energy saving trust

Guide to chargepoint infrastructure for business users

Contents

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Introduction

Choosing the correct charging infrastructure for your fleet and utilising it efficiently will ensure that operational requirements, such as charging speed and the number of vehicles capable of being charged at any given time, are met.

The specifications of charging infrastructure should address any electricity supply constraints whilst minimising the cost of installation.

For fleet managers it is important to understand the existing EV charging technologies including:

- Fast and rapid charging infrastructure
- Smart charging
- Load management

As well as being aware of emerging technology solutions including:

- Vehicle to grid (V2G)
- Inductive charging
- Energy storage

Considerations include their technical requirements and limitations, and the commercial settings in which they are most effective.

This best practice guide aims to help fleets understand the different aspects of charging infrastructure that need to be considered. This guide also highlights why it is important to consider vehicle choice at the same time as infrastructure, as vehicles can often only utilise certain chargepoint specifications. We therefore recommend reading this guide along with our best practice guide to ultra-low emission vehicles for fleet managers.

If you have any further questions on chargepoint utilisation best practice, or if you would like to discuss a chargepoint project with an Energy Saving Trust consultant, contact us at transportadvice@est.org.uk.

Ultra low emission vehicles

Ultra low emission vehicles (ULEVs), also known as plug-in vehicles, emit lower levels of motor vehicle emissions compared to other vehicles. UK Government's Office for Low Emission Vehicles (OLEV) define plug-in vehicles, those cars, vans and motorcycles which fall into the eligibility categories table below, as ULEVs. Grants towards the cost of eligible vehicles exist, with the highest grants available for vehicles with the lowest CO_2 emissions and the longest zero emission range.

ULEVs have been available for several years now and, compared to the first generation of modern electric cars, those on the market today are superior both technically – with ranges often exceeding 120 miles – and in terms of practicality, as shown in Figure 1 below.

ULEVs are only compatible with certain types and speeds of charging equipment and so this should be a primary consideration for fleet operators. This aspect is covered in further detail in the next section.

Table 1: Eligibility categories for ultra low emission vehicles

	Category 1	Category 2	Category 3
CO_2	<50g/km	<50g/km	50 – 75g/km
Zero emission range (miles)	70+	10 – 69	20+
Maximum grant available	£4,500	£2,500	£2,500
Price cap	N/A	£60,000	£60,000

Figure 1: Advancement in electric vehicle range[1]

Mitsubishi i-MiEV - 2010
93 mile range

Nissan Leaf - 2013
124 mile range

Renault Zoe - 2017
250 mile range

1. All range values are official New European Drive Cycle (NEDC) figures. The Energy Saving Trust would typically expect real-world range to be roughly 20% lower, depending on driving style.

Chargepoint power & speed

There have been significant recent advancements made in the speed at which EVs can be charged.

Chargepoints as powerful as 150 kW are entering production, and rapid chargers are now a common sight at motorway and main road service stations throughout the UK. It is anticipated that chargers as fast as 350kW will be available in the foreseeable future.

Electric vehicle charging is dependent both on technology built into the vehicle and built into the charging infrastructure. For example, when the charging capability of the vehicle is less than that of the charger then the vehicle will charge only at the maximum speed allowed by the vehicle. When the charging capability of the vehicle is greater than that of the charger than the vehicle will charge at the maximum rate allowed by the charger. Charging rates as shown below vary from slow chargers which can take more than 12 hours to completely replenish a battery, to rapid chargers which can provide 80% in 20-30 minutes.

From the perspective of both fleet managers and private users, one of the most significant considerations when operating ULEVs is the time required to charge. Also of great importance is daily mileage, downtime during the day and the numbers of vehicles needing to be charged. To meet such demands, vehicle and chargepoint manufacturers are increasingly promoting fast or rapid chargepoints. Table 2 (on the following page) shows the different costs associated with different types of chargers, highlighting the need to thoroughly understand your charging requirements.

Figure 2: Types of charging technology and the average time needed to achieve full charge

Three-pin socket 2.3kW, 12+ hours

energeasy drive by Rexel

Slow charger 3.5kW, c. 10 hours; Fast, 7kW c. 6 hours; Semi-rapid, 22kW, 2 hours

energeasy drive by Rexel

Rapid charger 50kW, 20-30 mins to 80% charge

APT Controls Group

Ultra-rapid charger 150kW+, <20 mins (estimated)

Table 2: Key facts on EV chargepoint types

	Slow	Fast	Rapid
Power rating	3.5kW-7kW	7kW-22kW	43kW-50kW
Electrical supply type	AC	AC & DC	AC & DC
Charge time	4 to 8 hours	2 to 4 hours	25 to 40 minutes (80% charge)
Vehicle range added in 15 minutes	3 – 6 miles	6 – 20 miles	35 – 40 miles
Cost (approximate)[2]	£500-1000	£2-3k (AC), £19k (DC)	£20k-40k

2. Costs are an approximation provided by a chargepoint provider and do not include installation costs.

Vehicle compatibility with chargepoints

Charging an electric vehicle requires compatibility through a connecting cable between the charger outlet (also known as a socket) and vehicle inlet. The connecting cable can either be tethered to the chargepoint or detached entirely. The most common connectors are outlined in Table 3 below. Type 1 (J1772) tethered cables may also be encountered, which are compatible with the vehicle inlet on many vehicles, including Mitsubishi and Nissan.

It is recommended that charging sockets are installed at depots rather than tethered cables, which would render the chargepoint vehicle-specific. It is necessary to provide the appropriate number of charging cables to account for the number and type of vehicles to be charged at the depot. Should rapid chargers be installed they will be equipped with up to three tethered cables to accommodate the vehicles to be operated.

Table 3: Chargepoint connector types

Connector Type	Profile	Typical charge speed and current	Associated manufacturers
Type 2 (Mennekes)		3.5kW, 7kW, 22kW, 43kW AC	Compatible with most vehicles, but not all will be capable of utilising the higher rates of charge (charge speed dependent on vehicle on-board charger)
Combined Charging System (CCS)		50kW DC (150kW DC being trialled[3])	BMW, Audi, Volkswagen, Porsche, Ford
CHAdeMO		50kW DC	Nissan, Kia, Citroën, Tesla (via adapter), Mitsubishi, Peugeot

3. https://electrek.co/2016/08/10/150-kw-fast-charging-station-switzerland/

Vehicle operating considerations

Consideration of both daily mileage and downtime is necessary to determine which type of chargepoint is most appropriate for a given fleet.

Daily mileage

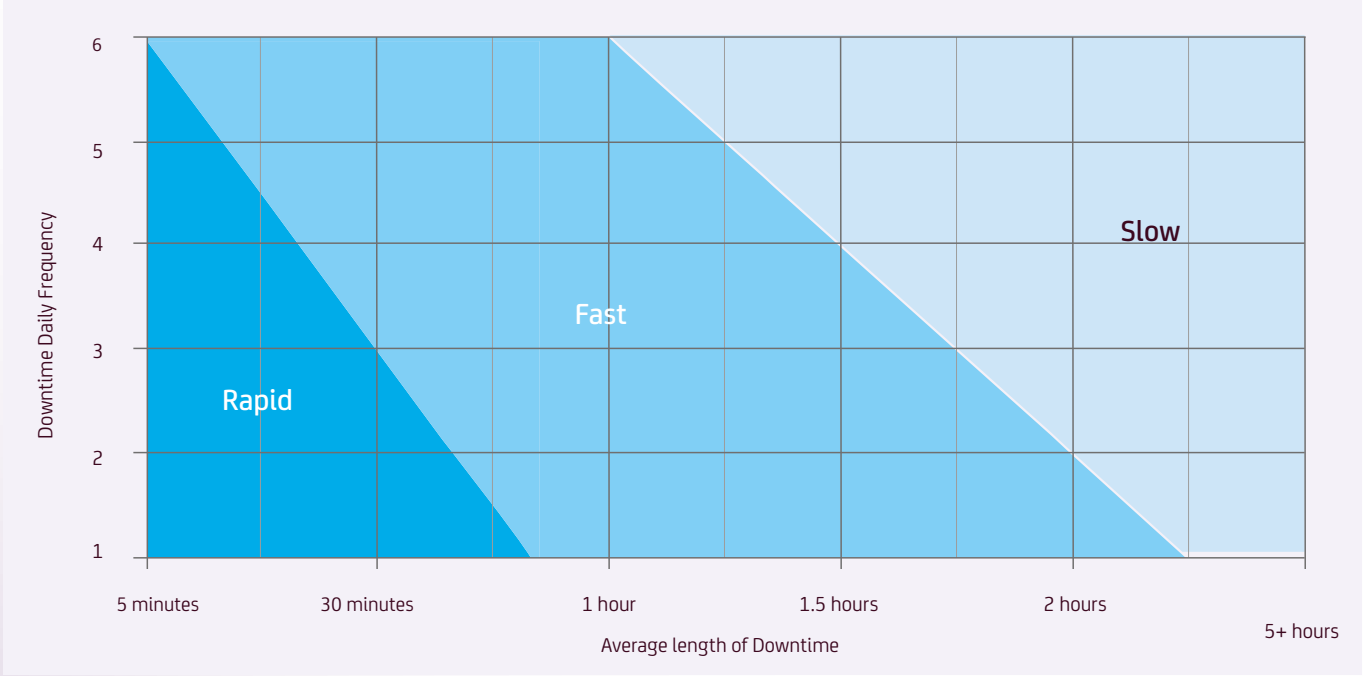
Typical daily mileage is arguably the most important consideration when deciding on which chargepoint type is most appropriate for a given fleet.
This becomes especially important when daily mileages start to exceed the maximum real-world range of the EV being considered, as charging time would then need to be factored into the working day.

Downtime

In some organisations, vehicles may regularly or routinely spend time stationary during their working day. If this downtime naturally exists in the operation of a fleet, it represents an opportunity to charge a ULEV with little or no change to driver behaviour. Downtime may occur in the depot or during transit when vehicles could be charged using public chargepoints. More information on the public charging infrastructure network is provided later in this guide.

A top-up of 15 minutes could provide up to 40 miles range using a 50kW rapid charger (as outlined in Table 1). Depending on the length and frequency of this downtime, different types of chargepoints may be appropriate and this knowledge is essential for efficiently planning and scheduling routes.
The relationship between these factors and the implications for which chargepoint types would be most suitable is shown in Figure 3.

Figure 3: Graph showing relationship between vehicle downtime and chargepoint type[4]



4. Figures assume that one full charge is required throughout the course of the day.

Chargepoint installation

Once it is decided which chargepoints and EVs are needed, then the process of planning, installation and procurement begins. Contracting the services of a reputable installer will help with this process and includes:

- Testing and surveying the power supply of your site to determine the available capacity i.e. the number and type of chargepoints it could support
- Liaising with the DNO on any upgrades needed to support the charging capacity that has been identified

Electrical demand

The planned number of EVs entering a fleet is important as it has implications for both the number and type of chargepoints and the total electrical demand from charging vehicles. For example, some vehicle models can only utilise slower chargepoints, whereas other similar types of vehicles can utilise faster chargers, or optional rates of charge may be offered. Faster charging will reduce the charging time but increase the electrical load.

Charging capabilities for vehicles under consideration should be researched before the vehicles are purchased or leased.

The number of vehicles being charged is closely linked to downtime in the sense that, in fleets where a large number of EVs charge for longer periods of time, a greater number of chargepoints will be required but they may not necessarily need to be fast or rapid.

On the other hand, in fleets where a large number of vehicles charge at different and for shorter periods of time, fast or rapid chargepoints become necessary to ensure vehicles receive an adequate charge before the next vehicle arrives. Most premises will have limitations to the electrical capacity available. This may be based on recent business need or on past use of the premises.

A site survey should be conducted to determine the supply and any spare capacity available (the difference between actual load used and the maximum available) before vehicles or infrastructure are acquired.

If electrical capacity limitations are identified on a site where many EVs are planned to operate from, it is important to consider that these limitations could quickly become an issue, regardless of the type of chargepoint used. For example, a very similar amount of available capacity would be required to run a fleet of 15 EVs in the following configurations:

- One 50kW rapid charger, with EVs scheduled to charge one-by-one
- Two 22kW fast and two 3.5kW slow chargers, all being used at the same time
- Fifteen 3.5kW slow chargers, all being used at the same time

This means that electrical capacity should be considered, ideally even before EVs are procured.

Case study: ALD Automotive

ALD Automotive is a vehicle leasing and fleet management company providing solutions to both corporate and consumer markets.

Challenge: In 2014, when ALD Automotive decided to build a new head office in Bristol, it was clear from the start that a charging capability for Electric Vehicles (EVs) would be a necessary part of the design. As the office project developed, so did the Alternative Fuel Vehicle (AFV) market and the rapid growth in this sector meant that the office build needed to adapt. What started out as a plan for a couple of slow 3.3kw chargers quickly developed into a more advanced and future-proof solution with the required flexibility to adapt to a rapidly changing market.

Process: In early 2016, as the building of the new offices advanced, it became apparent that the planned chargepoints were not going to be adequate to support ALD's ambitions to run the latest generation of AFVs in an efficient way.

Elektromotive, a company specialising in advanced recharging solutions, was enlisted to develop a robust strategy for implementation. Charging requirements, potential vehicle volumes and parking locations were reviewed and charging infrastructure was re-planned resulting in 7kW being chosen.

Result: The number of chargers required was balanced against the amount of electricity available and analysis and forecasting of vehicle volumes means utilisation of chargepoints will be maximised. The process of planning for workplace charging has allowed ALD Automotive to implement a range of initiatives including:

- Laying a conduit around the car park allowing more chargepoints to be added in the future without the need to dig up the car park
- Adding solar panels to the office roof to increase the amount of renewable electricity for vehicle charging
- Introducing 20 ALDs into its company car scheme
- Implementation of BEVs into a pool fleet for local business use

Managing electricity supply demand

Charging technology is rapidly developing to meet the varied needs of the market with solutions such as smart charging and load management providing options for fleet operators and an alternative to expensive connection upgrades.

Most chargepoints currently installed, simply supply power at a rate determined by the vehicle until fully charged. A number of chargepoint systems now on the market feature 'smart charging' able to manage charging systems and demand in real time, potentially decreasing or removing the need for expensive upgrades by the Distribution Network Operator (DNO). Smart charging can also assist in reducing energy costs by preferentially charging electric vehicles when lower time-of-use (ToU) tariffs are in effect (if subscribed to). It also provides the ability to access grid services such as frequency response.

Supporting rapid charging can require interventions ranging from upgrading the electrical supply to the premises all the way through to more expensive electrical distribution network upgrades at the sub-station level. It is recommended that a quotation is sought from the Distribution Network Operator in your area to determine any costs which may be incurred before purchasing charging equipment.

Load management

Load management systems offer a potential solution for multiple chargepoints to be operated without exceeding the maximum power capacity of a site. Load management can be achieved through dynamic power management to chargepoints, reducing the speed of charge as necessary to moderate total electrical demand, striking a balance between the number and the speed of chargepoints.

Load management systems can also be configured to limit the proportion of a site's total energy supply that EV chargepoints can use, again to prevent exceeding total capacity. The use of load management technology can avoid costly upgrades to electrical supply.

The principle of load management is that when a chargepoint is being used, the vehicle is charged at the fastest speed permitted by the chargepoint and vehicle in question. When several chargepoints are being used, the speed being delivered to each can be reduced. The following section shows three scenarios outlining how load management could work with increased demand by vehicles. It shows a bank of six chargepoints, with a maximum power rating of 22kW (80% charge in roughly an hour and full charge in around 2 hours), on a site with 32kW of spare electrical capacity. When one vehicle is charging, load management will provide the maximum amount of power that the charger is capable of supplying and the vehicle is capable of receiving. In this case, that is 22kW, although it is worth keeping in mind that few vehicles on the market today are capable of charging at this rate.

Organisations running fleets with a number of vehicles requiring quick top-up charges during shifts, and vehicles requiring a slow charge overnight at the end of a shift, could almost certainly benefit from load management systems, particularly if the system allows the business to avoid costly upgrades to its electrical supply. Fleet managers should consider the likely future growth of their EV fleet, as installing flexible load management technology at the outset can save on infrastructure replacement and upgrades later.

Chargepoints with features such as remote access functionality, back office integration and load management are also useful from a payment perspective. They can also include the ability to remotely control chargepoints (to end a charging session, for example) and to monitor the usage of charging infrastructure on site over time.

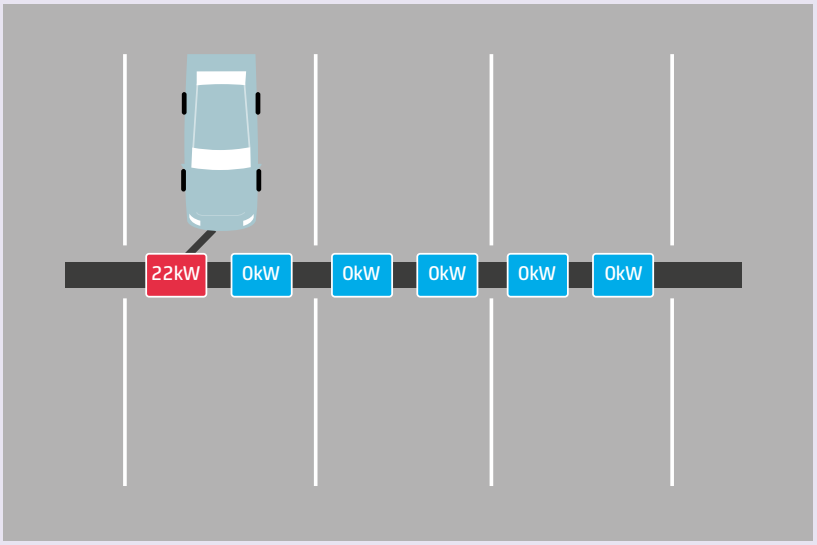
The end-user can often be identified through an RFID card or user app which is advantageous for determining the amount of electricity any particular vehicle is using, and allows individual vehicle and driver efficiencies to be determined and costs charged to cost centres.

Where employees are allowed to charge their private vehicles at work then the cost of the electricity they use can be recharged to them. In the same way visitors using the infrastructure on site can be identified and managed as deemed appropriate. Ultimately it is possible to incorporate charging on site, driver's home charging and public charging within one intelligent charging solution, providing visibility across the fleet in terms of vehicle efficiency and the reimbursement of expenses.

The principle of load management

A bank of six chargepoints, with a maximum power rating of 22kW, on a site with 32kW of spare electrical capacity.

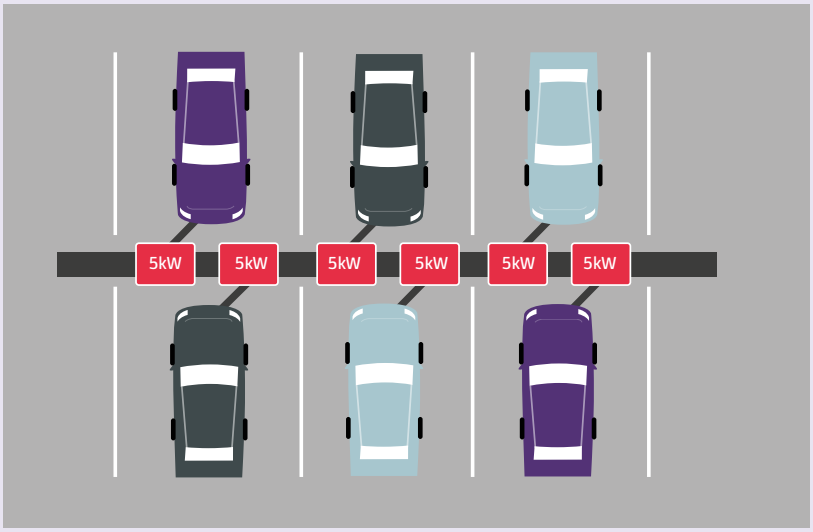
Total spare electrical capacity: 32kW



Chargepoint in use

Chargepoint not in use

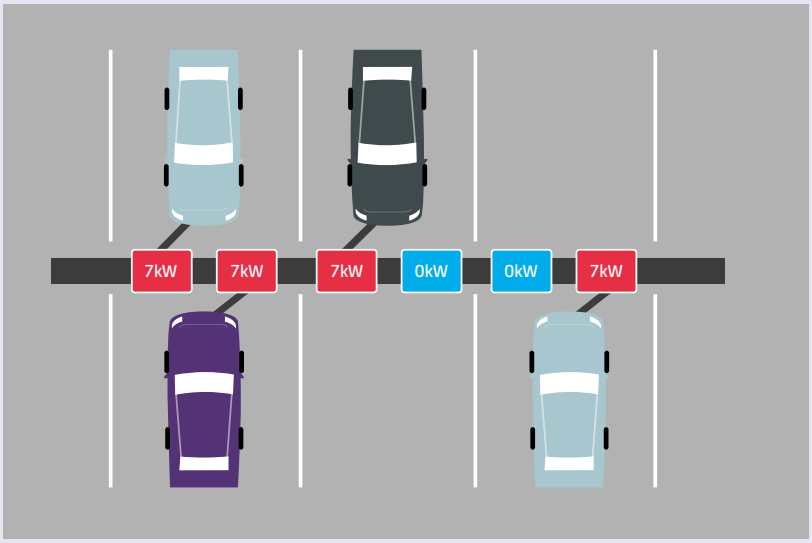
When all six chargepoints are being used, the load management equipment limits the amount of power at each chargepoint, to avoid exceeding the spare capacity.



Chargepoint in use

Chargepoint not in use

With any number between one and six vehicles, the load management equipment will ensure the maximum charge possible is delivered, whilst not exceeding spare capacity.



Chargepoint in use

Chargepoint not in use

New developments in charging technology

Charging technology will continue to develop to meet the needs of the market with a number of technologies being trialled and reaching early market. An example is load management technology able to monitor the state of charge of the vehicles connected, and adjust the power provided to individual chargepoints in real time. This allows the vehicles most in need of charging to be prioritised and is therefore a technology which is likely to become more widely available.

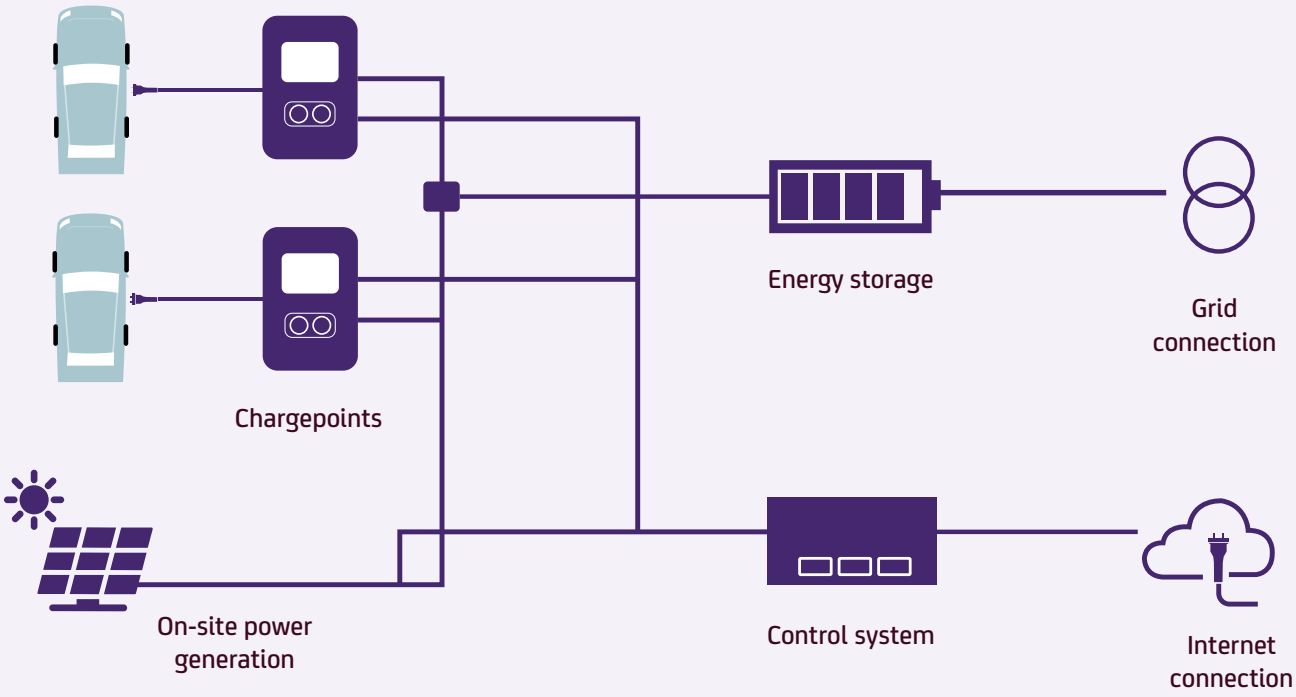
DNOs are also required to offer flexible connections if a customer is able to manage their peak load, which can avoid extra costs.

The Government has also established the Automated and Electric Vehicles Bill which will in the future, require all chargepoints sold or installed in the UK to be Smart.

Energy storage

Where charging requirements exceed capacity of the local network infrastructure, a potential alternative to a costly distribution network upgrade may be to install a chargepoint solution with energy storage. This would offer a means of storing electricity off grid to charge electric vehicles, but would also incorporate load management and integrate with a smart charging array as illustrated below.

The principle of energy storage



The main benefits of energy storage solutions include the ability to avoid upgrades to the local electricity supply, which may be preferable due to cost or uncertainty over tenure of a site.

Increased energy supply from battery storage can allow the expansion of a fleet of electric powered vehicles. In conjunction with load management and smart charging, storage can also reduce costs by avoiding peak-tariff periods. In markets where network incentives or feed in tariffs operate, energy storage could also act as an income source. Some energy storage systems can also act in 'island mode', providing energy security in the case of a power cut.

By integrating renewable energy generation such as solar panels or wind turbines, reduced drawdown from the grid will reduce carbon emissions. Energy storage solutions incorporating 2nd life EV battery packs can also assist with addressing the problem of what to do with used electric vehicle batteries once their capacity is depleted below a level deemed suitable for driving the vehicle. Batteries at this stage of their life will still retain sufficient capacity to provide a storage solution.

Vehicle to grid (V2G)

Another technological advancement is Vehicle-to-Grid technology (V2G), which looks and acts very similar to a standard charging installation, but which includes bi-directional inverters so that energy flows both to and from the vehicle. In effect, this turns a vehicle into a portable battery which can provide services to the home, business and grid such as storage and frequency response, and can maximise the benefits of charging on time of use tariffs. V2G technology is currently in the testing for commercialisation stage.

Inductive Charging

Inductive, or wireless, charging uses an electromagnetic field to transfer energy between an electric car and a charging pad through electromagnetic induction. This is a promising technology which could revolutionise electric vehicle use through doing away with charging cables. The first cars with inductive charging capabilities are expected to be introduced in the near future.

Public charging infrastructure

Operating public chargepoints

Government funding and private investment has facilitated the installation of more than 11,000 public chargepoints. There are multiple chargepoint operators whose networks provide different offers to consumers in terms of payments systems and subscription services.

We recommend that you familiarise yourself with the providers that have the most comprehensive network in the area you expect your vehicles to operate in and ensure that your drivers understand how to access the chargepoints. It is recommended that membership of network(s) should include those providing a range of standard and rapid charging.

The Government has recently established the Automated and Electric Vehicles Bill. The purpose of the Bill is to provide Government with powers to make regulations, if deemed necessary at a later date, requiring operators to provide a standardised means of accessing public charging points, ensuring that an electric vehicle can access and charge at any chargepoint without the need for membership.

The Bill will also enable Government to introduce regulations, if necessary, requiring that data on the location and availability of chargepoints is openly available. Additional powers to be provided by the Bill would enable minimum standards for physical connection to public chargepoints to be defined; that chargepoints are 'smart' and can interact with the electricity grid; and Motorway Service Area operators and large fuel retailers could also be obliged to provide electric chargepoints and hydrogen refuelling facilities.

Locating public chargepoints and planning your journey

Home and work recharging can be supplemented by the expanding public recharging network. This includes rapid chargers available at most service stations on the Strategic Road Network, which includes motorways and main routes. Public chargepoint operators and chargepoint map providers give details of charging infrastructure and location including:

- ChargePlace Scotland
- National Chargepoint Registry
- Plugshare
- Zap-Map

Planning routes to ensure access to public chargepoint infrastructure can make longer journeys a realistic proposition.

Grants

A number of Government grants available through the UK Government and the Office for Low Emission Vehicles (OLEV) exist to assist the transition to electric vehicles through chargepoint provision. Plug-in car, van and motorcycle grants; Workplace Charging Scheme; On-street Residential Chargepoint Scheme; and the Electric Vehicle Homecharge Scheme.[5]

Plug-in car, van and motorcycle grants

Grants towards the cost of eligible low emission vehicles are available from OLEV; ranging from £4,500 for cars with less than 50g/km CO_2 emissions and over 70 miles of zero emission range to £2,500 for cars with between 50 and 75g/km CO_2 emissions and from 10 to 69 miles of zero emission range and with a list price of no more than £60,000. Current levels of support are guaranteed to October 2017. The van grant covers 20% of the cost of a van, up to a maximum of £8,000 whilst the motorcycle grant covers 20% of the cost of a motorcycle up to a maximum of £1,500.

Workplace Charging Scheme

The Workplace Charging Scheme is a voucher-based scheme that provides support towards the up-front costs of the purchase and installation of electric vehicle chargepoints for use in the workplace for staff and fleet use. The contribution towards installation is limited to £300 for each socket up to a maximum of 20 across all sites for each application with further information and eligibility available on the OLEV website.

Businesses are responsible for determining whether the electricity used by their staff or their fleets constitutes a taxable Benefit in Kind (BIK). If this is the case, they must report the electricity usage to HMRC. Information about reporting BIKs to HMRC is available on the HMRC website. To find out whether the electricity provided is a taxable BIK, please refer to the Government's BIK calculator for electric vehicles

There are potential impacts to benefits in kind (BIK) for fleet users when considering chargepoints. More information is available in our guide to ultra-low emission vehicles for fleet managers.

On-street Residential Chargepoint Scheme

The On-street Residential Chargepoint Scheme is a funding source for Local Authorities to increase the availability of plug-in vehicle charging infrastructure for residents who do not have access to off-street parking. The funding available is for 75% of the capital costs of procuring and installing a chargepoint up to a maximum of £7,500. Further information on the scheme, advice, and guidance is available from the Energy Saving Trust website.

Electric Vehicle Homecharge Scheme

The Electric Vehicle Homecharge Scheme provides a grant of 75% towards the cost of installing an electric vehicle chargepoint up to a maximum of £500 at domestic properties across the UK. Find out more.

5. Further information on OLEV grants available on the OLEV website: https://www.gov.uk/plug-in-car-van-grants/what-youll-get and https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles

Glossary

Term	Definition
CHAdeMO	A charging protocol for delivering a DC supply to plug-in vehicles. CHAdeMO is primarily used Nissan, Mitsubishi, Citroen and Peugeot.
Destination charging	Undertaking charging as a secondary purpose to a primary activity e.g. charging whilst shopping, staying at a hotel.
Distribution Network Operators (DNO)	Companies licensed to distribute electricity in Great Britain by the Office of Gas and Electricity Markets. DNOs are also involved whenever electricity grid reinforcement work needs to be carried out e.g. when rapid chargepoints are being installed. The DNO will work with the network operator on the design of the installation
Fast charging	Charging a plug-in vehicle at typical rates of 7kW AC, 20kW DC or 22kW AC.
kW	Unit of power.
kWh	Unit of energy.
Load management	A system to ensure that chargepoints in use do not exceed the the admissible total output of a site.
On-board charger	Systems on-board plug-in vehicles which use a rectifier circuit to transform alternating current (AC) to direct current (DC) in order to charge the battery.
Opportunity (en-route) charging	Re-charging a plug-in vehicle during daily use (rather than overnight at home or depot). Typically requires a fast or rapid chargepoint.
Plug-in car grant/ plug-in van grant	Grant funding to support private and business buyers looking to purchase a qualifying ultra-low emission car or van.
Rapid charging	Charging a plug-in vehicle at typical rates of at least 43kW AC or 50kW DC.
RFID access	Radio-frequency identification
Slow or standard charging	Charging a plug-in vehicle at typical rates of no more than 3.7kW AC.
Smart chargepoints	Chargepoints capable of receiving, understanding and responding to signals sent by energy system participants such as Distribution Network Operators (DNOs), energy suppliers, National Grid or other third parties for the purposes of balancing energy supply and demand
SOC (State of charge)	Indicates the charge of a vehicle using percentage points as the unit. Equivalent of a fuel gauge for the battery pack in a plug-in vehicle.
Type two (Mennekes)	The recommended standard for public 3.5kW and 7kW AC chargepoints. It can also be used for fast AC charging at 22kW or rapid AC at 43kW.
Zero emissions capable	Vehicles which are able to operate with zero or near zero tailpipe emissions.

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