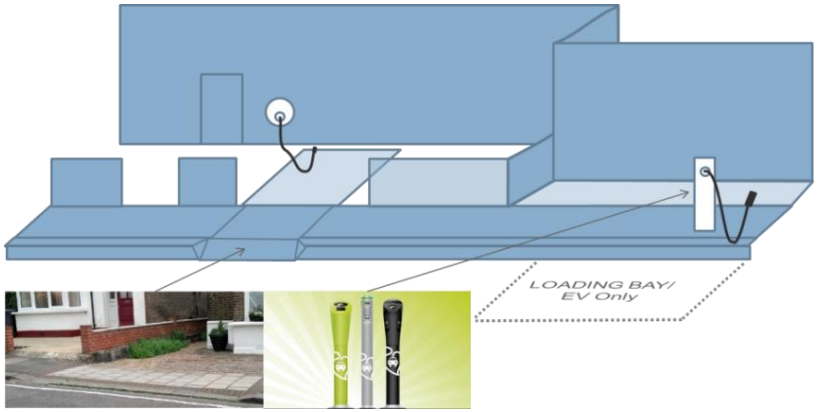
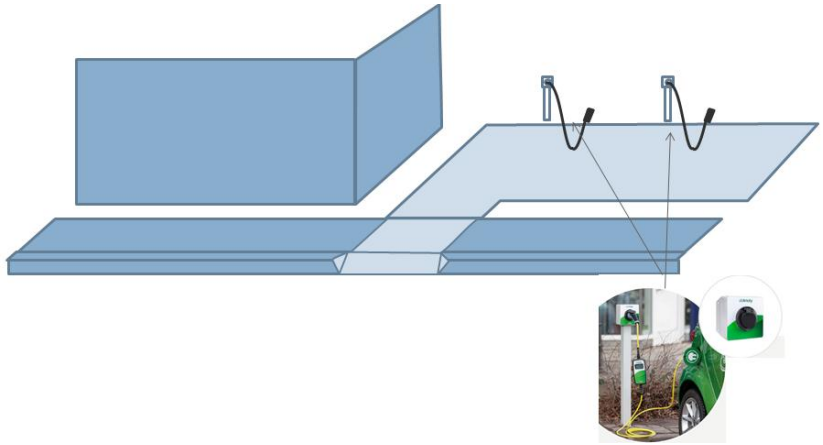



***Figure 26 Off-street parking with sockets mounted on posts***



4.10.4 Such an approach would reflect the rapidly evolving changing urban mobility landscape in London, where car ownership is becoming less common, with an increasing role for car clubs and car sharing. A feature of which is the use of increasingly sophisticated social media, websites and apps, as platforms to put drivers in touch with bespoke travel solutions, and redistribute underutilised parking supply amongst unfulfilled parking demand.

4.10.5 One such model are **Shared Parking Apps** (such as JustPark, formerly Park-at-my-House), which already includes a number of off-street bays at private homes with charge points.

4.10.6 Elsewhere there are already examples of **other third party sites** (businesses, councils, hospitals etc.), opening up their parking spaces for use by non-staff/visitors outside operating hours (Figure 21), providing additional revenue streams to the third parties, making better use of charging infrastructure, and in-effect increasing parking supply. In such circumstances the bays are usually let out on a subscription basis or operated as publicly accessible facilities.

**Pros**

- **Low cost option** – as in principle the charging infrastructure could potentially be more basic, i.e. either a domestic charger via a dropped kerb or Shared Parking Apps, or an Ubitricity type socket network model within a workplace car park.
- **Maximises efficient use of existing parking capacity**
- **Payment and administration can also be managed through Apps or Ubitricity type models**, minimising the burden on the "host".
- **Fits with rapidly evolving urban mobility landscape**
- **Deliverable** and already happening at a smaller scale
- **Dropped Kerbs enable straightforward domestic charging**

**Cons**

- **Limitations to the number of points provided** - limited to the number of suitable sites in proximity of a host site. Some Loading bays will not be suitable. Whilst most properties cannot accommodate new parking and dropped kerb. It is difficult to forecast the potential for these types of solutions, as they will be driven by the level of interest and awareness by both prospective hosts and users.
- **Dependencies on Third Parties and risk of access being removed** – if for instance a neighbour with a domestic charger had been a member of shared parking platform, but then moved away, the EV owner may be left with few alternatives. Additionally Boroughs would have no control over how much is charged, or on the quality of parking provision. Car Clubs would probably require formal contractual arrangements that EVCPs would be made available for at least certain duration.
- **Potentially increases parking supply and lessens scope to manage parking**

- **Detrimental impacts on loading bays** – which may require enforcement, if for example deliveries happen early and a resident charging overnight may result in them obstructing a delivery.
- **Issue with charging for electricity** - selling of electricity is tightly regulated, and cannot be billed explicitly, though there are work-arounds to this issue, such as charging at a flat rate premium for parking in an EV enabled bay, rather than for the electricity directly.
- **Accessibility** – in the case of third party sites, it clearly requires access to the car park outside of opening hours, which in many locations will present security risks and put off prospective hosts.

## 4.11 Long List Option Sifting

4.11.1 The long list options described in this section were assessed as part of an initial sift, based on their:

- Effectiveness as charging solutions, and their general suitability as part of the streetscene; and
- Deliverability, including whether they could be implemented at a sufficient scale in the short to medium term.

4.11.2 The shortlisted options are reported in Table 2 below.

4.11.3 It is important to note that there are some significant caveats associated with the option of trailing cables over a footway from a domestic charger, as described in this section.

4.11.4 However as part of discussions with stakeholders and the stakeholder workshop, we understand that although Boroughs are not specifically absolved of possible liabilities under existing legislation, some feel that the risk of successful prosecution remains very low, and in combination with the small numbers of residents likely to take up the option in the short to medium term, presents a negligible risk, and therefore should be considered as a possible charging option in places.

*Table 2 Long List Option Sifting*

| Option Types | Secondary Options or Characteristics | Effectiveness | Deliverability |
|---|---|---|---|
| **On-street charging near home - charging post** | A.) Commercially as part of IERs Source London Network | ✓ | ✓ |
| | B.) Parallel Network - Independent supplier and operator facilitated by Council or other 3rd Party | ✓ | ✓ |
| **On-street charging near home - taking supply from existing street furniture (i.e. Street lights)** | C.) Socket Network - Retro-fitting existing or replacement electrical street furniture – including Ubitricity, or Pop-up power / Power bollards | ✓ | ✓ |
| **Permit on-street charging near home – cable charging from home** | D.) Secured matting | ✓ | ✓ |
| | E.) Duct-and-chamber | X | ✓ |
| **On-street charging near home – alternative technologies** | F.) Inductive charging | ✓ | X |
| | G.) Portable chargers | X | X |
| **On-street charging within a reasonable distance of home – alternative technologies** | H.) Rapid Charger Stations | ✓ | ✓ |
| | I.) Battery swap | X | X |
| **Seek alternatives to on-street charging outside houses** | J.) Dropped Kerbs, Shared Parking Apps, nearby 3rd party sites (e.g. public or private car parks) and secure lease arrangements, night time use of business car parks, shared use with Loading Bays | ✓ | ✓ |

SECTION 5

# ANALYSIS OF SHORTLISTED OPTIONS

# 5 ANALYSIS OF SHORTLISTED OPTIONS

## 5.1 Approach to analysing shortlisted options

5.1.1 This section takes forward the shortlisted options identified through the long-list sifting process, and applies a further level of more detailed analysis and interrogation.

5.1.2 The section goes on to project our assessments for future scenarios, and the possible composition charging solutions for residents without off-street parking.

## 5.2 Case Studies

5.2.1 The analysis began by considering the shortlisted options within the context of four specific streets in London. The streets were selected to serve as generalised 'typographies' for generic types of street, including:

1) Terraced Street (Inner) – a narrow street with high parking demand, resident permit parking restrictions, and in a Conservation Area.
2) Semi Detached Street (Inner/Outer) – high vehicle ownership, some limited off-street parking, no parking restrictions.
3) Mixed land use Street (Central/Inner) – limited parking on-street, and some limited private parking off-street at businesses and retailers.
4) Flats/Apartments (Central) – near major attractors with no off-street parking, high parking demand, and resident permit parking restrictions.

5.2.2 The site visits took place on **Wednesday 3rd June 2015.**

5.2.3 Taking at random the specific house highlighted in each case study, we assessed in-situ the suitability and effectiveness of each of the shortlisted charging options, with the exception of the remote charging option (rapid charger stations), as these take place away from the resident's home.

5.2.4 This exercise provides a useful impression for how effectively the options might work in particular areas. These findings go on to inform the subsequent detailed options appraisal, and to what extent different options might represent part of the overall charging solutions mix.

## 1. Terraced Street - Middleton Road, Dalston

- Typical Inner London Victorian terraced street
- Very limited off-street parking throughout. At the time of our site visit (10.45am) bays were ~70% occupied along the full length of the street
- Densely inhabited and predominantly residential area
- Tube/overground stations within 10 minute walk.
- Resident permit holder's only parking restriction Monday to Friday, 8.30am-6.30pm.
- Designated conservation area.

**Source London** – the nearest Source London EVCP was approximately a 5-minute walk away, but at the time of writing was out of service. The next closest points were a 10-15-walk away, which may be too far for many prospective buyers to accept as their primary charging sources.

Notwithstanding some of the possible limitations to using Source points for residents charging described in the previous chapter (high usage costs and uncertain availability), the relative proximity of the nearest point makes this a credible option. In this instance the EVCP served two dedicated EV bays, and is next to a single car club bay.

As the area is predominantly residential, with few attractors in close proximity, it is unclear whether it would be a natural location for future EVCP bays to be installed however, so equivalent areas may be less likely to have a Source point as conveniently located.

**Parallel Networks** – the area might be conducive to such a model, whereby 3 residents each enter into an agreement for a fixed period to contribute to the installation costs. The density of homes improves the likelihood of prospective EV buyers living in close enough proximity for a mutually acceptable location to be found. An example of similarly funded infrastructure, an on-street cycle parking hanger, was evident nearby.

As a resident permit parking zone it would be easier to limit access to the privately funded, but otherwise publicly accessible EVCP, to residents within that permit holder zone, although the restrictions don't apply overnight.

The high levels of parking demand will pose challenges in identifying a suitable location though, and inevitably result in a loss of some standard bays. There was scope to accommodate a new bay in place of a build-out further down the street, but this would probably not be desirable for pedestrian safety, and would require the removal of a street tree.

**Socket Networks** – a streetlight is situated immediately opposite, on the kerb side, so would not entail trailing a cable across the footway. The lamp column dimensions also met with the minimum required diameter to install a socket.

In terms of access, unless sockets were readily available across the area, the level of parking utilisation would necessitate an EV only bay, which could perhaps be limited to an overnight only restriction. This would though result in the loss of some parking capacity for other residents so is likely to be unpopular.

**Secured matting and trailing cables** – notwithstanding the issues highlighted in the previous section concerning this option, in principle 2-3 parking bays are within reach of the house via a cable

connected to a conventional wall-mounted domestic charger. The charger could be mounted on the external wall of the basement or stairway, with the cable trailed within their private property up to the fencing, then covered by matting as it crossed the footway. Were a bolt installed into the kerbstone for it to be secured to, it would probably limit the reach to the bay directly opposite.

As with the other options, this may necessitate a formal EV only bay restriction, paired with the resident's restrictions, to ensure the resident could access the charger overnight. However as the bay would not provide a publicly accessible EV charge point, it may be more appropriate to limit restrictions to 'night time only when re-charging'.

Alternatively it might be effective to work at a community level, with some informal agreement amongst neighbours, perhaps reinforced by a polite notice opposite the home.

**Alternatives to On-street Parking** – the home could not accommodate off-street parking via dropped kerb, but could in principle make use of a neighbours drive-way a short distance away, were they willing to have a domestic charger or socket installed and belong to a Shared Parking type scheme. Very few properties in close proximity had off-street parking however, so the likelihood of any being willing hosts is limited.

**Summary - Terraced streets**

Most of the shortlisted options could in principle work in this location:

- **Source London** is an option, with a point available in close proximity once repaired. The availability of the bays and costs going forwards will be decisive.
- **Parallel Networks** – could work well in this area in principle, subject to there being sufficiently clustered demand from two nearby residents. The predominantly residential nature of the catchment would suit this type of provision, and resident permit parking restrictions help enforcement. Roadspace is in short supply though so a loss of parking spaces is likely.
- **Socket Networks** – also appear to be an option, with a street light immediately outside the home which could be cheaply adapted to incorporate a charging socket. An EV only bay would be required though, which could work well in conjunction with the resident only restriction. Restrictions could potentially be limited to overnight only, and when recharging, to lessen the impact on parking supply, but would still result in the loss of parking available to other residents.
- **Trailing Cable** – could work well in principle, a domestic charger could be accommodated and the footway isn't unduly wide, with few other obstacles. An EV only bay may be required, and could be limited to overnight only, and when recharging, to lessen the impact on parking supply, but it would still ultimately result in the loss of parking spaces available to other residents. As the charging facility would only be available to the specific resident, an informal community based agreement may be appropriate.
- **Alternatives to on-street parking** – no scope for driveway in the front garden. Very limited opportunities for using a neighbours off-street parking via a Shared Parking app, as few have any. Few other 3rd party sites within in walking distance.

**2. Semi Detached Street - Fountayne Road, Stoke Newington**

- Typical Inner or Outer London semi-detached street, lined with parked cars
- Predominantly residential area
- Overground station and local centre within 10 minutes' walk.
- Limited off-street parking, very high demand
- Parking is unrestricted, and at the time of our site visit (midday), ~95% occupied along the full length of the street.
- The street is also part of a designated conservation area.

**Source London** – the nearest Source London EVCP was approximately a 7 minute walk away, but at the time of writing was out of service. At 600-700m away this may be beyond some prospective buyer's acceptable walking distances, another point is located approximately 10 minutes away, but was also out of service. A third site was available in a supermarket car park approximately 20-25 minutes' walk away.

Notwithstanding some of the possible limitations to using Source points for residents charging described in the previous chapter, it could in principle be an option. In this instance the nearest EVCP is a single bay on a side road.

The area is predominantly residential, with few attractors in the immediate vicinity, though a nearby local centre is approximately 10 minute's walk away. So whilst the residential area itself may not present a natural location for future Source London EVCP installations, the local High Street may become an option.

**Parallel Networks** – the area might be suitable, as the density of homes improves the likelihood of 3 prospective EV buyers living in close proximity.

As there are no residents parking restrictions in place it would be challenging to limit use of the point, and ensure access to the applicants. It might be necessary to introduce a Borough specific green parking permit or alike to accompany the parallel bays, if installed in this type of location.

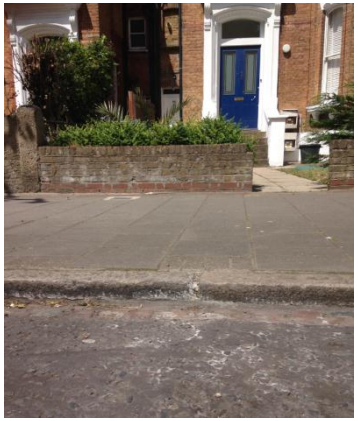
The very high levels of parking demand will undoubtedly pose some challenges in identifying a

suitable location though, and result in a loss of some standard bays. There might scope to redesign the nearby junction and create more parking to accommodate an EV hub, but it would entail significant works and would have to be part of a wider scheme.

**Socket Networks** – the nearest streetlights are located around 20m from the home on the same side of the road, or directly opposite on the other side of the road. Both are located on the kerb side, so would not entail trailing a cable across the footway. The lamp column dimensions also met with the minimum required diameter.

In terms of access, unless sockets were readily available across the area, given the level of parking utilisation it would be necessary to designate it an EV only bay, which could perhaps be limited to an overnight only restriction. This would though result in the loss of some parking capacity for other residents so is likely to be unpopular.

**Secured matting and trailing cables –** in principle 2-3 parking bays would be within reach of the house via a cable connected to a conventional wall-mounted domestic charger. Were a bolt installed in the kerbstone for it to be secured to, this would limit the reach to the single bay directly opposite.



A formal EV only bay restriction may be required to ensure the resident could access the charger overnight. However as the bay would not be providing a publicly accessible EV charge point, it may be more appropriate to limit it to a 'night time only when re-charging', to minimise as far as possible the impacts on wider parking supply.

The scale of the street may make an informal community level agreement, where neighbours agree to leave a space every Monday and Thursday night for example, less workable than other locations, as there is less likelihood residents will know each other.

**Alternatives to On-street Parking** – the home may be able to accommodate a driveway in the front garden, though some Boroughs may feel it is not desirable to encourage this. Additionally it would result in the loss of 1-2 on-street spaces.

They could in principle make use of one of several nearby private drive-ways, though many looked to be well used for their own vehicles.

There might be opportunities to use 3rd party sites at the nearby High Street/ local centre, though limited off-street parking was evident.

**Summary - Semi Detached Street**

Most of the shortlisted options could in principle work in this location:

- **Source London** is an option for this prospective EV owner, with a point in reasonable proximity once repaired. The availability of the bays and costs going forwards will be decisive.
- **Parallel Networks** – could work in this area in principle, subject to there being sufficiently clustered demand from two nearby residents. The absence of resident permit parking restrictions and comparatively short distance from a local centre/high street might mean it is less well suited than other options however.
- **Socket Networks** – could be an option, with two street lights nearby which could be cheaply adapted to incorporate a charging socket. An EV only bay would be required though, and in the absence of resident permit restrictions would be open to use by wider EV users. EV only restrictions could potentially be limited to overnight only, and when recharging, to lessen the impact on parking supply.
- **Trailing Cable** – could work well in principle, a domestic charger could be accommodated and the footway isn't unduly wide, with few other obstacles. As with the sockets, an EV only bay may be required. EV only restrictions could potentially limited to overnight only, and when recharging, to lessen the impact on parking supply, but it would still ultimately result in the loss of parking spaces available to other residents. The scale of the street may make an informal community based agreement less workable in practice.
- **Alternatives to on-street parking** – there is scope to introduce a driveway in place of the front garden, but at the loss of on-street spaces. There are opportunities for using a neighbours off-street parking via a Shared Parking App, though they appear well used so availability may be limited.

**3. Mixed land use Street – Well Street (A46), South Hackney**

- Central or Inner London street, with a patchwork of land uses, including residential, retail and offices.
- Very limited residential parking on or off-street. At 11.10am demand was reasonably high, with around 70% of bays occupied.
- Periphery of a local centre/ high street attractor.
- Resident permit holders only 8.30am to 6.30pm, or to max stay 4 hour pay and display.
- Neighbouring Lidl store operates a mid-sized private off-street surface car park, which at the time of our visit was full and operating on a one-in one-out basis.
- Office units on the other side of the road incorporate a handful of off-street bays in their frontage, which were 50% occupied.

**Source London** – the nearest Source London EVCP was approximately a 7 minute walk away. The next alternative point is approximately 15 minutes away.

At 600-700m away this may be beyond some prospective buyers acceptable walking distances, though the home is within reasonable proximity of other attractors (local centre/high street), so there's potential a slightly closer point would be installed in time.

Notwithstanding some of the possible limitations to using Source points for residents charging described in the previous chapter (high usage costs and regular usage by car club vehicles), it is an option.

**Parallel Networks** – the area may prove less conducive to this model, as the density of homes is less concentrated, and interspersed with other land uses, which will lessen the likelihood of 3 prospective EV finding a mutually acceptable location for a shared point. Additionally there a relatively few parking spaces available, and they double up as short stay spaces for visitors.

**Socket Networks** – the nearest streetlight is a short distance around the corner, but is adjacent to a section of double yellow lines, so there are no options to park alongside it. On the opposite site of the road a street light is available alongside a cluster of 6 parking bays. Both are located on the kerb side, so would not entail

trailing a cable across the footway. The lamp column dimensions also met with the minimum required diameter. As well as the street lights, it may be possible to utilise the bollards lining the bays to house the sockets.

In terms of access, unless sockets were readily available across the area, it would be necessary to designate an EV only bay, which could perhaps be limited to an overnight only restriction.

**Secured matting and trailing cables** – the home is set back from the street so would preclude any option to connect to a domestic charger.

**Alternatives to On-street** – there is no opportunity to accommodate a driveway. However there appear to be a number of opportunities to utilise 3rd party sites, in the form of Lidl's car park, which is publicly accessible and will be unused overnight.

Also the adjacent office unit's off-street parking bays are likely to be empty overnight. Both options are within a short distance of their home.

**Summary - Mixed land use Street**

Most of the shortlisted options could in principle work in this location:

- **Source London** is an option, with a point just about within range. Moreover the location on the periphery of a local centre attractor may improve the prospects of an additional Source London point closer to the resident in the future.
- **Parallel Networks** – may be less well suited to this area, as residential properties are less concentrated, and parking spaces are less resident orientated.
- **Socket Networks** – could be an option, with a street light nearby. There is also an opportunity to integrate sockets into bollards adjacent to the parking bays. An EV only bay would be required though.
- **Trailing Cable** – not an option in this case study.
- **Alternatives to on-street parking** – there are real opportunities for utilising 3rd party off-street parking at the nearby retailers and offices, provided the hosts are willing to engage.

## 4. Flats/Apartments with no off-street parking - Boundary Street, Shoreditch/Bethnal Green


- Typical Central London street, with high density flats and apartment's, set back from some core City streets and thoroughfares.
- Pockets of off-street parking throughout, but the majority of apartment blocks have very limited access to off-street parking.
- A predominantly residential street, but only a short distance from other attractors.
- Tube/overground stations within a 5 minute walk.
- Parking is in high demand. At the time of our site visit (10.00am) bays were ~90% occupied.
- Resident permit holders only between 8.30am and 7pm, or to max stay 4 hour pay and display/ pay-by-phone.

**Source London** – the nearest Source London EVCP was a 3 minute walk away, with another point only 4 minutes away, off-street in an NCP car park. There is one more point 7 minutes from the apartment, but at the time of writing it was out of service.

Notwithstanding some of the possible limitations to using Source points for residents charging described in the previous chapter, the relative proximity of the points makes this a credible option. The nearest point is a single point and dedicated bay on a side-street, and alongside a car club bay.

**Parallel Networks** – the area could prove to be conducive to such a model, as the density in terms of prospective EV buyers increases the likelihood of finding a mutually acceptable location. Additionally, the

more central location means Source London points will be in greater demand by non-residents and car club users, and so a parallel network catering for residents only may be more essential.

As a residents permit parking zone it would be easier to limit access to the privately funded but otherwise publicly accessible EVCP to residents within that permit holder zone, although the restrictions don't apply overnight, so in principle non-residents could park up and charge at the bay.

The high levels of parking demand will undoubtedly pose some challenges in identifying a suitable location though, and it will inevitably result in a loss of some standard bays. Though there is a prominent standalone bay that could be well suited to the role, see image to the left.

**Socket Networks** – a streetlight is situated immediately opposite the apartment, and is located on the kerb side, so would not entail trailing a cable across the footway.

The lamp column dimensions also met with the minimum required diameter. It may also be possible to utilise the bollards lining the bays to house the sockets.

In terms of access, unless sockets were readily available across the area, it would be necessary to designate an EV only bay, which could perhaps be limited to an overnight only restriction.

**Secured matting and trailing cables** – as a first floor apartment it would not be feasible to connect to a domestic charger from the kerbside.

**Alternatives to On-street Parking** – there appear to be a number of opportunities to utilise 3rd party sites, in the vicinity, including a small to mid-sized yard associated with Telecoms business (pictured), though the yard looks likely to be secured overnight so permitting access to the resident after-hours may prove challenging.

There is also what appears to be a servicing yard associated with the apartment block itself, which was only lightly used by vehicles and may be able to accommodate a number of communal charge points.

There are likely to be other potential host sites elsewhere given the central London location and range of land uses in the area, whether any are willing remains a key factor however.

**Summary - Flats/ Apartments with no off-street parking**

Most of the shortlisted options could in principle work in this location:

- **Source London** is an option, with a point in close proximity, and another nearby. Moreover the central location may improve the prospects of additional Source London points closer to the resident in the future. The availability of the bays and costs going forwards will be decisive.
- **Parallel Networks** – could work well in this area in principle, with reasonable prospects for clustered demand, and a need to cater to resident charging requirements in light of higher in-commuting and visitor use of EVCP bays. Roadspace is in short supply though so a loss of parking spaces is likely.
- **Socket Networks** – also appear to be an option, with a street light immediately outside the home which could be cheaply adapted to incorporate a charging socket. There is also an opportunity to integrate sockets into bollards adjacent to the parking bays. An EV only bay would be required though.
- **Trailing Cable** – not an option in this case study.
- **Alternatives to on-street parking** – there are real opportunities for utilising 3rd party off-street parking at the nearby businesses, or the apartment's own servicing yard, provided the hosts are willing to engage, utilising formats such as shared parking apps or socket networks.

## 5.3 Shortlisted Options Analysis

5.3.1 Based on the findings of the case studies, feedback from stakeholders and further research undertaken for each of the short listed options, detailed multi-criteria assessments were completed for each option, summarised in Tables 3 and 4.

5.3.2 The assessments seek to capture the relative strengths and weaknesses of each option, against the many and varied considerations, set out under two headings below:

- **Effectiveness** – the technical effectiveness and general suitability of the charging solution, how well it caters for the user and the implications on parking and the streetscene;
- **Deliverability** – which accounts for installation timescales, costs, commercial and business model feasibility etc.

5.3.3 The cost assessments seek to reflect not only capital costs and installation, but also operation and maintenance. For the purposes of this study they were completed in relative terms, rather than within explicit price ranges. Rapid Chargers for example were assessed as higher cost, and conventional charge points mid to high cost, whilst sockets and domestic chargers were lower cost.

5.3.4 Each of the headings is scored against a simple Red-Amber-Green (RAG) assessment, on a 5-point scale.


- 1 - Option performs poorly against in relation to the other options.
- 3 - Option delivers satisfactorily, or has a neutral impact on balance.
- 5 - Option is very effective versus the other options.

5.3.5 Additionally, each option has been scored for both a Low end and High end scenario. This is to account for the considerable range of uncertainties in speculating on factors such as future technologies and emerging business models a number of years into the future.

- A **Low End** assessment looks to score the option based on a more pessimistic interpretation of how it may fare, particularly where the option is less proven and so there are greater risk of technical, operational or commercial barriers hindering uptake.
- For example with the socket network, the technology is still under development and more significantly, commercial agreements with critical stakeholders (DNOs) and alike are not yet in place in the UK, which may delay or even entirely prevent their market entry.
- The **High End** assessment adopts a more optimistic outlook, and considers the potential afforded by each option, all other things being equal, and assuming that moderate technical, operational and commercial challenges can be overcome.

*Table 3 Summary of Shortlisted Charging Options Appraisal – Technical Effectiveness and Suitability*

| Option | | Effectiveness | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shortlisted Charging Options | Assessment Range (Low End equates to worst case, High best case) | Usability | Availability | Cost to User | Convenience of Charging Apparatus | Access - dependency on access to specific bay | Legibility as part of wider infrastructure | Impact on Parking Supply | Streetscene impacts | Fit with Car Clubs | Risks – Health & Safety and Legalities | Proportion of market catered for - scope for wider roll-out |
| **Source London** | Low | 2 | 1 | 1 | 4 | 2 | 5 | 2 | 2 | 1 | 4 | 2 |
| | High | 3 | 3 | 2 | 5 | 4 | 5 | 2 | 2 | 2 | 5 | 3 |
| **Parallel Networks** | Low | 3 | 2 | 1 | 4 | 2 | 2 | 2 | 2 | 2 | 4 | 2 |
| | High | 4 | 3 | 2 | 5 | 3 | 3 | 2 | 2 | 3 | 5 | 3 |
| **Socket Networks** | Low | 4 | 2 | 4 | 3 | 2 | 1 | 2 | 2 | 2 | 3 | 4 |
| | High | 5 | 5 | 5 | 4 | 5 | 4 | 3 | 3 | 5 | 5 | 5 |
| **Trailing Cables - Domestic Chargers** | Low | 5 | 2 | 4 | 3 | 1 | 2 | 2 | 2 | 1 | 1 | 2 |
| | High | 5 | 4 | 5 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 |
| **Remote Charging - Rapid Chargers** | Low | 1 | 2 | 3 | 4 | 5 | 4 | 3 | 3 | 3 | 4 | 2 |
| | High | 2 | 3 | 4 | 5 | 5 | 5 | 4 | 3 | 4 | 5 | 4 |
| **Alternatives to On-street Charging** | Dropped kerbs | 5 | 5 | 5 | 5 | 5 | 3 | 2 | 1 | 2 | 5 | 1 |
| | Third Party sites - Low | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 4 | 2 | 3 | 1 |
| | Third Party sites - High | 4 | 4 | 4 | 5 | 3 | 3 | 5 | 5 | 2 | 5 | 2 |

*Table 4 Summary of Shortlisted Charging Options Appraisal – Deliverability*

| Option | | Deliverability | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Shortlisted Charging Options | Assessment Range (Low End equates to worst case, High best case) | Timescales Short term/ longer term | Costs - installation, operation and maintenance | Technological Constraints/ Challenges, risks of obsolescence | Commercial Viability/ Acceptability, Business Models | Revenue Implications/ Generation Potential | Borough Resource Requirements | Impact on Electricity Network |
| **Source London** | Low | 3 | 2 | 4 | 3 | 3 | 4 | 3 |
| | High | 4 | 3 | 4 | 4 | 4 | 5 | 4 |
| **Parallel Networks** | Low | 3 | 2 | 4 | 2 | 3 | 3 | 3 |
| | High | 5 | 3 | 4 | 3 | 4 | 4 | 4 |
| **Socket Networks** | Low | 1 | 4 | 1 | 1 | 2 | 3 | 2 |
| | High | 5 | 5 | 3 | 4 | 3 | 4 | 4 |
| **Trailing Cables - Domestic Chargers** | Low | 4 | 5 | 4 | 5 | 1 | 3 | 3 |
| | High | 5 | 5 | 4 | 5 | 2 | 4 | 4 |
| **Remote Charging - Rapid Chargers** | Low | 4 | 1 | 2 | 3 | 2 | 4 | 1 |
| | High | 4 | 3 | 3 | 4 | 4 | 5 | 2 |
| **Alternatives to On-street Charging** | Dropped kerbs | 5 | 5 | 5 | 5 | 1 | 4 | 4 |
| | Third Party sites - Low | 2 | 4 | 4 | 2 | 2 | 3 | 3 |
| | Third Party sites - High | 4 | 5 | 4 | 4 | 3 | 4 | 4 |

5.3.6 The criteria have not been weighted for this assessment, as to do so would require further stakeholder engagement, to agree collectively the priorities, i.e. the relative importance of streetscene impacts over cost, and usability versus revenue potential for instance. In all likelihood these will vary by Borough depending on a host of other factors.

**Low End Estimates**

5.3.7 Perhaps not surprisingly the lower end, more pessimistic assessments favour the safer, more established charging protocols to some extent, with the following options scoring well overall in terms of effectiveness and deliverability:

- Alternatives to On-street Charging – Dropped Kerb;
- Remote Charging – Rapid Chargers; and
- Trailing Cables Domestic Chargers.

**High End Estimates**

5.3.8 A more optimistic review of each option favours those whose overall effectiveness as a charging solution is better, with deliverability playing a less influential part, including:

- Socket Networks;
- Alternatives to On-street Charging – Third Party Sites;
- Remote Charging – Rapid Chargers; and
- Trailing Cables Domestic Chargers; and
- Alternatives to On-street Charging – Dropped Kerb.

5.3.9 A notable finding of these wide ranging assessment criteria, is that even after all these different factors, on balance there is not much separating each option.

5.3.10 In fact besides the 'dropped kerb with a home charger option', which is something of an outlier, each scored between 48% and 57% of the available marks in the Low End estimates, and 71% to 86% in the High End estimates. This reflects that each option will likely constitute at least a part of the charging solutions mix in the short to medium term.

5.3.11 A further point to note is that this assessment attempts to score at an aggregate level for the whole of London how each option performs against the criteria.

5.3.12 As the case studies have demonstrated, the suitability of options will vary to quite a large degree, based on highly localised factors, and also on the behavioural traits of the prospective buyer, and in some cases the attitudes of prospective EVCP hosts or operators.

5.3.13 A key output of Table 3, which has been taken forward to inform the scenarios presented in Figures 27 to 29, is the 'proportion of the market catered for – scope for wider roll-out'. This figure attempts to describe what proportion of residents without off-street parking might be catered for by each option. For instance in the case of adding a driveway and domestic charger, clearly this option will be very much limited to the availability of suitable front gardens or alike, whilst the Parallel Network option is reliant on clustered demand for an

EVCP, at sufficient density that a convenient site can be identified for 3 residents. It is also reliant on them being willing and able to meet the very high front end capital investment costs.

## 5.4 Projected Charging Mix Scenarios

5.4.1 Figure 27 goes on to present two possible scenarios for how future residential charging provision may develop, based on the low range (comparatively pessimistic) and high range (comparatively optimistic) scenarios and appraisals completed in Tables 3 and 4.

5.4.2 The scenarios aim to provide some indication as to what the future charging infrastructure mix might look like for residents without off-street parking, to inform future decision making.

5.4.3 It is important to note that these scenarios are based on a qualitative review of each option, and further more detailed analysis and modelling would be required to evidence these estimates, as described in the concluding 'next steps' section'.

5.4.4 For the purposes of this assessment the Source London and Parallel Network options are assumed to consist of contemporary EVCPs.

5.4.5 In many cases the options are in direct competition against one-another, so our estimates have sought to account for some interrelationships between them. For instance as one option becomes more available, others may become less appealing.

**Short Term**

5.4.6 In the short term, defined here as 2015-17, we forecast that initially the more established and readily available options will predominate, to a greater or lesser degree in both the Low and High end estimates.

**Medium Term**

5.4.7 In the medium term, defined as 2018-20, we would anticipate a shift towards the more versatile socket networks.

5.4.8 In the low end estimates this is tempered by possible barriers to more widespread uptake (i.e. technical limitations with more street lights than anticipated, or slower integration within vehicles).

5.4.9 In the high end scenario, where delivery issues to do not hamper the socket network model, it seems likely their cost effectiveness and versatility would limit the attractiveness and viability of higher cost alternatives, like the parallel network option, which may instead serve very specific locations only.

5.4.10 A positive outcome is that in both the High and Low end scenarios we see the proportion of prospective buyers for whom no satisfactory solution is available rapidly diminish, from nearly 70% in 2015 to 10-25% by 2017, and 0-7% by 2020.

Evolving Options

5.4.11 The forecasts assume that as other alternatives become available, the use of options such Source London and Parallel Networks may become less appealing, or less essential, for residential charging,

either because the alternative solutions may be nearer to their homes, cheaper, or more readily available.

5.4.12 It is important to note that this is based on the Source London and Parallel Networks as described in Chapter 4, in terms of availability, pricing, and assuming they continue to comprise of conventional charge points.

5.4.13 In reality they are likely to adapt and evolve in line with emerging models, technologies and market rates, in which case we would anticipate the proportions of market share would adjust accordingly.

5.4.14 In time for example the parallel network option might adopt the socket technology rather than more costly conventional EVCPs, with the two options merging in effect. A similar scenario could be envisaged for the Third Party sites.

Variation by street type and Central/ Inner/ Outer areas

5.4.15 Whilst this study has chiefly approached the assessment of options at an aggregate level for London, some consideration was also given to how the effectiveness and deliverability of options might vary by street type and spatially.

5.4.16 We determined that of the assessment criteria applied in Tables 3 and 4, those most likely to vary when considering street type and location within London were:

- Usability
- Availability
- Access – dependency on access to specific bay
- Proportion of Market Catered for - scope for wider roll-out
- Commercial Viability/ Acceptability, Business Models

5.4.17 The difficulty however is that as revealed in the case studies, highly localised factors have a significant bearing on the usability, likely availability and accessibility of each charging option, which requires generalisations to be made about, for instance whether a resident is more likely to be able to park closer to home in central, inner or outer London, or whether an EVCP is more likely to be heavily used and therefore less available in central, inner or outer London.

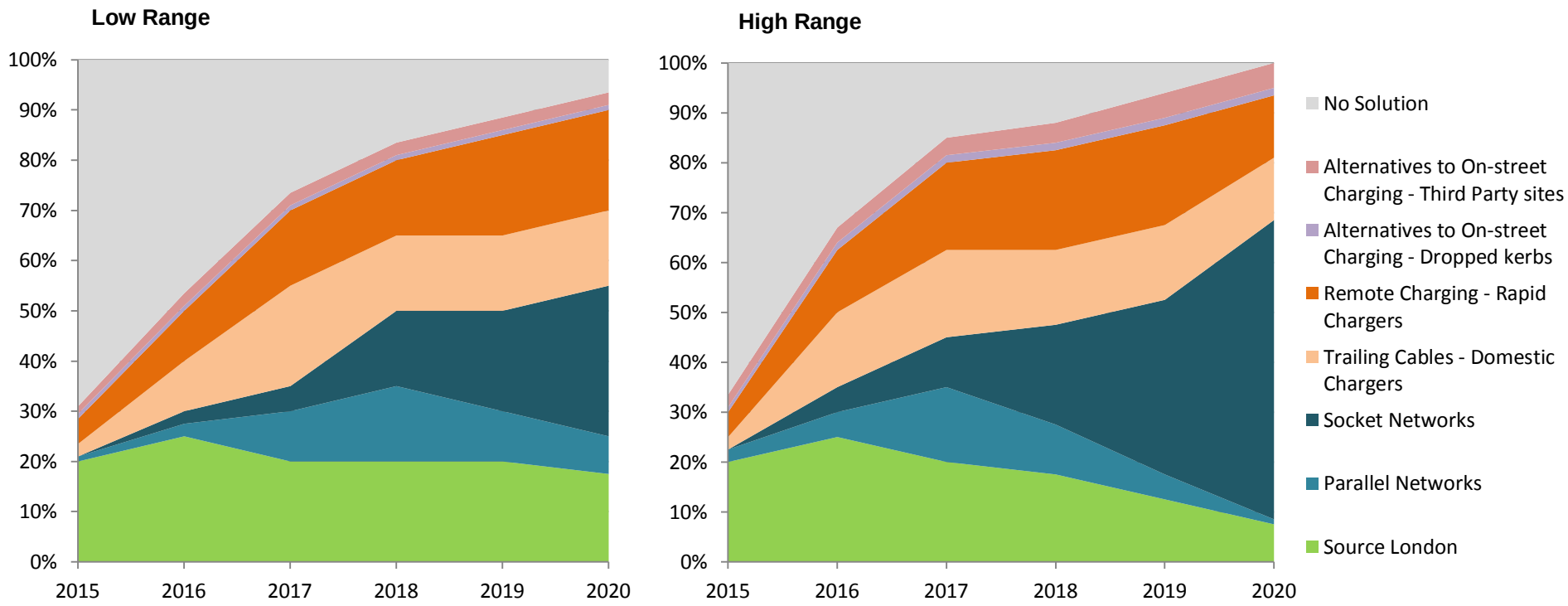
5.4.18 In practice this would of course depend on a wide range of factors, so the following assessments are intended only as generalised statements:

- In **Central and some Inner** London Boroughs we would anticipate the full scope of charging options being available, with Source London points being more concentrated, but also with more non-resident demand and car club vehicles occupying them during the daytime. We would also anticipate there being more opportunities for Parallel Network bays, as prospective EV buyers may be more concentrated, and with less likelihood of them having off-street parking
- In **Outer and some Inner** London Boroughs, Source London and Parallel Network points may be sparser, with fewer prospective buyers

clustered in close proximity and with no access to off-street parking.

- **Socket networks** could be equally applicable in both areas, but potentially to slightly different formats. In Outer London their provision in off-street car parks and employers car parks may be more prevalent, as well as clusters of residential streets without off-street parking. In Central and some Inner London Boroughs sockets may be more prevalent as part of the general streetscene, in streetlights, on masts, on walls or in floor-boxes, as well as off-street car parks where available.
- **Trailing cables** seem more likely to feature in Outer London Boroughs were they permitted, as they are likely to be reliant on the resident being able to park immediately outside their home and within reach of the cable. Whilst in central locations this would prove more challenging, and pose greater conflicts to pedestrian footfall.
- Remote charging via **Rapid charging stations** may be better suited to more Outer London Boroughs, where vehicles are used more regularly and do more miles. The more severe traffic congestion in central London may also dissuade residents from routinely driving to a remote site when other options are available. Outer London locations may also present more options for rapid charging stations to be developed, in terms of affordable land and plots with adequate electrical connections.
- **Alternatives to on-street charging** are likely to remain a niche option, but nonetheless are equally applicable in central, inner and outer London. Dropped kerbs and new driveways, will inevitably be more common in Outer London. The use of shared parking apps and third party parking could apply across the capital. The use of loading bays overnight would probably be more applicable in more central and inner London Boroughs.

*Figure 27 Projected Residential Charging Mix for Residents without Off-street Parking*



5.4.20 Figures 28 and 29 provide a snap shot of how we might anticipate people without off-street parking and wanting to buy an EV opting to charge their vehicle in 2017 and 2020, based on our appraisal of the options available.

5.4.21 As with Figure 27 on the preceding page, these are presented at an aggregate level for London as a whole.

***Figure 28 Projected Residential Charging Mix for Residents without Off-street Parking (Low Ranges - Short and Medium Term)***

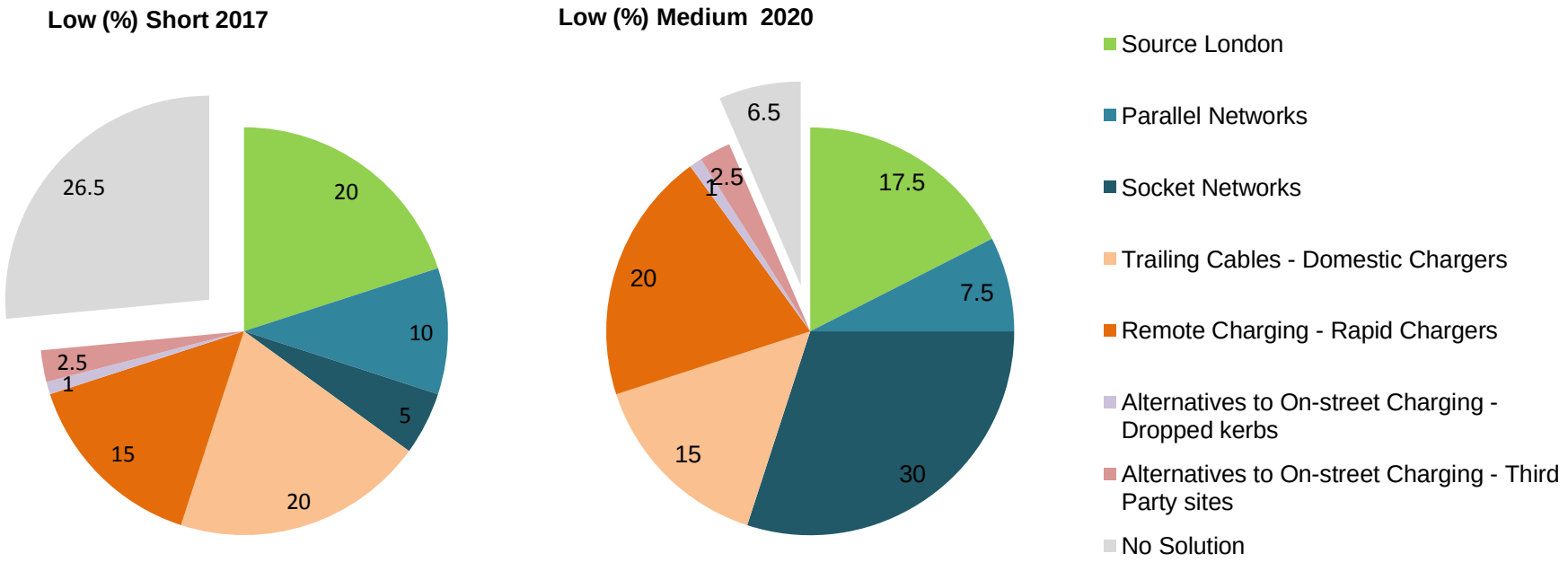
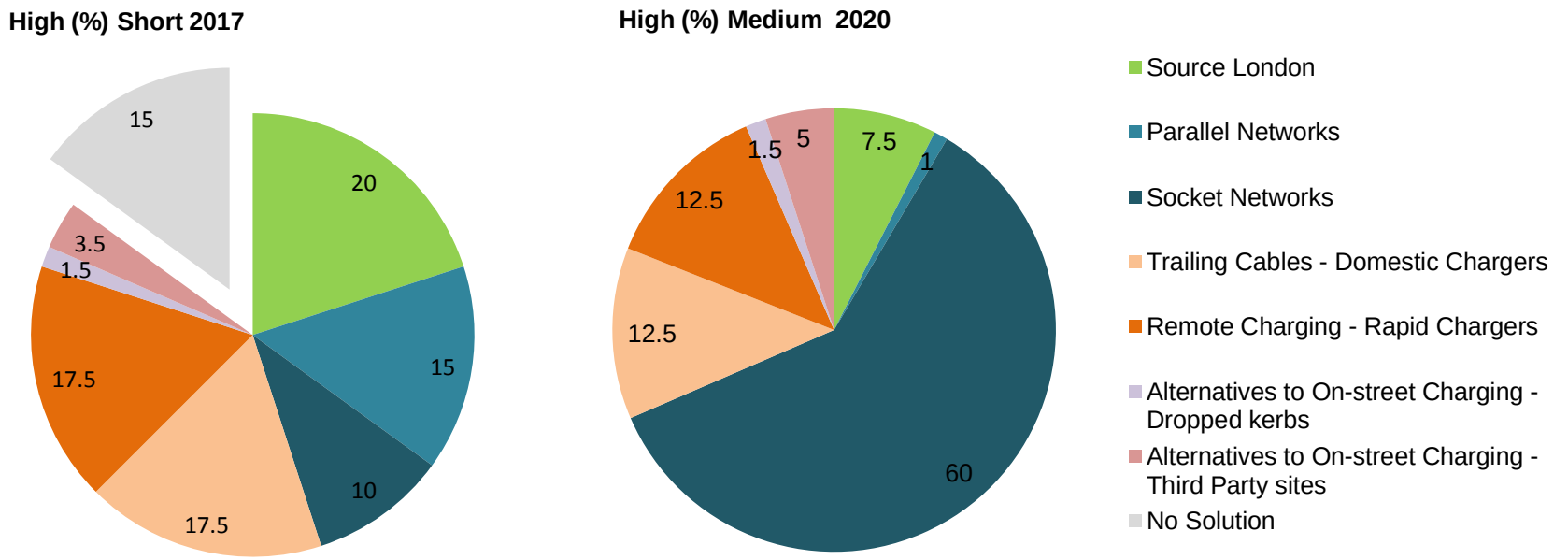


*Figure 29 Projected Residential Charging Mix for Residents without Off-street Parking (High Ranges - Short and Medium Term)*



SECTION 6

# SUMMARY AND RECOMMENDATIONS

## 6.1 Summary and Recommendations

6.1.1 This study has found that there is unlikely to be a one-size fits all solution for providing charging facilities to residents without off-street parking, or at least not in the short to medium term.

6.1.2 The problem is complex and requires consideration of a wide range of factors, including:

Effectiveness of the Charging Technology/ Model

- Usability
- Availability
- Cost to User
- Convenience of Charging Apparatus
- Access - dependency on access to specific bay
- Legibility as part of wider infrastructure
  Impact on Parking Supply
- Streetscene impacts
- Fit with Car Clubs
- Risks – Health & Safety and Legalities
- Proportion of market catered for - scope for wider roll-out

Deliverability

- Costs - installation, operation and maintenance
- Technological Constraints/ Challenges, risks of obsolescence
- Commercial Viability/ Acceptability, Business Models
- Revenue Implications/ Generation Potential
- Borough Resource Requirements
- Impact on Electricity Network

6.1.3 Each option has its own pro's and con's, and specific issues and limitations to overcome, some of which are resolvable over time, such as new technologies and business models, whilst others will always remain niche solutions.

6.1.4 The different challenges and issues associated with each option can be categorised in three key areas:

i.) Business models/ Market Acceptance

6.1.5 Of the options assessed several different business or operating models were considered.

- Source London – a publicly accessible network, operating in conjunction with the BlueCar EV car club, focusing on key attractor locations, with low upfront user registration costs, but premium charging rates.
- Parallel Networks – a resident focused, demand responsive model, servicing grouped applications from residents within highly localised area, high upfront user costs to pay for the EVCP, but lower charging rates thereafter, and improved availability relative an unrestricted public network like Source. Backed

by a private financier, but with low rates of return.

- Socket Networks – a model based on widespread availability, premised on the low cost of sockets, and the having removed the requirement for an intermediary to service payments etc., and instead enabling the user to pay the DNO directly, freeing the host site from any payment collection issues. But reliant on stakeholders (DNOs, TfL, Boroughs, host sites and possibly manufacturers) accepting that the intelligent charging cable will capture and record costs accurately and not burden the host with un-paid electricity use.
- Domestic Charging models – are the simplest business model as the commercial arrangements are left to the individual.
- Battery Leasing models –required for battery swapping, and entail a different vehicle purchase and contractual arrangement.
- Third Party Parking and Charging Apps – also represent a distinct business model, potentially operating like the domestic charger variant, where payment and contracts are handled via a third party administrator, or potentially at a more localised level, maybe facilitated by the Borough or TfL.

ii.) Charging Infrastructure and Technological Challenges

6.1.6 A number of distinct infrastructure types:

- Conventional EVCPs – such as those used by Source London, Parallel Networks and Domestic Chargers. Proven and well established, but high cost, particular on-street.
- Socket Networks – such as Ubitricity, which may be wall mounted, streetlight based, mast mounted or in floor boxes. Low cost, but with only limited real world operating experience to date.
- Inductive charging – an entirely different charging forma.
- Rapid Chargers – a well-established charging technology, but with significant additional requirements in terms of enabling electrical connections that have a bearing on locations

iii.) Charging Locations and Access

6.1.7 The practical implications of what each option entails in terms of access and enabling conditions has proven to be a key factor.

- On-street EV only bay
- On-street EV only bay at particular times only
- On-street EV only bay when recharging only
- On-street EV only bays and Permit Holder restrictions
- On-street in a specific bay opposite home to enable a cable to reach across the footway from a domestic charger.

- On-street in a specific bay opposite home, unrestricted, with informal agreements in place with neighbours
- Off-street bay – new driveway in front garden
- Off-street bay – third party parking

**A balanced assessment of deliverability and future solutions**

6.1.8 It has been necessary to assess each shortlisted option in both a Low end and High end scenario, to account for the considerable range of uncertainties in speculating on factors such as future technologies and emerging business models a number of years into the future. The Low End assessments are more cautious when it comes to less proven or developed options, whilst the High End considers the potential afforded by each option, assuming delivery challenges can be overcome.

**A patchwork solution over the short to medium term**

6.1.9 After a wide ranging assessment against many different factors, on balance there was not much separating each option. This reflects the fact each option will likely constitute at least a part of the charging solutions mix in the short to medium term.

6.1.10 As the case studies demonstrated, the suitability of each option varies to a large degree on highly localised factors. As well as the behavioural traits of the prospective buyer, and in some case also the attitudes of prospective EVCP hosts or operators.

6.1.11 A key consideration is the proportion of the market, and therefore the scope for wider roll-out afford by each option.

6.1.12 In the short term, defined here as 2015-17, we have assumed that initially the more established and readily available options will predominate, to a greater or lesser degree.

6.1.13 In the medium term, defined as 2018-20, we would anticipate a shift towards the more versatile socket networks. In the low end estimates this is tempered by possible barriers to more widespread uptake. In the high end scenario, it seems likely their cost effectiveness and versatility may limit higher cost alternatives to very specific niche applications.

**Source London**

Source London seems likely to continue to serve a proportion of the resident demand, particularly in the shorter term as it represents one of comparatively few options to prospective users. But going forwards many anticipate its focus is likely to be on providing EVCPs at hub/attractor locations, and supporting the BlueCar EV car club scheme.

It is likely to continue to service a proportion of demand, almost by coincidence, where a point is already in place, or newly installed in a convenient location to a user. If the usage charges are high as many anticipate, and geared more towards visitors, it may be that only 'captive' users choose to become reliant on a Source point, either because there is no alterative or their cost elasticity's are low.

**20% of the solution in the short term, diminishing to 7.5 - 17.5% in the medium term** as more cost effective, readily available or better located alternatives become available.

**Parallel Networks**

High upfront investment costs may dissuade mainstream cost conscious adopters, whilst the requirement for clustered demand of applicants within a reasonable proximity of one-another may mean it's more suited to central and inner hotspots. Though in principle as infrastructure costs come down, it may become more widely accessed. Additionally it may be that the sockets option can be delivered through a parallel network type model.

**10 - 15% of the solution in the short term, falling back to 1 - 7.5% in the medium term** as more cost effective alternatives become more prevalent.

**Socket Networks**

Probably 1-2 years off being more widely available and implemented, given the commercial agreements that will need to be secured. A good prospect for widespread roll-out in the medium term though, with greatly reduced costs, and streamlined billing requirements. The versatility of the sockets enables them to present an option in many different street environments. Whilst density of sockets remains low however the usual requirements for EV only bays restrictions remains.

**5 - 10% of the solution in the short term, rising to 30 - 60% in the medium term** as it becomes increasingly recognised amongst stakeholders, and if the intelligent charging cable function becomes incorporated into vehicles as standard.

**Trailing Cables – Domestic Chargers**

Likely to play an important role where local conditions are suitable, i.e. a domestic charger can be accommodated and a cable made to reach across the footway. The decisive factor remains whether Local Authorities feel content to permit resident to trail cables,

provided they commit to using a specified model/s of secured matting, or prefer to wait for a definitive provision to be made, placing the liability with the EV user.

**17.5 - 20% of the solution in the short term, diminishing to 12.5 - 15% in the medium term** as more convenient alternatives to trailing a cable and lower cost options to conventional domestic chargers become available.

**Remote Charging Rapid Charging Stations**

Rapids seem likely to make up a part of the charging mix, much like Source London in some respects, in that a network will be in place anyway to support wider EV usage (i.e. Car Clubs, Electric Taxi's), and so is likely to be utilised by some residents without off-street parking where it is convenient to do so, and can be incorporated into other trip purposes.

**15 - 17.5% of the solution in the short term**, and **potentially either growing to 20%** as the model becomes well established and users come to appreciate they do not need to charge on a daily basis, **or diminishing to 12.5%** as users opt for the greater convenience of more local but slower charging.

**Alternatives to On-street Charging**

Likely to represent a useful niche solution for some, and certainly part of the charging mix.

In the case of adding a driveway and domestic charger, clearly this option will be very much limited to the availability of suitable front gardens or alike.

The use of 3rd party sites is in keeping with the fast emerging new urban mobility and shared mobility models evolving across parts of London, and increasingly enabled through smart phone apps.

3**.5 - 5% of the solution in the short term, rising slightly to 3.5 - 6.5% in the medium term**, as a greater understanding and market acceptance develops for Shared Parking Apps and related models, amongst both users and hosts.

6.1.14 The proportion of prospective buyers for whom no satisfactory solution is available rapidly diminishes, from nearly 70% in 2015 to 10 - 25% by 2017, and 0 - 7% by 2020.

## 6.2 Next Steps

6.2.1 To take forwards the findings of this study, the key issues and outstanding questions associated with the shortlisted options should be addressed, with a view to informing subsequent decision making on infrastructure investment, policy making and strategy development.

6.2.2 Key actions include a number of specific items associated with shortlisted options, as well as some more general next steps:

- **Trailing cables**:
  - Seek further discussions with the GLA and other suitable bodies to clarify definitively whether as currently stated, the London Local Authorities and TfL Act 2013: Chapter 5. Section 5 does not explicitly enable Local Authorities to permit off-street charge points to trail cables over the footway and place fully liabilities on the EV user. If, as suspected it does not, then push for a further change to the Act incorporating the appropriate wording, and seek support from OLEV to do so.
  - In the interim individual Boroughs may wish to reach a position internally on the matter, and decide if they are comfortable in permitting trailed cable charging, provided secured matting is in place. This study found that the risk of all likelihood the existing legislation is probably sufficient to absolve the Council of liability, but as stated within the report, it is not possible to be definitive on this matter so it would be entirely at the Authorities own risk.
  - Agree a common London wide standard for matting; possibly including a lockable portal for the cable and means of securing it via a bolt in the kerb.
  - Investigate options for offering free or subsidised liability cover for EV users charging with trailing cables, provided they commit to following applicable guidelines.
  - Further investigate or trial the workability of a community initiative to informally reserve access to a particular bay twice a week over night, to enable charging via a trailing cable, and assess the likely effectiveness of such an approach more widely.
- **Socket Networks**:
  - Small-scale on-street trials to identify any technical challenges or differences in technical standards compared to Berlin and Munich.
  - Presentations to Borough Groups to build awareness of the socket charging option.
  - Market testing and exploratory discussions with key stakeholders, potentially supporting the supplier in reaching outline commercial agreements with key stakeholders.
  - Discussions with Socket Network providers such as Ubitricity concerning delivery timescales, commercials etc.
- **Rapid Chargers** – a strategic modelling study to inform potential spatial demand, and highlight the fit with deliverable sites for rapid

charging stations, accounting for suitable electrical connections and land availability.

- **Alternatives to On-Street Charging** Further investigate the scope for growth in Shared Parking App based options in the future, their implications on net parking stock, parking demand, revenues and the electricity network.
- **Source London** - maintain ongoing discussions with IER with a view to ensuring bays provide a competitive overnight recharging facility for residents.
- **Parallel Networks** - Monitor and evaluate the Westminster scheme trial, and investigate the scope and business case for an expanded scheme covering, for example across all central London Boroughs, though with EVCPs still limited to an individual Boroughs residents to avoid overlap with Source London.

6.2.3 **Ongoing liaison with key stakeholders** on all fronts, including car club operators, who have an important role to play and a strong interest in establishing an effective charge point network.

6.2.4 **Disseminate the study findings amongst Boroughs**, aided by a technical presentation. It may also prove helpful to convene practical workshops or forum to work through some of the more technical findings and their implications.

6.2.5 It would also be beneficial to input relevant evidence and findings from the study into the **Go-Ultra Low Cities Funding Bid** currently under development, as well as future policy and strategy documents where appropriate.

6.2.6 **Develop infrastructure strategies** for residents without off-street parking, based on the options presented as part of this study, either at pan-London or Borough/ multi Borough level. The strategies should review the forecast uptake in EVs reported in TfL's recent 'Feasibility Study into Electric Vehicle Uptake and the Impacts of Associated Infrastructure', at localised levels throughout the study area, and identify the likely blend of charging options required to cater for each based on local conditions, and develop a work programme to either proactively deliver or support the roll-out of enabling infrastructure.