A fleet manager's guide to plug-in vehicles

energy saving trust

learn how plug-in vehicles can work for you

Department for Transport

Contents

Introduction

Energy Saving Trust has produced this impartial guide to plug-in vehicles, to help SMEs consider whether an electric car or van might be suitable for their fleet.

After several years of slow development, the market for plug-in vehicles in the UK is growing rapidly. Most mainstream manufacturers now have at least one electric vehicle in their range or in development, with exciting new vehicles from BMW, Ford and Volkswagen anticipated to be on sale in 2013. However, there is so much information available about plug-in vehicles that it can be difficult to separate facts and figures from myths and misconceptions.

This guide provides straightforward answers to some of the most commonly asked questions about EVs such as:

- How do you recharge an electric vehicle?
- How long does it take?
- How far will they go on one charge?
- And perhaps, most importantly, how much do they cost to run?

We will also outline the various charging types and modes, and provide financial examples from organisations we have engaged with on their plug-in vehicle journeys.

For tailored, one-to-one advice on how plug-in vehicles could work in your business, including a full analysis of your existing vehicles, email us at:

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Types of plug-in vehicles

There are three categories of plug-in vehicles:

1. **Pure or fully electric vehicles (Pure-EVs)** are powered 100 per cent by electricity, which is stored in a battery in the vehicle.

- A pure-EV will typically cover up to 100 miles on a single charge.

2. **Plug-in hybrid electric vehicles (PHEVs)** combine petrol or diesel engines with a battery and electric motor. They can be plugged into the mains electricity to provide a substantial driving range on electric-only power.

- A PHEV will have an electric-only range of 10 to 30 miles and a total range comparable with that of a standard petrol or diesel car, typically over 500 miles.

3. **Extended-range electric vehicles (E-REVs)** are powered by an electric motor that takes energy from a battery. If the battery becomes depleted, a petrol engine generates electricity to power the electric motor.

- An E-REV will typically cover around 50 miles on electric only power, then a further 300 miles powered by electricity generated by the internal combustion engine.

The range of a plug-in vehicle will vary depending on the technology involved, the load placed on the battery by ancillary equipment such as air conditioning, and driving style.

The business case for plug-in vehicles

Financial

Although PIVs generally cost more than their petrol or diesel equivalents to buy or lease, it is crucial to look at the vehicle's total lifecycle costs. Applying a whole life cost (WLC) analysis often shows that a plug-in vehicle is cheaper than a conventional vehicle on a pence per mile basis. Electric cars cost around £2 to £3 to fully charge, for a typical range of 100 miles. An equivalent petrol or diesel car costs £12 to £18 to drive 100 miles – in other words, six times the cost of the electric car. Fuel prices are expected to continue rising, and if electricity, petrol and diesel prices all rise by the same percentage, the saving per mile travelled will increase.

In addition, there are currently a number of financial incentives in place to support the uptake of plug-in vehicles:

- The plug-in car grant provides 25 per cent towards the purchase price, up to a maximum of £5,000. The plug-in van grant provides 20 per cent towards the purchase price, up to a maximum of £8,000. A list of eligible vehicles can be found here.
- All types of plug-in vehicle are currently exempt from VED (Vehicle Excise Duty).
- For company car and van drivers who are permitted private use of the vehicle, there is zero 'benefit in kind' tax to pay on fully electric vehicles, until April 2015. Similarly, companies have zero Class 1A National Insurance Contributions to pay until that date.
- Businesses buying plug-in vehicles can write down 100 per cent of the purchase price against their corporation tax liability.
- All plug-in vehicles currently available attract a 100 per cent London Congestion Charge discount.
- Grants may be available for the installation of infrastructure.
- Some manufacturers have pricing plans, which help you to offset the higher purchase or lease cost of the vehicle, for example by buying the car or van, and then leasing the battery for a monthly fee.

Environmental

In addition to saving organisations money, electric vehicles have a wealth of environmental benefits.

Pure EVs, PHEVs and E-REVs (when driven on electric power) emit zero 'tailpipe' carbon dioxide emissions. Clearly, the vehicles are only as green as the electricity supply. However, plug-in vehicles charging from the UK's National Grid emit considerably less carbon dioxide per mile travelled than petrol or diesel models. Even considering the emissions associated with manufacture, electric cars and vans are less environmentally damaging than internal combustion models, and can help you meet your CSR objectives.

Driving using electric power does not produce local air pollutants such as nitrogen dioxide and particulate matter, which increase rates of heart and lung disease, cancer and asthma. Finally, plug-in vehicles produce less noise than conventional vehicles, bringing further benefits to urban areas.

Charging modes and types

The charging mode refers to the way you charge your vehicle (i.e. the level of communication between the charging infrastructure and the vehicle), rather than the type of plug and socket in use.

Additionally, there are four types of dedicated charging plugs and sockets. The four charging modes and plug types are explained in the Appendix of this guide, but the key points to note are:

- Mode 1 charging - plugging directly into a standard household socket - should not be used.
- A plug-in vehicle is most likely to be supplied with a cable with a three-pin plug for mode 2 charging, or a cable with a type 2 infrastructure connector for mode 3 charging. To ensure you can charge at most places, we recommend carrying one of each.
- The best practice approach is to use mode 3 charging with a tethered cable for workplace and home charging. The presence of a Residual Current Device (RCD) and communications technology in the dedicated outlet, plus the ability to use a faster rate of charging, ensures that charging is safe and is completed as quickly as possible.
- If multiple vehicles from different manufacturers are to be charged at the workplace then we recommend installing a type 2 infrastructure socket rather than a type 2 tethered cable. This will allow vehicles with a type 1 vehicle inlet (e.g. the Leaf or Ampera) to be charged.
- Public recharging outlets usually involve either mode 3, type 2 charging, or DC rapid charging with a tethered cable. There are however, some 'legacy' 3 pin plug (BS 1363) posts in use.
- Overnight, off-peak charging maximises the financial and environmental benefits of running a plug-in vehicle.

Home and work recharging will be supplemented by the expanding public recharging infrastructure, details of which can be found at the Electric Vehicle Network website, the Newride website and by searching Zap-Map.

The Government is investing heavily in developing the public recharging infrastructure. The first round of the Plugged-in Places programme made £30m of funding available to contribute towards a national target of deploying 8,500 chargepoints. In February 2013, an additional £37m funding package was announced for home and on-street charging, and for new charge points at railway stations and on public sector estate. This forms part of the Government's £400m commitment to increase the uptake of ultra-low emission vehicles.

Practicalities of running plug-in vehicles

The long-term life of an EV battery depends on the type of battery and the mileage covered. It is expected that most batteries will last at least eight years (SMMT, 2011) before any reduction in performance is significant for the user. Most manufacturers offer a battery warranty, which will cover the cost of a replacement if performance deteriorates noticeably.

One question often asked about running an electric vehicle is: does repeated fast charging damage the battery? The argument runs that repeated rapid charging may damage the lithium-ion battery. Tests carried out by the Massachusetts Institute of Technology (MIT) found that after 1,500 rapid charge-discharge cycles (equivalent to rapid charging five times a week, every week for almost six years), battery capacity had declined by less than 10 per cent. This compares favourably with manufacturers' predictions that, under normal use, batteries will reduce to 70 to 80 per cent of capacity after 10 years.

Range anxiety is one of the biggest barriers to EV adoption. This is the fear people have about the distance an EV can drive and the concern that the range may not be enough to reach their destination. However, if the correct vehicle is chosen and used appropriately, plug-in vehicles can meet the needs of the majority of journeys. Typically, Pure-EVs are best suited to either short journeys, within the vehicle's range, or regular journeys where recharging infrastructure is known to be available. Where more mixed or varied use is likely, a PHEV or E-REV may be more appropriate.

Under normal use, batteries will reduce to 70 to 80 per cent of capacity after 10 years.

Driving a plug-in vehicle

Modern electric vehicles have strong and smooth acceleration from rest and easily keep pace with other traffic. Electric cars are almost silent, and because there's no clutch or gears, they are ideal to drive in cities. The driving style, including use of ancillary equipment, can have a significant impact on range. Trials by the Energy Saving Trust found that, after training, drivers reduced energy consumption by 16 per cent, increasing range by 20 per cent. For more information, read our guide to ecodriving or find out more about our electric vehicle driver training programme. Finally, for businesses, route scheduling should be utilised to ensure that EVs are introduced into the fleet on appropriate duty cycles, building in opportunity charging as appropriate.

When it comes to servicing and maintenance, pure-EVs have significant advantages compared to internal combustion equivalents (including plug-in hybrids). There are fewer fluids to change, and fewer moving parts, so servicing costs are reduced. Regenerative braking, an energy recovery mechanism that converts some of the vehicle's kinetic energy into electrical energy and stores it in the battery, reduces wear and tear on the standard friction brakes.

Safety

Plug-in vehicles are subject to the same safety tests and legislation as conventional vehicles. Models tested recently by Euro NCAP have received four and five star ratings, illustrating that their safety performance is comparable with petrol and diesel vehicles. Overall, there is no evidence to suggest that driving or recharging a plug-in vehicle is any more dangerous than an equivalent petrol or diesel model. Additionally, European legislation will mandate a minimum level of sound for plug-in vehicles, to reduce risk to pedestrians and other vulnerable road users.

Driving style and use of ancillary equipment can have a significant impact on plug-in vehicle range.

Plugged-in Fleets Initiative

The Plugged-in Fleets Initiative (PIFI) involved experts from the Energy Saving Trust undertaking detailed analysis of twenty organisations to identify how plug-in vehicles could be integrated into their fleets and what the costs would be.

The findings have been published in our new report Plugged-in Fleets Initiative: Charging Forward, which contains unique insights from our analysis of public and private sector organisations across England. We also presented a webinar covering this project, which can be viewed online.

Whole life cost comparisons

Analysing the costs of plug-in vehicles should follow a whole life cost (WLC) approach, and this formed a key part of the PIFI assessments. Below are three anonymised examples taken from client reports, comparing a pure-electric car, an E-REV and a conventionally fuelled car for use as a pool vehicle; an E-REV and a conventional company car; and an electric versus a diesel van. These illustrate the various areas of the fleet where an EV may prove to be a worthwhile investment. While these examples are a useful guide, we recommend that you carry out your own comparisons, using quotes for the lease or purchase cost of the vehicles.

EV vs. internal combustion engine (ICE) pool car

3 years 45,000 miles	Ford Fiesta	Peugeot iOn	Vauxhall Ampera
Life cost (ex. fuel)*	£8,617	£8,604	£21,147
Life fuel cost	£3,810	£1,118	£2,111
Life total cost	£12,427	£9,722	£23,258
Pence per mile cost	27.6	21.6	51.7

For this private sector fleet, we compared the Ford Fiesta, which is often employed as a pool car, with the Pure-EV Peugeot iOn and the Vauxhall Ampera E-REV.

This shows that although the Ampera would appear to be a suitable pool car operationally (offering a much larger range than a pure-EV), the cost of the vehicle is not compensated for by lower fuel costs over three years. However, the iOn is suitable for journeys up to around 100 miles per day (or more depending on recharging infrastructure) and has a considerably lower lifecycle cost than the similar sized Fiesta.

E-REV vs. ICE company car

4 years 60,000 miles*	BMW 320d Modern Automatic	Vauxhall Ampera positiv
Life cost (ex. fuel)	£25,344	£24,398
Life fuel cost	£3,929	£4,261
Life total cost	£29,273	£28,659
Pence per mile cost	48.8	47.8

*60,000 lifecycle miles, of which 40,000 are business and 20,000 personal

In this example, we compared the Vauxhall Ampera to the BMW 320d as a potential company car offering. Although comparing a Vauxhall with a BMW may not initially appear like-for-like, this type of vehicle tends to attract early adopters who are attracted to the advanced technology in these cars.

In addition to reducing costs for the company, the Ampera is cost effective for the driver; Benefit in Kind tax savings are an average of £951 per year over the timescale in consideration.

EV vs. ICE van

5 years 50,000 miles	Renault Kangoo Ml19 dCi 75	Renault Kangoo Z.E.
Life cost (ex. fuel)*	£25,094	£22,823
Life fuel cost	£5,749	£1,440
Life total cost	£30,843	£24,263
Pence per mile cost	61.7	48.5

*Includes five weekly trips into the London Congestion Charge zone at £9 each

In the third and final example, we advised this fleet that considerable cost savings could be achieved by switching from a diesel to a plug-in Renault Kangoo van.

In this instance, the 100 per cent discount on the London Congestion Charge applicable to plug-in vehicles, tips the balance in favour of the Z.E. model.

Plugged-in Fleets Initiative 100

Following on from the success of the PIFI project, the Energy Saving Trust is offering a further 100 organisations free analysis and a tailored review.

Click **here** to apply and receive:

- analysis of where and how plug-in vehicles could work in your business
- a whole life cost analysis, comparing existing vehicles with suitable plug-in alternatives
- infrastructure advice

Appendix: charging modes and connector types

Charging modes:

- Mode 1 (slow) charging uses the standard electricity supply (typically 13 A, single-phase) and a non-dedicated outlet such as a household socket. The absence of a residual current device (RCD) means that this mode of charging should not be used.
- Mode 2 (slow) charging comprises the use of a specialist cable, including an RCD, plugged into a non-dedicated outlet, typically a household or blue commando socket. This mode of charging does not facilitate communication between the electrical supply and the vehicle.
- Mode 3 (slow or fast) charging is compatible with single or three-phase power supply and features a dedicated charging outlet with a built-in RCD. The dedicated outlet facilitates communication between the infrastructure and the vehicle, so that safety checks are automatically carried out, (e.g. to ensure that the vehicle is switched off) and to determine the charging rate to be supplied. In the future, this mode of charging will help to incorporate plug-in vehicles into a smart grid to manage overall demand. Mode 3 charging takes from one to eight hours to recharge a vehicle, depending on the electricity supply and the rate that the vehicle can be charged.
- Mode 4 (rapid) charging consists of an off-board DC charger, which can use a power supply up to 125 A for expedited charging, together with a tethered cable. The safety device and communications technology are housed within the dedicated outlet. Such outlets typically deliver an 80 per cent charge in 20 minutes.

Plug types:

- Type 1 is compatible with a single-phase supply, and is characterised by five pins. Type 1 sockets are found primarily in the USA and Japan, but are not widespread in Europe. Most Japanese and American vehicles are built with a type 1 socket on the car and are supplied with a cable attached to a three-pin plug. In order to use type 2 public recharging infrastructure, a driver of a Nissan Leaf or Vauxhall Ampera, for example, will need to purchase and carry a cable to connect type 2 infrastructure to a type 1 vehicle inlet.
- Type 2 is compatible with up to a 70 A single-phase or 63 A three-phase supply, and is characterised by seven pins on the plug. Most UK public charging infrastructure, including chargepoints installed under the Plugged-in Places scheme, use type 2 connectivity.
- Type 3 is compatible with a 32 A single-phase or three-phase supply, and can have either five or seven pins and a shutter, and is used by manufacturers in countries where a shutter is required to comply with legislation (e.g. France).
- Type 4 is currently the CHAdeMO plug and socket combination, and is used for DC rapid charging. Additionally, at the time of writing there is a European Commission proposal to standardise the Combined Charging System as the DC rapid charge connector.

For more technical information on EV charging, please refer to the BEAMA guide to electric vehicle infrastructure.

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