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Programme Area: Light Duty Vehicles

Project: Electricity Distribution and Intelligent Infrastructure

# Title: Recharging Infrastructure Implementation Recommendations


## Abstract:

This project was undertaken and delivered prior to 2012, the results of this project were correct at the time of publication and may contain, or be based on, information or assumptions which have subsequently changed. This report considers the commercial and regulatory requirements for the deployment of plug-in vehicle recharging infrastructure in the UK. It builds on the Charging Network Requirements Report, which considers the technical requirements. The most significant recommendation is the need for regulations to be developed and implemented to ensure load management functionality is available at public, commercial/workplace and domestic recharging places. This is critical to enable demand to be managed through time of use pricing, to mitigate the future impacts on electricity generation and distribution. This functionality will be a low priority for many private sector investors until market uptake becomes significant; hence regulation is important to ensure this functionality is implemented from the outset and available when needed.


## Context:

This project looked at the potential impact of electric vehicles on the UK electricity distribution grid.

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April 2011

# SP2/E.ON/07 RECHARGING INFRASTRUCTURE IMPLEMENTATION
**prepared for**
**ENERGY TECHNOLOGIES INSTITUTE**
**by**
**D Turner, T Allerton, P Bartlam, L Cherry, B Gowans, N Pogaku, A Bell**

## SUMMARY

This report is part of the ETI Electricity Distribution and Intelligence Infrastructure Project and is a deliverable of work package (WP) 2.5.

The aim of this report is to determine the regulatory, legislative and commercial issues associated with a PiEV recharging infrastructure and recommend how they should evolve for the UK.

It is recommended that the Smart grid technology be used in domestic properties to significantly delay the costly requirement for network upgrades.

It is recommended that regulations be developed to mitigate the impact (especially during the day) of PiEV load on electricity generation and the network for the longer term. In particular, both public charging points and commercial sites with a significant PiEV load must allow time of use charging and demand side management.

It is recommended that Ofgem should:

> Request DNOs to perform a more complete review of the possible impact upon the network of PiEV recharging rather than just processing a sequence of requests for increased supply.
>
> Clarify the responsibilities of the DNO regarding the ownership of charging points.

It is recommended that a subsidy is provided for the installation of charging points at domestic communal parking areas (e.g. for a block of flats).

It is recommended that in order to keep the cost of public recharging affordable, the local authority is allowed to initially subsidise the cost of operating and maintaining public charging posts.

The following is recommended to reduce the time and cost of installing public charging points:

- Provision of standard road traffic signs for recharging.
- Single organisations, rather than installer, DNO and meter owner, can perform the installation.
- Sharing the format of contracts between stakeholders.

It is recommended that a single fob should be used to access any public charging point.

It is recommended that options for time of use payment at public charging points be considered and these payment options should avoid the use of expensive and complex payment settlement systems. The work here suggests that currently a charge card system may be best though alternatives may be available in the future.

It is recommended that regulations be updated to require at least one of the following be implemented at domestic properties to allay concerns over the adequacy of domestic wiring for charging a PiEV:

- Require properties to have an electrical inspection when people buy electric vehicles.
- Install a separate supply for the electric vehicle charging.
- Install domestic load management system.

It is recommended that the IEE Wiring regulations (BS 7671) should be updated to specifically include the charging of electric vehicles.

It is recommended that regulations are required for a safety mat to both protect charging cables and avoid a tripping hazard resulting from the cables laying across a pavement.

| **Prepared by** | **Approved for publication** | **Approved for publication** |
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# 1 INTRODUCTION

This report presents work carried out to review regulatory, legislative and commercial issues associated with a Plug-in Electric Vehicle (PiEV) recharging Infrastructure. This is one of several reports on PiEVs that has been funded by the ETI under the Electricity Distribution and Intelligence Infrastructure Project.

## 1.1 Scope of the Report

The role of regulation related to the investment in, and control of, new charging infrastructure is identified. The specific regulation that may be affected and areas where new regulations are required is identified.

This report shows how the regulatory environment should develop to address this need. Possible solutions to any regulatory issues identified above will be summarised although detailed commercial or regulatory analysis of possible solutions will not be made.

The competition requirements surrounding multiple suppliers and post owners/operators operating within a given network area are identified and recorded in the report.

The report identifies planning/consent issues surrounding the installation of new charging posts.

The report considers the key electrical safety issues associated with plug-in vehicle infrastructure (e.g. recharging in wet weather, ownership and liability associated with the power cable, etc). Safety aspects during the installation of connection points will not be considered.

The report clarifies the obligation and risk to continuity of supply to charge points and the duty of care to consumers using those points, including durability, safety aspects, normal and abuse conditions.

## 1.2 Structure of the Report

The background to the power industry and current regulations is given in Section 2. The issues associated with domestic recharging of PiEVs are considered in Section 3.1. The issues are considered under different headings, network, regulations, competition, planning, safety and responsibilities. Sections 3.2 and 3.3 then consider the issues around the provision of recharging both on-street and at commercial properties. The issues that are currently not being addressed are pulled together in Section 4 and possible solutions identified in Section 5. The most effective solutions are identified in Section 6 followed by recommendations in Section 7.

# 2 BACKGROUND

## 2.1 Overview of the Power Industry

The bulk of electrical power generated in the UK is by large thermal power stations, mainly powered by coal, gas and nuclear energy, and over two hundred smaller wind farms, hydro plant and other small generators with capacity >1 MW. Most large generators deliver their power to the transmission network, which does the bulk long distance transmission of electricity at high voltage (400, 275 and 132 kV in Scotland). It is then fed into local distribution networks which deliver it to customers at lower voltages. Smaller generators typically feed their electricity directly into a distribution network.

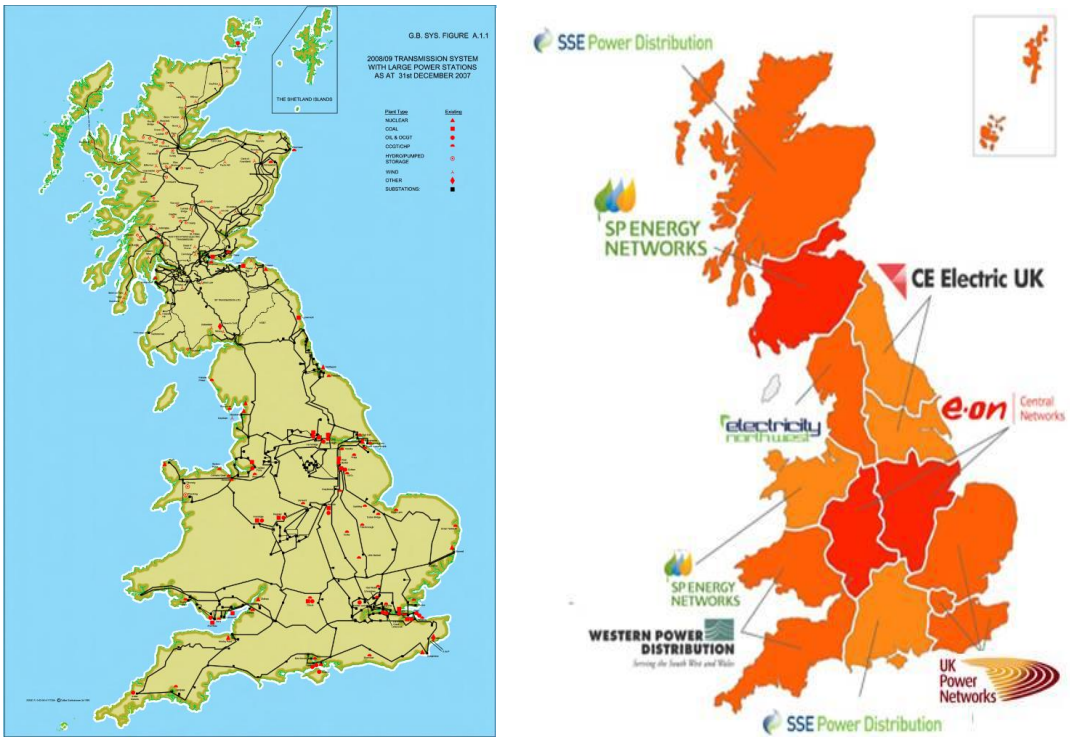


**Figure 1: Maps of the Transmission Network and Distribution Regions (Ref: National Grid Seven Year Statement & ENA)**

In England and Wales, the transmission network is owned and operated by a single company, National Grid plc. In Scotland, the transmission network is owned by Scottish Power and Scottish and Southern Energy, but operated by the GB system operator National Grid.

There are 14 Distribution Areas owned by seven different Distribution Network Operators (DNOs) as shown in Figure 1.

Generators sell their electricity to suppliers via bilateral contracts and on open power markets. Suppliers are companies who sell electricity to the final customer.

There are many companies performing the above activities: generation, distribution and supply, and in many cases the same company does more than one of the activities. Some of the major companies in the power industry, listing all of the DNOs, are shown in Table1.

**Table 1: Energy Companies Activity in the Electricity Industry**

| Company | Transmission | Generation | Distribution | Supply |
|---|---|---|---|---|
| **National Grid plc** | ✓(GB system operator) | | | |
| **Scottish Power** | (Owns network in S.Scotland) | ✓ | ✓(2 areas) | ✓ |
| **Scottish and Southern** | (Owns network in N.Scotland) | ✓ | ✓(2 areas) | ✓ |
| **E.ON** | | ✓ | | ✓ |
| **EDF** | | ✓ | | ✓ |
| **CE Electric** | | | ✓(2 areas) | |
| **Electricity North West** | | | ✓(1 area) | |
| **Western Power** | | | ✓(4 areas) | |
| **RWE npower** | | ✓ | | ✓ |
| **Centrica (British Gas)** | | ✓ | | ✓ |
| **UK Power Networks** | | | ✓ (3 areas) | |

There are many other companies that operate as only generators or only suppliers, some large generators are:

- Drax Power Limited.
- Barking Power Limited.
- GDF Suez.
- Immingham CHP LLP.
- International Power PLC.
- The Nuclear Decommissioning Authority.

Some independent suppliers are:

- OVO.
- First Utility.
- Good Energy.

Additionally some high street retailers now “supply” energy, although this is usually a partnership with another supplier. For example, Marks and Spencer partner with Scottish and Southern.

Electricity meters are owned and operated by Meter Operators [1] who are responsible for providing, maintaining and reading meters. Often, the large energy suppliers listed above have their own meter operations section. It is also possible for customers to own their own meter, although this is usually only large non-domestic customers.

There is an important distinction between supply and distribution. An energy supplier is responsible for metering and billing the customer according to their usage, while the DNO is responsible for the physical cables that deliver the electricity. The supplier will pay the DNO for carrying the electricity to their customer’s premises, which will be paid for from the customer’s

bills. It is the responsibility of the DNO to maintain their network and repair faults to ensure a secure supply, and to provide new connections to their network.

As a condition of their licence, some restrictions apply to who is able to hold licences for each of the activities. In particular, the holder of a distribution licence cannot also hold a supply licence. This is so that there is no restriction, prevention or distortion of competition in the supply of electricity. Scottish Power, Scottish and Southern both own a supply and distribution business. In fact the licence holders are separate legal entities, but to prevent unfair competition within the companies, they must observe strictly enforced business separation rules. This means that these companies cannot abuse their position and must ensure that the management and branding is distinct and the supply business does not have access to information about the distribution business, unless it is made available to all suppliers, or is in the public domain.

Electricity customers generally pay their supplier for their electricity by the kilowatt hour (kWh). The supplier purchases that electricity from generators wholesale, but the cost is more than just the cost of electricity. The price the customer pays includes:

- Wholesale electricity costs.
- Supplier running costs and margin.
- Environmental Subsidies.
- Distribution.
- Transmission.
- Metering.
- VAT.

According to Ofgem [2] the breakdown of each of these elements in a typical domestic electricity bill in June 2009 is shown in Figure 2.

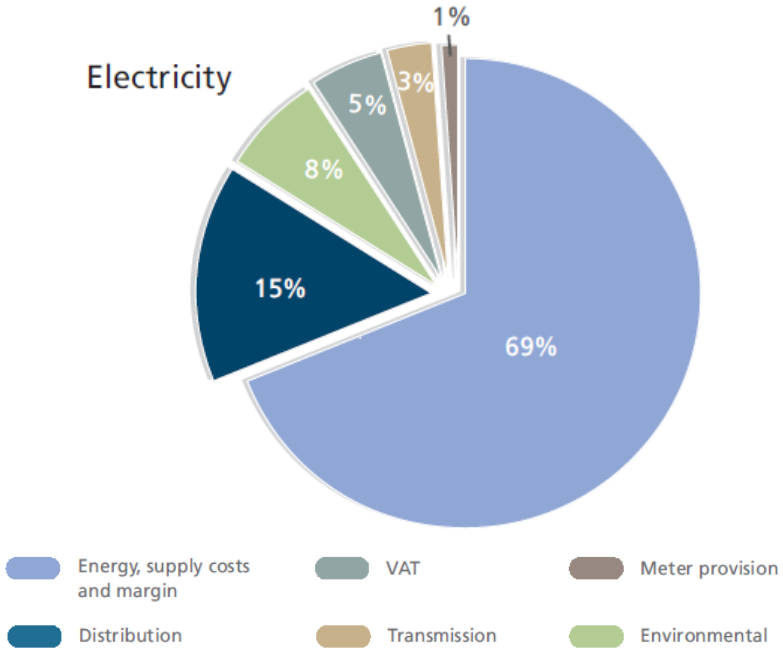


**Figure 2: What a Typical Electricity Bill Pays for**

Generators make their money primarily from selling the power they generate, and, if they are connected directly to the transmission network, they must pay transmission companies to transmit their power across the network.

Generators may also gain from selling ancillary services to transmission companies. These services are required by transmission companies to enable them to ensure the quality and reliability of the network. For example, they are responsible for ensuring supply and demand is balanced – these balancing services include generators being on standby in case of unexpected loss of supply or increase in demand. Large customers may also benefit from balancing services by offering to reduce usage when demand is high.

Transmission companies recover the cost of running the transmission network by charging both suppliers and generators – these charges are called the Transmission Network Use of System (TNUoS) charges. To account for transmission losses, and to try and share costs of transmission infrastructure according to use, the charges are higher for generators that are located further away from demand (e.g. in Scotland) and higher for suppliers with customers in demand centres (e.g. in London). However, following intense lobbying from northern generators (which is where most new renewable schemes are located) this system is under-review.

Distributors charge Distribution Use of System (DUoS) charges which are paid by the supplier. When a customer requires a new connection, distributors will charge customers directly for new network required for 'sole use' by the customer. The distributor will also charge for a share of any costs of local network reinforcement triggered by the need to handle extra capacity. Some of this connection work may be carried out by an independent third party, under Ofgem's arrangements for "competition in connections."

Figure 3 shows the electricity industry stakeholders and how money is exchanged between each party.

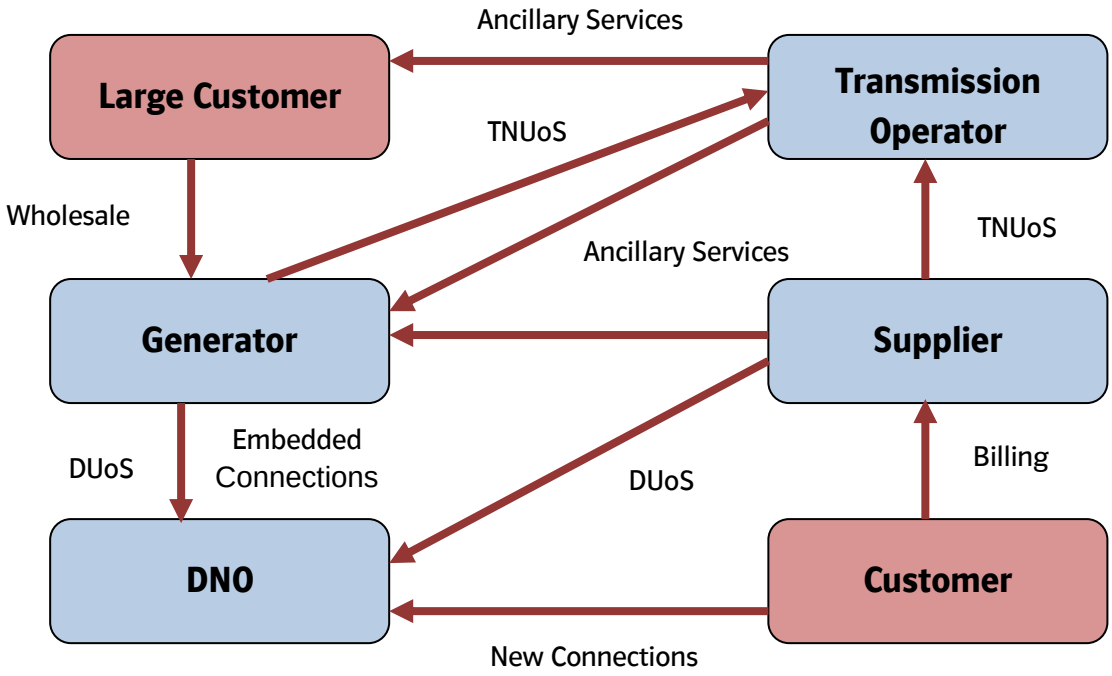


**Figure 3: Direction that Money Flows in the Power Industry**

Suppliers make their money from the final customer. In addition to purchasing wholesale energy, the bill must cover general running costs, and funding environmental measures under the Carbon Emissions Reduction Target (CERT) scheme [3]. The CERT scheme requires domestic energy suppliers to reduce the carbon emissions from domestic properties by promoting carbon reduction technologies, for example, insulation. The legislation setting out the targets is The Electricity and Gas (Carbon Emissions Reduction) Order 2008 and amending orders in 2009 and 2010.

Alongside CERT, suppliers and generators are also required to fund the Community Energy Savings Program (CESP) [4] which focuses on ”whole house” improvement within low income areas.

Suppliers also have to source a certain percentage of their electricity from renewable sources under the Renewable Obligation scheme [5]. Suppliers may trade their allowances, so those with excess renewable generation can gain by selling Renewable Obligation Certificates (ROCs) to those with a deficit. Any shortfall must be paid for in the form of a buy-out price, which is then redistributed to suppliers who sourced renewable energy.

#### 2.1.1 Ofgem

The Office of Gas and Electricity Markets (Ofgem) is the government regulator for the electricity market [6]. They ensure that the interests of customers are upheld by promoting competition, ensuring adequate investment and reasonable prices, and driving environmental measures.

All of the activities described in the preceding section are regulated and can only be carried out by a licensed person. Ofgem considers licence applications and decides whether or not to grant them.

Of particular interest in this report, Ofgem are responsible for regulating the natural monopolies of the electricity networks. They set price controls and limits on expenditure, while ensuring that there is sufficient investment in the network to handle growth and replace old assets. Ofgem also manages environmental schemes like the aforementioned CERT and Renewable Obligation. Section 2.2 below provides further details the role of Ofgem with regards to competition.

### 2.2 Competition in the Power Industry

#### 2.2.1 Distribution Price Controls

The distribution networks are monopolies because there is only one owner and operator for each area and so suppliers have no choice but to use that network. In the absence of competition, Ofgem sets controls [7] on the prices that DNOs can charge. This is to ensure both that customers receive a fair deal, and that the DNOs receive a fair return if they operate efficiently.

The current set of price controls runs from 1$^{st}$ April 2010 to 31$^{st}$ March 2015 and is the 5$^{th}$ set of price controls. Current and previous price controls are based on the “RPI-X” method, where the allowed price changes are based on the Retail Price Index (RPI) with an efficiency factor “X” subtracted.

On the 4$^{th}$ October 2010 Ofgem announced [8] their decision to overhaul the regulation of networks. The change is in recognition that the challenges facing the energy industry are different now to when the original rules were conceived. In particular, many network assets are reaching the end of their life and need replacing, and increased focus on renewable generation and electrification of heat and transport mean the way the network is used is poised to change.

The new model is called the RIIO Model (Revenue = Incentives + Innovation + Outputs) which include the decision to extend the length of price control to 8 years from the previous 5 years to encourage longer term planning, and has rewards and penalties for delivery performance and incentives and "prizes" for innovation. The new model will be applied during the Distribution Price Control Review 6 (DPCR6), which will be implemented from 1st April 2015.

### 2.2.2 Low Carbon Networks Fund

As part of the current set of price controls, Ofgem has set up the Low Carbon Networks (LCNF) fund [9]. This fund allows up to £500m of support to DNOs to try out new technology or novel operating or commercial methods to help facilitate the take up of low carbon technologies. Electric vehicles are mentioned specifically, and the fund is designed to allow partnering with other organisations, so this is therefore an ideal opportunity to address some of the issues that PiEVs will bring. Proposals for projects must meet at least one of the following criteria:

- A specific piece of new equipment that has a direct impact on the distribution system.
- A novel arrangement or application of existing equipment.
- A novel operating practice.
- A novel commercial arrangement.

It must also do all of the following:

- Accelerate the development of a low carbon energy sector.
- Have a direct impact on the operation of the distribution network.
- Create knowledge that can be shared amongst DNOs.
- Has the potential to deliver benefits to customers.
- Focuses on solutions which are at the trialling phase.

### 2.2.3 Connection Charges (network upgrade charges?)

Until October 2010, each DNO had its own Connection Charging Methodology [10], although they all shared the same basis; but there is now a common charging methodology between all DNOs to ensure consistency.

The methodology document describes how the DNO will calculate charges for new connections, who is able to carry out what work, who is able to apply for a connection, and how costs are apportioned when the connection requires reinforcement work to other parts of the network. The document lists charges for each activity, and many examples of projects and their cost.

The Apportionment Rules [??] determine how much a customer is required to pay for any additional work that is required to reinforce the distribution network to allow a new connection. There are several different elements to the cost, but the proportion of the cost that must be paid by the customer is generally determined by the required capacity of the new connection, and the new network capacity provided by the reinforcement. The customer's contribution to reinforcement costs is limited to one voltage level above the point of connection. If the connection is to be part of the network that has already been reinforced within 5 years, then the owner of the new connection may also be required to pay for a portion of the original reinforcement costs. In this case the original customer will get a proportional refund.

Work that must be carried out to physically install a new connection is split into 2 categories: contestable and non-contestable. Non-contestable work can only be carried out by the DNO, and tends to be work that directly interfaces with their network. Contestable work can be carried out by any approved provider, but can also be carried out by the DNO, and includes work such as digging trenches, or constructing buildings.

As a guide, an example cost of connecting a new domestic property to the network is given as £1,100 by most DNOs in their connection charges methodology document. This includes excavation and laying a new service cable, and jointing to the existing network.

2.2.4 Competition Law

Businesses selling products and/or services in UK markets, must comply with competition laws. In the European Union (EU) member states, competition law is covered by Articles 81 and 82 of the European Commission (EC) Treaty. In the United Kingdom (UK), competition law is set out in the Competition Act 1998.

The Competition Act is enforced by the Office of Fair Trading (OFT); however, some sector regulatory bodies help structure their respective markets to comply with the Competition Act and have the power to enforce competition law through the Competition Act (Concurrency) Regulations 2004. The relevant regulatory body for the electricity industry is the Gas and Electricity Markets Authority (Ofgem). PiEV recharging is likely to be covered under Ofgem rules, though there are grey areas that may not currently be covered by the trading structure.

Competition law is complex and whilst there are situations where it is clear that a beach of the law has occurred; there are inevitably cases that are ambiguous. Table 2 gives a list of relevant reference material that may be used to help assess a situation; however, it is advisable to seek legal advice or even approach the OFT directly. By taking such measures a business is demonstrating a proactive approach to meeting competition law / compliance. This will be taken into account should a case end up in court.

**Table 2: References Relating to Competition Law**

| References |
|---|
| Competition Act 1998 [11]. |
| Competition Act 1998 (Concurrency) Regulations 2004 [12]. |
| Competition Act 1998 (Office of Fair Trading's Rules) Order 2004[13]. |
| EC Treaty, Articles 81 and 82 [14]. |
| Electricity Act 1989, Section 43 [15]. |
| Enterprise Act 2002 [16]. |
| How the Enterprise Act 2002 affects the Competition Act 1998 [17]. |
| Cartels and the Competition Act 1998 [18]. |
| Competing fairly (OFT447) [19]. |
| How your business can achieve compliance (OFT424) [20]. |
| Agreements and concerted practices (OFT401) [21]. |
| Abuse of a dominant position (OFT402) [22]. |

The electricity distribution business is a natural monopoly and introducing competition for connections will not obviously benefit customers. Customers are protected through regulation as discussed in Section 2 and Ofgem uses a five year price control period to regulate costs.

Through this price control, DNOs are controlled in the amount of return they can make, whilst ensuring there is sufficient investment to maintain and invest in the distribution networks.

## 2.3 Existing Planning Legislation Pertaining to Electrical Connections

It is important to ascertain whether recharging infrastructure is classed as development, before a decision can be made as to the planning legislation that is relevant. This will depend on the location, connection and who installs and maintains it.

Section 55 of the Town and Country Planning Act 1990 [23] defines development requiring planning consent as:

> "..the carrying out of building, engineering, mining or other operations in, on, over or under land, or making of any material change in use of any buildings or other land.
>
> The following operations or uses of land shall not be taken for the purposes of this Act to involve development of the land –
> (a) the carrying out for the maintenance, improvement or other alteration of any building of works which -
>
> (i) affect only the interior of the building, or
>
> (ii) do not materially affect the external appearance of the building"

### 2.3.1 Advertising and Signage

The planning legislation for advertising is provided in the Town and Country Planning (Control of Advertisements) (England) Regulations 2007 [24]. Advertisements that are excluded from local authority control are:

Class A: advertisements displayed on enclosed land, which would include advertising on recharging points in enclosed car parks that are not readily visible from the outside.

Class D: advertisements displayed on an article for sale or on the container in, or from which, an article is sold. These must refer only to the article for sale, must not be illuminated, nor exceed 0.1 $m^2$ in area. This would only permit modest signs to be displayed on recharging points that relate to the fact it is a PiEV recharging point.

Advertisements for which the rules give a 'deemed consent' which means they may be displayed without an application to the planning authority. Deemed consent is provided under:

Class 1: for 'functional advertisements by public bodies' that permit signs needed by e.g. Local authorities (but probably not an electricity supplier) to give information or directions about the service they provide. Class 1 permits, for example, operating instructions to be displayed on a recharging point installed by a local authority either on or off street, but this does not extend to advertising for other purposes.

Class 6: for advertisements on forecourts of business premises for signs and advertisements to draw attention to any commercial services, goods for sale, or other services available at the premises. The total permitted area for all forecourt advertisements must not exceed 4.6 $m^2$ in each forecourt frontage. Forecourt

advertisements must not be illuminated. Class 6 provides a limited consent for using recharging points in e.g. supermarket car parks, to advertise goods on sale in the premises, if the limits have not already been taken by existing signage.

Class 9: for the smallest standard size of poster-panel (known as four sheet) to be displayed on structures or objects on highway land with the local council's approval under the Highways Act 1980 (Section 115E) [25]. The structure, such as a bus shelter or information kiosk, must be purpose-designed for displaying this size of poster-panel which must not exceed 2.16 $m^2$ in area; and must not be illuminated. Class 9 would provide deemed consent for specially designed recharging points installed on the highway, although these would need to be far larger than those so far installed in the UK.

Under the 2007 regulations, almost all commercial advertising on recharging points requires the express consent of the Local Authority unless the points are located within enclosed areas where the advertisement is not 'readily visible.'

## 2.4 Safety of Electrical Supplies

As with any electrical system, there is an inherent danger or risk to personal safety and one set of regulations covers domestic electrical work whilst the other covers businesses.

Any electrical work that is done in the home needs to comply with Building Regulations Part P (Electrical Safety) [26] which requires that installations meet the safety standards in British Standard BS 7671 Chapter 13 [27].

For commercial work, The Electricity at Work Regulations 1989 [28] define health and safety regulations that must be observed with regards to using electricity in work places.

## 2.5 DNO Responsibilities and Obligations for Electrical Supplies

The ESQC Regulations 2002 (Amended 2006) [29] specifies that DNOs, both public and private, must:

- Avoid interruptions to customers due to their own acts, e.g. switching errors and interruptions due to incorrect protection settings.
- Design and operate networks equipped with protective devices so as to limit the number of customers affected by a fault in the network.
- Ensure a specified level of power quality at the customer's supply terminals. Specifically, the supply frequency must be 50 hertz, not exceeding 1% above or below, and the supply voltage must be 230 volts, not exceeding 10% above or 6% below.

In specific circumstances the distributor (DNO), as defined by the regulations, may be permitted to disconnect the supply if the installation is deemed to be unsafe. An example may be where there are live, exposed conductors on the consumer's installation.

### 2.5.1 Performance Metrics and Guaranteed Standards

In addition to the above regulations, The Electricity Act 1989 [15] - in conjunction with its subordinate regulation: The Electricity (Connections Standards of Performance) Regulations 2010 [30] - prescribes the penalties that may be imposed on DNOs should they not meet specified levels of performance. These performance criteria include, amongst others, the

number of customer interruptions and the restoration time of consumer supplies (in the event of a fault).

Failure of the DNO to meet certain guaranteed levels of service means they must make a payment to the customer. These payments compensate the customer for the inconvenience of loss of supply, issues around new connections, inconvenience of a missed appointment etc. This is governed by The Electricity (Standards of Performance) Regulations 2010 [31]. This significantly increases the number of guaranteed standards that relate to new connections.

Guaranteed standards are set for some of the services that network operators provide. When the standards are not met then customers receive a payment which will depend on the standard and in some cases the type of customer. For example if an interruption to supply during normal weather is not restored within 18 hours domestic customers receive a payment of £54 whereas business customers receive a payment of £108. If the loss of supply continues, then additional payments of £27 are awarded for every additional 12 hour period without supply.

Different guaranteed standards apply for un-metered supplies which are typically owned by local authorities as shown in the Table 3.

**Table 3: Guaranteed Standards for Un-metered Supplies**

| **Service** | **Fault Repairs – street lighting or street furniture** | |
|---|---|---|
| **Type of Connection** | **Timescale** | **Failure Payment** |
| Works to remove immediate danger to the public or property. | Attend on site within 2 hours. | £50. |
| High priority fault repair to traffic lights. | Restore supplies within 2 calendar days. | £10 per working day late. |
| High priority fault repair not involving traffic lights. | Restore supplies within 10 working days. | £10 per working day late. |
| Multiple unit fault repair to street lights. | Restore supplies within 20 working days. | £10 per working day late. |
| Single unit fault repair to street lights or street furniture. | Restore supplies within 25 working days. | £10 per working day late. |

These standards have longer time periods and lower failure payments to reflect the lower degree of inconvenience arising from unavailability.

It is reasonable to extend the guaranteed standards to cover public recharging posts. However, it will be necessary to determine what time periods and failure payments would be appropriate for recharging posts as the degree of inconvenience is likely to be significantly less than other metered customers and more in line with standards for un-metered connections. Thus it may be required to amend the guaranteed standards to consider recharging posts as a different type of user and tailor the standards accordingly. For example, it may be appropriate for standards to differentiate between scenarios where such recharging points were the main way to recharge or if there are sufficient working alternatives.

# 3 THE RECHARGING OF PiEVs

The Charging Network Requirements Report [32] identifies three types of customers for recharging PiEVs and these are considered in the sections below. The use of PiEVs will probably increase the demand for electricity during the day and this is the first issue considered below.

## 3.1 Domestic Customers

### 3.1.1 Network to Supply Domestic Customers

The expected electrification of transport via PiEVs and heating via heat pumps will significantly increase demand for electricity, and unless mechanisms are provided to manage the demand then it will mainly be required during the peak evening hours, as shown in Figure 4 presented in ref [56]. If the peak demand for electricity increases then not only may a stronger network be required but more generating capacity will also be required to meet the peak demand. There is only very limited large scale electricity storage capacity within the UK and this is provided by pumped storage systems. If the daily peak demand increases then so will the electricity costs.

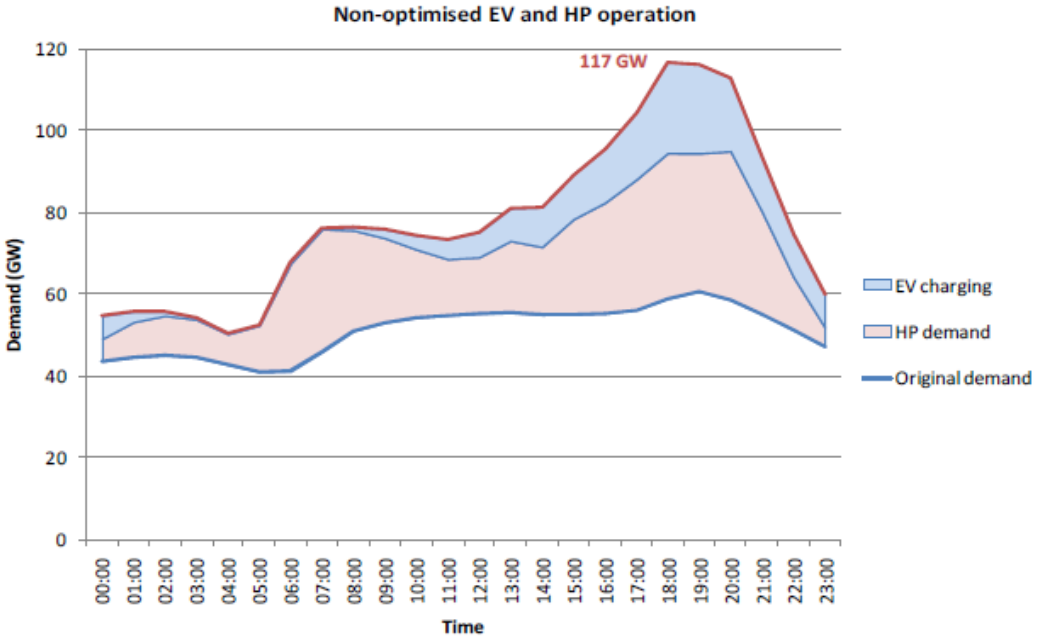


**Figure 4: Expected Unconstrained Demand for Power from Heat Pumps and Electric Vehicles if Owners Start Re-charging or Heating as soon as they get back from Work**

While there appears to be few regulatory barriers to overcome to enable the uptake of PiEVs, regulation should be considered to mitigate their impact on networks and generation (see Section 4.1).

In a typical connection arrangement for a residential house, the services for an individual dwelling are jointed directly onto the mains cable supplying typically 400 Amps to 100 houses. Service cables (these supply an individual property) are protected by a 100 Amp cut out fuse at the meter of each customer. The mains cable clearly has insufficient capacity to supply the maximum demand at each house at the same time and thus the load diversity within an

individual house also needs to be taken into consideration. A service cable is not frequently expected to be subjected to its 'calculated' maximum demand. Also, a service cable can carry up to double its rated current for a few hours. Similarly, a cut-out fuse can also carry up to 1.5 times its rated current for a short time.

The network structure has been sufficient historically since houses on the same mains cable have had different electrical demands. Thus the peak demands have been at different times and the peak for each house may only be for a short period.

Charge times for electric vehicles are also considered in the Charging Network Requirements Report [32]. To charge an electric vehicle will require 2 to 8 hours using 13 Amps, or 0.75 to 3 hours using a 32 Amps charger depending upon the existing level of charge in the battery. A general DNO view is that it is possible to manage one 32A recharging point, on top of storage heating load, without any significant adverse effect on the standard cut-out or service cable [33]. Currently the DNO must be notified of instantaneous shower unit loads exceeding 7.2 kW so they can assess the suitability of the local LV network [34]. It would seem reasonable that the same requirement will be introduced for 32Amps PiEV recharging due to the effects on network flicker levels.

As the use of electric vehicles increases then both the existing domestic service and mains supply may be insufficient to allow recharging of electric vehicles by each house at the same time on a single mains supply.

The electrical distribution network has evolved slowly over time with electricity demand typically growing at 1% per annum. The relationship between the regulator and the DNO has been based upon this slow evolution of the network, though a rapid take up in the use of electric vehicles has the potential to require a much more rapid change in the distribution network to provide the required power.

Domestic properties are currently supplied using single phase 230V AC supply. Each house is connected to one of three electrical phases. Each phase has the same electrical power and it is generally assumed that across a group of houses then the loading on each phase will be very similar. If there are large differences in the electricity demand of different properties due to charging PiEVs then there may be an imbalance in the power required from each phase which may increase beyond acceptable limits (as stipulated in Engineering Recommendation P29 [34]) and lead to more supply interruptions. The DNOs are obliged to mange the network to limit the supply interruptions (see Section 3.1.2 below).

A means of managing the recharging of electric vehicles at homes and appropriately sharing the cost of any network upgrades is required in the future.

### 3.1.2 Regulations Relevant to Domestic Electricity Supply

A useful summary of existing regulations pertaining to electricity generation, distribution and supply is given in Appendix A. In general most of these regulations will still apply for PiEV charging.

In the case of landlords of domestic properties with tenants on long term lets, then regulations [36] currently limit the price that electricity can be resold for to its original cost. The regulations about reselling electricity are to protect tenants from landlords charging anything they like for electricity where the tenant can't switch supplier (e.g. bedsits fed from one metered supply that the Landlord pays and then recharges the tenants).

It is not expected that the installation of charging posts will create a similar situation where someone is unable to access the service for the same price as someone else. Thus even in

areas where charging posts are installed in a communal parking area of a group of houses, then a charging post operator does not have the same potential to exploit individual occupants and reselling electricity legislation would not apply. It's much more likely that if the owner of the electric car lives in rented accommodation then they will pay the charging point operator directly rather than via the landlord.

The following issues for domestic PiEV charging arise with the current regulations:

Whilst there may not be any issues with the re-selling of electricity, there may be an issue about funding the installation and operation of the recharging posts in some cases. People who live in flats generally pay a maintenance charge for the common areas of the flat. This will include the parking though the company providing the maintenance work is unlikely to regard the current fee as including the provision of electric charging points for the parking area. In addition tenants may not see that they should pay an additional charge. It is thus difficult to see exactly who would pay for the provision of the charging points at the moment in accommodation where a maintenance fee is paid for the external communal areas (see Section 4.5).

There are no regulations to manage the recharging of electric vehicles in domestic properties. As can be seen in Section 3.1.1 above, the simultaneous recharging of too many vehicles on the same part of the network will disrupt supply to several homes (see Section 4.3).

The relevant part of the ESQC Regulations 2002 (Amended 2006) [29] is given in Section 2.5. The DNO is required to:

- Design and operate networks equipped with protective devices so as to limit the number of customers affected by a fault in the network.

It can be seen from Section 3.1.1 that the mains cable supplying several houses is insufficient at present to allow many houses to recharge electric vehicles at the same time. If electric vehicles are recharged using the existing domestic house ring then if no action is taken as their use increases then this will lead to an overload of the mains cable and thus more frequent supply interruptions. In this case these regulations may be interpreted (especially by a customer who does not own a PiEV) as the DNO is failing to design and operate a network that limits customers affected by a fault (see Section 4.6).

In addition, The Electricity Act 1989 [15] - in conjunction with its subordinate regulation: The Electricity (Connections Standards of Performance) Regulations 2010 [30] also given in Section 2.5 prescribes the penalties that may be imposed on DNOs should they not meet specified levels of performance.

Thus if supply interruptions increase due to the use of PiEVs then the DNO may be liable for payments to customers for failing to meet guaranteed levels of service (see Section 4.6).

The Distribution Price Control Review (DPCR) [7] sets limits on the price that distributors can recharge, which limits investment. The DPCR is set with agreement with the regulator Ofgem who firmly believes that the DNOs have enough money to perform their function. DNOs who invest their own money in improving network performance are rewarded via the incentive mechanism. There are some mechanisms in place whereby if load related investment is massively different to that planned and signed off in the price control DNOs can get some extra money. Thus if there is a significant uptake in PiEVs requiring additional investment in the network then there are mechanisms within the current arrangements that should handle the situation.

### 3.1.3 Competition to Provide Domestic Charging

It is expected that the existing structure of the electricity supply industry with the clear distinction between supply and distribution will not be changed by the use of PiEVs. Thus fair competition to supply domestic electric vehicle recharging will be covered by the existing industry structures.

### 3.1.4 Planning Affecting Domestic Charging Points

Planning permission is not required for external sockets at domestic properties when the power cable remains on the home owner's land. Thus if houses have drives and the car can be recharged off the public road then there is unlikely to be any planning issues.

There is likely to be Planning issues with houses that only have on-street parking and a recharging cable would extend from a house or flat across a pavement to an electric car (see Section 4.13).

The recharge points for blocks of flats are more closely related to those provided for commercial properties.

### 3.1.5 Safety of Domestic Charging Points

An analysis of potential hazards associated with PiEV recharging is given in Appendix A. The existing legislation is sufficient to cover protection from the following hazards since these are not specific to PiEV charging:

- Water ingress.
- Extreme temperatures.
- Cable can withstand being driven over.
- Exposure to common solvents or chemicals.
- Exposed live electrical parts due to an insulation failure.
- Recharge equipment designed to withstand the demands of normal 'everyday' use.
- Power should not be fed back into a de-energised grid.

Several safety concerns have been noted regarding the recharging of electric vehicles. It would seem to be the responsibility of the car and /or charging post manufacturer to address the following concerns. Options for resolving these are not within the scope of this document on infrastructure and will not be considered further:

- If the car is driven away whilst still connected to the charging point then it is possible that the cable may break and electrical wires be exposed, presenting a safety hazard.
- The PiEV recharges at a rate above the rating of the recharging point then this may lead to an electrical fire.
- If the battery of the electric vehicle is used as an energy store then it will be possible for energy to flow from the vehicle. The vehicle cannot be fitted with a standard plug with exposed pins since this will clearly present a hazard if the car is disconnected whilst providing energy back into the house or local network.

The recharging of PiEVs in domestic properties presents several safety concerns and these are described below.

Loss of the main DNO protective conductor to a domestic property may result during charging in the body of the electric vehicle being raised to 230V AC presenting a serious safety hazard.

The recharging of electric vehicles in houses will typically use a 13 or 30 Amp cable. There are however concerns that if the electrical wiring in a house is old then it may be insufficient for the several hours it will take to recharge an electric vehicle. This may present a safety hazard in that an electrical fire may start.

3.1.6 Responsibilities and Obligations for the Supply of Domestic Charging Points

The responsibilities of the various organisations involved in providing recharging points are described in Section 3.2.6 for the case of providing public charging points. The information is presented here since this is the most complex case.

If PiEVs have a capability for a fast charge using a higher electric current than domestic circuits can provide, then the car manufacturer will be responsible for ensuring that the faster charge cannot be inadvertently be used in homes. Each home will have a separate circuit breaker that will provide a second layer of protection if too much current flows.

In a row of terraced houses the owners generally park their car on the street. If someone charges an electric vehicle then the cable from the house to the car will lay across the pavement. Guidance is required to ensure that the cable does not present a tripping hazard to people walking along the pavement (see Section 4.13).

## 3.2 Public Charging Points

Public recharging points are regarded as recharging locations which the public may use regardless of recharge point ownership. This may, however, require a user to register to gain access to the charging point which may have a protective lock of some form.

Public parking locations are generally associated with inner cities and on-street parking; however, there are numerous other possible locations which may yield a variety of requirements.

3.2.1 Network to Supply Public Charging Points

The possible effect of electric vehicles on the daily peak demand for electricity has already been considered in Section 3.1.1. If public charging points become widespread in UK cities then these are likely to lead to an increase in the electricity demand during the day and this will have an adverse effect upon the cost of electricity, particularly over the peak time. People's habits may create a morning commute related peak when people plug in at the station / park and ride on their way to work or at their place of work when they arrive. A means of managing the use of public charging points at times of high demand is required (see Section 4.1).

There are obvious concerns over the limited range of PiEVs (typically less than 100 miles) currently on the market making then unsuitable for long journeys. The technical feasibility of providing a fast or rapid charge is considered by Credit Suisse, see Charging Network Requirements Report [32]; however, the implications for the infrastructure and competition are considered in Section 4.7.

### 3.2.2 Regulation

A useful summary of existing regulations pertaining to electricity generation, distribution and supply is given in Appendix A. It is expected that the installation of a public charging point will be covered by the existing regulations for a new connection. Thus the customer will buy the charging point equipment, a third party can bid for the contestable part of the work and the DNO receives a connection charge as agreed by the regulator.

The following issues arise with the current regulations regarding public charging points:

DNOs don't currently have the responsibility to own and maintain public charging points. The maintenance of the posts could not be financed from the DUoS charges relating to the electricity used at the charging points themselves, thus the DNO would have to use money that is raised generally via DUoS charges (i.e. all electricity customers would subsidise charging points whether they had an electric car or not). In this scenario the DNO could be exposed to an increasing commercial risk as the number of public charging points increases.

In order to perform 'street works' to install a charging point then there are numerous permits that must be obtained. In addition installation of a charge point generally requires the DNO to make the electrical connection and someone from a metering organisation to install the meter for the charging point. This all requires additional coordination, especially if the work cannot proceed on the dates planned perhaps due to cars parked in the wrong area. In this case the permits and work may need reorganisation. This is done most easily if there are fewer parties involved in any single charging point installation. It is possible that in the future the installation will be handled by a single organisation to simplify the process.

Under the current regulations the DNO maintains the network and is not allowed to supply electricity. Thus if the DNO owned the charging point then the electricity on offer at the charging post would be provided by an electricity supplier, possibly another part of the same organisation. If the installation of the charging posts moves to authorised third party installers doing all the work for each installation, with little contact with the DNO perhaps other than to inform the DNO about connection to their network, then there seems no reason why the regulations cannot change to allow the DNO to be paid for the electricity if they own the recharging point.

#### 3.2.2.1 Data Protection

The Data Protection Act 1998 describes what organisations can and cannot do with data that identifies living people. Notably, data may only be used for the specific purpose that it was collected and must not be passed on to other parties without consent. There are two ways that this may impact PiEV recharging: identifying the user of a recharge point, and controlling demand side management (DSM).

In the first case, the likely reason for data collection is to allow payment to be processed in the case of the user having an account from which payment is deducted or charged to. This is unlikely to cause any issues as this type of payment is commonly done so the data protection issues are well understood, or may not even be relevant if, for instance, pre-paid cards were purchased in advance.

In the second case it is uncertain exactly what data may need to flow to allow DSM. It is possible that signals indicating that DSM is required could be broadcast to PiEV users in which case no personal information would be processed. It is likely that finer control would be required to better manage the network and to compensate the user for supplying DSM. Therefore information may need to flow between the supplier and the DNO, which causes no

problem providing the PiEV user was aware what information was being collected and who it was being sent to.

### 3.2.3 Competition

Whilst the PiEV industry is in its infancy, many public charging posts are owned by Local Authorities. There is clearly a problem here in that the Local Authority has a monopoly on Planning Consents in a given area. The 'Permitted Development' allows the Local Authority an unfair advantage over other providers of public recharge points. The current Planning situation presents serious competition issues if Local Authorities are both providing public recharge points and giving Planning Consent for competitors.

Public recharging points may be in a variety of locations, usually associated with parking spaces. These may be on-street parking, council or private owned car parks, or car parks associated with shopping or other commercial activity.

For public points, e.g. on-street parking, there are several possible owners of the points:

- Recharge point manufacturer.
- A third party recharge point provider.
- The owner of the parking space (e.g. the council, retail park owner, etc).
- An electricity supplier.
- The network operator (DNO).

It is possible that if a third party supplier owned all the recharge posts in an area giving them a local monopoly then there may be competition issues. However if the third party supplier is required to apply for permission to site the posts then the competition issues can be managed by the Local Authority in reviewing the applications. Thus significant competition issues are unlikely if the recharge point is owned by an independent third party supplier or an electricity supplier. The competition issues that may arise with the other organisations owning public recharge points are discussed in Section 5.8.

To allow fair competition, the electricity industry maintains a strict separation between the DNO and the electricity supplier. The new companies involved in the provision of public charge points find the segmented structure of the electricity industry less than optimal. For example, when installing a public charge point it may be necessary to coordinate work with the DNO and the meter owner (see Section 3.2.6 responsibilities). This type of coordination occurs to provide the electrical supply to new houses. It is possible that in the future the installation may be handled by a single organisation to simplify the process. The wouldn't seem to be any obvious competition issues if several companies were able to compete for the work and each had the same access to the DNO network. This will essentially reduce the amount of non-contestable work associated with an installation and increase the contestable part.

At present, electricity at charging points is provided at no additional cost to the user. The cost of the electricity is borne by the Local Authority, who wants to promote electric vehicles or the retailer who wants to attract customers. There may be an administrative charge levied by the Local Authority for managing a key scheme for access to the charging points. The main benefit of public charging infrastructure is to overcome customers' "range anxiety" which prevents people from buying/using an electric car in the first place.

It would seem that convenience is a key factor in determining whether people choose to recharge their electric vehicle. Thus whilst people are making relatively short journeys in electric vehicles then those people with off-street parking are likely to recharge their vehicle at home overnight. Thus it would seem that people will only use public charging points if they need them and start making longer journeys exceeding the range of the vehicle. It would thus seem that if people have off-street parking that encouraging them to charge their vehicle in the city centre in the evening, say when they are attending the theatre will not be successful. Consideration of recharging for homes without off-street parking is provided in section 5.13. If charging points were located where it's convenient to leave the car as part of normal day to day activity (e.g. in workplace car parks, train station car parts etc.), then these may be used routinely to top up the battery if there is not a high price differential. There is a delicate pricing issue to attract the appropriate amount of charging during the day, not adversely affect the peaks, but to provide some reduction in the load on the residential network. It seems likely that the residential network will see a significant increase in electricity demand through the uptake of PiEVs.

In addition to the cost of electricity, the installation, operation and maintenance of public recharge points requires additional expenditure. It is currently difficult to see how companies can make a financial return with these assets when people can merely recharge their vehicles at home. This will result in high recharge costs to PiEV users in comparison to domestic recharging; ultimately shaping consumer behaviour such that the recharge posts may be infrequently used (Section 4.8).

Once people start making longer journeys then there will be a market for a limited number of charging points for the situations where charge is required and the driver can't charge at home. Like filling up with petrol at a motorway services – we all know it's more expensive, but we sometimes can't avoid it. However, there would be a high degree of commercial risk in owning and operating these charging points as the emergence of hybrids and longer range EV's may destroy their market, and they would face uncertain competition from fast charging locations.

### 3.2.4 Planning

The current planning legislation (see Section 2.3) regarding public recharging points must be complied with and has the following implications:

- The installation of a recharging point i.e. upstand, outside of a building (public/private outdoor car park, on street parking bay) constitutes development.
- If the recharging cord is linked to an existing piece of street furniture (e.g. a parking meter) it may be constituted as development due to the change in use.
- The installation of a recharging point on the side of a building (wall box) is not development if it does not change the external appearance of the building and there are no other restrictions, such as the building is listed, in a conservation area or has had the benefit of permitted development removed by the planning authority.
- A recharging point located in an indoor car park is not development, unless installation changes the use of the building, i.e. cars were entering to recharge only creating a refuelling station in the car park.

For those situations where the proposal is classed as development it may under The Town and Country Planning (General Permitted Development) Order (GPDO) 1995 (as amended) [37] be permitted development for which planning permission is not required. The consideration is where the recharging infrastructure is to be located and who is installing it.

Part 12: Development by local authorities: Class A provides permitted development status for -

> "lamp standards, information kiosks, passenger shelters, public shelters and seats, telephone boxes, fire alarms, public drinking fountains, horse troughs, refuse bins or baskets, barriers for the control of people waiting to enter public service vehicles, and similar structures or works required in connection with the operation of any public service administered by them."

Most street furniture is currently provided by local authorities as permitted development under Part 12 and it is likely that both off-street and on-street recharging points provided by Local Authorities would be included in this category if the Local Authority administers the service of charging the vehicles.

3.2.4.1 Proposals for Change to the Legislation

It is acknowledged by the government that few regulatory planning issues have arisen with regard to the installation of PiEV recharging infrastructure to date but that clarification on the status in planning terms is necessary (DCLGa) [38]. The Government issued a consultation document, in 2009, which proposed changes to permitted development rights. The changes included those sections of the GPDO that could benefit PiEV recharging infrastructure (DCLGb) [39].

Proposed changes to Parts 2 and 12 of Schedule 2 of the GPDO are detailed in Section 5.9. The changes would mean that organisations other than Local Authorities could provide off road recharging infrastructure without the need for planning permission subject to the infrastructure meeting design requirements on volume/height/location etc.

A new class for deemed consent of advertisements under Town and Country Planning (Control of Advertisements) (England) Regulations 2007 is also proposed to allow the display of a nameplate or the recharging point provider and/or the energy supplier on a PiEV recharging point. Again this will be subject to size restrictions and location of the recharging point.

In recent government publications [38] [39] it has been acknowledged that there may be a large number of recharging points established in the future and that the planning legislation in its current form is not consistent across the range of types of infrastructure (as it was not written with such infrastructure in mind). Proposals are thus required to regularise the requirements for public recharging points.

There is currently no approved Road Traffic Signs for public PiEV infrastructure. Appropriate signs are required before PiEVs become more widespread.

3.2.4.2 Future Changes to Planning Regulations

There are a number of government documents out for consultation which include sections relating to the establishment of recharging infrastructure and planning considerations; however, as of October 2010 there has been no publication relating to the government's response on the consultations, or advice on the direction that they may take in the future in terms of regulation. It is understood from the planning management department of DCLG that the Government should be making a decision on the proposals shortly.

The most relevant documents that have been identified are:

Planning policy statement: Consultation.

*DCLG, Planning for a Low Carbon Future in a changing climate, March 2010* [40]

> The draft planning policy is focused on new development schemes and states that for car parking within new development infrastructure should be included as integral to the design of the development. In policy making the Local Authority should be writing policy with the objective of bringing such infrastructure forward, but not making development unviable. For this study it is assumed that the recharging infrastructure that will be installed will be in established development and streets.

*DCLGa, Review of permitted development for charging points for electric cars, (Nov 2009)* [38]

> This report provides the findings of a study into the barriers in the planning system and how they can be removed to facilitate the installation of a national network of PiEV recharging points. The study examined primary and secondary legislation that might affect recharging points and it concludes that whilst these have not been written with recharging points in mind, it would be inappropriate to make major changes to them at this time; instead clarification of the existing legislation would be desirable.

DCLGb, Permitted development rights for small scale renewable and low carbon energy technologies, and electric vehicle charging infrastructure (Nov 2009) [39]

> This report puts forward proposals for changes to the planning system in relation to permitted development rights for small scale renewable and low carbon energy development and PiEV recharging infrastructure. Minor amendments to existing planning legislation are put forward in order that the Government can promote a switch to PiEVs.

3.2.4.3 City of Westminster Case Study

The City of Westminster has installed recharging points in its area [41]. As they were installed and maintained by the Local Authority they were all installed without planning permission under Schedule 12 of the GPDO. A small advert to show the electricity provider was included on each point. Again this was done with the benefit of deemed consent. A report providing information on the considerations taken into account by the local authority when designing the infrastructure included:

- The City of Westminster detailed design criteria adopted by the council,
- Suitability of use for disabled users and
- Compatibility with the majority of electric vehicles used in London.

The suitability of use for disabled users is covered in Section 5.6 of the Westminster report; standardisation of connectors is discussed in project report SP2/E.ON/04 [32] leaving the design criteria as the remaining area of interest for planning consent.

The City of Westminster's Design Criteria relevant to recharging infrastructure is:

- **Quality:** Westminster's public realm requires high quality furniture components, materials, scheme design, implementation and detailing.
- **Durability:** The choice of material must reflect the anticipated demands of the high levels of use and ensure long term, sustainable solutions can be implemented.

- **Character:** The city's distinctive black livery should be adopted for all street furniture items, unless specifically identified as an established exception to this rule.

- **Clutter Free:** Minimise the occurrence of street furniture obstruction, by removing obsolete items, co-locating elements where appropriate and only installing new items were considered necessary. This will ensure ease of pedestrian movement and the delivery of a truly inclusive public realm.

3.2.4.4 Suitability of Use for Disabled Users

While not a mandatory requirement, many councils will require that the design of the PiEV recharging stations comply with the regulations on approaches to meeting the needs of disabled people as laid down in BS EN 8300:2009+A1:2010 Design of Buildings and their Approaches to Meet the Needs of Disabled People. Code of practice [42].

This standard provides recommendations for the design of buildings and their approaches to meet the needs of disabled people. It applies to car parking provision, setting-down points and garaging, access routes to and around all buildings, and entrances to and interiors of new buildings. The recommendations also apply to routes to facilities associated with and in the immediate vicinity of buildings and are therefore directly applicable to recharging infrastructure.

According to Section 4.4.4.3 of the standard, the height of the controls for ticket dispensers, coin slots, RFID tags and cable connecter/ sockets etc. should be such that they can be operated from a wheelchair and therefore at a height of between 750 mm and 1200 mm from the ground. For non wheelchair users the height of these may be between 1000 mm and 1400 mm.

Therefore, either two user interfaces at different heights are required, or more likely the interface height will fall in the overlap between the requirements of wheelchair and non-wheelchair users (i.e. between 1000-1200 mm).

The space in front of the user interfaces should be level, free from obstruction and at least 1850 mm wide (tangential to the interface) and 2100 mm deep parallel to the interface to allow a wheelchair to manoeuvre. For maximum accessibility any plinth under the recharging point should not project beyond the front of the user interface.

Figure 5 shows these two requirements diagrammatically.

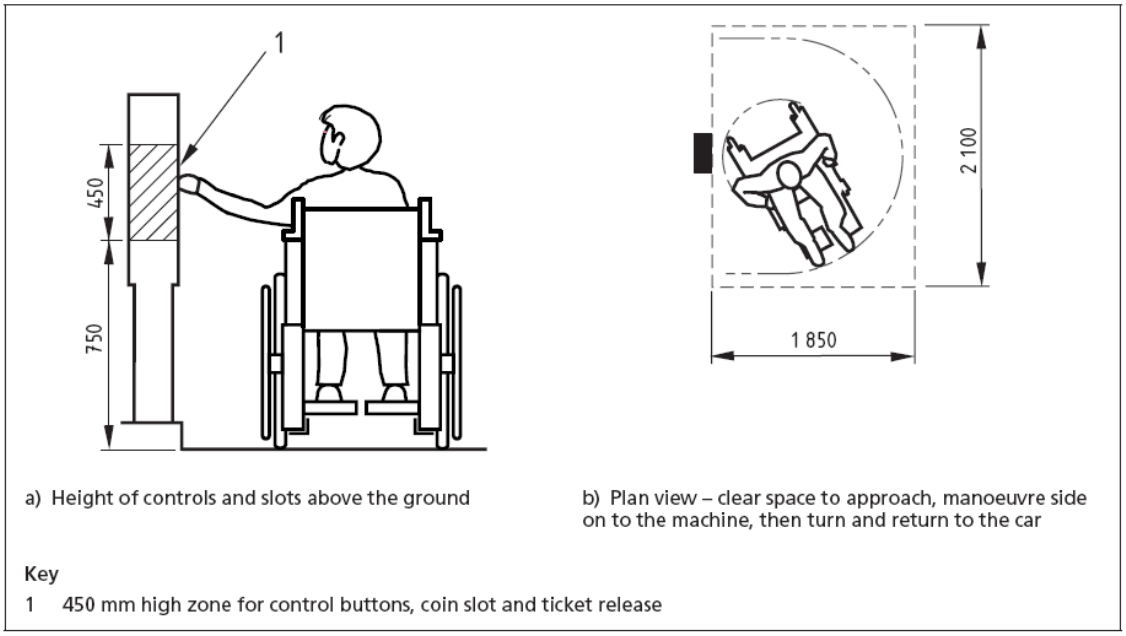


**Figure 5: Key Dimensions Relating to Ticket Dispensing Machines for use by Wheelchair Users (dimensions in millimetres)**

In practice this means that the user interfaces will generally face away from the road so as to provide the shortest recharging cable run to the PiEV to reduce tripping hazards and provide the largest area for wheelchairs to manoeuvre.

Section 5.7.1.2 states that freestanding posts should have a visual contrast with the background. It is desirable to incorporate a band 150 mm high, whose bottom edge is 1500 mm above ground level, which contrasts with the remainder of the post.

Section 10.2 covers ATMs and other coin and card operated devices and numerous requirements on these for partially sighted people, although probably not directly applicable to recharging infrastructure (it is unlikely that partially sighted will drive) the guidelines in this section could be considered general best practice, for example screens should be shielded to avoid glare and reflection, the instructions and signs should be illuminated and in certain positions, clear typefaces should be used for instructions, ideally with universally recognised pictograms (possibly important for foreign drivers).

Disabled parking bays are covered in this standard (Section 4), although the design of these is outside the scope of this report.

Parking meters, parking controls and ticket dispensers are covered in BS EN 12414 [43].

3.2.4.5 Summary of Planning for Public Charging Points

Current legislation (which was not designed to govern PiEV recharging infrastructure) limits the development and advertising that can be undertaken without the need for an application to the Local Planning Authority (LPA).
For recharging posts that may be designed, installed and maintained by operators other than the Local Authority the design, location needs to be considered carefully and it may be necessary to obtain planning consent for the installation under the current legislation.

The Government is proposing changes to the planning system with regard to recharging infrastructure which will make clearer the situation for organisations other than Local Authorities wishing to install infrastructure. It is anticipated that the regulations will be finalised by the government in 2011.

Changes to the existing Traffic Signs and Road Markings regulations to incorporate some standard PiEV recharging signage would significantly reduce administration in providing PiEV parking signage. It is not clear that this is included in the proposed changes to the planning regulations, and this is considered in Section 5.9.

### 3.2.5 Safety

The safety concerns for the charging of a PiEV were considered in Section 3.1.5. The additional concerns for the use of public charging points are:

A third party (passer by) removes the plug from the PiEV whilst it is charging. This is, however, an issue for the post and / or car manufacturer and will not be considered further in this report.

### 3.2.6 Responsibilities and Obligations

The responsibilities of the various organisations involved in the manufacture, installation, operation, maintenance and decommissioning of a public charging point are summarised in Appendix C. In the case of a public on-street charging point then the site owner is the Local Authority. More detail regarding the responsibilities of the various parties is provided in the sections below.

The installation process for public charging points is also summarised in Appendix C. It is typical for the charging point owner to lease the land for the charging point from the site owner. A lease between the two parties must be negotiated and this is generally the most complex part of the whole installation process. Indeed commercial arrangements are required between the charging point owner and all other separate organisations involved in the process, e.g. it is possible that the installer may be different to the owner etc.

The installation, operation and maintenance of a public charging point will clearly be simpler if fewer organisations are involved in the process. The description below identifies different roles, e.g. installer, owner and operator. Although different roles are identified it does not mean that some roles cannot be performed by the same organisation.

#### 3.2.6.1 Duty of Care

Safety is arguably the most important aspect of PiEV recharging and should be an integral part of the design, manufacture, supply, installation and use of the recharge posts. Duty of Care to users and the general public extends from the manufacturer of the equipment through to the operator who must ensure that a person is not harmed as a result of running his or her business.

#### 3.2.6.2 Responsibilities of Equipment Manufacturers and Distributors (Product Safety)

The duty for guaranteeing the fundamental safety of the equipment before it is available for purchase falls to both the manufacturer and distributor of the equipment. This includes equipment integral to the recharge point, the recharging cable and any equipment which forms part of the PiEV.

Some of the statutory duties placed on producers and distributors of equipment are specified within The Consumer Protection Act 1987 [44] and The General Product Safety Regulations

2005 [45]. The law states that no producer shall supply or place a product on the market unless it is safe. The producer also has a duty to sample test marketed products and investigate any safety complaints. Furthermore, they are also required to provide consumers with information such that they can assess the risks inherent with a product and take precautions against those risks.

Obligations placed on the distributors of products include a duty not to posses, agree to supply or supply a product which is dangerous. They must also participate in the monitoring of safety of a product placed on the market by measures such as: passing on information on the risks posed by a product and keeping the documentation necessary for tracing the origin of a product.

Contravention of these regulations could result in up to 12 months imprisonment and a £20,000 fine. A civil suit may also be brought against a distributor or producer if a consumer has suffered any injury or loss as a result of using a dangerous product, whether or not they have supplied the product.

In addition to safety of equipment, manufacturers are also duty bound to ensure that the manufactured equipment does not generate an electromagnetic disturbance which will prevent radio and telecommunications or other equipment from operating. These duties are detailed further in the Electromagnetic Compatibility Regulations 2006 [46].

Distributors have a responsibility to ensure that the equipment they are supplying satisfies the requirements of accessibility (see Section 3.2.6.7).

It would seem that the responsibilities regarding charging post manufacturers and distributors are covered by existing legislation.

3.2.6.3 Responsibilities of the Installer

The identification of a suitable site for public charging posts will either be with the installer or the site owner.

If it is necessary to amend traffic regulation/ order /parking designation order then this will be initiated either by the installer or charging post owner with the site owner providing the required notification for the site and if necessary any notification of local businesses.

The installer will be responsible for commissioning a site survey. This will ensure that there is a sufficient electrical power source close to the proposed site, that the site will comply with appropriate regulations (e.g. disability discrimination act) and that the post is not likely to be damaged as the vehicles arrive or leave, etc.

The installer will be responsible for providing the ‘Opening Up notice’ that is required before work can commence in a public place.
Either the installer or the site owner will be responsible for preparing the application to install the charging point in a public location. The installer and the site owner will clearly need to agree between themselves who is responsible for each application.

The installer is responsible for the work on site and if necessary coordination with the meter owner and the DNO for the connection of the charging point to the new feeder pillar on the existing network.

The installer is responsible for commissioning the charging point.

The installer will have a duty of care to ensure the installation does not present a hazard, however the site owner is responsible for the site safety inspection after installation.

3.2.6.4 Responsibilities of the DNO

The DNO has a responsibility for the reliability of supply as already discussed in Section 2.5.1.

A public, on street, recharge point installation will usually comprise DNO equipment, such as a low-voltage feeder pillar (see Figure 6), underground cabling up to the point of supply (usually the electricity meter) and the recharge post equipment itself.

As discussed previously, the ESQC Regulations (Amended 2006), describes the safety requirements of equipment owned and operated by an electricity distributor (DNO). In this example this would comprise the feeder pillar and the possibly the underground cable to the recharge post. The requirements include a duty to prevent danger, interference with or interruption of supply and to ensure their equipment is sufficient for the purposes in which it is used. The distributor must also regularly inspect and maintain their equipment and keep a record that the inspections have been carried out. Additionally, the regulations specify a general requirement to ensure that faults are disconnected with sufficient rapidity to prevent danger. This can be achieved by using protective devices which must be applied to all networks. General Earthing obligations for DNOs, covered by the regulations, state, for example, that all metalwork must be connected to earth and that all networks should be designed and operated to accommodate safely the largest possible fault current that could flow through the network.

**Figure 6: Recharge Post and DNO Owned Feeder Pillar**

3.2.6.5 Responsibilities of Recharge Post Owners

The duty for ensuring safety of the recharge post installation itself will differ depending on the situation, but generally this responsibility will fall to the approved installation contractor and/or the recharge post owner, whether they are a Local Authority, third party operator or private consumer.

Owners of public recharge posts which are operated as part of a business, or commercial recharge posts installed at a place of work, will be duty bound by the Health & Safety at Work

Act 1974 (HASAWA 1974) [47] and the Electricity at Work Regulations 1989. There is a general duty that employers and the self-employed must ensure the safety of anyone, other than their own employees, who may be affected by their undertakings. This involves actively reducing the risk of danger to users and the general public arising from the equipment itself, maintenance activities or any other work activity associated with owning and operating a recharge post. In addition to the general duties as imposed by the HASAWA 1974, there are specific requirements for employers with respect to electrical systems within the Electricity at Work Regulations 1989 [28].

Where recharge post installations form an integral part of a building (i.e. those which are mounted on a wall in a commercial or domestic property), as a minimum, these should all conform to the British Standard BS 7671 – Requirements for Electrical Installations; the IEE wiring regulations.

Choosing an appropriate location for the recharge post, especially for on-street installations, is an important requirement for owners and operators. Not only will location impact user access, it also has large implications for public safety. Account must be taken of a number of factors:

- Pedestrian flow (including disabled pedestrians).
- Available footway widths.
- Parking and loading requirements.
- Land uses adjacent to the recharge post.
- Security.

It is the responsibility of the recharge post owner to minimise the impact to the streetscape as a result of their recharge post network. Currently, regulations state that the footway clearance zone must be at least 1000 mm but good practice suggests that the preferred minimum clear width should be 2000 mm. This would allow 2 wheelchair users to pass one another comfortably. Using this guidance, the impact to visually impaired pedestrians is also minimised and it will help reduce the likelihood of contravening The Disability Discrimination Act 1995 [48].

If the recharge post owner is different to the operator then the owner will have responsibility for ensuring that the operator has appropriate procedures in place to guard against theft prevent (equipment and electricity) and misuses of the posts (see Section 3.2.6.7 below).

Loss of an electricity supply in general can have a profound impact on customers and as such there is legislation governing interruptions in supply. This is equally true of recharge posts where the inconvenience of a loss of supply can be likened to a vehicle breakdown. Whereas a user can mitigate the risk of a breakdown by ensuring adequate vehicle maintenance; public or commercial recharge point maintenance is beyond the control of a PiEV user. It is therefore the responsibility of the recharge post owner to provide continuity of supply. If the owner is separate to the operator then the owner should ensure that the operator has procedures in place to provide continuity of supply. Petrol stations do not have a responsibility to never run out of fuel; they just lose business if they do. The current electricity regulations regarding continuity of supply will place a bigger burden on the provision of public charging points than on petrol stations.

3.2.6.6 Responsibilities of Recharge Post Operators

Safety is arguably the most important aspect of PiEV recharging and should be an integral part of the design, manufacture, supply, installation and use of the recharge posts. Duty of Care to

users and the general public extends from the manufacturer of the equipment through to the operator who must ensure that a person is not harmed as a result of running his or her business.

Operators of public recharge points are presently not bound by the same legal obligations as the DNO with respect to availability of supply and quality of power. However, in order to maintain a successful business, it is in their best interest to make sure that an electricity supply is always available and that any downtime is resolved quickly. Where the recharge point is owned by the Local Authority but operated by a third party, a Service Level Agreement written into the contract, with penalties for poor performance, could reduce the likelihood of an operator neglecting to maintain his network of recharge posts.

Slips and trips are one of the biggest causes of injury in the workplace and for the general public. It is the operator's responsibility to actively reduce the risks of trips which may be caused by his equipment. Current mitigation measures include the use of a high visibility, yellow cable which is coiled to prevent trailing on the ground. Figure 7 shows an example of this.

**Figure 7: High Visibility Recharging Cable**

If the recharge post operator is different to the owner then the operator may also have responsibility for ensuring that the site for the charging point is appropriate (see Section 3.2.6.5 above).

It is reasonable to assume that the recharge post operator is also responsible for theft prevention (equipment and electricity) and taking preventative measures against the misuse of recharge posts, for example: the use of unauthorised cables or adaptors and the malicious unauthorised disconnection of unattended vehicles. In some circumstances, the police or traffic wardens may require an ability to remove a vehicle from a charging point. This may arise if for example the parking fee has expired or there are other problems with the vehicle. It will most likely be the responsibility of the charging post operator to work with the services to make the disconnection. This can only be done if posts are manufactured with an override key that allows the post operator to disconnect vehicles if necessary.

CCTV surveillance or regular manual inspections could be used to monitor charge point locations and enforce actions against the misuse of charge points. Such measures might also improve personal security of charge point users which should be a significant concern for operators. Alternatively, the associated natural surveillance of a busy location with high footfall may help increase the security of charge point users at night or during off-peak periods.

Recharge post operators have a responsibility for accessibility of the equipment (see below).

The post operator should have procedures in place to deliver the owner's responsibilities to provide continuity of supply, though under the existing regulations this is currently more onerous than the responsibilities of the owners of petrol stations.

3.2.6.7 Accessibility

Accessibility is a general term used to describe the degree to which a product, device, service, or environment is accessible by as many people as possible. The Disability Discrimination Act 1995 states that it is unlawful for a provider of services not to provide a service to a disabled person which he provides, or is prepared to provide, to members of the public. Therefore it is the duty of recharge post suppliers and operators to consider the following:

- **Access to the recharge post charge socket:** The socket should be at a reasonable height and angle such that a person in a wheelchair can easily access it. Consideration should also be made as to the distance of the recharge post from the kerb. This is covered in greater detail in Section 5.

- **User Interface Design and Location:** The interface, including user controls, should be situated that they are easily accessible to a person in a wheelchair (as covered in greater detail in Section 5). Design considerations should also be made to accommodate other disabilities such as visual impairment or colour blindness.

- **Communication Methods:** Both audible and visual information should be available to the user to accommodate those with hearing impairment and mental disabilities such as dyslexia.

By making these considerations, the operator ensures that his network of recharge posts is accessible to a larger user base and reduces the risk of possible legal action due to contravention of The Disability Discrimination Act.

3.2.7 Communications Network for Public Charging Points

It is clear that if public charging points are used then there is some communication required between the customer and the service provider. It would seem that information exchange in at least the following areas is required:

Price of the electricity.

Energy provided during the recharging.

Payment including VAT details

It is likely that at some charging points or in time the following will also be required:

Option to choose the charge rate.

Demand side management at times of peak demand.

Note that the same communications capability is also required to serve the needs of the Recharge Post Operator including for example remote monitoring and diagnostics, (e.g. is the point functioning normally or does it have a fault?), and maintenance – software downloads etc. It seems that the more information that must be exchanged between the customer and the service provider then the more expensive it will be to manufacture the recharge post and it is likely that the cost of the communications infrastructure will also increase. The ETI PiEV Work

Package 2.4 [49] provides a lengthy discussion of network communications for public charging points, including what data might be exchanged, how it might be processed and used, and who might be involved – including Recharge Post Operators and an Intelligent Infrastructure Operator. Further consideration of paying at public recharging points is given in Section 4.12.

The price of the electricity could easily be described as a peak (day time) and an off-peak (evening) price. This could be set in the charging post and would not require any additional communication. In the longer term the electricity generation will include much more wind energy and thus the price may vary depending upon the wind. The demand however in a city area is likely to follow the current trend with a higher demand during the day and lower at night. A simple two price charging system is likely to be sufficient and there may be no need to follow the electricity generation price in the short term. Since the electricity demand is higher during the winter, there may be a seasonal variation in these charging prices though it will be a commercial decision of the post owner whether or not they vary the prices over the year.

The duration of the charge can easily be set at the post depending upon how long the customer wishes or is allowed to leave his car parked in the space. This does not necessarily require the communication of additional information beyond the post itself.

Various options for payment of the electricity at the public recharge post are considered in Section 4.12.

If a post can charge PiEVs at different rates then it is expected that this will be selected at the post by the customer. It will be necessary for the PiEV and recharge post manufacturers to agree on a method that prevents damage to either in the event of an erroneous selection by the customer. It would thus seem unnecessary for significant additional communication for this service.

If the recharge post is providing demand side management then this will really just be a reduction in the charging at peak times and taking energy out of the PiEV is not considered. The demand side management is currently only required at around 4.00 to 7.00 pm on some week days during the winter period. Thus as the PiEV recharging market is developing then a notice on the post saying that during these times from say 15$^{th}$ November to 15$^{th}$ February then recharging may be only say at the rate of 70% of the selected power flow. A communication signal is required to enact the demand side management at the post and it will be helpful to vary the amount of reduction. There is generally some advance warning of when demand side management is required and it is expected that this could be displayed on a screen on the post on those days. If people receive less energy due to demand side management or say a power failure then both customers and Ofgem will no doubt require the paying system to be sufficiently flexible not to charge people for the energy that has not been provided. Thus it should not be too expensive to implement demand side management at public recharge posts, though it will require additional flexibility in the payment method which is considered in Section 4.12.

### 3.3 Charging Points on Commercial Sites

Commercial premises considered in this report are those that may have recharge points operated for the private needs of the organisation concerned, possibly including the recharging of commercial vehicles which have higher power consumption requirements than cars. In general this section considers commercial businesses, but due to similarities of requirements and installations, it will also include some public service organisations, for example car parks used for park and ride schemes and operated by local authorities.

Commercial premises will also include supermarkets and hotels wishing to provide a charging facility for their customers.

Commercial recharging will be associated with a wide range of locations including: industrial warehouses, business compounds, employee car parks, supermarkets, hotels and university campuses. As a result, there is no one typical location.

### 3.3.1 Network to Supply Commercial Sites

The electrical load at various commercial sites together with a spread of possible recharging scenarios has been considered in EON 04 [32] and the main points to note for this report are:

In some cases the recharging of just a few electrical vehicles at some commercial premises may require the upgrade of the electrical supply to the site.

Applications such as supermarkets will have large electrical loads (refrigeration, heating, lighting, lifts etc.), hence these are mostly HV supplied. The addition of PiEV load is not expected to change the overall load significantly, assuming low to medium penetration levels, as the non PiEV load is already very high.

Most public parking areas (paid parking in multi storied buildings or park and ride locations) have only low electrical load and if PiEVs are to be provided then a significant upgrade of the network will most likely be required.

If many work car parking places provide charging of a PiEV then it is possible that if people arrive at work in the morning and start to charge their vehicle then this creates a peak in the early morning demand. Indeed if many vehicles charge overnight and they stop charging at say 7.00 am, then if others forget to charge overnight but start charging when they arrive at work say between 8.00 and 9.00 am then in the longer term when there are many PiEVs used there could be a sharp swing in demand over a few hours. It is thus suggested that workplaces that have a significant PiEV load should be required to spread the load to reduce the severity of the dip in electrical demand (see Section 5.1.2).

### 3.3.2 Regulation

For installations on private land, downstream of the meter, then these are easier than in public places. A single contractor can perform the work and there is no need to coordinate work with the DNO and meter owner or provide notification of work in public places.

If the recharging of just a few electrical vehicles at some commercial premises requires the upgrade of the electrical supply to the site and if these sites are in built up areas then the apportionment of network costs may be difficult. Whilst each application may be straightforward if there are several applications in a short period then significant network reinforcement may be required.

If electric vehicles are being charged on commercial premises then this may add to the daily electricity demand rather than spreading the load onto the night time demand. Furthermore, if there are several small businesses close together and some apply for charging points which results in a network upgrade then this may mean that other companies may subsequently face increased costs if they require more power to expand their business. Later applications may be required to contribute payment for network upgrades that occurred within the previous 5 years. It is likely that in these areas network grades triggered by PiEV use will be contentious, since without the PiEV use the existing capacity may have been sufficient for the businesses to expand. Thus for commercial premises in built up areas a longer term view of the require network upgrade may be preferable to a case by case incremental change (see Section 4.10).

In time, it would seem desirable to establish fast charging services along the motorway network. Though hotels situated near the junctions are likely to fall into this category with significant

network reinforcement required if fast charging services are to be provided. A similar situation may occur with the provision of fast charging services on the outskirts of cities. At least in these areas the apportionment of network upgrade costs should be clear and easily covered by the existing regulations.

### 3.3.3 Competition

There are already companies such as Elektromotive and POD Point which own a number of recharging points and manage payment and data. Car park owners could contract out to these third party companies to own and operate recharge points on their behalf. This promotes competition and should result in companies providing a range of services that are designed around customer needs (a DNO would find this business model difficult as they normally operate on the basis of providing the same level of service to all customers). These companies would be experts in installation, running and maintenance of recharge points, and have a smaller number of owners and operators could make it easier for PiEV users to use recharge points and pay for electricity.

It is very likely that most owners of large commercial car parks will install electric vehicle charging points gradually over time as demand for recharging increases. The first phase of the installation is likely to be from a single charging post supplier. At the moment manufacturers of charging points use their own recognition fob. Thus to avoid customers carrying a recognition fob for each type of recharge point, the car park owner may subsequently feel obliged to use the same post supplier. If this situation arises he is then likely to receive far less favourable terms for the cost of the recharge points for later phases. This will clearly lead to anti-competitive practice and it is not clear that the present market place will avoid the situation (see Section 4.11).

Some national chains of hotels, supermarkets or car parks may prefer to adopt a conventional business model for the provision of recharging. Thus they buy the recharging equipment and pay to have it maintained and charge customers for the service. This may be fine for hotels when most of the recharging demand may reasonably be expected overnight. If the hotel is in a residential area then the effect becomes similar to additional domestic demand. In the case of supermarkets however they may choose to discount the cost of the electricity during the day to attract customers. This will have an adverse effect upon the daily demand if the recharging may otherwise be done overnight. Since people can cheaply recharge their car at home overnight then this stimulus on the day time demand is unlikely to be too significant.

Some commercial organisations may see the provision of a ‘fast’ charge as a commercially viable business, since they will be able to charge a premium for the service. The provision of ‘fast’ charge services on longer routes is to be encouraged since this will likely stimulate the market for PiEVs and contribute to an increased take up.

### 3.3.4 Planning

The Planning issues have been covered in Section 3.2.4. It is worth repeating here that planning permission is not required for:

- The installation of a recharging point on the side of a building (wall box) is not development if it does not change the external appearance of the building and there are no other restrictions, such as the building is listed, in a conservation area or has had the benefit of permitted development removed by the planning authority.

- A recharging point located in an indoor car park is not development, unless installation changes the use of the building, i.e. cars were entering to recharge only creating a refuelling station in the car park.

### 3.3.5 Safety

There are no specific issues for installations on commercial premises. The issues have been covered previously in Sections 2.4 and 3.3.4.

### 3.3.6 Responsibilities and Obligations

If the commercial charging points are on private land and situated downstream of the meter then the DNO is not responsible for maintaining the equipment. The DNO is not exposed to the same risks as in the case of on-street sites considered in Section 3.2 above.

The responsibilities are shown in Section 3.2.6 for the installation of public charging points.

### 3.3.7 Communications Network for Commercial Charging Points

The installation of charging points at commercial sites may allow the use of simpler and cheaper recharging posts and simplify the payment requirements, since the cost may just be added to the bill of an existing customer. In these cases the installations at commercial sites may be very competitive with public charging posts. It will still be necessary for commercial sites with a large amount of PiEV recharging to participate in demand side management though this may be done through a central point controlling the charging rate through all the charging posts on site. Thus again each most will be much simpler than considered above for public charging points.

# 4 REQUIRED DEVELOPMENTS NOT COVERED BY EXISTING ARRANGEMENTS

The required developments that are not covered by the existing arrangements are identified in the sections below with possible solutions identified in the corresponding sub-sections of Section 5.

## 4.1 Manage the Daily Peak Electricity Demand

The use of PiEVs will probably increase the peak demand for electricity during the day. This may be costly if it results in the need for more generation and transmission capacity in the country and / or more capacity in both the high and low voltage distribution networks.

Regulations do not exist for the exchange of information to allow demand side management using PiEVs.

## 4.2 Manage Recharging of Electric Vehicles at Individual Dwellings

Time of use pricing is an important element in helping to manage the load at an individual dwelling. The factors considered under this section are in addition to a time of use tariff when the electrical demand through the use of PiEVs has increased so that time of use tariff is no longer sufficient.

The service cable to an individual dwelling may be insufficient to allow PiEV charging at the same time as using other electrical equipment, such as electrical heating.

With the increased electrical load from PiEV charging, the phase imbalance of domestic properties on single phase connections may go beyond acceptable limits.

## 4.3 Manage Domestic Recharging at Houses Connected to the Same Mains Cable

While time of use pricing is an important element in helping to manage the electrical load, eventually as the load increases then the system requires either more capacity or better management. Alternative means must be found of managing the recharging of electric vehicles at domestic properties since the capacity of the electrical network is likely to inadequate without significant investment.

## 4.4 Apportion Domestic Network Upgrade Costs Fairly

A means must be found of fairly apportioning the costs of network development to supply domestic properties among all users.

## 4.5 Provision of Charging Points at Accommodation with Communal Parking Areas

As indicated in Section 3.1.2, it is unclear who will pay for the provision of these charging points and options are discussed in Section 5.5.

## 4.6 Regulatory Issues if Domestic Charging of Electric Vehicles is not Managed

The current regulations for the DNO to manage their network have been developed and applied during a time when the demand for electricity has increased only gradually. It is possible that the take up of electric vehicles may result in an exponential increase in demand in some domestic areas and this may lead to a significant requirement for upgrades to the network. The DNO may have neither the staff nor the funding to deliver network upgrades in a short space of time. The DNO is thus more likely to encounter difficulties in providing the guaranteed levels of

service and face additional penalties. It is not clear that in this situation the current regulations will meet the needs of the customer, regulator and DNO.

### 4.7 Ownership of Charging Points

There is a potential conflict of interest with Local Authorities, DNOs and charging post manufacturers owning posts and these are considered in Section 5.7.

### 4.8 High Cost of Electricity from Public Recharge Points

It is clear that initially the public recharging of PiEVs will not be financially viable. Options for providing a subsidy need to be considered.

### 4.9 Reduce the Cost and Time to Install Public Charging Points

It is clear that the installation of recharging points on private land is much easier than in public places. This is necessarily the case though Section 5.9 considers several options that will reduce the cost and time to install public charging points.

### 4.10 Cost Apportionment of PiEV Impacts on Networks

In some locations the cost apportionment for PiEV impact upon networks is easy to determine, however in other locations it is much more difficult and treatment of this latter category is considered in Section 5.10.

### 4.11 Standardisation for Public Recharging Points

Avoid anti-competitive practices in the gradual role out of public recharge posts.

### 4.12 Payment Methods at Public Recharging Points

Currently there is no charge for the electricity at most public charging points. People pay for another service, i.e. parking and since the electricity is cheap this is included in the cost of the other service. If electricity remains free in the future at public charging points then potentially the electrical load may increase significantly with no control over demand. Alternatively if the electricity is very expensive, say due to recovering high costs of managing payments, then the public charging posts will not be used since almost everyone will recharge their vehicle at home. It is thus important to provide a low cost payment method at public charging points with the flexibility outlined in Section.3.2.7. Various options for charging are considered in Section 5.12.

### 4.13 Tripping Hazard caused by Recharging Cables laying across the Pavement

This issue arises for owners of electric vehicles with no drives.

### 4.14 Inadequate Domestic Electrical Wiring

Possible solutions are considered in Section 5.14.

### 4.15 Loss of the Main DNO Protective Conductor to a Domestic Property

Mitigation is described in Section 5.15.

# 5 POSSIBLE MEANS OF PROVIDING THE REQUIRED DEVELOPMENT

## 5.1 Options to Manage the Daily Peak Electricity Demand

### 5.1.1 Time of Use Tariff

By 2020, all homes should have smart meters fitted. A smart meter will potentially allow electricity suppliers to get much more information about the usage of electricity, so rather than getting a possibly estimated reading every few months, they could get detailed information about precisely when during a day electricity was used.

This creates the possibility of charging customers a different price depending on the time of day they consume power, i.e. electricity would be more expensive at peak times. In effect it would be a more complex version of Economy 7. This will help flatten the daily demand curve by encouraging use at off-peak times. Varying tariffs at during the day is a good way of managing demand to limit peak demand.

In the case of public charging points then there should be a similar varying tariff during the day. Clearly the customer will need to know in advance what the tariff is when they charge their vehicle though this will discourage people topping up batteries at peak times when they don't really need a recharge.

Work Packages 2.1 and 2.3 within this project provide a lengthy discussion on the case for Time of Use Tariffs [56].

### 5.1.2 Compulsory Demand Side Management Capability for PiEV Charging Points

The peak electricity demand in the UK occurs during the winter. At times there may only be a small margin between the available generating capacity and the demand. This is referred to as the supply margin. The power industry has a long tradition of having contracts in place with large power users who reduce load a few times during the year when the supply margin becomes tight. If many public charging posts are installed and used then it would seem sensible that they participated in the demand side management when the supply margin is tight. It should be compulsory for public charging points to have the facility to provide demand side management. This may just be reducing the load being taken for a short time and not necessarily supplying energy back into the network. There is generally a few hours notice of when the demand side management is required and thus this information should be available to a customer when they stop at the charging point.

This is also a valuable technique for limiting the impact of an early morning peak when staff arrive at work and start to charge their PiEV as noted in Section 3.3.1.

### 5.1.3 PiEVs used as a Store of Electrical Energy

Vehicles tend to be driven for a small proportion of time during the day, and while a PiEV is not being used, its battery could potentially be used as an energy store. This energy could be used within the home, for instance at times of the day when electricity is more expensive or in high demand, to reduce costs or requirement for network capacity. Alternatively the power could be sold back to the grid, and if controlled by the network operator, could be used to smooth out peaks in demand.

Vehicle to grid is not expected to be commercially viable until battery technology improves. The cost associated with additional battery degradation from ad-hoc recharging and discharging would be greater than the expected revenues from electricity supplied to the grid. For further details on vehicle to grid and vehicle to home see report reference [50].

In this case the PiEV is considered as embedded generation and should meet the requirements set out in Engineering Recommendation G83/1-1: “Recommendations for the Connection of Small-scale Embedded Generators (Up to 16A per Phase) in Parallel with Public Low-Voltage Distribution Networks” [49] from the Energy Networks Association.

Work Package 2.3 within this project provides a lengthy discussion on Vehicle to Grid and Vehicle to Home [50].

## 5.2 Options to Manage Recharging of Electric Vehicles at Individual Dwellings

### 5.2.1 Provision of Three Phase Supply

A potential solution to the service cable loading problem is to recommend, where appropriate, a three phase supply to domestic properties with electric storage heating and PiEV loads. A three phase supply costs approximately 10% more than a single phase supply to install [51]. This is really only a feasible solution for new house builds.

### 5.2.2 Provide a Local Load Management Scheme

An alternative solution is to install a load management scheme such that the cumulative loading does not exceed the cut-out/service cable rating at any given time. The load management scheme would only allow charging of the PiEV if the price of the electricity was low enough. It would also automatically reduce the power being used to recharge the electric vehicle if other electrical items (e.g. electric shower and / or electric heating) are switched on and the service cable is insufficient. The load management would automatically restore the charging of the vehicle when the other items in the house are switched off.

### 5.2.3 Provide Dedicated 16/20/32 Amp Circuit

A dedicated 16/20/32 Amp circuit should be installed in the property with a dedicated overload protection device. Automatic disconnection of supply would be in accordance with BS7671 and this is no different to existing requirements for a separate circuit for any other high load such as a cooker or shower.

## 5.3 Options to Manage Domestic Recharging at Houses Connected to the Same Mains Cable

### 5.3.1 Upgrade the Domestic Electricity Network

Ofgem is the regulator for the DNO supplying residential properties. Ofgem has a mixed set of responsibilities that includes both being a customer champion and also enabling the government to achieve its $CO_2$ objectives. Under the customer champion responsibility Ofgem is unlikely to authorise customer funding to upgrade the residential supply when less than 10% of the people on that supply are using electric vehicles, since this will spread the costs across all the people on the feed. However, if Ofgem feel they should enable the government to achieve its $CO_2$ objectives then it is likely to authorise funding at a lower utilisation of the assets. It is thus difficult to know how Ofgem will manage the authorisation of customer funding given the current network.

It is clear, however, that traditional network reinforcement would spread the costs across all customers rather than those who are generating the need for greater capacity, and that unless there are load management systems in place to minimise the additional capacity required this will lead to very high costs associated with assets that are under utilised for most parts of the day. The situation will be further complicated by other factors like the increased use of heat

pumps and distributed generation while PiEVs are likely to drive reinforcement, they will not be the only factor.

### 5.3.2 Charging using Radio Controlled Switching

This is the technology that is used for switching on and off equipment on the Economy 7 tariff. Provided the electric vehicles were fitted with a non-standard 13 Amps plug then the installation of this type of system could be used to manage the load while there are a small number of electric vehicles. The technology is rather old and inflexible though it will be relatively cheap.

### 5.3.3 Smart Grids

Problem is that PiEVs are fitted with a standard 13 Amps plug and thus there is no means of knowing when a car is to be charged or managing the recharging so that the electrical system is not overloaded. Thus although the overnight demand for electricity in the country may remain low, it is possible that for residential areas the overnight demand may be significant if enough people want to recharge electric vehicles.

For the purposes of this report, the term smart grid will be used to mean a communication between a transformer and the houses it supplies allowing some scheduling of their load to ensure the use of electricity remains within local supply limits. As previously indicated, houses within the UK will be fitted with smart meters by 2020 and thus the smart grid could be operational everywhere in the UK by 2020.

A typical domestic supply uses a 400 Amp cable to provide energy to up to 100 houses. This is sufficient to recharge 30 vehicles simultaneously at 13 Amps, or 12 vehicles simultaneously at 30 Amps, provided there is virtually no other electrical load which is often the case overnight. If an electric car typically has a range of 80 to 100 miles and people travel an average of 25 miles per day then each electric car will require a substantial charge about every third evening on average. Thus if recharging can be managed using the Smart grid then this will mean the present network capacity should be sufficient for 50% of households to own and use an electric vehicle. The existing domestic network thus capacity to recharge several million electric vehicles spread across the UK and the most optimistic projections are suggesting one million electric vehicles by 2020. In some areas many households may have an electric vehicle and in these areas some network upgrade may be required.

Work Packages 2.1 and 2.3 within this project provide a lengthy discussion on the use of Smart Grid technology (‘Full Smart Charging’) [56].

### 5.3.4 Embedded Generation

There is currently a significant drive towards power generation (DG) on the lower voltage levels. This is generally referred to as either distributed or embedded generation and people are able to export surplus power to others on the network, possibly even with power flowing from lower voltages to higher voltages through some transformers at various times of the day.

If this distributed generation was accompanied by electricity storage placed on the lower voltages, then this stored energy may be used later to recharge electric vehicles and thus further delay the requirement to upgrade the residential power supply. In the case of Photovoltaics (PV) installed at the lower voltages, then the power generation would be during the day and it may be sensible to store this in a small flow battery to further delay the requirement to upgrade the network.

It is likely to be several years before electrical energy storage [59] is viable. Since there are currently no firm prices for energy storage its cost cannot be compared to the cost of reinforcing several voltage levels in the local network.

There are currently other technologies being developed to provide distributed generation (e.g. fuel cells). Whilst some of these technologies may only have a limited impact upon the carbon emissions, they could be very valuable in helping a regulator hold down the costs of the electricity network in the future.

It is expected that the regulator will factor in some distributed generation when reviewing DNO estimates for the requirements for future residential electric networks.

#### 5.3.5 Restrict Phase Imbalance of Domestic Properties to Acceptable Limits

In existing domestic areas then the smart domestic community network outlined in Section 5.2.2 could be used to exchange information on the phase imbalance and slightly reduce the charging of some electric vehicles to maintain the phase imbalance within acceptable limits. This would not be necessary for new houses if they are fitted with a 3 phase supply in the future.

### 5.4 Options to Fairly Apportion the Costs of Upgrading the Domestic Network

While network upgrades or reinforcement can be charged to the owner of a new connection, this may not be the only instance where network reinforcement is required to cope with increased demands, particularly in domestic areas. The network capacity built to supply to a group of houses is calculated based on an expected diversity of demand, i.e. it is assumed that people will use electricity at different times of day so the capacity to the group of houses is lower than the combined peak capacity to each house.

If a large number of those houses have PiEVs, then the calculated diversity may not be accurate and the network would need upgrading to cope with the extra demand e.g. while a group of customers would not be likely to all run their electric showers at the same time, they are more likely to all charge their electric cars at the same time, especially if there is a price signal to do so. Even if the demand remains diverse and within limits, the extra energy supplied may reduce the lifespan of network assets due to extra thermal stresses. In either case the DNOs will incur an expense either maintaining or upgrading the network. If network reinforcement at higher voltage levels is triggered by the recharging of electric vehicles then the network upgrade costs may be significant. The current method for apportioning network upgrade costs is briefly outlined in Section 2.2.3. It could be considered unfair to recoup these costs through increased Distribution Use of System charges applied to all customers when the extra demand is caused by only a few who have PiEVs.

#### 5.4.1 Smart Grids

The operation of Smart grids was mentioned earlier in Section 5.3.3 and here the cost of the smart grid is described. The cost of the Smart grids is likely to be considerably less than traditional reinforcement costs. The regulator is funding research to determine the most cost effective ways to create low carbon networks via the low carbon network fund. Some of the projects which have been approved will trial smart grid technology and help to lower the costs for implementing smart grids across the nation. Where DNO's plans to create smart grids can be shown to be cost effective, the regulator will authorise them to be funded from the DUoS charges. The DNO will monitor the usage of the network and gradually roll out the Smart Grid starting with the areas where the supply margin of the network is least. It is expected that in many cases the use of the smart grid will increase the proportion of houses on a single cable that can own an electric vehicle before a network upgrade is required. Thus in the future when

this situation arises it will be more acceptable to include the costs of the network upgrade in the DUoS charges, paid by all electricity consumers.

Many industrial customers have interruptible supply contracts that enable them to obtain electricity cheaper when demand is low in return for them reducing load at times of high demand. It is expected that a set of interruptible supply contracts will be developed for domestic customers if it is thought beneficial for customers in an area to participate in demand side management and reduce electrical load at times of high demand. The smart grid concept requires the installation of a home area network in each property that can communicate with the local transformer and action the reduction and possible increase in domestic load as required. The interruptible supply contracts for domestic customers will provide favourable terms for the use of each unit of electricity though it will only be beneficial for customers with a large power consumption and thus overall their payments will increase which will fund the smart grid infrastructure.

There are several options for the funding of the home area network. One option would be that the DNO provides a very basic system just for managing the electrical load. This could be funded from the DUoS charges or possibly with a small additional quarterly charge. Alternatively the home area network may be something that is seen as providing much more capability connecting computers, TVs, videos, central heating etc. with the electrical load management just a small part of the system. In this case the interruptible supply tariffs encourage the use of the load management and it may not be necessary for the DNO to install additional equipment at the home.

If a smart grid is to be installed then it makes no sense to limit the system just to PiEV charging. It is expected that other loads with a high electrical demand, i.e. heat pumps and possibly washing machines will be included within the load management. It would thus seem that the interruptible supply tariff should be structured so that it encourages users to include other equipment.

Work Packages 2.1 and 2.3 within this project provide a lengthy discussion on the use of Smart Grid technology (‘Full Smart Charging’) – this work is summarised in SP2/EDF EN/04: Electricity Distribution Network Assessment and Analysis Final Report [ref 56].

### 5.4.2 Mandatory Registration of PiEV Charging Points

If there was mandatory registration of PiEV recharge points then a premium could be charged but this would apply to all the electricity used by the customer. PiEV users may think that it is unfair that they are being charged more for the same electricity as their non PiEV owning neighbour, and it is a disincentive to owning a PiEV. This could be mitigated by introducing a capacity element to the charging. This could be calibrated such that normal household usage is still charged on a similar basis between PiEV and non PiEV homes, but where recharging leads to higher maximum loads this can trigger higher charges. This would be seen as fairer as peak demand is a stronger driver for reinforcement work than total usage.

### 5.4.3 Additional Payments for Periods of High Domestic Demands

By 2020 each domestic property in the UK will be fitted with a smart meter that will provide the electricity usage by half hour. Thus it will be possible for the electricity retailer to provide the DNO with information about customers who regularly have a high usage at peak times. With this approach all customers who have a high electrical load, whether from a PiEVs or heat pump etc., will be treated equally. Again a capacity element should be included in all billing to encourage households to spread their electrical loads.

### 5.4.4 Tax when a PiEV is Purchased

A one-off “tax” could be charged when a PiEV is purchased which goes to DNOs to provide network upgrades. This will discourage uptake and would go against the government PiEV subsidy. The existing high cost of PiEVs is already seen as a major barrier to their increased usage and thus it is not realistic to impose further initial costs.

### 5.4.5 Special Fittings for PiEV Charging

If the future electric vehicles are fitted with a special plug and the owner would then have to purchase and install a recharging point. This would allow the option for a second meter and the price of electricity for recharging electric vehicles could be different to that used in the rest of the house. The use of a special plug may not be sufficient since people may simply cut off the plug and use a standard plug if the cars charge at 13 Amps. There is then no way of charging separately for the PiEV charging. It may be necessary to send a special high frequency signal between the PiEV and the charging point to ensure that the special charging point is used.

### 5.4.6 Summary of Funding Options for the Upgrade of LV Network

This section provide a summary of the advantages and disadvantages of the various methods considered above for funding development of the LV network to provide the energy required to recharge PiEVs. The summary is given in Table 4 below.

**Table 4: LV Network Upgrade Options Summary**

| Funding Option(s) | Pros | Cons | Recommendations |
|---|---|---|---|
| Reinforce LV network to allow any PiEV charging. | Well known, low risk solution. | Very expensive requiring a significant increase in electricity bills. | |
| | | Significant costs paid by people who don't use PiEVs and may not even have a car. | |
| | | Significant disruption to urban areas during network upgrade. | |
| Smart Grid (Communication between local transformer and customer). | Builds on existing planned installation of smart meters. | It is possible that customers may require a significant incentive through the interruptible supply tariff to participate. | Smart grid technology should be adopted. |
| | Ofgem expected to agree funding from DUoS charges. Payment is spread across all electricity users. | | |
| | Cheap compared to network upgrade and thus only a small increase for any user. | | |
| | Roll out targeted to areas of high demand. | | |
| | Provides better use of existing network. | | |
| | Defers investment in existing network. | | |
| | Customers offered lower tariffs in return for some supply interruption when demand is high. | | |
| Additional payments for periods of high domestic demands. | Builds on existing planned installation of smart meters. | Limited improvement of existing network since no coordination of different users. | May be useful with smart grid as additional management. |
| | Very cheap option. | | |

**Table 4: LV Network Upgrade Options Summary** (continued)

| Approach Option(s) | Pros | Cons | Recommendations |
|---|---|---|---|
| Tax on PiEV Purchase. | PiEV users pay for the network development. | Provides additional cost barrier to the take up of PiEVs.<br>To be fair this approach would require a similar payment from other large electrical appliances, e.g. heat pumps. This will drive the wrong behaviour in encouraging a low carbon future.<br>Possibly a long period of time between payment and network reinforcement. | A bad idea. This drives the wrong behaviours. |
| Special Fittings – Electricity to recharge an electric vehicle can be priced differently to other uses. | PiEV users pay for the network development. | By itself this does nothing to optimise the use of the existing network. | May be useful in the future with other options to enable the government to tax PiEV use differently to other electrical appliances. |

### 5.5 Provision of Charging Points at Accommodation with Communal Parking Areas

This issue was highlighted in Section 3.1.2 and relates to cases where private dwellings have a communal or shared parking area. In these cases neither the occupants nor the maintenance company may be willing to pay for the installation of PiEV charging points. Clearly with new developments the provision of some initial PiEV charging points can be made part of the planning consent together with the maintenance charge covering the provision of additional charging points in the future as the PiEV market develops. It would seem that without legislation or subsidy to provide the first few charging points in communal parking areas then the residents will not be early adopters of PiEVs. Later, as the PiEV market develops, there may be a charging post operator who has created a business out of providing the charging posts. The charging point operator could recoup costs directly from users via a scheme using a registered RFID tag etc for access, rather than via landlords – which would be unnecessarily complex and unfair to users who don't use the facility.

### 5.6 Regulatory Issues if Domestic Charging of Electric Vehicles is not Managed

The Smart grid has already been mentioned in Sections 5.3.3 and 5.4.1. It is expected that even with the increased use of PiEVs, the introduction of the Smart grid will enable the DNO to satisfy the regulatory requirements regarding reliability of supply up to the end of the next price review period in 2023. Decisions will be made in the future regarding the appropriate mix of embedded generation and network upgrades to meet the regulations beyond 2023.

## 5.7 Options for Ownership of Charging Points

### 5.7.1 Recharge Point Manufacturer owns the Recharge Point

In the future customers may be required to pay for electricity from public recharge points. If the manufacturers own the recharge points then a situation may develop where each manufacturer will have their own identity tag and a customer will be required to carry a separate tag for each type of recharge point. In this situation customers may be required to have an account with each manufacturer or risk not being able to use particular recharge posts. This is very similar to the situation that may arise if the car companies owned the petrol stations. In this case petrol stations may only service particular makes of car and it may be necessary for a customer to drive to another service station to be served. It is possible however that charge point manufacturers will welcome a common standard as this encourages the uptake of PiEVs generally and increases their business.

If some of the charging points are owned by manufacturers and others by third party organisations, then competition issues may arise in that the third party organisations may feel they don't get good support from the manufacturers. In this situation the manufacturers may not have an incentive to provide the third party operators with the best service.

It is actually very costly to develop a national network. This was demonstrated by the cable companies who invested huge sums in developing their networks and many went bust in the process. It is thus not viable to expect a few recharging post manufacturers to role out a network of recharging posts across the country. It is suggested that in the longer term there will be more investment in recharging infrastructure, allowing increased uptake of PiEVs, if more parties are involved in owning recharge points. It is unlikely that the post manufacturers will see owning a network of posts as a viable business.

Thus in the long term as the PiEV industry matures then it would seem that if recharge point manufacturers own the recharge points then this may lead to a less than optimal service for the customers.

### 5.7.2 Local Authority Owns the Recharge Point

Whether ownership of a recharge point by a local authority creates any potential problems depends upon whether owning a charging point is seen as a viable business opportunity or providing a public service.

The Local Authority is involved in the process of providing the permission for public charging points, certainly on-street and often many in car parks. If the Local Authority owns some of the recharging points and these are viewed as good business opportunities then this will present serious competition issues since this may make working with third parties more difficult.

If the Local Authority owned all the recharge points in its area then this would seem to create an unnecessary monopoly and again is likely to result in a less than optimal service for the customer. No-one, is however, bothered by the Local Authority having a monopoly of ownership of street lighting. It may be that the Local Authority has ownership of on-street "slow" charging posts but that all fast charging points, where charging quickly provides added value to the customer, are owned and operated by private companies.

Currently electricity from many Local Authority owned public recharging points is provided to the PiEV free of charge. The local authority obtains payment perhaps from the parking charge. The parking charge is likely to be significantly more than the electricity, with the current rate of tax on electricity. If the local authority owned the charging point then they may decide to continue providing the electricity for free and just collect a parking charge. This would clearly be

anti competitive if there are independent third party companies developing a business in providing charging points and they had to give the parking charge to the Local Authority.

It is possible to maintain a separation between businesses with the same owner, e.g. a DNO and the Retail business. This has been managed in the electricity industry for several years. If charging posts are a good commercial opportunity, it would be possible for the Local Authority to form a separate business to own and promote recharge posts. They would be required to maintain a strict separation between the function of 'managing' public spaces and charging posts.

### 5.7.3 DNO Owns the Recharging Point

The ownership and/or operation of public recharge posts by a DNO is one area which may be contentious. This area may be seen to be beyond the scope of an electricity distribution company whose boundary point of supply is typically the metering point. However, DNOs have experience of electrical maintenance and safety, response to outages and asset management and they may be attracted to recharge post ownership and operation in the future. For DNOs to migrate into the recharge post business there are some general pointers of competition law to consider in order avoid anti-competitive behaviour. These are summarised below indicating how they may refer to the PiEV recharging infrastructure. For greater detail see OFT document 402 on "Abuse of a dominant position" [22].

Firstly businesses should not partake in anti-competitive agreements. This may be particularly significant to the early stages of development of the PiEV industry, whereby pioneering companies are working together to promote the industry as a whole. In these early stages, companies are developing their business models considering how they perceive the market will grow. Due to the uncertainty of the market growth and how the industry will become structured, there is the increased opportunity for businesses to form anti-competitive agreements.

Secondly a business must not abuse its dominant position in the market. A market is determined based on the product and the geographic extent of the market. The threshold of the market is not clear for the PiEV industry. This may be bound by the UK, countrywide, countywide or city/town level. The electricity distribution system is divided into 14 regional areas. A business owning one regional network is not dominant in the UK but is dominant within its own region. This is a factor to consider for recharging infrastructure ownership by DNO's as to what is a regulated asset and what is not. The level of dominance is ambiguous, with the EC considering a market share persistently above 50%, and the OFT considering that it is unlikely that a business is dominant if its market share is less than 40%. However, there may be other factors that weaken the position of competitors that could be considered as abusing a dominant position, even through their market share is lower than the aforementioned percentages.

Being dominant in a market is fine so long as businesses do not abuse that position. Abusive conduct could be, exploiting customers or suppliers, or exclusionary behaviour. For example imposing excessively high prices or removing / weakening the competition i.e. imposing needless stringent demands for connections. Another point could be on the local pricing of charging points. Petrol cars have a long range, so local hot-spots of high price don't develop strongly as you can drive on somewhere else. At the moment EVs have a limited range and it is quite possible that you simply wouldn't be able to drive to the next town to recharge. Thus if there are large differences in charges between different areas then companies will be exposed to potential competition issues.

Businesses found to be anti-competitive can face penalties of up to 10% of their worldwide turnover plus damages to any third party businesses affected. Thus any accidental infringement of competition law by a DNO even with the best of intentions in supporting a

developing market for recharging PiEVs may be punished severely due to the size of their existing network business.

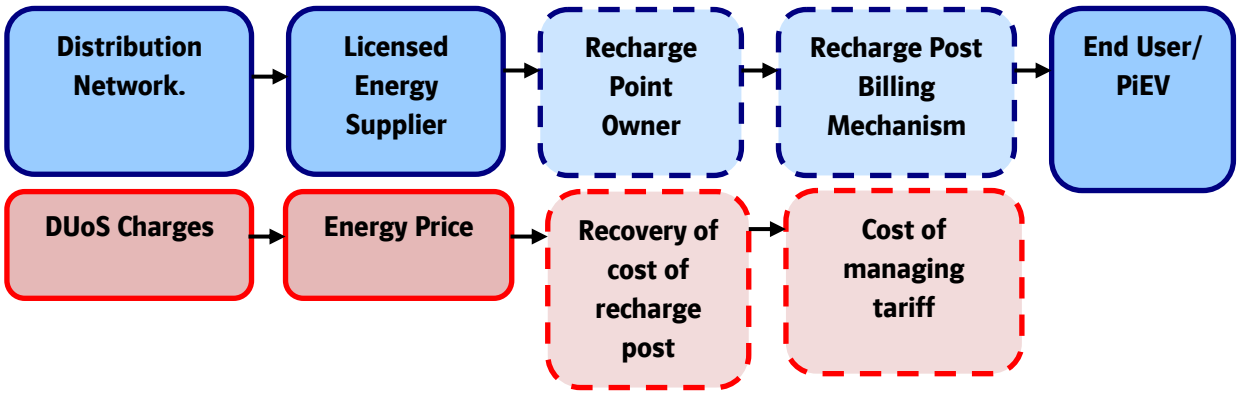


**Figure 8: Industry Sectors and Costs to the User**

Figure 8 outlines the structure of the electricity supply industry from the distribution network to a customer. The solid outlined boxes shows sectors that are covered by the present regulated structure and the dashed boxes indicate additional sectors that will be introduced as a result of public recharging. These additional sectors will introduce new businesses which could operate outside the present regulatory framework, thus presenting the possibility for anti-competitive behaviour.

Even if the DNO owned the charging point then the energy will be provided by a licensed energy provider since the DNO is not allowed to be an energy supplier. Thus the charges for the energy and billing mechanism above will be paid to another organisation and the DNO will receive the charges on the bottom row of Figure 8 above, thus for the cost of the recharge post and most likely the tariff for management of the posts. Whilst business separation may be beneficial if the service is fragmented into too many separate businesses then it is likely to be costly rather than optimal for the customer. The costs will start to increase due to all the business interfaces and checking of payments that will be required in a very fragmented business model.

The DNOs currently operate electrical networks in a low risk regulated business. Whilst their technical expertise may be transferable to operating public recharging posts the business is very different. The recharge posts are located in easily accessible public places and they may be often damaged. Thus the DNOs may see charging post ownership as a high risk business and not a good fit with their current commercial operations.

The electricity industry is used to operating different businesses. For several years, the electricity industry has maintained a separation between businesses with the same owner, e.g. a DNO and the Retail business. It would thus seem feasible for the DNO to create a separate business to operate the charging posts. This arrangement would be very similar to many already existing in the industry. With this arrangement the separate business may also supply energy and managing the post billing system thus reducing the fragmentation of the service.

### 5.7.4 Private Ownership

For private owners where there is no potential conflict of interest then the relative merits of their ownership of recharge posts was considered in Section 3. For completion they have been included in Table 5 below.

5.7.5 Summary of Issues Regarding Ownership of Public Recharging Posts

This section provides a summary of the relative merits of different organisations owning recharging posts. The summary is given in Table 5.

**Table 5: Charge Post Ownership Options Summary**

<table>
<tr><th>Option</th><th>Pros</th><th>Barriers</th><th>Changes Needed to Overcome Barriers)</th></tr>
<tr><td rowspan="2">Local Authority.<br>(own budget).</td><td>Provides subsidy to develop the public charging market.</td><td>May appear uncompetitive since the Local Authority provides approval for post locations.</td><td rowspan="2">Transfer expertise to a separate business though with the same owner as the market develops.</td></tr>
<tr><td>May offer low value low cost ‘slow’ charging points as a public service.</td><td>May appear uncompetitive when public recharging is a commercial business.</td></tr>
<tr><td rowspan="2">Government, via dedicated grants/ subsidy to LAs<br><br>(e.g. Plugged-in-Places).</td><td>Provides subsidy to develop the public charging market.</td><td rowspan="2">May appear uncompetitive when/if public recharging is a commercial business.</td><td rowspan="2"></td></tr>
<tr><td>Ensures ring-fenced funding to meet national strategy.</td></tr>
</table>

**Table 5: Charge Post Ownership Options Summary** (continued)

| Option | Pros | Barriers | Changes Needed to Overcome Barriers) |
|---|---|---|---|
| DNO | Local business with many of the technical skills required to maintain charging posts. | Resource limitations may reduce the speed of installation of charging points. | Allow third party organisations to perform the complete post installation. |
| | | May appear uncompetitive for third parties wishing to install public charging posts. | |
| | | Risk from accidental infringement of competition law may outweigh business benefit. | |
| | | Current regulations regarding continuity of electricity supply may disadvantage the DNO. | Clarify the regulations regarding continuity of supply for recharge posts. |
| Land/Site Owner. | Possible low cost installation and maintenance of charging points. | Business not viable until journeys are longer and home recharging is not an option. | Maintain public awareness of the change to a low carbon economy. |
| | Simple pricing and billing. | | |
| | Installation at hotels will probably stimulate longer PiEV journeys. | | |

**Table 5: Charge Post Ownership Options Summary** (continued)

| Option | Pros | Barriers | Changes Needed to Overcome Barriers) |
|---|---|---|---|
| Charge point manufacturer. | May stimulate the initial market before business becomes commercially viable. | May appear uncompetitive when public recharging is a commercial business.<br>May limit the investment in public recharging and thus the take up of PiEVS. | Separate post manufacture and ownership when the recharging market matures. |
| Third Party. | Possible early adoption of commercially viable 'fast' charging.<br>The provision of more charging points will encourage longer PiEV journeys.<br>Managing PiEV load at times of high demand may be easier with some large third party owners. | Low cost home charging may mean that it is a long time before recharging PiEVs becomes a commercial business. | Subsidy required for the provision of a fast charge capability. |

## 5.8 Mitigation of Possible High Cost of Electricity from Public Recharge Points

If there are only a few public charging points and they have only a low utilisation, then it will be difficult for a private company to recover the costs of operating the posts while there is only a low level of business.

### 5.8.1 Subsidy from Parking Charges

While the public charging industry is in its infancy then the cost of operating and maintaining the charging posts could be subsidised by the Local Authority. This would be a viable option until the business grew sufficiently that private companies could perform the function. Indeed, to promote competition, then the transfer from the Local Authority to the private company should occur when the business is sufficient to support two companies.

### 5.8.2 Regulated Assets

In general for electricity supplies, the DNO owns the equipment and cables up to the meter and the customer owns the equipment and cables beyond the meter. The parts owned by the DNO are called regulated assets. If DNOs take ownership of recharge posts and they are adopted as a regulated asset, the rules are clear under the present regulation. The actual revenue the DNO can recover for the charging posts will relate to the capital allowances for installing them,

the length over which they are depreciated, the operating cost allowances and not the actual post usage. If the DNO is given the right allowances then the income will be recovered from the entire customer base via Duos not just those using the charging posts. However, each PiEV recharge socket will be subject to guaranteed standards, opening the DNO to the risk of penalties with little gain. It is not clear whether DNOs would see this as an attractive option even if the regulator allows lower guaranteed standards for the recharge points.

## 5.9 Options to Reduce the Cost and Time to Install Public Charging Points

### 5.9.1 Standard Road Traffic Signs for Recharging

The Traffic Signs Regulations and General Directions (TSRGD) 2002 [52] lay down the strict rules for traffic signs, including road markings to be lawfully placed on or near public highways in the England, Scotland and Wales.

These regulations do not currently include provision for PiEV infrastructure signage. Therefore, signs and road markings for PiEV infrastructure (e.g. indicating that a bay is for PiEVs only, use while recharging only etc.) need to be approved by the Department for Transport before they can be erected. Figure 9 shows an example of such an approved sign. As this approval process can take up to three months each time it is likely that councils will limit the number of different types of signage they erect and may copy other councils approved signage to speed acceptance of their own signs. This may lead to an unofficial standardisation in PiEV related road signage.


**Figure 9: Sample Recharging Traffic Sign**

### 5.9.2 Installation Contractors

The installation of a public charging point currently requires the coordination of three organisations, the installer, DNO and meter owner. It would be simpler if this could be done by a single organisation. It is understood that in some areas where most public charge points are currently installed that this is the case. There are authorised contactors to connect the charging post to the DNO's network and install the meter. Whilst most DNOs may be happy to allow authorised contractors to connect to LV cables, this is quite different to allowing authorised contractors access to a transformer to provide more cables. It is not clear that there should be any need to allow authorised contractors access to the transformer.

### 5.9.3 Share the Format of Lease Agreements

Most of the time in the process of installing public charging points is currently spent in producing the commercial contracts between the different stakeholders. The lease between the post owner and the site owner is often the most complex. It will clearly help organisations who have not previously been Involved with charging points to obtain the typical format of the agreements.

## 5.10 Cost apportionment of PiEV Impacts on Networks

Whilst the current set of rules for apportioning costs for new connections are fine whilst the network has evolved slowly, it is likely that the demand from PiEVs will be significant and the current set of rules may not be suitable. For example, the provision of fast charging should be at locations both where it is required and where it can be provided without large increases in the need to upgrade the network. It may be appropriate for the DNO to perform a more structured review of potential network developments since costly network upgrades for PiEV charging will be contentious.

## 5.11 Standardisation for Public Recharging Points

It is suggested that public recharge posts should be accessible via a single electronic fob so that customers don't have to carry a different fob for each type of recharge post.

## 5.12 Alternative Payment Methods at Public Recharging Points

### 5.12.1 Coin Operated Machines

This is essentially like an existing parking meter. Customers put coins in the machine though it will have the additional complexity of charging different rates at different times of the day. This will be cheap but it is not convenient for the customer who will be required to carry coins around to insert in the meter. This probably won't provide the flexibility required for demand side management and offer a refund if less energy is provided. Machines that can provide change tend to be larger and more expensive. They are not suitable for siting on-street and would presumably become a target for theft.

### 5.12.2 Electronic Payment Method

It would be very convenient for users if each public charging point was fitted with a credit or debit card payment system. It may be too expensive to provide each charging post with the card facilities including the connection for central payment. It is well known that cheques may be phased out in the next ten years and if this is the case then they will be replaced by an alternative electronic payment system. It is possible that this payment system becomes sufficiently widespread and cheap that it could be fitted to each charging post. Thus while electronic payment at each charging post may currently be too expensive it may become viable in the next ten years. At some locations text messages may be used to pay for parking spaces and thus the same system may be used in the future to pay for both parking and recharging.

### 5.12.3 Charge Card

With this system, a customer could go to a shop and pay for electricity using a normal credit card and then have the money placed on a charge card that can then be used at the public charging post. They would swipe the card at the start of recharging, having accepted the cost information provide at the time. They would then swipe their card again at the end of the recharging if they think a refund is due. This will provide a cheap and flexible payment method for public charging points with no transfer of payment information required beyond the post. These posts will thus only require the relatively low level information about prices and demand side management information to be transferred from a central location. In particular there will be no need for the post to transfer information to a central location. A record of the transactions could be stored locally if an advanced electricity meter was used with each post. This information could be collected with the meter reading. It would be sensible to combine the charge card considered here with the single fob for accessing recharging posts considered in Section 5.11 above.

It seems likely that a charge card will require money for different post owners since otherwise there is a complex settlement operation between the money the customer pays when putting credit on the charge card and the recharge post owners where they recharge their electric vehicle. It should be possible for customers to easily swap unused money from one post owner onto another if they wish. This would seem to be the simplest way to implement this type of payment method.

The Local Authority could also use this method to collect parking charges. This will reduce the need to empty parking meters on a regular basis and presumably reduce the cost of managing the parking meters. The owner of the public charging post could recover their payment from the Local Authority on presentation of the meter readings from the charging post. It is beyond the scope of this document to consider this in too much detail, though it would seem possible to use the savings in emptying the parking meters to include the parking charges within the payment system without creating an expensive settlement and billing process.

5.12.4 Accounts and Other Means of Payment

In addition to the mechanisms above, it can be anticipated that consumers in the future will want to have other means of payment at their disposal, especially those which do not involve payment at the point of use, but payment after the charging event ('on account'). This demand for other payment types is anticipated after considering the provision of other consumer services which have moved to an account style mechanism, which has advantages both for the consumer (payment comes later) and the provider (we know who the customer is and we have detailed information about him/her). ETI PiEV Work Package 2.4 [49] provides a lengthy discussion of these payment options (together with those described above), and describes how the payment mechanisms might work in terms of data and information flows, between, for example, the consumer, the Charge Post Operator, the Intelligent Infrastructure Operator, the owner of the land and the Electricity Retailer.

### 5.13 Recharge Cables for Electric Vehicles Laying across the Pavement between a House or Flat and the PiEV may cause a Hazard

5.13.1 Provision of a Public Charging Point at the Edge of the Pavement

The advantages of this option are that the home owner will be able to park further along the street and still recharge their vehicle. Since this would be a new connection then there are no concerns with the integrity of the current household wiring.

The disadvantages are that often pavements are narrow and there may be issues with the disability discrimination regulations. It is also likely to be an expensive option.

5.13.2 Protection for Cable Laying across the Pavement

The simplest solution would be to allow people to buy a rubber cable protection for the cable over the pavement. This will provide protection for the cable and prevent it being a tripping hazard. This option is only viable if it does not lead to a significant increase in compensation claims.

5.13.3 Inductive Recharging

The inductive recharging of electric vehicles is being considered. The most likely scenario is that a low pad is placed on the ground and the car drives over the pad. A coil is situated below the car which can be charged inductively from the coil in the low pad. There is thus no need for a physical cable connecting the car to the charging point. This is currently only used in low power devices like electric tooth brushes.

It is currently difficult to know how efficient the inductive charging will be, but if the coil under the car can be lowered close to the cover of the coil in the low pad then it will be assumed that the inductive losses can be reduced to a level where slow (a few hours) charging becomes feasible. The inductive charging would offer a good solution for charging at homes without off-street parking since the pad is small and since it is in the road it will not obstruct the pavement like a standard charging post considered in section 5.13.1. It would be possible to install a payment system somewhere along the street to manage the inductive charging of several pads along the street. This would offer a good solution for London where there are many streets of terraced houses and it is expected that people living here will want to buy an electric car.

Whether inductive charging is viable is clearly an issue for the PiEV and recharging post manufacturers.

### 5.14 Concerns over Old Electrical Wiring in a House or the Service Cable to the House may be Inadequate

It is suggested that houses should have a 5 year electrical certificate before the house wiring is used to recharge electric vehicles. If necessary, a house load management scheme is provided as discussed in Section 5.2.2.

### 5.15 Loss of DNO Protective Conductor

While there are no specific requirements for electric vehicles or charge points within the IEE Wiring regulations (BS 7671), it is reasonable to assume that the requirements for a caravan park installation would apply to a vehicle. In this case, a TT earthing system (as defined in BS7671) could be employed for earthing vehicle charge points in domestic and industrial premises. This system requires a local earth electrode at the charge point and an RCD at the charge point for earth fault clearance. In the event that the main protective conductor is lost, the vehicle and the ground below the user will rise to the same potential.

# 6 FUTURE PiEV RECHARGING INFRASTRUCTURE

## 6.1 Stakeholders in PiEV Recharging Infrastructure

The Tables D1, D2 and D3 in Appendix D summarise the stakeholders in the PiEV infrastructure discussed above. The various stakeholders are identified in the first row of the Tables and the capabilities that should be provided are shown in the left hand column of the Tables. The tables show the involvement of each stakeholder in providing the capability; it may be financial investment required, regulations, safety, potential issues with competition etc. From the tables it is easy to see where financial incentives or regulations are required to bring about the desired capability of the PiEV infrastructure in the future. Once the PiEV infrastructure starts to develop then it will be more difficult to bring in some changes later, say for demand side management if the concept is not included in the early equipment. The most effective solutions are considered in the next section.

## 6.2 Identification of the Most Effective Solutions

i. The Smart grid has been identified as providing a cost effective means of managing the PiEV load at domestic properties. This will allow the recharging of electric vehicles overnight whilst probably delaying significant investment in domestic network upgrades to beyond the end of the next DNO price review in 2023.

ii. If smart grid technology is to be used then the interruptible supply tariff should be structured so as to encourage users to include other equipment as well as PiEV charging.

iii. Time of use charging has been shown over many years to be very effective at spreading the electricity demand and limiting the peak demand. Measures that mitigate the impact of PiEV charging on the network upgrade costs should be mandatory in the future. These measures may include time of use charging, a capacity element in domestic billing and a demand side management capability for public charging points and commercial sites with a large PiEV recharging load, though not those providing a rapid charge.

iv. In some areas, particularly where there are several small businesses, then the cost of network upgrades triggered by the uptake of PiEVs will be a contentious issue. It is thus suggested that it will be more effective for the DNO to perform a more complete review of the network in these areas rather than just processing a sequence of requests for increased supply.

v. A stimulus may be required as the PiEV market develops for the installation of some initial charging posts at dwellings that have a communal parking area, e.g. a block of flats.

vi. Whilst the public charging business is developing then the operation and maintenance of the charging point is likely to require some subsidy. Two options were considered, one where the Local Authority provides the subsidy and the other where the charging point becomes regulated assets of the DNO. Both are possible solutions and it will depend upon the organisations involved (including Ofgem) to decide a way forward.

vii. If public charging of PiEVs becomes a commercially viable business, then organisations necessarily in a monopoly situation, e.g. Local Authorities and DNOs, should consider setting up wholly owned subsidiaries to avoid issues of unfair competition.

viii. All three options considered for reducing the cost and time to install public charging points should be very effective, namely:

- Provision of standard road traffic signs for recharging.
- Single organisations to perform the installation.

- Sharing the format of contracts between stakeholders.

ix. Competition issues regarding the installation and use of public charging points can be avoided if customers can use a common fob to access public charging points.

x. It will be necessary to pay for electricity from public charging points in the future. Low cost payment methods that still allow users the convenience of accessing any recharging infrastructure are required.

xi. There are several possible effective solutions to the concerns over the adequacy of domestic wiring for PiEV charging:

- Require properties to have an electrical inspection when people buy electric vehicles.
- Install a separate supply for the electric vehicle charging.
- Install domestic load management systems.

The choice of the most effective solution will depend upon the property.

xii. IEE Wiring regulations (BS 7671) should be updated to specifically include the charging of electric vehicles.

xiii. Inductive charging could offer a good charging solution for people without off-street parking though development of the technology will rely upon the PiEV and recharging post manufacturers.

xiv. Regulations are required for a safety mat to both protect charging cables and avoid a tripping hazard for the cables and mat laying across the pavement.

## 7 RECOMMENDATIONS

It is recommended that the Smart grid technology be used in domestic properties to significantly delay the costly requirement for network upgrades.

It is recommended that regulations be developed to mitigate the impact (especially during the day) of PiEV load on electricity generation and the network for the longer term. In particular, both public charging points and commercial sites with a significant PiEV load must allow time of use charging and demand side management.

It is recommended that Ofgem should:

Request DNOs to perform a more complete review of the possible impact upon the network of PiEV recharging rather than just processing a sequence of requests for increased supply.

Clarify the responsibilities of the DNO regarding the ownership of charging points.

It is recommended that a stimulus be provided as the PiEV market develops for the installation of some initial charging posts at dwellings that have a communal parking area, e.g. block of flats.

Whilst the public charging business is developing then the operation and maintenance of the charging point is likely to require some subsidy. It is recommended that interested parties, Local Authority, DNO, Ofgem etc. should decide how the subsidy could be provided.

The following is recommended to reduce the time and cost of installing public charging points:

- Provision of standard road traffic signs for recharging.
- Single organisations, rather than installer, DNO and meter owner, can perform the installation.
- Sharing the format of contracts between stakeholders.

It is recommended that a single fob should be used to access any public charging point.

It is recommended that options for time of use payment at public charging points be implemented.

It is recommended that regulations be updated to require at least one of the following be implemented at domestic properties to allay concerns over the adequacy of domestic wiring for charging a PiEV:

- Require properties to have an electrical inspection when people buy electric vehicles.
- Install a separate supply for the electric vehicle charging.
- Install a domestic load management system.

It is recommended that the IEE Wiring regulations (BS 7671) should be updated to specifically include the charging of electric vehicles.

It is recommended that regulations are required for a safety mat to both protect charging cables and avoid a tripping hazard resulting from the cables laying across a pavement.

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[56] *SP2/EDF EN/04: Electricity Distribution Network Assessment and Analysis Final Report.*

# APPENDIX A

Summary of Regulations and Other Useful References for PiEV Recharging

| Reference | Information |
|---|---|
| Standard Licence Conditions [53] | Covers licensable activities: generation, transmission, distribution, supply etc. Licensees are obliged to comply with licence terms and industry codes. |
| Electricity Act 1989 as amended [15] | Main legislation covering the electricity industry. |
| Carbon Emissions Reduction Target (CERT) [3] / The Electricity and Gas (Carbon Emissions Reduction) Order 2008, 2009, 2010 | Requires suppliers to invest in domestic carbon reduction measures. Currently runs to 2012. |
| Community Energy Savings Program [4]<br><br>Electricity and Gas (Community Energy Saving Programme) Order 2009 | Requires suppliers and generators to invest in energy savings measures taking a whole house approach and focusing on low income areas. Currently runs to 2012. |
| Renewable Obligation [5] | Requires suppliers to source a minimum percent of their energy from Renewables. Runs to 2037. |
| Distribution Price Control Review (DPCR) [7] | Sets limits on the price that distributors can recharge, which limits investment. Runs from 2010 to 2015. Recent modifications change the methodology and increases period to 8 years. |
| Low Carbon Network Fund (LCNF) [9] | Support for low carbon projects from Ofgem. Part of the current DPCR so runs until 2015. |
| Connection Charging Methodology [10] | Sets out charges for new connections from each DNO. Ofgem are considering having a common methodology for all DNO's. |
| Planning Regulations [54] | Sets out what can be built where. |
| Building Regulations Part P (Electrical Safety) [26] | Standards for safe electrical wiring in domestic properties. |
| The Electricity at Work Regulations 1989 [28] | Health and safety for electricity in the workplace. |
| Electricity Safety, Quality and Continuity Regulations 2002 [29] | General health and safety requirements of electricity work, and quality of supply. |
| New Roads and Street Works Act 1991 [54] | Requirements for road works and street furniture. |
| Engineering Recommendation G83/1-1 [35] | For connecting domestic generation to the distribution network. |
| Data Protection Act 1998 [55] | Limits what processing can be done to personally identifiable data. |
| The Electricity (Standards of Performance) Regulations 2010. [31] | Guaranteed level of performance from distribution companies. |
| The Electricity (Connections Standards of Performance) Regulations 2010 [30] | Guaranteed level of performance from distribution companies and for new connection requests. |

# APPENDIX B

Identification of Hazards, Risks and Likely Consequences

| Safety Issue | Hazard ID. | Hazard | Risks / Consequences | Additional Information | Mitigation | Responsible Parties |
|---|---|---|---|---|---|---|
| Design & Specification | 1 | Equipment and associated accessories are under rated for the prospective short circuit current (fault level) of the electricity supply. | 1) Fire or explosion at recharge point caused by an electrical fault with the potential to kill or seriously injure the user or member of the general public.<br>2) Fire or explosion causing damage to equipment and nearby property, including vehicles. | The prospective short circuit current (fault level) may vary at commercial locations and at different locations within the electricity distribution network. Fault levels may also vary at domestic properties with installed generation sources (diesel etc.) | 1) A fault level study at the point of supply should be undertaken prior to the design and specification of equipment.<br>2) Recharging equipment and accessories should be rated above the prospective short circuit current at all foreseeable charge locations. | 1) Public and commercial recharge point owners and designers<br>2) Approved installation contractors for domestic locations |
| | 2 | Equipment and associated accessories are under rated for the nominal load or overload current required by the PiEV. | 1) Electrical fire at the recharge point or accessory with the potential for injury or death.<br>2) Fire at the recharge point causing damage to equipment and nearby property, including vehicles. | Without preventative measures in place, a cable with a low current rating could potentially be connected to a high power recharge point. | 1) Installed recharging equipment and all supplied accessories should be rated above the nominal current required by the vehicle with an allowance made for potential overload conditions.<br>2) Power interrogation electronics to determine power requirements of PiEV and maximum rating of electric vehicle supply equipment (EVSE) - Does not apply to Mode 1 charging.<br>3) Mechanical measures such as standardised plug and sockets, to prevent connection of a PiEV to an under rated supply point.<br>4) Automatic Disconnection of supply<br>5) Recharge point is installed in compliance with BS 7671 | 1) System owners, designers and suppliers of equipment (commercial and public locations).<br>2) Approved installation contractors for domestic locations |

| Safety Issue | Hazard ID. | Hazard | Risks / Consequences | Additional Information | Mitigation | Responsible Parties |
|---|---|---|---|---|---|---|
| | 3 | Installation of a domestic charge point de-rates (overloads) existing household mains circuits. | Risk of household fire | Typically applies to domestic properties whereby the recharge point is connected to an existing 13A or higher mains circuit | 1) A dedicated 16/20A circuit should be installed in the property with a dedicated overload protective device.<br>2) Automatic disconnection of supply in accordance with BS7671 | Approved installation contractors for domestic locations |
| **Environment** | 4 | Ingress of water | 1) Electrical fault at recharge point or PiEV causing fire resulting in injury, death or property damage.<br>2) Electrocution resulting in serious injury or death | Ingress of water is foreseeable during periods of heavy rain, washing of the PiEV and at domestic properties utilising sprinkler systems. | 1) Recharge point enclosures and accessories should have a minimum ingress protection (IP) rating as specified in BS EN 61851-1<br>2) Automatic disconnection of supply in accordance with BS7671 | 1) Public and commercial recharge point owners<br>2) Manufacturers and suppliers of equipment and accessories<br>3) Approved installation contractors for domestic locations |
| | 5 | Recharge point equipment and accessories exposed to extreme temperatures | Degradation and breakdown of electrical insulating materials resulting exposed, live conducting parts. Risk of electric shock or electrocution in the event of human contact. | High temperatures may be present within the EVSE during normal operation. | Thermoplastic and rubber materials should be designed to withstand temperatures and fire (increasing resistance to ageing) as specified in BS EN 62196-1 | Manufacturers and suppliers of equipment and accessories |
| | 6 | High speed vehicle impact with recharge point | Damage to recharge point resulting in exposed, hazardous live parts. Risk of electric shock or electrocution in the event of human contact. | | 1) Recharge points fitted with impact detection are de-energised in the event of a collision<br>2) Installation of overload and fault current protective devices such as a circuit breakers, fuses which automatically disconnect the supply in the event of a fault.<br>3) RCD for electric shock | 1) Recharge point owners<br>2) Manufacturers and suppliers of equipment (commercial and public locations).<br>2) Approved installation contractors for domestic |

| Safety Issue | Hazard ID. | Hazard | Risks / Consequences | Additional Information | Mitigation | Responsible Parties |
|---|---|---|---|---|---|---|
| | | | | | and additional earth protection | locations |
| | 7 | Vehicle drive-over of recharging cable | Damage to external cable sheath and/or cable insulation resulting in exposed, hazardous live parts. This presents the risk of electric shock or electrocution when the system is energised. | | 1) Recharging cables and connectors should be designed to withstand the impact force of the tyre on a slow moving vehicle (approximately 5000N) as specified in BS EN 61851-1 and BS EN 62196-1.<br>2) Fault protection devices for automatic disconnection of supply<br>3) Pilot circuit and protective conductor detection (Modes 2, 3 and 4 only) | 1) Manufacturers and Suppliers of the PiEV, equipment and accessories<br>2) Recharge point owners<br>3) Approved installation contractors for domestic locations |
| | 8 | Potentially explosive atmospheres | Sparking or arcing during normal operation ignites the gas within an explosive atmosphere resulting in an explosion causing property damage, injury or death. | Explosive atmospheres may be present within fuelling stations which supply LPG | 1) Recharging points installed with a minimum degree of separation from potentially hazardous zones<br>2) EX rated equipment installed at recharge point as defined by the Dangerous Substances and Explosive Atmosphere Regulations (DSEAR). | 1) Recharge point owners<br>2) PiEV and equipment manufacturers and suppliers |
| | 9 | Exposure to chemicals and other hazardous substances | Degradation and breakdown of electrical insulating materials resulting in exposed, live conducting parts. Risk of electric shock or electrocution in the event of human contact. | Substances such as brake fluid, diesel, petrol and engine oil may be present at recharge point locations. | The inlet, plug, connector and cable is designed to resist the effect of normal automotive solvents and fluids appropriate to the application as defined in BS EN 61851-1 | PiEV and equipment manufacturers and suppliers |

| Safety Issue | Hazard ID. | Hazard | Risks / Consequences | Additional Information | Mitigation | Responsible Parties |
|---|---|---|---|---|---|---|
| Fault | 10 | Undetected third party damage to recharging cable or accessory | Exposed cable conductors present the risk of electric shock or electrocution when the system is energised. | Damage to cable or recharge point from a third party (theft, misuse or vandalism) may expose conductive parts without damaging the protective earth or pilot cable. | 1) Additional protection against electric shock and earth fault provided in the form of a MCB / RCCB (residual current circuit breaker)/ Residual Current Device (for sockets with a rated current not exceeding 20A)<br>2) Regular inspection and maintenance of recharge point locations<br>3) Supervision of recharge location by trained and competent person | 1) Recharge point owner<br>2) Approved installation contractors for domestic locations |
| | 11 | An overload condition resulting in an excess current flowing through an intended path. | Over heating of recharging cables, equipment and accessories resulting in fire. | This could be caused by a fault or a vehicle drawing more current than the recharge point equipment and accessories are rated to carry. | 1) Installation of an overload protection device such as a Miniature Circuit Breaker (MCB) or Fuse for automatic disconnection of supply<br>2) Installation in accordance with BS7671 | Recharge point owners, designers and installers. |
| | 12 | A short circuit condition resulting in an excess current flowing through an unintended path (with no exposed, hazardous live parts as a result). | Fire or explosion | A typical cause would be a charger cable insulation failure. | 1) Installation of an overload protection device such as a Miniature Circuit Breaker (MCB) or Fuse for automatic disconnection of supply. The protective device should have a rated Breaking Capacity greater than the largest potential short circuit (fault) current.<br>2) Installation compliance with BS7671 | Charge point owners, designers and installers. |

| Safety Issue | Hazard ID. | Hazard | Risks / Consequences | Additional Information | Mitigation | Responsible Parties |
|---|---|---|---|---|---|---|
| | 13 | Exposed live parts as a result of an insulation failure | Indirect contact with conductive parts which have become hazardous live parts resulting in electric shock which can cause serious injury or death | Protection against indirect contact should consist of one or more of these measures as specified by BS EN 61815-1 and detailed within IEC 60364-4-41 (Clauses 411 to 413). One or more of these protective measures are also required to comply with BS7671: 'Requirements for Electrical Installations' - The IEE Wiring Regulations. | 1) Reinforced or supplementary insulation<br>2) Protective equipotential bonding<br>3) Automatic disconnection of supply in the event of a fault (MCB or Fuse)<br>4) Simple separation of live parts<br>5) Installation of a Residual Current Device (mandatory supplementary protection)<br>6) For separated and isolated EVSE, an insulation monitor, that monitors the electrical isolation from earth of an isolated circuit, should automatically disconnect the supply under fault conditions.<br>7) double insulated equipment where possible | Charge point owners, designers and installers. |
| | 14 | Exposed live parts as a result of an insulation failure - supplementary measures | Indirect contact with hazardous live parts resulting in an electric shock causing serious injury or death. | These are mandatory supplementary measures for modes 2, 3 and 4 which will enhance protection during charging | A control pilot circuit which comprises a control pilot conductor, the protective earth conductor, supply equipment control electronics and further electronics aboard the electric vehicles. The circuit should be capable of performing the mandatory functions as described in BSEN 61815-1 Sections 6.4.1.1 to 6.4.1.5 | Charge point owners, designers and installers. |

| Safety Issue | Hazard ID. | Hazard | Risks / Consequences | Additional Information | Mitigation | Responsible Parties |
|---|---|---|---|---|---|---|
| | 15 | Loss of the main DNO protective conductor to a domestic premise. | The loss of main protective conductor (combined neutral & earth) from the electricity distribution network could result in the vehicle chassis potential rising to 230V AC, while the surface beneath the user remains at 'true ground'. This presents a serious risk of electric shock should the user come into contact with the PiEV metalwork. | This scenario is most prevalent within a domestic property whereby the main protective conductor into the property (taken from the electricity distribution network) has been used to earth the charge point and subsequently the electric vehicle (common for a TN-C-S type earthing arrangement). A neutral fault in the supply network would mean a loss of protective conductor to the property and vehicle. This may also prevent an earth fault protective device, such as an RCD, from operating. | While there are no specific requirements for electric vehicles or charge points within the IEE Wiring regulations (BS 7671), it is reasonable to assume that the requirements for a caravan park installation would apply to a vehicle. In this case a TT earthing system (as defined in BS7671) could be employed for earthing vehicle charge points in domestic and industrial premises. This system requires a local earth electrode at the charge point and an RCD at the charge point for earth fault clearance. In the event that the main protective conductor is lost, the vehicle and the ground below the user will rise to the same potential. | Approved installation contractors for domestic locations |

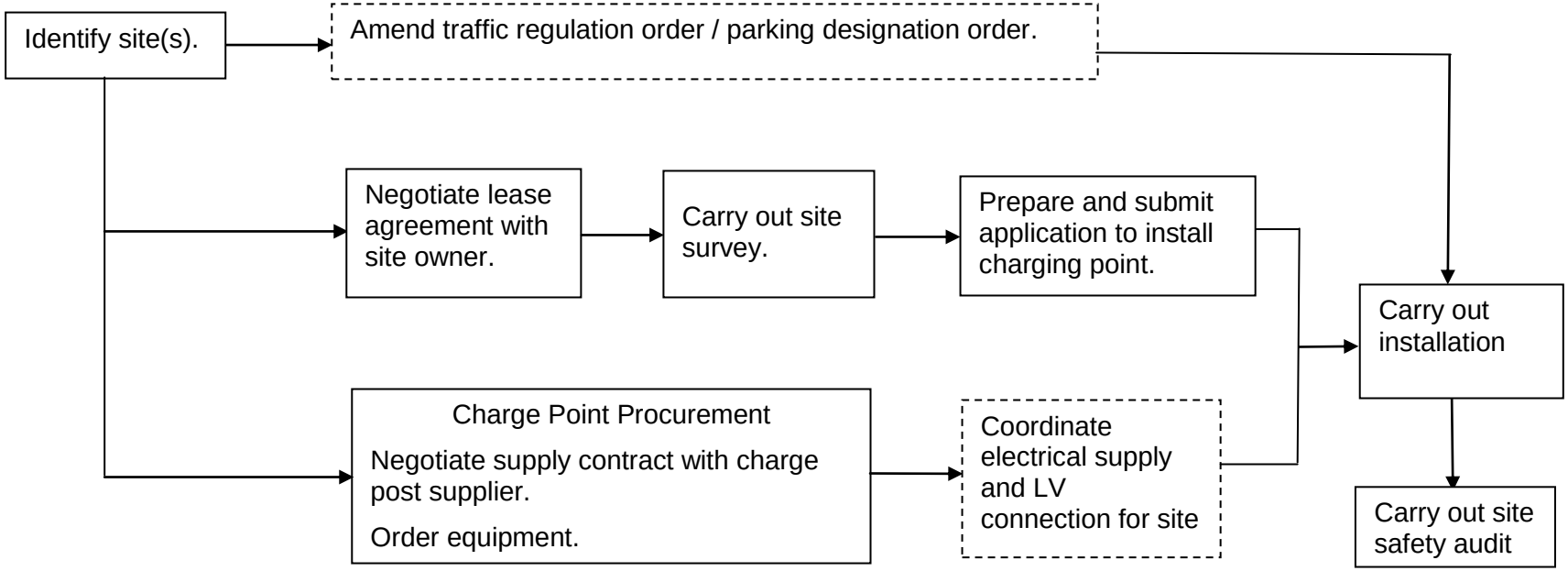
| Safety Issue | Hazard ID. | Hazard | Risks / Consequences | Additional Information | Mitigation | Responsible Parties |
|---|---|---|---|---|---|---|
| General Use | 16 | Continual use of charge point, PiEV inlet or equipment accessory (including cable) | Damage to recharge point equipment or accessories resulting in exposed, live conducting parts. Risk of electric shock or electrocution in the event of human contact. | Recharge point equipment must be able to withstand the demands of normal 'everyday' use. | 1) The inlet/connector and plug/socket outlet should be designed with a service life as specified in BS EN 61851-1<br>2) Plugs and connector should be designed and manufactured such that they withstand impact of dropping and normal use as defined in BS EN 62169-1 and BS EN 61851-1<br>3) The recharging cable should be designed and manufactured such that the flexibility and mechanical characteristics should conform to the requirements of IEC 60245-66 and BS EN 61851-1 | Vehicle and equipment manufacturers and suppliers |
| | 17 | Driving the PiEV while connected to a charge point at nominal current | Damage to recharging equipment or the PiEV with subsequent exposure of hazardous live parts presenting the risk of electric shock. | | 1) Control pilot circuit with protective conductor detection (modes 2, 3 & 4)<br>2) PiEV traction interlock preventing driving PiEV when connected to a recharge point is detected (Modes 2,3 and 4)<br>3) Automatic disconnection of supply | 1) Public and commercial charge point owners and installers<br>2) Approved installation contractors for domestic locations |

| Safety Issue | Hazard ID. | Hazard | Risks / Consequences | Additional Information | Mitigation | Responsible Parties |
|---|---|---|---|---|---|---|
| | 18 | Manual disconnection of the recharge cable while the recharge point is in operation | Arcing at the plug or socket causing degradation and eventual failure of insulating materials. Subsequently exposed, hazardous live parts present the risk of electric shock causing injury or death. | | 1) The plug, socket outlet, inlet and connector should be designed with sufficient breaking capacity as specified in BS EN 61851-1<br>2) For mode 2 and 3 recharging systems, the pilot conductor should be disconnected before the live and neutral conductors. This action will de-energised the EVSE, thus preventing an electrical arc. | PiEV and equipment manufacturers and suppliers |
| | 19 | Stored Energy in capacitors and equipment with an inherent capacitance | A residual voltage, after de-energisation, between any accessible conductive parts or an accessible conductive part and earth presents the risk of electric shock. | | As detailed in BS EN 61851-1: The equipment should be designed such that one second after having disconnected the EV from the supply, the voltage between any accessible conductive parts shall be less than 42,4V peak, 60V DC and the stored energy shall be less than 20J. | Manufacturers and suppliers of equipment (commercial and public charge locations). |
| **Inspection & Maintenance** | 20 | Inspection, Test & Maintenance of live equipment | Contact with hazardous live parts resulting in electric shock causing injury or death | | 1) A point of electrical isolation should be installed at all recharge point locations<br>2) Regular inspection and test of the installation in accordance with BS7671 | Recharge point owners, designers and installers. |

# APPENDIX C

Organisational Diagrams for Public Charging Posts

**Installation Process for Public Charging Posts**



**Responsibility Matrix for Public Charging Posts**

| | | | | | | |
|---|---|---|---|---|---|---|
| Pre-Installation | Charge Point Design | Charge Point Procurement | Post Branding | | | |
| | Manufacturer | Owner | Owner | | | |
| | Identify Site | Amend Traffic Regulations | Lease Agreement | Site Survey | 'Opening Up' Notice | Application |
| | Installer / Site Owner | Installer /Owner Initiates<br>Site Owner - Information | Post and Site Owner | Installer | Installer | Installer or Site Owner |
| Installation | Charge Post | Installation Electricity Meter | LV Connection | Commissioning | Site Safety Audit | |
| | Installer | Meter Owner | DNO | Installer | Site Owner | |
| Operation | Charging Infrastructure Ownership | Planned Maintenance | Unit non-Operational Vandalised | Unit Damage<br>Make Safe Repair | Data Downloaded | |
| | DNO | Manufacturer / Supplier | DNO / Manufacturer | DNO Manufacturer | Owner / Manufacturer | |
| Decommissioning | Remove Charging Point | | | | | |
| | Owner | | | | | |

# APPENDIX D

The Role of Stakeholders in PiEV Infrastructure

## Table D1: Stakeholders in Domestic Charging PiEV Infrastructure

| Stakeholder / Capability Required | PiEV Owner | PiEV Manufacturer | Recharge Post Manufacturer | Charge Post / Site Owner | Electricity Supplier | DNO | Local Authority (LA) | Government | Intelligent Infrastructure Operator |
|---|---|---|---|---|---|---|---|---|---|
| **Home recharging** | Small cost, increases in some business models. | | In communal parking cases. | | | | Possible issues with cables over pavements. | HSE may have concerns over safety of home recharging. | |
| **Management of domestic load** | Small cost for additional equipment. | | | | Attractive tariff. | Required with current supply regulations, smart grid favoured. | | | |
| **More power on the domestic LV network** | | | | | | Yes, but expensive. | | Concern if costs increase significantly. | |
| **LV equipment maintenance** | | | | | | Yes, but small addition to existing costs. | | | |

**Table D2: Stakeholders in Public (on-street) Charging PiEV Infrastructure**

| Stakeholder / Capability Required | PiEV Owner | PiEV Manufacturer | Recharge Post Manufacturer | Charge Post / Site Owner | Electricity Supplier | DNO | Local Authority (LA) | Government | Intelligent Infrastructure Operator |
|---|---|---|---|---|---|---|---|---|---|
| **Provision of public recharging posts** | | Provide PiEV with ability to recharge at different rates | Provide post with required capabilities. | Potential conflict of interest if DNO or LA. | | Approve and provide connection. | Approve charging post site. | Current subsidy to local authority. | No business without central settlement. |
| **Simplified post installation** | | | May require product development. | Reduced costs. | | | | Better value for subsidy provided. | |
| **Common access system for easy use** | Better service. | | May prefer to use individual access systems. | Better customer satisfaction. | | | | | |
| **Provide real time pricing for public recharging posts** | | | Additional cost for communication required in charging post. | More expensive charging posts. | Provide tariff information. | | | | Possibly unnecessary additional link. |
| **Payment** | Probably expensive compared to home charging. | | Additional cost for communication required in charging post. | More expensive charging posts. | | | | Concern if price restricts use. | Expensive investment in complex back office billing in one business model. |
| **Equipment Maintenance** | | | | Possibly expensive in public place. | Concern if failure loses data. | Exposed to additional costs. | | | Concern if failure loses data. |

## Table D3: Stakeholders in Commercial Charging PiEV Infrastructure

| Stakeholder / Capability Required | PiEV Owner | PiEV Manufacturer | Recharge Post Manufacturer | Charge Post / Site Owner | Electricity Supplier | DNO | Local Authority (LA) | Government | Intelligent Infrastructure Operator |
|---|---|---|---|---|---|---|---|---|---|
| **Recharging capability at commercial sites** | | Provide PiEV with ability to recharge at different rates. | Possibly only cheap recharge post required. | Potential conflict of interest if DNO or LA. | | Yes | | | |
| **More power on commercial LV network** | | | | Likely to pay directly for network reinforcement. | | Ensure low network reinforcement costs. | | Concern over possible large cost increases. | |
| **Demand reduction at large PiEV charging (not-rapid) sites at times of high demand** | Possible adverse reaction if power reduction large. | | Small additional cost since each charging post may be fairly simple. | Potential Impact upon business. | Interruptible tariff. | Network management obligations. | | | |
| **Payment if recharging post used by different people** | Probably expensive compared to home charging. | | | Probably cheaper if payment is collected on site, perhaps part of other service, e.g. car parking. | | | | | |
| **Rapid charge capability** | Willing to use PiEV on longer journeys. | Provide PiEV with rapid charge capability. | Develop post for rapid charge. | High risk initially. | Standard tariff. | Network upgrade required. | Approve rapid charging site. | Subsidy initially. | |
| **Equipment maintenance** | | | | Low cost if cheaper post installed. | | | | | |