

A person's hand is shown plugging a white charging cable into the charging port of a dark-colored electric vehicle. The vehicle's charging port is open, revealing internal components and a yellow warning label. The background is a blurred outdoor setting. The entire image has a blue overlay.

A guide to ultra low emission vehicles for Fleet Managers



Department
for Transport

Introduction





Ultra low emission vehicles (ULEVs), also known as plug-in vehicles, emit extremely low levels of motor vehicle emissions compared to other vehicles. Pure electric vehicles (EVs), plug-in hybrid vehicles (PHEVs), range-extended electric vehicles (E-REVs), and hydrogen fuel cell electric vehicles (FCEVs) are all ULEVs. Energy Saving Trust has produced this guide to ULEVs to assist organisations when considering whether such vehicles might be suitable for them.

The ULEV market in the UK has recently expanded considerably with support from the Government's plug-in car and van grant schemes. During the last five years we have witnessed a significant growth in the sales of ULEVs climbing from just 1,541 plug-in car grant eligible vehicles in June 2011 to 76,590 in September 2016. The most impressive increase happened between 2013 and 2014 where plug-in vehicle sales increased by 186% in one year.

In September 2016 the proportion of cars eligible for the plug-in car grant constituted 1.3% of total new car registrations.¹ This growth in ULEV adoption has been facilitated by simultaneous expansion in charging infrastructure, an ever-greater choice of new models and advances in battery technology. Most major manufacturers have released, or are expected to release, ULEV models while others are redesigning their existing vehicles to offer ULEV alternatives.

For tailored, one-to-one advice on how plug-in vehicles could work for your business, including a full analysis of your existing fleet, contact us on **transportadvice@est.org.uk** or visit **<http://www.energysavingtrust.org.uk/transport>** to find out more.

Types of ULEVs

Vehicle Type	Definition	
1. Battery electric vehicle (BEV or pure EV)	A vehicle powered only by electricity. The vehicle is charged by an external power source and incorporates regenerative braking which helps to extend the available range. Car examples include: KIA Soul, Mercedes B250e, Nissan Leaf, Renault Zoe and Tesla Model S. Van examples include: Citroen Berlingo, Nissan E-NV200, Peugeot Partner and Renault Kangoo.	
2. Plug-in hybrid electric vehicle (PHEV)	A vehicle which combines a battery, electric drive motor and an internal combustion engine (ICE) and the ability to charge the battery from an external power source. The vehicle can be driven by the ICE, by the electric drive motor, or both together. Audi A3 e-tron, Mercedes C 350e PHEV, Mitsubishi Outlander and Toyota Prius PHEV, are examples of cars available in this rapidly growing category.	
3. Extended range electric vehicle (E-REV)	A vehicle which combines a battery, electric drive motor and an ICE. The electric motor always drives the wheels with the ICE acting as a generator when the battery is depleted. The BMW i3 Range extender is an E-REV model.	
4. Hydrogen fuel cell electric vehicle (FCEV)	A vehicle which operates by taking hydrogen fuel and reacting it with oxygen to produce electricity. They produce zero CO ₂ and air pollutant tailpipe emissions as water is the only waste product. Vehicles available include: Honda Clarity FCV, Hyundai ix35, and Toyota Mirai. For more information on Hydrogen Vehicles, see the Appendix .	

Ultra low emission vehicles

The range of an ultra low emission vehicle will vary depending on the technology involved, the load the vehicle is carrying, the drain on the battery by ancillary equipment such as air conditioning and driving style. For an illustration of the driving ranges of ULEVs under different driving and payload conditions see the graphs on page 9. Typical tested ranges for mainstream cars are as follows:

- A pure-EV will cover from 100 up to 200 miles on a single charge.
- A PHEV will have an electric-only range of 10 to 40 miles and a total range comparable with that of a standard petrol or diesel car, typically over 500 miles.
- The E-REV currently available in the UK will cover around 150 miles (NEDC) on electric only power then a further 80 to 90 miles powered by electricity generated by the internal combustion engine.

Examples of recent developments include a new variant of the Nissan Leaf which offers a larger 30kWh battery (standard model is 24kWh) which increases the car's range from 124 to

155 miles (NEDC) on a single charge. Similarly, BMW has increased the battery range of the i3 BEV by 50% achieving 195 miles on the New European Driving Cycle (NEDC) test cycle. Renault has also released a Zoe featuring a 41kWh battery pack for a NEDC 250-mile range.

Government support of hydrogen vehicles has recently increased with the announcement of the [£2 million fuel cell electric vehicle scheme](#)² in May 2016 to encourage more businesses to switch to hydrogen-fuelled vehicles. This fund supports public and private sector fleets with up to 75% of the total cost of procuring Fuel Cell Electric Vehicles (FCEVs) and their running costs including fuel, insurance and user training.³ The new fund follows the Government commitment of £5 million in 2014 through the Hydrogen for Transport Advancement Programme for 12 hydrogen refuelling stations. For more information about hydrogen vehicles please see the [Appendix](#).

2 <https://www.gov.uk/government/publications/hydrogen-fuel-cell-vehicles-funding-fleets-to-be-early-adopters>

3 The Plug-in Car or Van Grant may not be claimed for vehicles supported under the fuel cell electric vehicle fleet support scheme. See ULEV guidance for more information: <https://www.gov.uk/plug-in-car-van-grants/eligibility>



The Business Case

Financial

Although ULEVs generally cost more than their petrol or diesel equivalents to buy or lease, it is crucial to look at the vehicle's lifecycle costs. Applying a whole life cost (WLC) analysis often shows that the ULEV is cheaper than a conventional vehicle on a pence per mile basis. Electric cars cost £2-3 to fully charge, for a typical range of 100 miles. An equivalent petrol or diesel car costs £9-13 to drive 100 miles – typically four times the cost of an electric car.

Some predicted that lower oil prices since mid-2014 would slow down the growth of the ULEV market due to petrol and diesel vehicles having a more competitive price. However, while ULEV sales may have been influenced in the short term, their long term viability should not be in doubt. This is due to the wider benefits offered by ULEVs including improved air quality, lower noise pollution, better driving experience, reduced dependence on imported energy and lower maintenance costs.

In addition, there are a number of financial incentives⁴ in place to support the uptake of ULEVs:

- The Plug-in Car Grant offers 35% of the cost of a car, up to a maximum of either £2,500 or £4,500 depending on the model.
- The Plug-in Van Grant offers 20% of the cost of a van, up to a maximum of £8,000 – eligibility depends on the category the vehicle belongs to. The Grant was extended in Autumn 2016 to include vans above 3.5t GVW with the first 200 qualifying vehicles registered in this category eligible for a grant of 20% off the list price up to a total of £20,000.

- Most plug-in vehicles are currently exempt from VED (Vehicle Excise Duty) however the basis on which VED is calculated changes from April 2017 and brings some ULEVs into a charging band. [Find out more](#)⁵ about these changes.
- Businesses buying cars can write down 100% of the purchase price against their corporation tax liability if the vehicle emits no more than 75g/km CO₂, this is planned to reduce to 50g/km CO₂ from the 2018/19 tax year. In the case of zero emission vans the vehicles are eligible for the Plug-in Van Grant or the First Year Allowance.
- Vehicles emitting no more than 75g/km CO₂ are eligible for a 100% London Congestion Charge discount.⁶
- Grants are available for the [installation of charging infrastructure](#).⁷
- Free parking and/or reduced cost of resident parking permits may also be available to further encourage the uptake of electric cars in some urban areas.
- There are fewer regular service items such as oil and filters than conventional vehicles so service and maintenance costs are likely to be lower.
- Some manufacturers have pricing plans which help fleet managers 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.
- Some energy companies offer tariffs that reward for charging ULEVs at off-peak times, such as overnight. [Find more tips](#)⁸ on how to save money whilst charging at home.

⁴ These financial incentives were correct at time of writing and are subject to change. Visit <https://www.gov.uk/plug-in-car-van-grants> for the most up-to-date information.

⁵ <https://www.gov.uk/government/publications/vehicle-excise-duty/vehicle-excise-duty>

⁶ Correct at time of writing. Visit <https://tfl.gov.uk/modes/driving/congestion-charge/discounts-and-exemptions> for up to date information.

⁷ <https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles#electric-vehicle-homecharge-scheme>

⁸ <http://www.energysavingtrust.org.uk/travel/electric-vehicles/electricity-tariffs-electric-vehicles>

Benefits of ULEVs

The used ULEV market

Since the introduction of the Plug-in Car Grant there have been 76,590⁹ ULEVs registered in the UK. Taking into account that over 80% of ULEV sales took place in the last few years the availability of used vehicles potentially opens up new opportunities for ULEVs. These vehicles can provide businesses and individuals with an excellent opportunity to reap the benefits of low running costs while paying less for the vehicle itself. Energy Saving Trust is working with the industry to assist fleet and private buyers to identify when a used ULEV could make financial sense for them.

Environmental

In addition to saving organisations money, electric vehicles have a wealth of environmental benefits. ULEVs (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 organisations meet their corporate social responsibility (CSR) objectives.

Companies that integrate ULEVs into their fleets can gain a competitive advantage, attracting additional business, saving money and enhancing their environmental credentials.

Driving using electric power does not produce local air pollutants such as nitrogen dioxide and particulate matter, which contribute to poor air quality and increase rates of heart and lung disease, cancer and asthma. As a result the use of electric vehicles in towns and cities can help improve air quality and in turn people's health. Finally, ULEVs produce less noise than conventional vehicles, bringing further benefits to urban areas. This aspect of ULEVs has been further considered by 'quiet deliveries' campaigns focusing on 'out of hours' deliveries to improve fuel efficiency, reduce congestion and minimise the likelihood of incidents between commercial vehicles and vulnerable road users such as cyclists.

Charging technology

Charging technology has also undergone significant advancements. Electric vehicle charging technology has rapidly advanced over the last decade in terms of charging time, power used to charge the vehicle and charging modes. A plug-in vehicle is most likely to come equipped with a cable which can be plugged into a three-pin domestic socket, or a cable with a "Type 2" seven pin plug which can be plugged into all of the latest public chargepoints. Assuming plug-in vehicle drivers have a home chargepoint fitted, the most appropriate cable to specify for the car is the one compatible with public infrastructure (Type 2). The most common vehicle charger rates are summarised in the table on page 7.

9 As of September 2016

Charging technology

Vehicle chargepoint	Typical charging time
3kW Standard	6-8 hours
7-22 kW Fast	3-4 hours
43kW-50kW Rapid	20-30 mins
150+ kW Ultra-Rapid-Charging	<20 mins (estimated)

Other points to consider about charging infrastructure and technology are provided below:

Charging technology innovations

Inductive or wireless charging is an innovative technology currently being developed. Wireless charging uses electromagnetic fields to safely transfer power from a transmitting source in or on the ground to a receiving device fitted on the underside of a vehicle for the purposes of charging a battery. As the name suggests, there is no need for a charging cable, the vehicle is simply parked in position over the inductive pad. The driver is guided to the correct position by in-car guidance technology. The first vehicle manufacturers are likely to introduce this technology in the next couple of years.¹⁰

Vehicle to grid technology under development and on trial could offer electric vehicle owners the opportunity to charge their vehicle, or sell the excess electricity stored from their vehicle battery back to the grid. Using electric vehicles as battery storage assets could help the electricity network cope during peak electricity demand, offer a financial incentive to prospective ULEV buyers and benefit the environment.

Other charging considerations

Vehicle manufacturers use either Type 1 (e.g. Nissan Leaf) or Type 2 (e.g. VW Golf) vehicle inlets, therefore to allow vehicles from different manufacturers to be charged using the same infrastructure, we recommend the installation of Type 2 infrastructure sockets rather than a Type 1 or Type 2 tethered cables. This will allow vehicles with Type 1 or Type 2 inlets to be charged with the appropriate cable in each case.

The financial and environmental benefits of running a plug-in vehicle can be maximised through utilising overnight, off-peak charging. Some energy companies offer tariffs¹¹ that would reward ULEV owners for charging their car at off-peak times, such as overnight.

Home and work recharging can be supplemented by the expanding public recharging infrastructure, details of which can be found at Zap-Map¹² and Plugshare.¹³ Chargepoints, including rapid chargers are available at most service stations on the Strategic Road Network which includes motorways and main routes.

To help owners of plug-in vehicles offset some of the upfront cost of the purchase and installation of a dedicated home recharging unit, the Government has launched the Electric Vehicle Homecharge Scheme.¹⁴ Individuals who are the registered keeper, lessee or have primary use of an eligible electric vehicle may receive up to 75% (capped at £500, inc VAT) of the total capital cost of the chargepoint and associated installation costs.

For more detailed information on chargepoints, please see our guide for Chargepoint Utilisation Best Practice.¹⁵

10 <https://www.press.bmwgroup.com/global/article/detail/T0186710EN/bmw-group-is-pressing-ahead-with-the-development-of-systems-for-inductive-charging-of-electric-and-plug-in-hybrid-cars?language=en>

11 <http://www.energysavingtrust.org.uk/travel/electric-vehicles/electricity-tariffs-electric-vehicles>

12 <https://www.zap-map.com>

13 <https://www.plugshare.com>

14 <https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles#electric-vehicle-homecharge-scheme>

15 <http://www.energysavingtrust.org.uk/business/transport/guides-fleet-briefings-and-webinars>

Practicalities of running ULEVs

1. Who should buy a ULEV?

ULEVs have low operating and maintenance costs and emit zero tailpipe emissions. They can help an organisation achieve significant fuel and cost savings but this does not mean they will be practical for everyone.

One of the most important factors that needs to be taken into account by future ULEV buyers is how far they drive on a daily basis. Range anxiety is one of the biggest barriers to plug-in vehicle 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. Models such as the Nissan Leaf 30 kWh offer 155 miles range on a single charge¹⁶, however, for drivers who occasionally undertake long-distance motorway journeys a PHEV, E-REV or efficient internal combustion engine vehicle may be more suitable. On the other hand, for those who have a regular commute, or rarely drive more than the range of an EV battery in a rural or urban setting, an electric vehicle could be a practical, economic solution. Currently, pure electric vehicles are best suited to those typically driving between 30 and 80 miles a day in order to benefit from the lower “fuelling” costs. Recent increases in vehicle range and developments in charging technology are making longer daily journeys a wholly practical proposition however. A comparison of the impact of driving conditions and payload on battery usage and range in a BEV, PHEV and an electric van, is illustrated in the graphs on page 9.

For most drivers access to off street parking or a garage will be required for overnight battery recharging. For some drivers it may be possible to

use one of over 6,000 public chargepoints (including almost 1,000 rapid chargers) available around the country.

Currently, relying exclusively on public chargepoints is unlikely to be a practical solution for most drivers who do not have access to off street parking. In recognition of this many local authorities, including those cities successful in bidding for a share of the [£40 million Go Ultra Low Cities](#)¹⁷ fund are developing plans for the installation of practical street charging facilities to enable electric vehicles to be routinely owned and operated in urban environments. In addition, the Office for Low Emission Vehicles (OLEV) has announced £2.5m funding for local authorities as part of the On-Street Residential Chargepoint Grant Scheme. The grant aims to increase the availability of electric vehicle charging infrastructure for those who do not have access to off-street parking.

2. How long do batteries last?

The long-term life of an EV battery depends on many factors such as the type of battery and the mileage covered. Generally speaking, manufacturers have found that under normal use and charging patterns, batteries will maintain between 70 to 80% of their initial capacity after 10 years.¹⁸ Research undertaken in the U.S. concluded that at such levels, batteries continue to meet the daily travel needs of a significant proportion of drivers.¹⁹ Even so, it is at this point that batteries are considered to be at the end of their useful life by many manufacturers who offer battery warranties which cover the cost of replacement should battery capacity fall below these levels during the warranty period.

¹⁶ The range figure refers to the NEDC range and it is likely to be less in real world conditions.

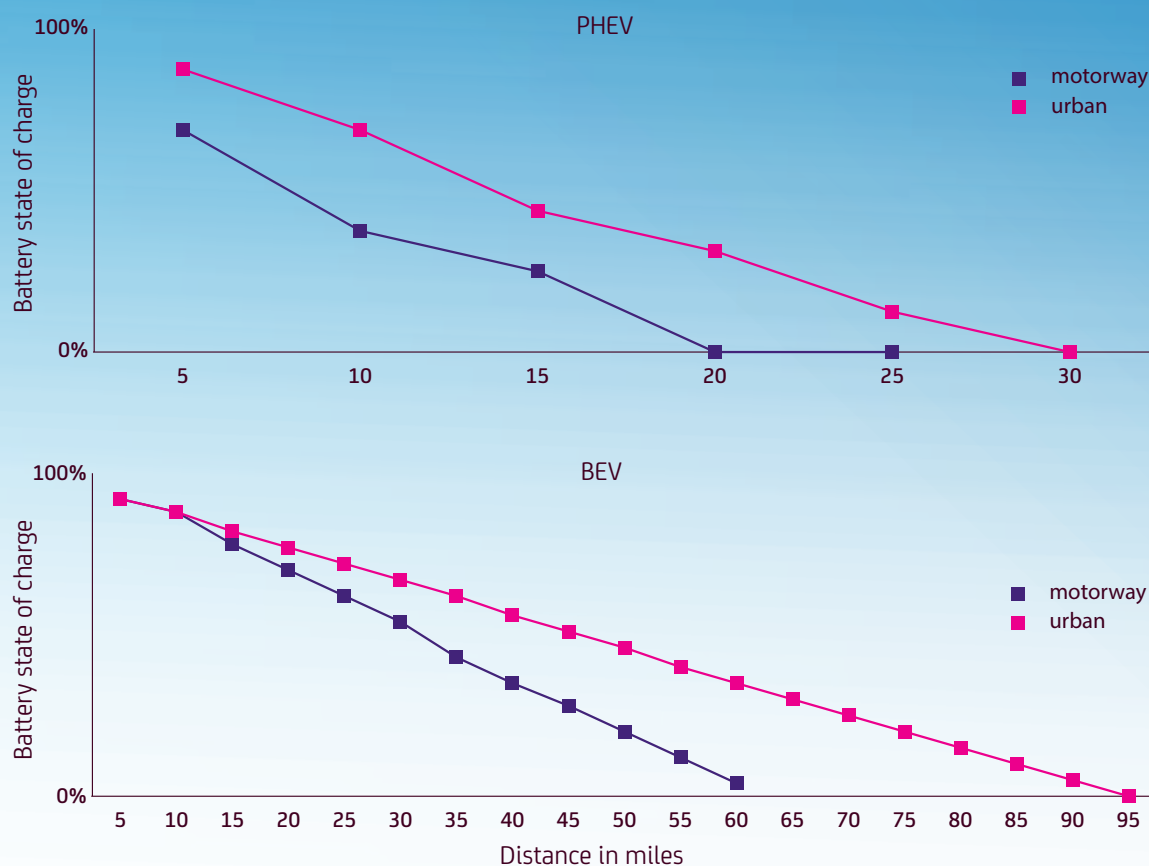
¹⁷ <https://www.gov.uk/government/news/40-million-to-drive-green-car-revolution-across-uk-cities>

¹⁸ SMMT, Ultra Low Emission Vehicles Guide 2016

¹⁹ S. Saxenaa; C. L. Floch, J. MacDonald, S. Moura, Quantifying EV battery end-of-life through analysis of travel needs with vehicle powertrain models, Journal of Power Sources, Vol.282, May 2015, p.265 - 276

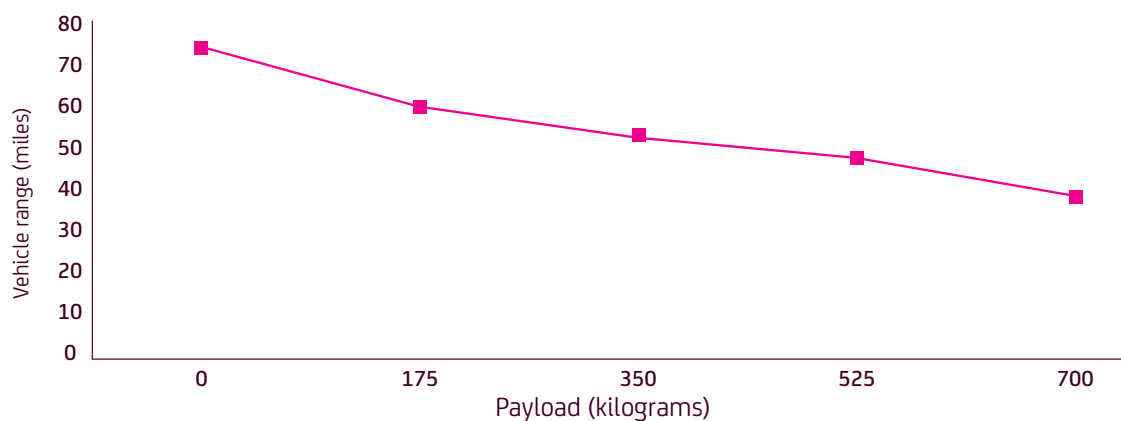
Battery Usage Profiles

The vehicle range of a PHEV and BEV under standardised urban and motorway driving conditions



Data obtained from range testing conducted by Arval UK, 2016

Vehicle range under different payload conditions



Range testing conducted with a benchmark electric van over a 33.58 mile standardised test route covering urban (16.8%), sub-urban (32.5%), dual carriageway (21.5%) and rural driving (29.1%) conditions. Tests undertaken with the same driver and with non-essential ancillary items switched off. Range calculated by comparing the actual range without cargo with the proportion of this range used for each test. Manufacturer's published range was 106 miles (NEDC). Testing conducted by Arval UK Limited, 2016.

Practicalities of running ULEVs

3. Driving a plug-in vehicle

Electric vehicles have strong and smooth acceleration, many drivers find them quiet and relaxing to drive and because there is no clutch or gears they are ideal to drive in urban environments. Driving style, including use of ancillary equipment, can have a significant impact on range. Trials conducted by the Energy Saving Trust found that, after training, drivers reduced energy consumption by 16%, increasing range by 20%. For more information on efficient driving styles or to enquire about training, visit <http://www.energysavingtrust.org.uk/travel> or contact us at ecodriving@est.org.uk. For businesses, route scheduling should be utilised to ensure that ULEVs are introduced onto the fleet on appropriate duty cycles, building in opportunity charging (charging during the working day) as appropriate.

4. Running costs

ULEVs are cheaper to run due to the low cost of electricity compared to petrol and diesel. ULEVs therefore offer a way of future proofing a fleet from the unpredictable cost of petrol and diesel. A plug-in vehicle becomes more cost effective when it covers a higher mileage, whether it is used over short distances in urban driving or longer journeys in rural driving. The key is that vehicles are fully utilised in order to ensure that any purchase price premium is more than recouped in fuel savings.

When it comes to servicing and maintenance, pure EVs have significant advantages compared to internal combustion equivalents (including plug-in hybrids). There are fewer service requirements such as oils and filters, reducing servicing costs. Regenerative braking, an energy recovery mechanism that converts some of the vehicle's kinetic energy under braking into electrical energy and stores it in the battery, also reduces wear and tear on the standard friction brakes, extending their life and reducing replacement costs.

5. Safety

ULEVs 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. Additionally, legislation proposing a minimum level of sound for plug-in vehicles to reduce risks to pedestrians and other vulnerable road users has been passed by the European Parliament.²⁰

Case study: Derbyshire Community NHS Trust

Operating in the health sector can pose some serious challenges to integrating plug-in vehicles into a fleet. With guidance from Energy Saving Trust going back to 2013, Derbyshire Community NHS Trust has been able to take the necessary steps to adopt plug-in vehicles and is now seeing the benefits.

In 2014, Derbyshire Community NHS Trust won funding from the Office for Low Emission Vehicles to install a dual 22kWh chargepoint at one of their community hospital sites where they trialed an electric pool car. Energy Saving Trust then analysed the business case for replacing their conventional vehicles with ultra-low emission vehicle equivalents, particularly as pool cars to tackle grey fleet.

Derbyshire Community NHS Trust has since increased their pool fleet to 20 cars including seven Mitsubishi Outlander (4x4) plug-in hybrid vehicles, with an electric range of up to 30 miles, and 5 regular hybrids. This has led to a considerable reduction in mileage claims from drivers now using pool cars instead of their regular vehicles. Dual 22kWh fast chargers were installed at a further 7 community hospital sites which gave access to charging across Derbyshire for the general public as well.

Two pure electric Nissan e-NV200 vans were also added to the organisation's fleet, replacing diesel vans driving about 10,000 miles per year. Replacing these diesel vans which have 177g/Km CO₂ emissions with the electric vans is expected to save 2.8 tonnes CO₂ each per year. The team using these vans has been so impressed with their performance and ease of use that an order for another e-NV200 has been placed.

“Pool vehicles average about 30 miles/day so they will do the majority of this on electric. We chose the 4x4s due to their excellent size for nursing staff and trainers to carry bulky equipment and to allow home-visit patient services to continue running throughout bad Derbyshire winters. We hope to save approximately 1.5 tonnes CO₂ from each vehicle.”

**Mark Armstrong-Read, Senior
Project Manager at Derbyshire
Community NHS Trust**



Whole life cost comparisons

When analysing the costs of ultra low emission vehicles it is important that a whole life cost (WLC) approach is used to determine whether they could provide financial savings compared with conventionally fuelled vehicles. The WLC approach takes into consideration that higher lease or purchase costs of ULEVs are often offset by cheaper running costs and additional incentives (e.g. tax breaks, grants etc) over the period the vehicle is operated by the organisation.

Below are three examples of WLC comparisons of pure-electric vehicles and conventionally fuelled vehicles for different applications. 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 comparisons are always carried out with the most up-to-date quotes from suppliers.

EV vs. ICE pool car

For this fleet, we compared the Ford Fiesta, which is often employed as a pool car, with the pure electric Kia Soul. The comparison shows the fuel cost of the Ford Fiesta is significantly higher compared to that of a Kia Soul although other operational considerations such as range should be taken into account.

5 years/50,000 miles*	Ford Fiesta	Kia Soul
Life cost (excl. fuel)	£15,053	£15,079
Life fuel cost	£4,761	£1,411
Life total cost	£19,814	£16,490
Pence per mile cost	40	33

*Includes lease and service rental costs provided by Alphabet.

EV vs. ICE company car

In this example, we compared the Ford Focus to the pure electric Nissan Leaf as a potential company car offering. It is worth noting that the Ford Focus is a fuel efficient diesel vehicle and the fuel cost difference between the Focus and the Leaf would be even greater for a less efficient company car. In addition to reducing costs for the company, the Leaf is cost effective for the driver through benefit in kind tax savings of £1,296 over the course of four years and savings on fuel benefit of £9,324.

Cost to the company

4 years 60,000 miles*	Ford Focus	Nissan Leaf
Life cost (excl. fuel)	£21,532	£20,102
Life fuel cost	£4,175	£2,628
Life total cost	£25,707	£22,730
Pence per mile cost	43	38

Cost to the driver

4 years 60,000 miles*	Ford Focus	Nissan Leaf
Company car tax over term	£4,016	£2,720
Cost of private fuel over term	£1,670	£876
Life total cost	£5,687	£3,596

*Includes lease cost and service rental costs provided by Alphabet, insurance, non-recoverable VAT, Class 1A National Insurance, Plug-in Vehicle Grant and 3 weekly trips into London Congestion Charge zone at £10.50 each (Autopay rate). 60,000 lifecycle miles, of which 40,000 are business and 20,000 personal.

EV vs. ICE van

In this last example we have compared a Citroen Berlingo and a Nissan eNV200. The pure electric eNV200 has lower lifetime running costs and this is mainly attributed to significantly lower fuel costs.

3 years 45,000 miles*	Citroen Berlingo	Nissan eNV200 Acenta
Life cost (excl. fuel)	£15,786	£14,661
Life fuel cost	£3,444	£1,446
Life total cost	£19,230	£16,107
Pence per mile cost	43	36

*Includes lease and service rental costs provided by Alphabet and Fleet News.

Conclusion

This guide has focused on the benefits ULEVs can offer to fleets. Energy Saving Trust offers free advice and information to private and public organisations considering using, or expanding use of, ULEVs within their fleet.

Please contact us for more information at **transportadvice@est.org.uk**.

Appendix

Hydrogen vehicles

Hydrogen vehicles include hydrogen ICE and Fuel Cell Electric Vehicles (FCEVs). Hydrogen ICE vehicles use an ICE and are designed or modified to run on hydrogen.

How do they work?

FCEVs combine hydrogen gas and oxygen in an electrochemical reaction to produce electricity, which powers an electric motor as in a battery electric vehicle. Since they are powered entirely by electricity, FCEVs are considered electric vehicles but unlike other EVs, their range, refuelling processes and times are comparable to conventional cars and commercial vehicles.

How clean are hydrogen vehicles?

Converting hydrogen gas into electricity produces only water and heat as a by-product, meaning fuel cell vehicles do not create tailpipe pollution when they are driven. The manner by which hydrogen fuel is made and delivered can, however, affect how clean hydrogen fuel cell vehicles truly are.

Refuelling fuel cell vehicles

Refuelling a fuel cell vehicle is comparable to refuelling a conventional car or commercial vehicle; pressurised hydrogen is dispensed at purpose built hydrogen refuelling stations, taking less than 10 minutes to fill current models. Access to hydrogen refuelling stations is of critical importance to influence early adopters of this innovative technology. At the time of publication there are limited hydrogen refuelling stations available to the public. However, the Government is committed to increasing the number of refuelling stations through its Hydrogen for Transport Advancement Programme for the installation of 12 hydrogen refuelling stations by the end of 2016, which is a step towards a national network.

Available models

Three hydrogen fuel cell models are being trialled in the UK market – the Toyota Mirai, the Honda Clarity FCV and the Hyundai ix35. A conversion of the electric Renault Kangoo ZE vehicle by Symbio adds a range extending fuel cell to the in-built battery providing a total range of nearly 200 miles. Several vehicle manufacturers are working on prototypes and we are likely to see new models being introduced in the near future.

How much do they cost?

At the moment the running cost of hydrogen vehicles is significantly higher than conventional petrol and diesel vehicles, hence the government's Office for Low Emission Vehicles (OLEV) has launched a £2 million fund where public and private sector fleets can bid for funding towards adding hydrogen-powered vehicles (up to 75% off the vehicle and associated costs) to their fleets.

Comparison with electric vehicles

Hydrogen vehicles offer a greater driving range than most electric vehicles and refuelling time is comparable with petrol and diesel vehicles. Hydrogen refuelling infrastructure is currently limited so FCEVs face a similar problem to that faced by electric vehicles a few years ago when fewer publicly accessible chargepoints were available. Electric vehicles are currently cheaper to buy, although hydrogen vehicles' prices are expected to fall when more models are released. There is currently very limited availability of hydrogen vehicles compared to the rapidly increasing choice of BEVs and PHEVs. It is likely that both technologies will find their place in the future transport landscape.

Glossary of terms

Term	Definition
Battery electric vehicle (BEV or pure-EV)	A vehicle powered only by electricity. It is charged by an external power source and incorporates regenerative braking which helps to extend the available range.
CHAdeMO	A charging protocol for delivering a DC supply to plug-in vehicles. CHAdeMO is primarily used by Nissan, Mitsubishi, Citroen and Peugeot.
Class 1A National Insurance (NI)	A contribution made by employers for most benefits provided to employees, e.g. a company car.
Conventional hybrid	Vehicles powered by petrol or diesel which also have a storage battery charged by regenerative braking. This stored energy is then used to drive an electric motor which can assist the conventional engine or drive the vehicle entirely for a short distance.
Extended range electric vehicle (E-REV)	A vehicle combining a battery, electric motor and an ICE. The electric motor always drives the wheels with the ICE acting as a generator when the battery charge is depleted.
Euro (3, 4, 5 or 6)	Increasingly stringent standards for the acceptable limits for exhaust emissions of new vehicles sold in EU member states.
ICE	Internal Combustion Engine.
Fast charging	Charging a plug-in vehicle at typical rates of 7kW AC, 20kW DC or 22kW AC.
FCEV	Fuel Cell Electric Vehicle.
kW	Unit of power.
kWh	Unit of energy.
Mennekes plug (Type two)	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.
Euro NCAP	The European New Car Assessment Programme awards 'star ratings' based on the performance of the vehicles in a variety of crash tests.
NEDC	New European Driving Cycle is designed to assess the emission levels of car engines and fuel economy in passenger cars.
NO_x	A generic term for nitric oxide, nitrous oxide and nitrogen dioxide.
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.
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.
Plug-in hybrid electric vehicle (PHEV)	Similar to a conventional hybrid, with a larger battery and the ability to charge the battery from an external power source.
PM (10 and 2.5)	Suspended particulate matter categorised by the size of the particle (for example PM10 is particulate matter 10 micrometers or less in diameter).
Rapid charging	Charging a plug-in vehicle at typical rates of at least 43kW AC or 50kW DC.
Regenerative braking	Converting the kinetic energy of the vehicle under braking into electricity which is stored in the battery.
Slow or standard charging	Charging a plug-in vehicle at typical rates of no more than 3.7kW AC.
Whole Life Cost (WLC)	The full cost of owning or operating a vehicle, including purchase / lease cost, fuel, tax, insurance and residual value.

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