SMMT ENVIRONMENT

ELECTRIC CAR GUIDE 2011
QUESTIONS AND ANSWERS

THE SOCIETY OF
MOTOR MANUFACTURERS
AND TRADERS LIMITED

INTRODUCTION

Over the past decade, the pace of technological developments in the automotive industry has picked up considerably as vehicle manufacturers focus on increasing the fuel efficiency of their vehicles and cutting CO_2 emissions. The refinement of existing technologies and development of next generation petrol and diesel engines, alongside a range of alternative fuel vehicles, has never been higher, with manufacturers striving to deliver ultra-low carbon solutions.

The work of the Automotive Council aims to ensure the UK motor industry plays a significant role in the development of exciting, low carbon transport solutions.

Working to achieve this, the Automotive Council will promote collaboration between industry, research communities and government to make the UK the location of choice for the development, demonstration and marketing of low carbon vehicles and fuels.

The industry consensus technology roadmap charts the sector's expected progression through micro hybrids to mass market electric and fuel cell vehicles, all designed radically to reduce transport CO_2 emissions. Equally important is our responsibility to guide motorists through the increasing range of choices they now face. It is vital they understand the benefits they can experience, equipping them with the best information to make the right purchasing decision for their driving needs.

Paul Everitt
Chief Executive
The Society of Motor Manufacturers and Traders

The Society of Motor Manufacturers and Traders Ltd would like to thank all members who contributed to the Electric Car Guide. In addition, thanks to the following organisations who offered input from a non-vehicle manufacturer perspective:

ROLE OF ELECTRIC VEHICLES IN THE AUTOMOTIVE INDUSTRY

Electric vehicle (EV) is the umbrella term for any vehicle that is powered, in part or in full, by a battery that can be directly plugged into mains electricity. In short, any vehicle that can be plugged in including pure-electric, plug-in hybrid and extended-range electric vehicles.

The New Automotive Innovation and Growth Team (NAIGT)[1] report, a consensus industry and government view on the future of the UK motor industry, was published in 2009. The report set out a 30 year vision for the UK automotive sector and included a technology roadmap (below) to illustrate the likely route and rate of progress towards ultra-low carbon transportation.

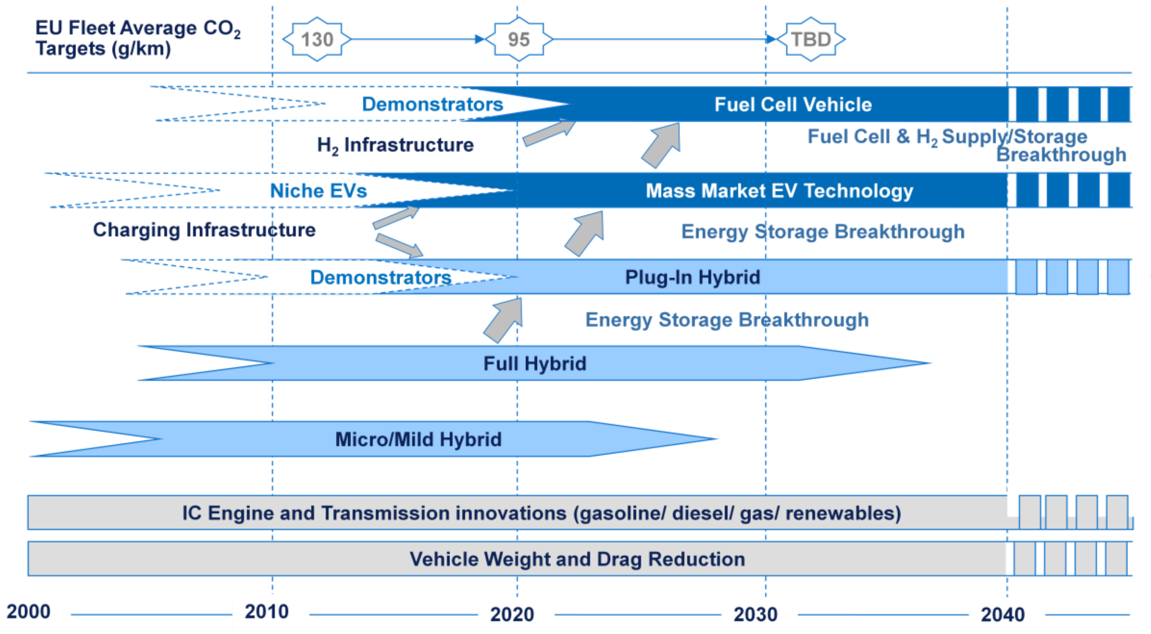
The NAIGT report clearly demonstrates two key points:

1. The internal combustion engine will continue to form the bedrock of the market for the foreseeable future with significant developments reducing carbon emissions.

2. A portfolio of new technologies, such as micro hybrids, full hybrids, electric vehicles and fuel cells, is emerging in addition to the development of traditional technology.

For the automotive industry to achieve and exceed emissions targets set by the EU, all technologies will play a part. Electric vehicles represent one option in a range of technologies being developed by the motor industry.

The purpose of this document is specifically to clarify a number of issues relating to the emerging electric car industry.



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GLOSSARY

Vehicle glossary

Abbreviation	Full description	Explanation
EV	**Electric Vehicle/Electric Car** This document is aimed at personal road users and will therefore focus on electric cars when referring to EVs.	A vehicle powered, in part or in full, by a battery that can be directly plugged into the mains. In short: any vehicle that can be plugged in.
Pure-EV/ Pure-Electric Car	**Pure-Electric Vehicle** Alternative descriptions: • Electric • All Electric • Battery Electric Vehicle (BEV) • Fully Electric	A vehicle powered solely by a battery charged from mains electricity. Currently, typical pure-electric cars have a range of approximately 100 miles.
PHEV	**Plug-In Hybrid Electric Vehicle** Alternative descriptions: • Plug-In Hybrid Vehicle (PHV)	A vehicle with a plug-in battery and an internal combustion engine (ICE). Typical PHEVs will have a pure-electric range of over 10 miles. After the pure-electric range is utilised, the vehicle reverts to the benefits of full hybrid capability (utilising both battery power and ICE) without range compromise.
E-REV	**Extended-Range Electric Vehicle** Alternative descriptions: • Range Extended Electric Vehicle (RE-EV) • Series hybrid	A vehicle powered by a battery with an ICE powered generator on board. E-REVs are like pure-EVs but with a shorter battery range of around 40 miles. Range is extended by an on board generator providing many additional miles of mobility. With an E-REV the vehicle is still always electrically driven.
Electric quadricycle	This document does not include quadricycles when referring to EVs.	An 'electric quadricycle' is a four-wheeled vehicle that is categorised and tested in a similar way to a moped or three-wheeled motorcycle. Quadricycles typically do not have the same performance as EVs and under EU legislation, electric quadricycles are not required to be tested to the same high standards as vehicles which have gone through the 'type approval' process (such as crash tests).

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Hybrid	**Hybrid** Alternative descriptions: • Hybrid Electric Vehicles (HEV) • Normal hybrid • Parallel hybrid • Standard hybrid	A hybrid vehicle is powered by, either or both, a battery and an ICE. The power source is selected automatically by the vehicle, depending on speed, engine load and battery charge level. This battery cannot be plugged in; charge is maintained by regenerative braking supplemented by ICE generated power. A number of fuels can power hybrid ICEs, including petrol, diesel, Compressed Natural Gas, Liquid Petroleum Gas and other alternative fuels.
	Full Hybrid	A full hybrid has the same attributes as a hybrid (above) plus the ability to operate solely on battery power although the battery cannot be plugged in.
	Mild Hybrid	A mild hybrid vehicle cannot be plugged in, nor driven solely on battery power.
	Micro Hybrid	A micro hybrid normally employs a stop-start system and regenerative braking which charges the vehicle's 12 v battery.
	Stop-start Hybrid	A stop-start system shuts off the engine when the vehicle is stationary. An enhanced starter is used to support the increased number of engine starts required in a stop-start vehicle.
AFV	**Alternatively Fuelled Vehicle**	Any vehicle which is not solely powered by traditional fuels (ie petrol or diesel) is referred to as alternatively fuelled.
ICE	**Internal Combustion Engine**	Petrol or diesel engine, including those adapted to operate on alternate liquid or gaseous fuels.

Additional terms

Range anxiety	Range anxiety refers to 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.	This document aims to allay this fear by explaining how EVs can meet the needs of many journeys.
Plug-In Car Grant	The government grant to reduce the purchase cost of eligible pure-electric, plug-in hybrid and hydrogen cars by 25% (to a maximum of £5,000)[2].	This document aims to support the Plug-In Car Grant, which started in January 2011, by answering frequently asked questions about plug-in cars.
Plugged-In Places	The government scheme to trial a range of charging technologies in regions around the UK which will inform roll-out plans for a UK-wide infrastructure network[3].	This document aims to demonstrate how EV owners will be able to charge their vehicles. Note: other locations, in addition to Plugged-In Places, will also be installing charge points.

Battery and charging glossary

Charge times	**Charge time** Alternative terms: • EV charge time • Recharge time	The time it takes to charge an EV. EVs require different lengths of time to charge according to the size of the battery, how much charge is left in the battery before charging and the type of charger used. The information below is based on the example of a pure-electric car to illustrate the most extreme charge time. PHEVs and E-REVs will take less time to charge.
	Standard charge (3kW) Alternative terms: • Slow charge • Normal charge	Standard charge is available in all UK homes[4]. It will take approximately six to eight hours to charge the average pure-electric car[5].
	Fast charge (7kW) Alternative terms: • Faster charge	Fast charge will normally occur at dedicated charge bays rather than at home. This will fully charge an average pure-electric car in three to four hours.

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	Rapid charge (20-50kW) Alternative terms: • Quick charge	Rapid charge will only occur at dedicated charge bays. This will charge the average pure-electric car in around 30 minutes.
	Opportunity charge Alternative terms: • Top up charge	Opportunity charging means the vehicle is charged whenever there is a chance to do so, allowing the battery to be topped up, for example, at a supermarket whilst you shop.
	Cycle Alternative terms: • Name plate cycle	A cycle is the battery charge from completely flat (0% charge) to full (100% charge) and back to flat (0% charge).
Alternative charging methods	**Inductive charging**	Inductive charging means energy is transferred via an electromagnetic field from one inductor to another inductor, which then stores the energy in the batteries. There is a small gap between the two inductors, meaning energy is transferred wirelessly. This charging method is being developed to charge EVs.
	Battery exchange Alternative descriptions: • Battery swap	Battery exchange systems allow a depleted battery to be quickly exchanged for a fully charged battery at a battery exchange (or swap) station. Vehicles must be specially designed to accommodate battery exchange technology.

SUMMARY

1. Electric vehicle performance

The term ‘electric vehicle’ (EV) refers to any vehicle powered, in part or in full, by a battery that can be directly plugged into the mains. In short, any vehicle that can be plugged in. Performance will depend on the type of EV.

All **pure-electric** cars qualifying for the Plug-In Car Grant must be able to travel at least 70 miles on a single charge and many are capable of 100 miles.

Plug-in hybrid cars qualifying for the Plug-In Car Grant must be able to travel in excess of 10 miles on battery power, although many are able to travel further, before reverting to the benefits of full hybrid capability (utilising both battery power and ICE) without range compromise.

Extended-range electric cars qualifying for the Plug-In Car Grant must meet requirements relating to Plug-in hybrids, but are typically able to travel in excess of 40 miles on battery power with hundreds of miles of additional range via the on-board generator.

The average individual journey length in the UK is 8.6 miles[6] and the average total daily distance travelled is 25 miles[7]. These distances can be comfortably achieved using pure-electric cars and many journeys can be made with plug-in hybrid or extended-range electric cars using only battery power.

2. Infrastructure and charging

Most electric cars will be charged at home[8]. However, public charging infrastructure will be also available to charge cars when drivers are away from home: As part of the ‘Plugged-In Places’ scheme, UK government is co-funding the roll-out of around 9,000 charge points by March 2013 in London, the North East and Milton Keynes, Scotland, Northern Ireland, Manchester, the Midlands and the East of England. The lessons learned during this programme will influence plans for a national charging network. An increasing number of public/business/retail car parks and new housing developments offer charging facilities.

According to the Department for Transport (DfT), there is sufficient generating capacity to cope with the uptake of EVs, particularly where charging takes place overnight when there is excess electricity production. Where local energy networks are already close to capacity, localised upgrading of the network may be necessary for a future cluster of vehicles charging during peak hours. Electricity companies are working with EV manufacturers to prepare for the future increase in demand from EVs. This includes the development of smart metering systems which can automatically select charging times and tariffs. This can also help to manage demand on the grid[9].

3. On the road cost and incentives

Electric vehicles have very low running costs, which means the total cost of ownership can be attractive. Additionally, the purchase price will fall as EVs become more common. The Plug-In Car Grant offers 25%, up to £5,000, off the purchase price of qualifying EVs.

Many tax incentives apply to EVs, such as paying no VED (road tax) and, in some areas, benefit from 100% congestion charge discount and free parking. The typical cost of electricity to charge an EVs is approximately £0.03[10] per mile, compared to fuel costs of £0.16[11] per mile for an ICE.

4. Emissions

Electric vehicles have zero emissions at the point of use, so-called 'tank-to-wheel', when powered solely by the battery. The 'well-to-wheel' analysis includes the CO_2 emissions during electricity generation, which depends on the current mixture of fuels used to make the electricity for the grid. To make a correct comparison with emissions from all cars, you have to use the 'well to wheel' figure, which includes the CO_2 emissions during production, refining and distribution of petrol/diesel.

To demonstrate the most extreme case, here is an example of typical pure-electric car emissions compared to emissions from small to medium sized ICE cars:

Pure-EV 'tank to wheel' average	= 0g CO_2 /km
Pure-EV 'well to tank' average	= 77g CO_2 /km[12]
Pure-EV 'well to wheel' average	= 77g CO_2 /km
ICE 'tank to wheel' average	= 132.3g CO_2 /km[13]
ICE 'well to tank' average	= 14.7g to 29.0g CO_2 /km[14]
ICE 'well to wheel' average	= 147.0g to 161.3g CO_2 /km

As electricity production decarbonises through an increase in low carbon generation, the overall emission figure for running an EV will drop further. The current lowest emitting ICE produces tailpipe (tank to wheel) emissions of 86g CO_2/km[15]. Adding the average 'well to tank' proportion (which starts at 10% and equates to 9.6g CO_2/km) means ICEs can achieve 'well to wheel' emissions as low as 95.6g CO_2/km and ICE vehicles are being refined to further reduce the 'tank to wheel' emissions.

It is worth noting that the standard industry metrics only consider CO_2 emissions. However tailpipe emissions include oxides of nitrogen (NOx) and particulate matter (tiny particles of solid or liquid matter suspended in a gas or liquid) which contribute to air pollution. This is why vehicle manufacturers are striving to reduce tailpipe emissions and why any vehicle operating solely on battery power can play a significant role in improving local air quality.

5. Safety

Electric vehicles are tested to the same high standards as other vehicles currently on UK roads. Electric quadricycles are often confused with pure-electric cars. Under EU legislation, electric quadricycles are not required to be tested to the same high standards as vehicles which have gone through the type approval process (such as crash tests). In February 2011 the first pure-electric car was assessed and passed the renowned Euro NCAP test.

Pedestrian safety: the quietness of EVs is a benefit but can pose a threat to sight and hearing-impaired people, particularly at low speeds. Having seen a vehicle, pedestrians are capable of reacting to avoid an accident at vehicle speeds up to 15 mph[16]. In addition, research found that tyre noise will alert pedestrians to a vehicle's presence at speeds greater than 12.4mph[17].

CHAPTER 1 – OPERATIONAL

Vehicle experience, range, speed, suitability

1.1 What Electric Vehicles (EVs) are available?

The term 'EV' refers to any vehicle that is powered, in part or in full, by a battery that can be directly plugged into the mains. This document concentrates on cars.

EVs encompass the following technologies[18]:

- **Pure-Electric Vehicles** (Pure-EVs)
- **Plug-In Hybrid Electric Vehicles** (PHEVs)
- **Extended-Range Electric Vehicles** (E-REVs)

Pure-Electric Vehicles (Pure-EVs) - wholly electric vehicles powered by a battery. Currently most manufacturers offer pure-electric cars with a range up to 100 miles.

Plug-In Hybrid Electric Vehicles (PHEVs) - battery range in excess of 10 miles. After the battery range is utilised, the vehicle reverts to the benefits of full hybrid capability (utilising both battery power and ICE) without range compromise.

Extended-Range Electric Vehicles (E-REVs) - similar to pure-EVs but with a shorter battery range of around 40 miles, range is extended by an ICE on-board generator providing many additional miles of mobility. With an E-REV, the propulsion technology is always electric, unlike a PHEV where the propulsion technology can be electric or full hybrid.

1.2 What are EVs like to drive?

EVs are easy and fun to drive. Smooth, swift acceleration and light handling make the driving experience very enjoyable. Also, electric motors are very quiet, which means the driver is in a quiet, calm environment. Finally, similar to automatic cars, there is no gearbox in a pure-EV, which is particularly useful in built-up areas or heavy traffic. Electric cars require the same driving licence as traditional cars (category 'B') and pure-electric cars can be driven on an automatic-only driving licence.

1.3 What are the benefits of EVs?

Electricity is one of a number of options which has great potential as an alternative to oil. It can be produced from sustainable sources, it can be readily supplied, and it produces no emissions at the point of use. This means EVs can offer significant environmental benefits when used as urban commuter transport. Here are some of the benefits of EVs when operating solely on battery power:

- no emissions at the point of use
- a quiet driving experience
- fun to drive
- easy to use infrastructure
- practical and easy to drive, particularly in urban stop-start traffic
- home charging is convenient and avoids queuing at petrol stations

1.4 What is the top speed and acceleration of an EV?

Electric vehicle specifications indicate that EVs are able to achieve similar speeds to their ICE counterparts during everyday driving. All EVs which qualify for the government's Plug-In Car Grant must be capable of reaching speeds of 60mph or more. Some pure-electric cars can reach speeds up to 125mph where permitted.

Power is delivered by the electric motor as soon as the vehicle begins to move which gives smooth and swift acceleration. For more information on speed and vehicle performance, visit the manufacturers' websites.

1.5 Does an EV have adequate range for all my needs?

Range depends on the type of EV and how it is driven. Currently, most pure-electric cars offer a range up to 100 miles and are ideal for short to medium length journeys. If you are likely to be regularly driving short to medium range journeys and over 100 miles then an E-REV, PHEV or alternative fuel/ low carbon ICE may be more suitable.

The average individual journey length in the UK is 8.6 miles[19] and the average total daily distance travelled is 25 miles[20]. In Europe, more than 80% of Europeans drive less than 63 miles in a typical day[21]. This shows that a significant number of journeys could easily be made using an EV.

1.6 Will EVs suit everyone?

Not all vehicles in the market are suitable for all drivers but EVs match the transport needs of a great proportion of the population very well.
The intended use will determine what type of EV is most suitable. Manufacturers are introducing more car models, which will satisfy the demand for vehicles of different size and capacity. Whilst the majority of EVs on the market are likely to be city-sized vehicles, research is also being carried out on cars in the super luxury market.

Until recently, pure-electric cars have been used mainly in commercial and urban environments.

Following the introduction of the Plug-In Car Grant in January 2011, there will be a gradual increase in the number of passenger EVs on the road.

Charging

1.7 How much does it cost to charge an EV?

The cost of charging an EV depends on the size of the battery and how much charge is left in the battery before charging. As a guide, charging an electric car from flat to full will cost from as little as £1.03[22] to £4.01[23]. This is for a typical pure-electric car with a 24kWh battery which will offer around 100 mile range. This means the average cost of 'fuel' will be approximately £0.03 per mile.

If you charge overnight you can take advantage of the cheapest electricity rates when there is surplus energy. The cost of charging from public infrastructure will vary; many will offer free electricity in the short term.

1.8 How long does it take to charge an EV?

How long it takes to charge an EV depends on the type of vehicle, how depleted the battery is and the type of charge point used.

Typically, pure-electric cars using standard charging will take between six and eight hours to charge fully and can be 'opportunity charged' whenever possible to keep the battery topped up.

Pure-EVs capable of using rapid charge points could be fully charged in around 30 minutes and can be 'topped up' in around 20 minutes, depending on the type of charge point and available power. PHEVs take approximately one and a half hours to charge from a standard electricity supply. E-REVs take approximately four hours to charge from a standard electricity supply. PHEVs and E-REVs require less time to charge as their batteries are smaller.

1.9 Why does standard charging take this long?

Charging a battery is not the same process as replacing fuel in a tank. Current battery technology means that it takes longer to charge an EV than it would to refuel a conventional car with petrol or diesel. However, if you have access to off-street parking at home, the process of charging is potentially very simple. You just plug in your EV when you get home and leave it to charge.

1.10 What happens if my pure-electric car runs out of juice?

Manufacturers take every precaution to ensure the vehicle informs the driver of the available charge remaining in the battery. As with ICEs, a 'fuel' gauge will indicate how much charge is left in the battery. If the driver continues without recharging the consequence will be similar to running out of fuel and breakdown assistance organisations can assist motorists to reach their destinations and charge their battery. Breakdown assistance organisations are considering the use of equipment which can offer an opportunity charge to help drivers reach a nearby destination, although this will take longer than topping up with traditional fuel.

1.11 How can I charge if I arrive at a charge point which is already occupied?

Charge points will be bookable online so EV drivers can plan their journey and charging. Also, a number of mobile applications are available to highlight where alternative charge points are located. Finally, charge scheme providers are on hand to provide assistance to EV drivers looking for charge posts.

Publicly accessible charge posts will display how long the car occupying the charger has left to charge so that drivers looking to charge can plan ahead. Opportunity charging is possible but the majority of EV drivers will charge at home or at work on a regular basis.

1.12 Where can people charge EVs?

EVs can be charged at home, at some workplaces, on-street and in a number of public places such as car parks and supermarkets.

UK and overseas trials suggest most EVs will be charged at home. Home charging is relatively easy to arrange - this can be done by installing dedicated weatherproof sockets outside or in a garage. A dedicated EV circuit is recommended for the charging socket - similar to those required for other high power appliances such as power showers and electric cookers[24]. It is advisable that customers ensure that their charging socket and wiring have been approved by a qualified electrician before they commence home charging. A timer can control charging to occur only at night which means advantage can be taken of off-peak electricity rates.

For those without access to off-street parking at home, charging infrastructure will be required in public locations and, where possible, at work. Further information about the charging infrastructure can be obtained from local authorities. Information on national infrastructure can be found at www.ev-network.org.uk and www.newride.org.uk.

However, please note that as the installation of charging points is gathering pace, this information should be seen as a guide to what is available rather than a definitive list.

Plugged-In Places regions are working together to ensure that charging infrastructure will be 'interoperable', so that drivers can use the installed infrastructure wherever they are driving.

1.13 How many public charge points are there in the UK and what is being done to increase this number?

Over 300 charge points already exist in the UK and government is providing seed funding up to £30 million under the Plugged-In Places scheme to ensure public charging infrastructure is available in a number of UK locations. London, Milton Keynes, Midlands, Greater Manchester, East of England, the North East, Scotland and Northern Ireland will collectively install around 9,000[25] charge points by March 2013.

In addition to Plugged-In Places, charge points have been installed in areas throughout the UK to support the Technology Strategy Board's Ultra-Low Carbon Vehicle Demonstration programme.

1.14 Is there a 'chicken and egg' scenario for the vehicles and charging infrastructure?

Many electric car users with access to off-street parking at home or at work will not need to make use of public charging infrastructure on a regular basis. Government is developing a national recharging network strategy for electric vehicles. This strategy will aim to establish how many public charging points and what type of technology will be necessary to support a national EV fleet and will consider for example those with restricted access to off-street parking and the infrastructure necessary for longer journeys.

The Plugged-In Places programme will provide evidence about how various types of infrastructure in a number of key locations are used, to ensure that the UK uses the right type of charge point in the right place.

1.15 Will I need to install special equipment to charge an EV at home?

It is strongly recommended that customers ensure their home charging socket and wiring have been installed and approved by a qualified electrician before they commence charging. A home charge point with its own dedicated circuit is a sensible means of charging your EV safely and the most economically[26]. This will ensure the circuit can manage the electricity demand from the vehicle and that the circuit is activated only when the charger communicates with the vehicle, known as the 'handshake'. It will also be programmable, enabling you to benefit from off-peak electricity tariffs without having to remember to switch on the circuit late at night.

If you are charging outdoors, a number of EV manufacturers offer home charge points in association with energy companies, which are fully weatherproof and safe to charge outside.

For rapid charging, special equipment and an upgraded electrical supply would be required and is therefore unlikely to be installed at home, where most consumers will charge overnight.

Depending on the location of the charger, you may need to check with your local authority, the vehicle manufacturer or organisation installing your charge point whether you need planning permission. Listed building consent, where applicable, may be required.

The Institution of Engineering and Technology is preparing a Code of Practice to guide electricians installing electric vehicle charging equipment.

CHAPTER 1 – OPERATIONAL

1.16 I live in a flat with no dedicated parking; where could I charge an EV?

If you do not have access to dedicated parking, you will need to establish what sort of public charging infrastructure is available in your area. You can do this by contacting your local authority.

1.17 Will there be wires trailing across the pavement?

Charging EVs using public infrastructure should not involve trailing wires. It is not recommended that people without an off-street parking facility (for example, garage or driveway) charge at home, so home charging should not involve trailing wires.

1.18 How do I pay for charging?

If you charge your vehicle at home, the cost of the electricity used will simply be reflected in your electricity bill. Vehicle manufacturers are working with electricity companies to look at how to install smart chargers so that you can choose when to charge your vehicle and so take advantage of lower rates (eg overnight).

At present, different areas will have different arrangements for paying for electricity from public infrastructure. In the short term, many areas are incentivising electric car usage by offering free electricity from public charging infrastructure.

Most of the publicly accessible infrastructure is accessed via a local scheme such as 'Source London'. To access the charge points on these schemes you generally pay for a membership period. You then receive a card or tag which allows you to use any of the points on that scheme and gain free electricity (note that parking charges may be extra, depending on location).

1.19 How can I charge my EV from low carbon energy?

All electricity has an element of renewable electricity in it as a result of the 'Renewable Obligations' placed on electricity suppliers.

If charging from your home supply, you may request a green electricity tariff from your supplier. By signing up to a green electricity tariff your electricity supplier has to provide evidence to demonstrate that its tariff results in a reduction of a minimum threshold of carbon dioxide emissions.

Electricity suppliers must show that the activity associated with the green tariff is in addition to what they already have to do to meet existing government targets for sourcing more renewable electricity and reducing household carbon emissions.

It is worth knowing that not all green tariffs provide 100% additional renewable electricity. The Energy Saving Trust gives advice on buying green electricity: www.energysavingtrust.org.uk/Generate-your-own-energy/Buying-green-electricity.

1.20 Do all EVs and charging points have a standard plug and socket? Will my EV charge in other countries?

The EU is currently working on developing EU-wide standards for EV-specific plugs and sockets. It is anticipated that these standards will be in place in 2011 or 2012 which means EVs will be able to charge using the same plug in the UK and abroad. It is best to check with the vehicle manufacturer about charging equipment, such as the cable, which may be provided with the vehicle.

1.21 Can anyone unplug my car when it's charging?

For those charging at home this is unlikely to occur. The majority of public charge points are lockable, meaning passers-by cannot unplug the cable. Some charge points can send a text message to the car owner if the vehicle is unexpectedly unplugged, or tell you when the vehicle is fully charged. If the charge cable was removed, charging would cease until the charger was re-set by the authorised user.

1.22 Is it safe to charge in wet weather?

Yes, it is safe to charge in wet weather. Weatherproof charging equipment can be installed and if you are installing a charging facility at home, your supplier will be able to provide further advice about charging safely.

1.23 What rate of charging will be available?

Under the Plugged-In Places scheme, different areas will be installing a range of charging technologies, including standard (3kW)[27], fast (7kW) and rapid charging facilities (22-43kW AC, 20-50kW DC). Initially, most will be standard or fast charge. You can find further information about the sort of charging infrastructure available near you by contacting your local authority. Further information on national infrastructure can be found at www.ev-network.org.uk and www.newride.org.uk.

Batteries

1.24 How long will the battery last in my EV?

Battery manufacturers usually consider the end of life for a battery to be when its capacity drops to 80% of its rated capacity. This means that if your original battery has a range of 100 miles on a full charge, after eight to 10 years (depending on how much the vehicle has been driven) this may have reduced to 80 miles.

However, batteries can still deliver usable power below 80% charge capacity, although this will produce shorter range. Whether you want to exchange it at that stage for a newer battery will partly depend on your driving habits. A number of vehicle manufacturers have designed the battery to last the lifetime of the car.

1.25 Does using the radio and lights etc flatten the battery?

Yes, this will impact on the range to some extent, particularly in pure-electric vehicles. As with conventional ICE vehicles, if you run air-conditioning excessively the fuel consumption of the vehicle will be affected. Many vehicle manufacturers are using innovative solutions, such as LED exterior lights, to reduce energy consumption and control systems can be used in EVs to minimise the amount of energy used by additional items, like air-conditioning and heating. Mains-powered cabin pre-heating (or cooling) is becoming common, allowing an EV driver to start their journey with the interior at a comfortable temperature without having drained the battery of any energy.

1.26 What is the cost of a replacement battery?

That depends on the size and type of the battery, which are determined partly by the vehicle. Batteries are relatively expensive at the moment but it is likely that prices will come down, as technology improves and volumes increase. Customers are advised to speak to manufacturers for more information.

1.27 Will the price of copper, lithium or rare earth metals have an effect on the cost of an EV?

Despite fluctuations in the market price of raw materials over the last three years there has not been a corresponding impact on the cost of these materials (specifically copper) to EV battery manufacturers. The same applies to lithium, although securing sufficient levels of supply could cause temporary price increases if there is a huge and sudden increase in battery production.

There have been suggestions that various rare earth metals (used in permanent magnets for EV motors, for example) may be in short supply or restricted (eg China limiting exports) – which could impact EV manufacture. However, other geographical sources of rare earths are now being actively explored and alternatives to these elements are also being researched.

1.28 Aren't we waiting for a breakthrough in battery technology?

A number of EVs are already on the road which are easily capable of catering for the majority of journeys made daily[28]. Battery technology continues to improve, which increases range and power while decreasing cost, weight and size, but significant changes will take time.

Servicing, repair and breakdown

1.29 Where will I be able to get an EV repaired or serviced?

Manufacturers will ensure that service technicians are provided with detailed service instructions and training, just as they do for ICE vehicles. In addition, industry training programmes are being developed to ensure dealers, technicians, manufacturing staff, emergency services and breakdown assistance staff can become qualified to handle EVs[29]. Motor Codes, the industry regulatory body, will list all registered EV service and repair centres on its search engine at www.motorcodes.co.uk.

1.30 Do electric cars require an MOT?

Yes. Just like any ICE vehicle, after three years, electric cars will require annual MoT tests, in line with current legislation.

1.31 What will it cost to service a Pure-EV?

There are fewer moving parts in a Pure-EV, which should reduce servicing costs and downtime. When the Pure-EV does require servicing it will be similar to an ICE service. Although the powertrain is different, many of the service actions for Pure-EVs are similar to ICEs.

1.32 What warranty can I expect?

The warranty of an EV will be in line with current warranties on ICE vehicles. All manufacturers who utilise the Plug-In Car Grant must offer a minimum three year battery warranty on the car as standard, as well as an option for the consumer to purchase a further two year warranty extension.

1.34 Can EVs be towed like regular cars?

In most cases, yes. The manufacturers' emergency response guides provide advice on appropriate recovery and towing methods for the vehicle. If towing is permitted, the restrictions that apply are similar to those for automatic vehicles (eg driven wheels must be lifted from the ground, limited speed and/or distance for towing).

1.33 Are the breakdown assistance organisations and emergency services trained to deal with EVs?

The industry training programme for EV-specific qualifications are being rolled out to dealers, technicians, manufacturing staff, emergency services and breakdown services[30]. Vehicle manufacturers provide emergency response guides to advise first responders on how to identify an EV, the location of its major components and the procedures for performing emergency operations on a disabled vehicle, including rescue of occupants and recovery of the vehicle.

1.35 Do EVs work in cold weather?

Yes. As with any newly developed vehicle, manufacturers have carried out extensive testing in extreme weather conditions. In addition, there have been a number of 'real life' trials of EVs in the UK since 2009. During February 2010 everyday users drove their EVs in the worst winter weather conditions in the UK for 30 years. The range of EVs may be affected by cold weather; the use of heating and other items is likely to increase the load on the vehicle system and reduce the range, particularly of pure-EVs, in cold weather.

Control systems can be used in EVs to minimise the amount of energy used by additional items, such as air conditioning and heating. Finally, it is worth knowing that EVs don't need a warm up period like many conventional ICE vehicles in the winter.

CHAPTER 2 – FINANCIAL

General costs

2.1 How much does it cost to own an EV?

The tables on the following pages set out example running costs for a pure-electric car and demonstrate how the additional purchase cost can be offset when you consider the total cost of ownership.

To offer a fair assessment, these figures compare an ICE, such as a fuel-efficient medium-sized diesel car (107g CO_2/km), to a pure-electric car of a similar size. Please note, this example compares two extreme cases, from ICE to pure-electric cars. More detail will be available in the near future regarding PHEVs and E-REVs.

2.2 How much does it cost to charge an EV?

The cost of charging depends on the size of the battery, how depleted the battery is and how quickly you charge it. As a guide, charging a pure-electric car from flat to full will cost from as little as £1.03[31] to £4.01[32]. This is for a typical pure-EV with a 24kWh battery which will offer around 100 miles range.

This means the average cost of 'fuel' will be approximately £0.03 per mile. Similar costs will apply to PHEVs and E-REVs, although the battery will be smaller, meaning it costs even less to charge the battery in these vehicles.

If you charge overnight you can take advantage of the cheapest electricity rates when there is surplus energy.

2.3 Is there an economic case to run an EV?

As demonstrated on the following pages, the total cost of ownership of an electric car is similar to an ICE. If the car is being used in London and/or as a company car there are additional savings and tax benefits to be considered (please see the table on page 18).

2.4 What is the residual value/the second hand price of an EV?

The residual value will depend on a number of factors. For example if EVs prove to be reliable, practical and popular then they could retain at least 40% of the original purchase price after three years.

Although other alternatively fuelled vehicles currently on the market have set a good precedent with high residual values there is no consensus opinion on residual values for EVs.

Two of the largest residual value companies, CAP and Eurotax Glass's Guide, have published EV residual values which are competitive with similar sized ICE vehicles. It is anticipated that there will be a strong demand for the first EVs when they become available on the used car market.

2.5 Can I lease an EV?

Yes, a number of leasing companies in the UK can offer you advice on the leasing costs of an EV. It will also be possible to rent an EV.

CHAPTER 2 – FINANCIAL

Cost comparison over three years, covering 10,000 miles per year:

Term, mileage, fuel cost	**ICE**	**Pure-EV**	**Notes**
Term in years	Three	Three	
Total mileage	30,000	30,000	
		£0.17	Standard rate electricity (£/kWh)[33]
Cost of Fuel (Diesel £/litre including VAT)	£1.45	£0.04	Low rate electricity (£/kWh)[34]
Vehicle cost information			
Purchase price	£19,650	£29,300	This ICE is not brand specific, but is a premium medium sized hatchback which may reflect the type of car a potential EV purchaser currently drives
Plug-In Car Grant		-£5,000	A grant to reduce the purchase cost by 25% (up to £5,000)[35]
Purchase price (net)[36]	£19,650	£24,300	
Residual value (RV)	£9,175	£11,350	The Pure-EV RV is based on the same % RV as the ICE car in question[37]
Depreciation cost[38]	£10,475	£12,950	Figures as per Fleet News estimates
Service, maintenance and repair (over three years)[39]	£540	£474	Based on average of published figures.
Other information[40]			
Official g CO_2/km	107	0	Emission at the point of use
Official combined cycle mpg[41]	68.9 mpg	152.2 Wh/km	Electricity consumption (Wh/km)
'Real world' mpg[42]	58.6 mpg	175.0 Wh/km	Real world consumption (Wh/km)[43]
Total fuel costs (over three years)	£3,374	£881[44]	Average of electricity rates used
Vehicle Excise Duty and First Registration Fee	£95	£55	Over three years
TOTAL COST	£14,484	£14,360	Over three years
TOTAL COST	£4,828	£4,787	Per year
TOTAL COST	48.3p	47.9p	Pence per mile

CHAPTER 2 – FINANCIAL

Cost comparison over three years, covering 15,000 miles per year:

Term, mileage, fuel cost	ICE	Pure-EV	Notes
Term in years	Three	Three	
Total mileage	45,000	45,000	
		£0.17	Standard rate electricity (£/kWh)[45]
Cost of Fuel (Diesel £/litre including VAT)	£1.45	£0.04	Low rate electricity (£/kWh)[46]

Vehicle cost information			
Purchase price	£19,650	£29,300	This ICE is not brand specific, but is a premium medium sized hatchback which may reflect the type of car a potential EV purchaser currently drives
Plug-In Car Grant		-£5,000	A grant to reduce the purchase cost by 25% (up to £5,000)[47]
Purchase price (net)[48]	£19,650	£24,300	
Residual value (RV)	£8,500	£10,500	The Pure-EV RV is based on the same % RV as the ICE car in question[49]
Depreciation cost[50]	£11,150	£13,800	Figures as per Fleet News estimates
Service, maintenance and repair (over three years)[51]	£981	£833	Based on average of published figures

Other information[52]			
Official g CO_2/km	107	0	Emission at the point of use
Official combined cycle mpg[53]	68.9 mpg	152.2 Wh/km	Electricity consumption (Wh/km)
'Real world' mpg[54]	58.6 mpg	175.0 Wh/km	Real world consumption (Wh/km)[55]
Total fuel costs (over three years)	£5,062	£1,321[56]	Average of electricity rates used
Vehicle Excise Duty and First Registration Fee	£95	£55	Over three years
TOTAL COST	£17,288	£16,009	Over three years
TOTAL COST	£5,763	£5,336	Per year
TOTAL COST	38.4p	35.6p	Pence per mile

Additional savings may be available to pure-electric cars, for example:

Potential additional savings for pure-electric cars	Company savings	Driver savings	Notes
Company Car Class 1A NIC	£1058		Over three years at current rate
Free fuel Class 1A NIC	£1012		Over three years at current rate
Company Car Tax		£1,533 £3,066	20% tax payer 40% tax payer
Company car Fuel Tax		£1,466 £2,932	20% tax payer 40% tax payer
Congestion Charge		£6,834[57]	Over three years at £2,278 pa
Free parking			Total saving depends on location

Incentives, tax

2.6 What incentives are in place for EVs in the UK?

At national level, the government is offering a subsidy of 25% towards the cost of an eligible electric car, up to a value of £5,000, through the Office for Low Emission Vehicles' Plug-In Car Grant.

Tax incentives for use of electric vehicles are also on offer, for example[58];

- Vehicle Excise Duty exemption.
- Fuel Duty exemption.
- Enhanced capital allowances.
- No Company Car Tax (Benefit in Kind)[59].

Local level incentives to encourage the use of ultra-low emission cars are also being offered in some areas. These might include, for example;

- Free or subsidised parking.
- Free electricity from public recharging infrastructure.
- 100% discount from the Central London Congestion Charge[60].

You can find more information about any incentives on offer in your area by contacting your local authority or transport authority.

2.7 Do EVs pay road tax, fuel duty or Congestion Charge?

Pure-EVs, PHEVs and E-REVs are exempt from paying Vehicle Excise Duty and are entitled to register for a 100% discount from the Central London Congestion Charge.

Currently EVs pay no fuel duty on the electricity they use.

2.8 Are there any incentives or grants to install a charge point at home?

At national level, there are currently no central government incentives or grants available to install charge points at home.

At local level there are some grants available through the Plugged-In Places scheme, such as partial funding available subject to local terms and conditions for home charging.

CHAPTER 2 – FINANCIAL

2.9 Are there any investment opportunities in the EV industry?

Plenty – it's a growth market with new elements in the value chain, including vehicles, components, infrastructure, utilities, renewable energy generation, telematics, system networking, back office support, retailing, service and parts supply.

In addition, the UK is at the forefront of EV industry development; for example, extensive nationwide EV pilot trials and many world class EV technologies have been demonstrated in the UK. A number of British EV products and services are experiencing international demand and significant investment has been committed by major manufacturers to produce and sell EVs in the UK. This high degree of activity has increased the rate of progress in the UK industry and has multiplied the number of investment opportunities.

Contact SMMT (evgweb@smmt.co.uk) to find out more about investment opportunities in the UK EV industry.

CHAPTER 3 – ENVIRONMENTAL

Emissions, electricity, grid

3.1 Will an increase in EVs lead to more emissions (from electricity generated by fossil fuelled power stations)?

No. The energy industry in Europe is constrained by legally binding limits on the total amount of CO_2 emitted each year, up to 2020 (EU Emissions Trading Scheme 2009/29/EC). This limit reduces year on year to achieve an overall reduction in CO_2 emissions.

This means, in practice, that if overall energy demand increases as a result of electric vehicles (or for any other reason) then the increase in demand must be met with electricity from renewable or low carbon generation sources.

In 2010, around 25% of UK electricity was generated from low carbon sources (6.6% from renewable and 18% from nuclear[61]). This means that in the short-term, to minimise EV emissions it is important that most charging takes place outside peak hours (peak demand is between 18:00 and 22:00, off peak hours run overnight). The proportion of coal and gas-fired power generation is lower overnight so an EV charged overnight effectively has lower 'well-to-wheel' emissions than one charged during peak hours[62].

3.2 Why, according to some sources, do electric cars produce approximately 80g CO_2/km?

The metrics for determining vehicle emissions have always been tailpipe emissions, so-called 'tank-to-wheel'. EVs have no emissions at the point of use when powered solely by battery power.

The reference to 80g CO_2/km is based on a 'well-to-wheel' analysis, which includes the CO_2 emissions during electricity generation for the UK grid mix and was quoted in the King report[63]. The government uses this figure as the long term marginal average electricity figure, which means it takes future grid decarbonisation into account.

To make a correct comparison with emissions from all cars, you have to use the 'well-to-wheel' figure which includes the CO_2 emissions during production of petrol/diesel.

The average well to wheel emissions for small and medium-sized ICE vehicles sold in the UK in 2010 ranges between 147.0g and 161.3g CO_2/km[64] (tank-to-wheel 132.3g CO_2/km is the UK sales weighted average of A to C segment cars sold in 2010[65]). Not only do EVs have zero tailpipe emission but research suggests, using the current UK power mix, EVs could realise up to 40%[66] benefit in CO_2 savings compared with a typical family petrol car in the UK over the full life cycle. Larger emission reductions will be realised over time as the UK moves to lower carbon sources of power generation[67].

3.3 How much of our electricity is low carbon?

In 2010, of all UK electricity generation, 6.6% came from renewable sources. 18% of electricity was from nuclear power[68].The UK'S renewable energy target under the Renewable Energy Directive (RED) is 15% by final energy consumption[a] by 2020 and the Department for Energy and Climate Change's UK Renewable Energy Strategy's lead scenario suggests that up to 30% of our electricity could be generated from renewables to meet this target, with the remaining energy coming from renewable heating and transport. Much of this electricity will be from wind power, on and offshore, but biomass, hydro, and potentially wave and tidal electricity generation will also play an important role[69].

3.4 Will the grid be able to cope with increased demand?

According to research completed for the government[70], if charging takes place in off-peak periods the grid will be able to cope with new demand from EVs. Off-peak charging will enable surplus energy to be used, resulting in more efficient use of the electricity generated.

Before adding a charging point at any site, a competent installer will assess whether the available electrical capacity is sufficient, and they will sometimes need to inform the local distribution network of charging points they install. As local networks are already close to capacity, there may be distribution issues and localised upgrading of the network may be necessary for a future cluster of vehicles charging during peak hours.

Electricity companies are working with EV manufacturers to prepare for the future. Electricity demand will be managed through the development of smart metering systems which can automatically select charging times, as well as tariffs which incentivise off peak charging[71].

However, the grid has time to adapt as the mass uptake of EVs will take time. Even in the most optimistic scenarios for EV market growth, EV electricity demand will not exceed 0.3% of total electricity consumption by 2020[72].

3.5 What will happen if everyone charges their EV at the same time?

It is expected that EVs could be programmed to charge during off-peak times and therefore balance the demand on the grid.

Being able to pre-programme EVs to charge during these hours will allow drivers to take advantage of cheaper electricity prices, whilst using any surplus electricity. It is also likely that drivers will charge at different times, depending on their vehicle and driving patterns.

In addition, the development of smart metering systems which can automatically select charging times and tariffs can also help to manage demand on the grid[73]. The National Grid manages the grid on a second by second basis to ensure that supply and demand are met and to indicate to the market if there is a shortfall or surplus of power. However, where local networks are already close to capacity, localised upgrading of the network may be necessary for a future cluster of vehicles charging during peak hours.

3.6 What's being done to decarbonise production of electricity?

The Committee on Climate Change[74] explains the progress required for the UK to meet its carbon reduction commitments.

The previous government[75]:

- Set a target of 30% of our electricity from renewables by 2020 by substantially increasing the requirement for electricity suppliers to sell renewable electricity.
- Stated it would invest £120 million in offshore wind and up to £60 million in marine energy.

The coalition government[76] has stated that it will:

- Seek to increase the target for energy from renewable sources, subject to the advice of the Committee on Climate Change.
- Continue public sector investment in carbon capture and storage (CCS) technology for four coal-fired power stations.
- Deliver an offshore electricity grid to support the development of a new generation of offshore wind power to encourage community-owned renewable energy schemes where local people benefit from the power produced.
- Allow communities that host renewable energy projects to keep the additional business rates they generate.

3.7 What's happening to decarbonise ICE fuel?

EU legislation is a strong driver for change. The SMMT CO_2 report[77] shows that since records began in 1997, vehicle manufacturers have reduced average vehicle emissions by over 24% (from 189.8g CO_2/km to 144.2g CO_2/km). By optimising ICE technology fuel consumption can be reduced, which leads to a reduction in carbon emissions. In addition, the fuel itself can be decarbonised in various ways, one of which is by using sustainable biofuel[78].

3.8 How can I charge my EV from low carbon energy?

If charging from your home supply, you may request a green electricity tariff from your supplier. By signing up to a green electricity tariff your electricity supplier has to provide evidence to demonstrate that its tariff results in a reduction of a minimum threshold of carbon dioxide emissions. Electricity suppliers must show that the activity associated with the green tariff is in addition to what they already have to do to meet existing government targets for sourcing more renewable electricity and reducing household carbon emissions. It is worth knowing that not all green tariffs provide 100% additional renewable electricity. The Energy Saving Trust gives advice on buying green electricity: www.energysavingtrust.org.uk/Generate-your-own-energy/Buying-green-electricity.

3.9 Will the oil companies or large vehicle manufacturers resist the uptake of EVs?

As explained in the NAIGT report[79], the automotive industry has a clear direction which includes the continued development of efficient ICEs and the increase in a range of alternative low carbon technologies. Many vehicle manufacturers are investing heavily in the design, development and production of EVs. Manufacturers and governments around the world are working together to speed up the development of low carbon vehicles. Oil companies, too, are engaged in the plans. For example, Shell and BP are heavily involved in work by the Energy Technologies Institute (ETI)[80] which develops and tests the pathways to a self-sustaining mass-market for plug-in vehicles.

3.10 How much CO_2 does it take to manufacture an EV?

There is no standard methodology to assess the CO_2 emissions associated with the manufacture of vehicles. However, vehicle manufacturers are considering emissions at all stages of the manufacturing process with the aim of reducing the environmental impact of vehicle production.

3.11 What happens to the EV at the end of its life?

European legislation (End of Life Vehicle (ELV) Directive 2000/53/EC) ensures that manufacturers of cars and light vans (including EVs) have 85% of the vehicle re-used, recycled or recovered at the end of its life. This will rise to 95% recovery by 2015.

Authorised treatment facilities (ATFs) carry this out by stripping the vehicles after de-polluting them of all environmentally hazardous components such as batteries, tyres and oil. The ELV Directive also ensures good product design to avoid the use of harmful heavy metals, increase the use of recycled materials and designing them for reuse or recycling.

The RRR (reusability, recyclability, and recoverability of vehicles) Directive 2005/64/EC takes this a stage further, requiring manufacturers of cars and light vans introduced after December 2008 to be 85% reusable and/or recyclable and 95% reusable/ recoverable by mass.

In addition, EV batteries could have significant value after automotive use. Various organisations are exploring ways in which these batteries could be used, such as extra domestic electricity storage where the battery could work in conjunction with a home solar panel to store electricity, or utility companies using batteries to store renewable electricity on a larger scale.

3.12 Will EVs significantly impact on CO_2 emissions over the next 10 years and solve the climate change problem?

A recent report by the Committee on Climate Change suggests that the change over this period will be modest. However, as the grid becomes cleaner so do all the vehicles recharged from it and as a result the benefit is cumulative. The Committee on Climate Change has also stated that the widespread uptake of EVs is necessary if carbon reduction targets beyond 2030 are to be met.

EVs alone cannot solve the climate change problem but an increased uptake of EVs is an important step to help meet UK carbon reduction targets. The NAIGT roadmap explains the industry direction and how a range of technologies, including EVs, will play an important role in reducing CO_2 emissions[81].

3.13 Are EVs the only way of reducing automotive CO_2?

No, much can be achieved by choosing the most fuel efficient model (and therefore least CO_2-emitting vehicle) in the class of vehicle that you are considering.

Reducing the mileage that you drive and learning and putting into practice an economical driving style will also significantly reduce the CO_2 emitted by your vehicle. In addition to ICE developments and the increase in low carbon vehicles, a range of technologies will be introduced by manufacturers to reduce emissions. For example, reducing the weight of vehicles reduces the emissions, whichever fuel is used, simply by requiring less energy to move the vehicle. Using a hybrid or alternative fuels, such as bio diesel, are other ways to reduce emissions.

3.14 If there are more EVs on the road will congestion become worse?

EVs are not expected to affect the total demand for cars. Generally, it is expected that when customers are considering buying a new vehicle they will replace their current car with an EV, a Hybrid or another ICE vehicle, depending on their requirements.

In urban areas in particular, people are encouraged to make use of other modes of environmentally friendly transport such as public transport, walking and cycling.

Batteries

3.15 How long will an EV battery last?

Battery manufacturers usually consider the end of life for a battery to be when the battery capacity drops to 80% of its rated capacity. This means that if the original battery has a range of 100 miles on a full charge, after eight to 10 years (depending on how much the vehicle has been driven) the range may have reduced to 80 miles.

However, batteries can still deliver usable power below 80% charge capacity, although they will produce shorter range. A number of vehicle manufacturers have designed the battery to last the lifetime of the car. EV batteries could have a secondary life in shorter-range vehicles, grid load levelling and renewable energy systems.

3.16 What happens to the battery at the end of its life?

All battery suppliers must comply with 'The Waste Batteries and Accumulators Regulations 2009'. This is a mandatory requirement, which means manufacturers take batteries back from customers to be reused, recycled or disposed of in an appropriate way.

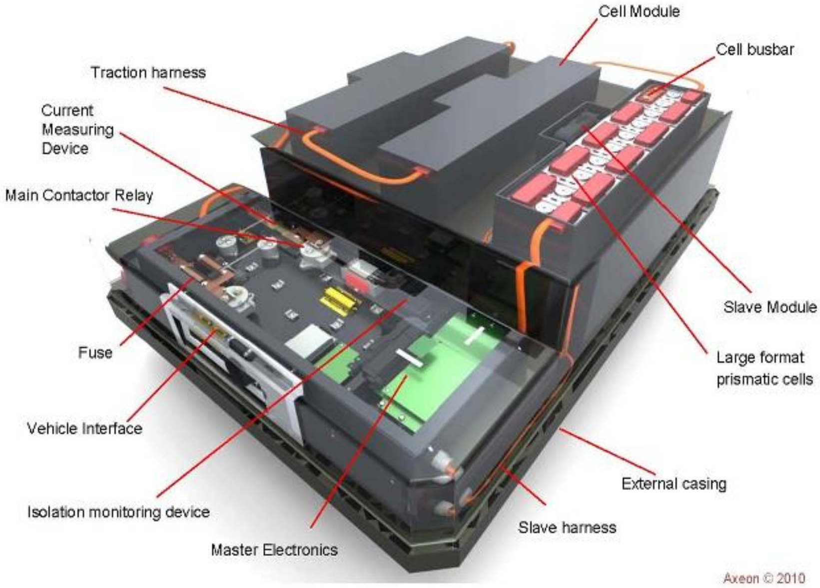
While lead from lead acid batteries is the world's most recycled material (over 90% of all batteries), the volume of lithium recycling is still very small at the moment. Lithium ion cells are considered non-hazardous but they contain elements that can be recycled. These include metals (copper, aluminium, steel, manganese, cobalt and iron) as well as plastics.

3.17 How are batteries recycled?

Battery contents - lithium, metals (copper, aluminium, steel), plastic, cobalt and lithium salts - can be recovered by recycling.

Various methods can be used:

- **Hydrometallurgy**: mechanical treatment, separation and grinding. Hydrometallurgy with acid route and complementary electro-chemical process.
- **Thermal treatment (distillation and pyrolyse):** deactivated, crushed, ground. Powders are treated by a hydrometallurgical process to separate lithium and cobalt.
- **Vacuum-distillation:** metallurgical treatment of sorted, pre-treated batches: separation of battery containing metals by vacuum distillation of heavy metals (Cd, Zn, etc).
- **Pyrometallurgy:** The pre-sorted batteries are neutralised and crushed, or smelted. The components such as ferrous metals, non-ferrous metals, cobalt, manganese oxide and plastic are separated and returned to the raw material recycle.



3.18 Where does lithium come from?

The main sources of lithium for EV batteries are brine lakes and salt pans, which produce the soluble salt lithium chloride. The main producers of lithium are South America (Chile, Argentina and Bolivia), Australia, Canada and China. Lithium can also be extracted from sea water and in March 2010 Korea announced plans to do this commercially.

3.19 How secure is the supply of lithium?

The current estimates of worldwide lithium reserves total about 30 million tons (or 150 million tons of lithium carbonate). Around 0.3 kg of lithium is required per kWh of battery storage. The consensus of experts is that with EVs achieving 60% penetration of the new car market, these reserves will last well over a thousand years! The take-up of EVs will be gradual in the first few years and the amount of lithium used in these vehicles will also be very limited.

However, going forward it is expected that the recycling of lithium batteries will become more cost-effective, as in the case of mobile phone and the recycling of laptop batteries. In addition, EV batteries have significant value after automotive use. Vehicle manufacturers are exploring ways in which ex-EV batteries could be used after automotive use, such as storing home solar-generated electricity, or for utility companies to store electricity on an industrial scale.

3.20 How can we obtain lithium without harming the environment?

Lithium refineries are a 'closed circuit' system, which means that salts precipitated in the evaporation pools are returned to the brine, minus the lithium that has been extracted. Brine extraction takes advantage of the fact that lithium is leached from certain volcanic rocks and, when the surface or ground water flows into closed basins, becomes more concentrated.

The lithium is recovered after the brine is concentrated by solar evaporation, and the alkalines are removed by precipitation. Evaporative brine mining has less environmental impact than hard rock mining and very little carbon footprint. It does, however, use more water than traditional mining methods.

3.21 What is the environmental impact of battery manufacture and disposal?

It is difficult to give a precise answer on the environmental impact of battery manufacture. However, lithium ion batteries have a lower environmental impact than other battery technologies, including lead-acid, nickel-cadmium and nickel-metal-hydride.

Lithium ion cells are composed of much more environmentally benign materials; in particular they do not contain heavy metals (eg cadmium) or compounds that are considered toxic, eg lead or nickel. Lithium iron phosphate is essentially a fertiliser. Clearly, as more recycled materials are used the overall environmental impact is reduced.

CHAPTER 4 – TECHNICAL

4.1 Are electric cars safe[82]?

Yes, as with ICE cars, there is specific legislation to ensure that EVs are safe. All EVs type-approved in Europe have to comply with these regulations.

EVs qualifying for the Plug-In Car Grant must meet the same safety standards as conventional cars by obtaining ‘whole vehicle type approval’. Alternatively, manufacturers can provide evidence that the car complies with appropriate international safety standards. Particular attention is paid during crash testing to ensure the EV-specific safety features operate as specified. Individual components such as the battery pack are also subjected to impact testing and other abuse tests.

In February 2011 the first pure-electric car was assessed and passed the renowned Euro NCAP test.

EVs typically use an inertia switch or a signal from the airbag system to disconnect the electrical traction supply if the vehicle is involved in a collision. This is very similar to conventional vehicles where an inertia switch is provided to stop the fuel supply in a crash. Furthermore, battery packs are designed with internal contactors so that if the 12V electrical supply is cut for any reason, the traction electrical supply is automatically shut off.

4.2 Will EVs produce any sound?

EVs are quieter than ICE vehicles because an electric motor produces much less noise than a traditional engine. This has the potential to reduce sound levels, particularly in noisy cities making these environments more pleasant to be in.

Although EVs still generate tyre noise, this question is also of interest to sight and hearing impaired people, particularly when a vehicle is travelling at very low speeds. Vehicle manufacturers, government transport authorities and psycho-acoustic scientists are conscious of these factors and are researching whether artificially generated sounds are necessary for road user safety.

4.3 Does any part of or the whole vehicle need CE certification[83]?

A CE marking certifies that a product has met EU consumer safety, health or environmental requirements. At present the charger needs CE certification as per the Low Voltage Directive.

Proposed changes to UNECE Regulation 100 mean that the vehicle will not require CE certification and therefore is not classified as an electrical appliance.

4.4 Are there suitable tests to validate performance claims by EV manufacturers? ie 60 mph and 100 mile range.

As with any vehicle, EV range depends on a number of factors, such as driving style, environmental conditions and the use of auxiliary systems in the vehicle. Performance claims should be seen as an indication of the capabilities of the vehicle but some of the performance indicators may involve trade-offs; for example, as with ICE vehicles, maximum range is unlikely to be achieved in a usage style based on rapid acceleration, high speeds and heavy use of auxiliary systems, such as heating and air conditioning.

Specifically for EVs, UNECE Regulation 101 measures range, and the result of the electric energy consumption must be expressed in Watt hours per kilometre. The test uses the same driving cycle as that which is used for measuring the fuel consumption and CO_2 of combustion-engined cars.

The most efficient driving style for an electric vehicle, similar to conventional vehicle technology, is to maintain smooth and progressive driving. The efficiency difference between an EV and a conventional vehicle is most apparent where frequent stop-starts, such as inner city driving, or in hilly areas characterised by long downhill coasting where the EV is able to store the energy normally lost through breaking and deceleration[84].

CHAPTER 5 – GENERAL

5.1 When will EVs be a mass market proposition?

There have already been announcements from many major manufacturers regarding plans for the introduction of mass production for EVs from 2010. However, it is expected that 2011/2012 will be key years for the majority of brands entering the market with sales increasing year on year and for the next decade.

The NAIGT report includes a technology roadmap which illustrates the direction of the industry and timescales for the development of various technologies[85]. According to this roadmap, EVs will be available in significant numbers between 2015 and 2020.

5.2 Why will EVs take off now, when we've seen many false dawns in the past?

EVs offer a number of benefits besides reducing CO_2 emissions and having very low running costs. In recent years, the understanding of these benefits has combined with three key forces which have the potential to kick-start the EV market in the UK.

Firstly, the government has set ambitious targets for reducing carbon emissions and in a bid to achieve them is offering significant grant and taxation incentives for EVs. The Plug-In Car Grant, for example, reduces the purchase price of electric cars which meet certain criteria. In addition, the Plugged-In Places programme will inform plans for a UK-wide charging infrastructure.

The taxation incentive focuses on Company Car Tax BIK (Benefit In Kind) savings and savings in capital writing-down allowances.

EVs do not pay fuel duty on the electricity they use currently.

Secondly, there is growing public awareness of the need to protect the environment and to reduce CO_2. Linked to this is a much greater understanding of the advantages of EVs and how EVs can help significantly to reduce emissions.

Finally, technological improvements have enabled the introduction of new vehicles from major manufacturers that are designed and manufactured to meet the quality consumers have been accustomed to by ICE vehicles.

The combination of these three forces is unprecedented and is the key difference which has the potential to secure the future of EVs.

5.3 Which electric cars are on the UK market already?

BRAND	MODEL	TYPE	COMMENTS
Allied Electric Vehicles	e-Bipper Tepee	Pure-EV	Based on Peugeot Bipper
Allied Electric Vehicles	e-Expert Tepee	Pure-EV	Based on Peugeot Expert
Allied Electric Vehicles	e-Partner Tepee	Pure-EV	Based on Peugeot Partner
Citroën	C-Zero	Pure-EV	
Mitsubishi	iMiEV	Pure-EV	
Nissan	LEAF	Pure-EV	
Peugeot	iOn	Pure-EV	
smart	ED	Pure-EV	Lease only
Tata	Vista	Pure-EV	
Tesla	Tesla	Pure-EV	Sportscar

5.4 Which electric cars are coming onto the UK market and when?

BRAND	MODEL	TYPE	ESTIMATED UK LAUNCH DATE
Hyundai	Ix-metro	Pure-EV	Winter 2011
Westfield (race car)	iRacer	Pure-EV	2011
Chevrolet	Volt	E-REV	Spring 2012
Lightning Car Company	The Lightning GT	Pure-EV	Spring 2012
Renault	Fluence Z.E.	Pure-EV	Spring 2012
Vauxhall	Ampera	E-REV	Spring 2012
Renault	ZOE	Pure-EV	Autumn 2012
Audi	E-Tron	Pure-EV	2012
Ford	Focus	Pure-EV	2012
Morgan	Lifecar2	Pure-EV	2012
smart	ED	Pure-EV	2012
Tesla	Model S	Pure-EV	2012
Westfield	Sport-E	Pure-EV	2012
Axon	E-PHEV	PHEV	2012
Toyota	Prius PHEV	PHEV	2012
BMW i	i3	Pure-EV	2013
BMW i	i8	PHEV	2013
Ford	C-MAX	PHEV	2013
Porsche	918 Spyder	PHEV	2013
Westfield	GMT Electric	Pure-EV	2013
Volkswagen	Up! blue-e-motion	Pure-EV	2013
Volkswagen	Golf blue-e-motion	Pure-EV	2013/2014
Fisker	Karma	PHEV	TBC
Ginetta	G50	Pure-EV	TBC
Th!nk	City EV	Pure-EV	TBC
Th!nk	Ox	Pure-EV	TBC

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[1] Source NAIGT report: http://www.smmt.co.uk/wp-content/uploads/NAIGT-report-2009pdf.pdf

[2] http://www.dft.gov.uk/pgr/sustainable/olev/grant1/

[3] http://www.dft.gov.uk/pgr/sustainable/olev/infrastructure/

[4] It is recommended to install a home charging unit on a dedicated EV circuit. This will ensure the circuit can manage the electricity demand from the vehicle and that the circuit is activated only when the charger communicates with the vehicle, known as the 'handshake'. If you are charging outdoors, an external weatherproof socket can also be installed.

[5] For this example we have assumed the vehicle is a standard EV sized car and that the battery is completely empty before recharging. An average pure-electric car can travel 100 miles on a single charge. However, charging can take longer when the vehicle is connected to domestic sockets (such charging cables will limit the amperage draw by the car in order to reduce the load on the electricity circuit and ensure maximum safety for the user).

[6] UK National Travel Survey, 2008 data published in 2009.

[7] UK Office for National Statistics.

[8] It is recommended to install a home charging unit on a dedicated EV circuit. This will ensure the circuit can manage the electricity demand from the vehicle and that the circuit is activated only when the charger communicates with the vehicle, known as the 'handshake'. If you are charging outdoors, an external weatherproof socket can also be installed.

[9] BERR and DfT, Investigation into the scope for the transport sector to switch to electric vehicles and plug-in hybrids, 2008.

[10] Based on a 24kWh battery delivering 100 miles. Calculated using an average of standard and low rate electricity.

[11] Based on a petrol price of £1.33 per litre and average petrol car emissions of 144.2g CO_2/km (the average emissions of all vehicles in 2010).

[12] Based on UK electricity supply. See A Review of the UK Innovation System for Low Carbon Road Transport Technologies (E4tech, 2007) page 121. http://www.dft.gov.uk/pgr/scienceresearch/technology/lctis/e4techlcpdf.pdf which is within the range suggested in Investigation into the Scope for the Transport Sector to Switch to Electric Vehicles and Plug-in Hybrid Vehicles (Arup/CENEX for BERR/DfT, 2008) http://www.berr.gov.uk/files/file48653.pdf, page 13.

[13] 132.3g CO_2/km is the UK sales weighted average of A to C segment cars sold in 2010. (Source: SMMT MVRIS data) We have not used the UK sales weighted average across all cars (144.2g CO_2/km) for this calculation as the latter figure includes vehicles which are likely to be larger than most EVs. (Source: SMMT CO_2 report: http://www.smmt.co.uk/wp-content/uploads/SMMT_New_Car_CO2_Report_2011.pdf)

[14] 14.7g and 29.0g CO_2/km are derived from the assumption that 10-18% of the total well-to-wheel emissions are well-to-tank. This is the range suggested by various sources, such as:

- Electric Vehicles In The Context Of Sustainable Development In China (UN Commission on Sustainable Development, 2011, paragraph 57), http://www.un.org/esa/dsd/resources/res_pdfs/csd-19/Background-Paper-9-China.pdf
- Investigation into the Scope for the Transport Sector to Switch to Electric Vehicles and Plug-in Hybrid Vehicles (Arup/CENEX for BERR/DfT, 2008, page 13) http://www.berr.gov.uk/files/file48653.pdf.

[15] Source: SMMT Motor Industry Facts 2011 (Page 29) www.smmt.co.uk/mif2011

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[16] Source: RoadSafe (www.roadsafe.com)

[17] Source: Brigade Electronics (www.reverseinsafety.co.uk)

[18] NB: This document does not include quadricycles, motorcycles or bicycles when referring to EVs.

[19] UK National Travel Survey, 2008 data published in 2009.

[20] UK Office for National Statistics.

[21] Source: Nissan, May 2009: Survey conducted online among 2,319 intending purchasers of a new car within five years (UK, France, Germany, Spain, Italy)

[22] Based on 4p per unit: Cheapest core/E7 rate available across all suppliers and regions (E7 night rate, British Gas, Yorkshire region), March 2011.

[23] Based on 17p per unit: Most expensive core/E7 rate available across all suppliers and regions (E7 day rate, npower, Midlands region), March 2011.

[24] Separate circuits are installed for units which draw a large amount of electricity to prevent overload on the household supply.

[25] This compares to around 10,000 petrol filling stations in the UK (Source: Shell).

[26] Separate circuits are installed for units which draw a large amount of electricity to prevent overload on the household supply.

[27] This is for use with standard 13A domestic electricity supply.

[28] The average individual journey length in the UK is 8.6 miles and the average total daily distance travelled is 25 miles (Source: UK National Travel Survey, 2008 data published in 2009, and UK Office for National Statistics).

[29] The Society of Motor Manufacturers and Traders (SMMT) is working with the Institute of the Motor Industry (IMI) and vehicle manufacturers to introduce dedicated EV training. Contact SMMT for more information.

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[31] Based on 4p per unit: Cheapest core/E7 rate available across all suppliers and regions (E7 night rate, British Gas, Yorkshire region), March 2011.

[32] Based on 17p per unit: Most expensive core/E7 rate available across all suppliers and regions (E7 day rate, npower, Midlands region), March 2011.

[33] Most expensive standard rate available across all suppliers and regions (npower, Midlands region), March 2011.

[34] Cheapest standard / off peak rate available across all suppliers and regions (E7 night rate, British Gas, Yorkshire region), March 2011.

[35] www.dft.gov.uk/pgr/sustainable/olev

[36] Typical ICE running costs are taken from the ‘Fleet News running cost tables’. The same source has been used for Pure-EV cost calculations.

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[37] Residual values for EVs are being debated. Although other alternatively fuelled vehicles currently on the market have set a good precedent with high residual values there is no consensus opinion on residual values for EVs. For the purposes of this guide, we have assumed an equivalent residual value percentage as ICEs. CAP and Eurotax Glass's Guide are the main organisations looking at this area. Each organisation has a different view regarding whether the battery should be sold with the vehicle or leased separately. This makes it difficult to suggest a consistent residual value at this stage. Some residual values have been published and true residual values will be know in time. For this reason we have taken an estimate of the residual value based on the traditional ICE counterpart, assuming new technology with have neither a positive or negative effect on residual values.

[38] Typical ICE running costs are taken from the 'Fleet News running cost tables'. The same source has been used for Pure-EV cost calculations.

[39] Typical ICE running costs are taken from the 'Fleet News running cost tables'. The same source has been used for Pure-EV cost calculations.

[40] Insurance costs have been excluded from this table as no standard insurance cost has yet been established. However, insurance costs will be comparable to any vehicle today of similar size, cost and performance. Vehicle insurance costs will depend on the vehicle's performance, value and the driver's personal circumstances (eg home address, parking off-street, driver's age, experience and type of use).

[41] Typical ICE running costs are taken from the 'Fleet News running cost tables'. The same source has been used for Pure-EV cost calculations.

[42] ICE cars typically consume 15% more fuel in real life motoring conditions (Source: Arval/Energy Saving Trust 2006). A pilot Smarter Driving training programme is being run by the Energy Saving Trust during early 2011 for the early adopters of electric cars. Initial results suggest that after training EV drivers reduce their energy consumption by an amount consistent with the improvement in fuel consumption demonstrated by drivers of ICEs. Therefore for this comparison the same increase in energy consumption for an EV in real life motoring conditions compared with test data has been made. European drive cycle data indicates that ICEs are most fuel efficient when driven on motorways and EVs most energy efficient in a city environment.

[43] ICE cars typically consume 15% more fuel in real life motoring conditions (Source: Arval/Energy Saving Trust 2006). A pilot Smarter Driving training programme is being run by the Energy Saving Trust during early 2011 for the early adopters of Electric Cars. Initial results suggest that after training EV drivers reduce their energy consumption by an amount consistent with the improvement in fuel consumption demonstrated by drivers of ICEs. Therefore for this comparison the same increase in energy consumption for an EV in real life motoring conditions compared with test data has been made. European drive cycle data indicates that ICEs are most fuel efficient when driven on motorways and EVs most energy efficient in a city environment.

[44] Calculation uses real world electricity consumption and takes an average of the standard and low electricity rates.

[45] Most expensive standard rate available across all suppliers and regions (npower, Midlands region), March 2011.

[46] Cheapest standard/off peak rate available across all suppliers and regions (E7 night rate, British Gas, Yorkshire region), March 2011.

[47] www.dft.gov.uk/pgr/sustainable/olev

[48] Typical ICE running costs are taken from the 'Fleet News running cost tables'. The same format has been used for Pure-EV cost calculations.

[49] Residual values for EVs are being debated. Although other alternatively fuelled vehicles currently on the market have set a good precedent with high residual values there is no consensus opinion on residual values for EVs. For the purposes of this guide, we have assumed an equivalent residual value percentage as ICEs. CAP and Eurotax Glass's Guide are the main organisations looking at this area. Each organisation has a different view regarding whether the battery should be sold with the vehicle or leased separately. This makes it difficult to suggest a consistent residual value at this stage. Some residual values have been published and true

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[50] Typical ICE running costs are taken from the 'Fleet News running cost tables'. The same source has been used for Pure-EV cost calculations.

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[52] Insurance costs have been excluded from this table as no standard insurance cost has yet been established. However, insurance costs will be comparable to any vehicle today of similar size, cost and performance. Vehicle insurance costs will depend on the vehicle's performance, value and the driver's personal circumstances (eg home address, parking off-street, driver's age, experience and type of use).

[53] Typical ICE running costs are taken from the 'Fleet News running cost tables'. The same source has been used for Pure-EV cost calculations.

[54] ICE cars typically consume 15% more fuel in real life motoring conditions (Source: Arval / Energy Saving Trust 2006). A pilot Smarter Driving training programme is being run by the Energy Saving Trust during early 2011 for the early adopters of Electric Cars. Initial results suggest that after training EV drivers reduce their energy consumption by an amount consistent with the improvement in fuel consumption demonstrated by drivers of ICEs. Therefore for this comparison the same increase in energy consumption for an EV in real life motoring conditions compared with test data has been made. European drive cycle data indicates that ICEs are most fuel efficient when driven on motorways and EVs most energy efficient in a city environment.

[55] ICE cars typically consume 15% more fuel in real life motoring conditions (Source: Arval / Energy Saving Trust 2006). A pilot Smarter Driving training programme is being run by the Energy Saving Trust during early 2011 for the early adopters of Electric Cars. Initial results suggest that after training EV drivers reduce their energy consumption by an amount consistent with the improvement in fuel consumption demonstrated by drivers of ICEs. Therefore for this comparison the same increase in energy consumption for an EV in real life motoring conditions compared with test data has been made. European drive cycle data indicates that ICEs are most fuel efficient when driven on motorways and EVs most energy efficient in a city environment.

[56] Calculation uses real world electricity consumption and takes an average of the standard and low electricity rates.

[57] Based on saving of £2,278 (assuming daily amount of £9 via Auto Pay) over a working year. (Source: Transport for London)

[58] Further information on these incentives can be found at: www.hmrc.gov.uk/index.htm

[59] http://www.hmrc.gov.uk/cars/rule-changes.htm

[60] www.cclondon.com

[61] Source: EDF Energy.

[62] Fuel used in electricity generation and electricity supplied, March 2010: www.decc.gov.uk

[63] King review (October 2007), p36, Chart 3.2, http://www.low-carbon-ktn.org.uk/KingReviewReport.pdf

[64] 147.0g to 161.3g CO_2/km is calculated by adding the average tailpipe emissions of A to C segment cars (132.3g CO_2/km, Source: SMMT MVRIS data) plus the average well-to-tank emission figure, ranging from 10% to 18%, i.e. 14.7g to 29.0g CO_2/km. This is the range suggested by various sources, such as:

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[65] 132.3g CO_2/km is the UK sales weighted average of A to C segment cars sold in 2010. (Source: SMMT MVRIS data) We have not used the UK sales weighted average across all cars (144.2g CO_2/km) for this calculation as the latter figure includes vehicles which are likely to be larger than most EVs. (Source: SMMT CO_2 report: http://www.smmt.co.uk/wp-content/uploads/SMMT_New_Car_CO2_Report_2011.pdf)

[66] http://www.dft.gov.uk/pgr/scienceresearch/technology/lowcarbonelecvehicles/

[67] www.dft.gov.uk/pgr/sustainable/olev

[68] Source: DECC UK Average Fuel Mix (1 April 2009-31 March 2010) as shown on edfenergy.com

[69] DECC; UK Renewable Energy Strategy: http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx and DfT, Investigation into the scope for the transport sector to switch to electric vehicles and plug-in hybrids, 2008.

[70] BERR and DfT, Investigation into the scope for the transport sector to switch to electric vehicles and plug-in hybrids, 2008.

[71] BERR and DfT, Investigation into the scope for the transport sector to switch to electric vehicles and plug-in hybrids, 2008.

[72] Source: EDF Energy (0.3% - based on 660k plug-in vehicles with an average electric mileage of 7,500 miles)

[73] BERR and DfT, Investigation into the scope for the transport sector to switch to electric vehicles and plug-in hybrids, 2008.

[74] The Committee on Climate Change (CCC) is an independent body established under the Climate Change Act to advise the UK government on setting carbon budgets, and to report to Parliament on the progress made in reducing greenhouse gas emissions. www.theccc.org.uk.For more information refer to the NAIGT report: http://www.smmt.co.uk/wp-content/uploads/NAIGT-report-2009pdf.pdf

[75] HM government, Low Carbon Transition Plan: National Strategy for Climate and Energy, 2009.

[76] http://www.cabinetoffice.gov.uk/media/409088/pfg_coalition.pdf

[77] SMMT CO_2 report: http://www.smmt.co.uk/wp-content/uploads/SMMT_New_Car_CO2_Report_2011.pdf

[78] Source: Lotus Engineering.

[79] For more information refer to the NAIGT report: http://www.smmt.co.uk/wp-content/uploads/NAIGT-report-2009pdf.pdf

[80] www.energytechnologies.co.uk

[81] For more information refer to the NAIGT report: http://www.smmt.co.uk/wp-content/uploads/NAIGT-report-2009pdf.pdf

[82] NB: This document does NOT include quadricycles when referring to EVs. Please see glossary for more information.

[83] CE Certification is a mandatory conformance mark on many products placed on the single market in the European Economic Area (EEA). The CE marking certifies that a product has met EU consumer safety, health or environmental requirements.

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http://www.cenex.co.uk/LinkClick.aspx?fileticket=L2mk6XhufzQ%3d&tabid=119&mid=695

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