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POSTNOTE

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Electric Vehicles

Interest in the use of electric vehicles (EVs) for road transport is increasing. Potential benefits for the UK include business opportunities and, in the longer term, carbon emissions savings and a reduced dependence on oil. This POSTnote focuses on the extent to which EVs could reduce carbon emissions and examines issues that would surround widespread uptake.

Overview

- Electric vehicles (EVs) are more energy efficient during use than petrol or diesel vehicles, and produce less air pollution.
- The carbon emissions of an EV depend on how the electricity it uses is generated.
- Given the UK's current electricity mix, the carbon emissions due to driving an EV are comparable with the most efficient diesel cars, and are around 30% less than the average for new fossil fuel cars.
- Currently, the main barriers to uptake are cost (notably, battery cost), limited range between recharges, long recharge times and a lack of recharging infrastructure.
- A combination of industry regulation, pilot projects and consumer incentives is being used to encourage uptake in the UK.

Background

Electric vehicles run on electricity some or all of the time. There are many different types (see Box 1). This POSTnote focuses on **all-electric EVs** and **plug-in hybrid EVs**, which can complete a significant proportion of journeys electrically and are closer to market than fuel cell vehicles. As well as recent battery technology developments, interest in EVs has been motivated by the carbon emissions savings they could achieve. These savings are due to their increased efficiency (Box 1) and because the electricity on which they run can be generated from low-carbon sources. As cars and vans account for 70% of domestic transport emissions this note does not specifically discuss larger vehicles such as HGVs.

The UK is bound to cut greenhouse gas emissions by 80% by 2050 by the 2008 Climate Change Act. In 2007, the government commissioned the King Review of low-carbon cars. This review concluded that, in addition to other low-carbon technologies and behaviour change, EVs would be necessary to achieve an 80% reduction in transport emissions. In addition to widespread EV uptake, the proportion of electricity generated from low-carbon sources would need to increase significantly to meet this target. EVs are not expected to make a major contribution to emissions reduction until after 2020. However, the review argued that the market for low-carbon vehicles needs to be developed now to meet long term emissions reduction targets.

Box 1. What is an Electric Vehicle?

Electric vehicles use electric motors to drive their wheels. They derive some or all of their power from large, rechargeable batteries. The distance an EV can drive between recharges is known as its **range**.

Different categories of EV include:

- **All-electric EVs**, where the battery is the only power source. Most current (non-luxury) models have a quoted range of 80-120 miles (130-190 km). In practice, range varies according to driving style, terrain and the use of auxiliary equipment such as heating/air conditioning.
- **Plug-in Hybrids** (PHEVs) can switch between running on electricity or fossil fuels. They typically have a smaller battery, and therefore a lower battery powered range of between 10-40 miles (15-60 km). However their maximum range is equivalent to a petrol car. Both plug-in hybrid and all-electric EVs are recharged by plugging them in to the electricity grid (see image).
- **Hybrids** (HEVs) which do not plug in, such as the Toyota Prius, have a much smaller battery which is recharged while driving. HEVs can drive in electric mode for a few miles.
- **Fuel Cell Vehicles** generate their own electricity on-board from a fuel such as hydrogen, and do not need to plug in to the electricity grid to recharge. Re-fuelling is similar to a petrol car.

Energy Efficiency

The combination of battery plus electric motor is more efficient than an internal combustion engine (ICE), used in a fossil fuel car. Around 80% of the energy stored in an EV battery goes to driving the wheels, whereas ICEs are only around 20% efficient with much of the energy lost as heat. The overall efficiency of an EV is reduced by the losses which occur when electricity is generated.

The EV market is still in its very early stages. Of the 28.5 million cars in the UK, there are only a few thousand all-electric EVs, mostly in London. From 2012, European regulation to limit average emissions from new cars is being phased in, and has provided a financial incentive for manufacturers to develop EV models. From 2011, several major manufacturers will launch new EVs in Europe, with mid-size cars expected to cost £20,000-£40,000. EV users need access to recharging points either at home, at work or in public places such as car parks. The Coalition Agreement 2010 commits to "mandating a national recharging network for electric and plug-in hybrid vehicles".

Policy Context

EU Policy

European regulation approved in April 2009 aims to limit the average emissions of new cars sold in the EU. Emissions targets will be phased in from 2012, with manufacturers facing fines for non-compliance. All-electric EVs will be considered 'zero-emission' as only exhaust carbon emissions ('tailpipe' emissions) are counted - emissions from associated electricity generation are not included. Targets will be progressively tightened each year. The 2020 target represents a 40% reduction in average tailpipe emissions from 2009 levels, but this target is subject to review. Vans will also be regulated in the near future.

Until 2016, each car sold in the lowest emissions band will count as more than one car when a manufacturer's average is calculated. The only cars likely to fall into the lowest band will be all-electric and plug-in hybrid EVs. Thus the regulation incentivises these technologies. This is intended to encourage the early development of EV technology, as EV sales in the next few years could substantially offset sales of higher emitting cars. While manufacturers feel that, as far as practicable, "interventions by Government should be technology neutral",[1] it is recognised that support for a technology at the early stages may be appropriate.

UK Policy

The Department for Transport (DfT) and the Department for Business, Innovation and Skills (BIS) have led on EV policy in recent years, with a raft of initiatives put in place since 2007. Research and development has been part-funded by government and several trials are now under way (see Box 2). In 2009, the Office for Low Emission Vehicles (OLEV) was created jointly within DfT, BIS and the Department of Energy and Climate Change (DECC) to oversee aspects of EV funding, including the 'Plugged-in Places' (PiP) scheme. PiP helps regions meet up to 50% of the installation costs of recharging posts. In the first competition in February 2010 £8.8m was awarded to London, the North East, and Milton Keynes.

Consumer Incentives

Plans for a consumer subsidy for EVs from January 2011 were announced by the previous government. EVs which meet performance, reliability and safety criteria will be eligible for a 25% purchase price subsidy, up to a maximum of £5,000. In July 2010, £43m funding for the scheme was confirmed, with a review of the subsidy amount per car planned for March 2012. Tax measures designed to encourage the sale of lower emitting vehicles include Graduated Vehicle Excise Duty and Company Car Tax.

National Policy in Other Countries

Several European countries will offer subsidies of around €5,000 to early purchasers of EVs in order to grow their EV markets from 2011-2015. The highest incentives will be in Norway and Denmark, where EVs will be exempt from vehicle purchase tax, which can be in excess of €10,000. Several governments have announced ambitious targets for EV uptake in the next 10 years. The Japanese government has set a target of 20% 'next-generation' cars by 2020, including hybrids, plug-in hybrids, all-electric and fuel cell vehicles. In the US, the Recovery Act of 2009 included $2.4 billion funding to support next generation EVs.

Box 2. Electric Vehicles in the UK

Vehicle Trials

Trials will monitor vehicle performance, users' recharging habits and consumer attitudes.

- **Ultra Low Carbon Vehicle Demonstrators** – The largest EV trial in the UK is being overseen by the Technology Strategy Board with £25m of government funding, matched by industry. Eight consortia made up of manufacturers, energy companies, local authorities and universities will trial 340 cars for up to a year. The first cars were deployed in December 2009.
- **Low Carbon Vehicle Public Procurement programme (LCVPP)** Initial funding of £20m has been made available to help public sector organisations such as Royal Mail purchase low-carbon vans for their fleets. This year, 210 electric and hybrid vans will be entering public sector service via the LCVPP.

Pilot Infrastructure

- **London** – There are currently around 250 charging posts in London, mainly in car parks. Transport for London is aiming for 25,000 charging posts by 2015, of which 90% will be in workplace car parks and 250 will be fast charge. From 2011, the Electric Vehicle Discount will exempt all-electric EVs from the congestion charge, and this may be extended to plug-in hybrids in the future.
- **North East** – over the next three years 1,300 charging posts will be installed across Newcastle, Sunderland and Middlesbrough, including fast charge points on main trunk roads.

Other cities with EV infrastructure strategies include Milton Keynes, Birmingham, Coventry, Glasgow and Oxford. Compatibility between regions is partly being facilitated by the 'Joined-Cities' network, a joint government/industry funded initiative.

Emissions and Pollution

The carbon emissions of an EV arise from both:

- **generating the electricity** used for recharging; and
- **manufacture and disposal** of the battery and vehicle.

The majority of emissions are due to recharging. Figures for emissions due to manufacture and disposal are scarce for EVs; estimates suggest they will be higher for an EV than a fossil fuel car due to production of the battery.

Emissions from Electricity Generation

Electrification of road transport means emissions reduction can take place at the point of power generation, rather than

solely through drivers buying more efficient models. Currently, over 80% of electricity in the UK is generated using fossil fuels. Given this grid mix, EVs are estimated to offer around 30% emissions savings during use compared with average fossil fuel cars,[1] but the most efficient diesel cars also offer this level of savings.[2] The government's Low Carbon Transition Plan 2009 outlines plans for 40% of electricity to come from low-carbon sources by 2020. If this target were met, EVs could offer as much as 55% emissions savings during use compared with average fossil fuel cars. While there is a general consensus that this is achievable, many groups have highlighted the challenges of substantially increasing low-carbon electricity generation.[2] 'Decarbonisation' of the grid is discussed in POSTnotes 268, 280 and 318.

Reducing Emissions through Off-Peak Charging

The time of day that electricity is used affects the resulting emissions. For example, if large numbers of EVs were plugged in to recharge at 6pm when demand is highest, extra fossil fuel generation may be used, as this can be switched on at short notice unlike nuclear or renewables. The optimum times for EV recharging would be overnight or in the middle of the day, when demand is lower. If EVs were recharged between 10pm-6am, up to 20 million could be supported nationally with negligible extra generating capacity.[2] Off-peak charging could be encouraged by varying electricity prices according to supply and demand, but this would require upgrades to both the electricity distribution grid and electricity meters (see POSTnote 301). Use of a timer switch to delay recharging until after 10pm is a more immediately available option.

Alternatives for Carbon Emissions Reduction

Many stakeholders, including the Low Carbon Vehicle Partnership which represents 170 organisations, believe the main options for vehicle emissions reduction up to 2020 are:

- **improvements to fossil fuel engines and reduction in vehicle weight**, which could deliver 15-30% savings in new car emissions by 2020. Fossil fuel vehicles will be unable to deliver 80% savings in the long term.
- **biofuels**, which can offer emissions savings of 20-80% (see POSTnote 293), but will not be able to meet all of the UK's transport energy requirements due to constraints on land availability.[3] There may be scope to increase sustainable biofuel use to 8% of transport fuels by 2020, corresponding to 4-5% emissions savings.
- **increased use of public transport, cycling and walking**. The 'Smarter Travel Choices' programme was trialled in three UK towns between 2004 and 2009 and achieved a 5-7% reduction in distance driven.

Some groups, including Friends of the Earth, believe that meeting emission targets will also require **curbing the growth in transport demand**.[4]

Air and Noise Pollution

Electric vehicles produce no exhaust emissions when in electric mode, so widespread use could improve air quality in congested areas. They are also very quiet at speeds of less than 30 mph (50 km/h); at higher speeds tyre noise becomes more audible. Concerns have been raised regarding pedestrian safety, especially for the visually impaired. Manufacturers are trialling the use of artificial sounds for cars travelling at low speeds.

Requirements for EV Uptake

Vehicle Range

Limited range (see Box 1) is seen as a barrier to consumer uptake of EVs. A major technological challenge for manufacturers is to increase range while keeping battery size and cost down. Range can also be increased using plug-in hybrid EVs (Box 1). PHEVs can complete journeys of up to 40 miles (60 km) in electric mode, but fossil fuels are used for longer journeys or when recharging facilities are unavailable. Journeys of less than 25 miles (40 km) account for 93% of car trips and 60% of car emissions in the UK.[5]

Mass Production

EVs are unlikely to be produced in large volumes before 2014.[1] Many of the first EVs sold in Europe will be made in Japan. Plants in Europe plan to begin mass production in the next few years. From early 2013, the Nissan factory in Sunderland is scheduled to produce 60,000 EVs per year, including assembly of the batteries. Currently in the UK around 2 million new cars are bought and 3 million fossil fuel engines are manufactured each year.

Provision of Recharging Points

Recharging can take place using a power socket or outdoor charging post. Manufacturers anticipate the first users of EVs will be those who can recharge at home overnight or at work during the day. An EV battery which gives a 100 mile (160 km) range takes around 8 hours to recharge from a domestic (3kW) power supply. For safety reasons, it is recommended that a dedicated socket on a separate circuit is used. This costs around £500 to install in a garage.

It is not yet clear how many publicly accessible recharging posts will be required to support EVs, or who is best placed to provide and maintain them. Visibility of charging facilities may encourage uptake and reassure drivers taking longer journeys. On-street posts with a payment system currently cost £5,000+ to supply and install, partly due to the works licence required. Pilot projects (Box 2) should help to inform infrastructure planning. Europe-wide standardisation of charge points is being developed but is not yet in place.

Several all-electric EVs launched in 2011 will also have fast charging capability. Fast charge posts can reduce recharge time to less than 30 minutes for an 80 mile (130 km) range. They can be installed at locations with access to commercial type electricity infrastructure, such as service stations or retail outlets. They are likely to cost upwards of £40,000.

Consumer Demand

Most people have never driven in or recharged an EV. Test drives appear to improve people's opinion, with one trial

finding that after a test drive 72% of people said they would use an EV as their regular car, compared with 47% beforehand.[6] In the next few years, the main barriers for consumers will be the high initial cost of EVs, the limited range of all-electric EVs, and limited choice. In addition, one third of UK households do not have off-street parking, so EVs will not be readily accessible to them unless public or workplace charge points become more widely available.

Costs and Savings

To gain mass-market appeal, the costs to the consumer of an EV would need to be comparable with or lower than those of a fossil fuel car. Costs and savings include:

- **battery cost**. The price of an EV battery which can give a range of 100 miles (160 km) is similar to the price of an entire small petrol car. In addition, battery replacement may be needed after 5-10 years. Battery leasing can be used to share the cost between the consumer and the manufacturer, who can sell the battery on for use in energy storage, or for recycling. Battery cost is likely to fall as production increases. Some manufacturers believe it could halve in the next 5 years.
- **fuel savings**. At current electricity prices, manufacturers estimate that driving 100 miles (160 km) will cost around £2 compared with £10-£15 in a petrol car (where the latter includes a significant tax element). Fuel savings could increase with rising oil prices.
- **national and local incentives**. The government subsidy of up to £5,000 aims to bring the cost of EVs closer to fossil fuel cars in the early years while the technology is most expensive. Over the next few years, several city charging networks will have an annual membership fee but the electricity will then be free. In London, exemption from the congestion charge has been particularly effective in encouraging sales of alternatively fuelled vehicles.

Vehicle Fleets

Fleet buyers, including company car schemes, account for around 50% of new car sales. The resale value of vehicles is a major consideration for fleet buyers, and is not easy to predict for EVs. EVs may be well suited to use as delivery vehicles with a known routine of less than 100 miles (160 km) per day, and fuel savings may be significant. A lack of public recharging infrastructure is not seen as a problem for vehicles returning to the same place each night. [6]

2020 and Beyond

Future EV numbers are difficult to predict and forecasts vary from 1-10% of cars in the UK by 2020. Different technologies may begin to compete for different market sectors. Countries with early EV markets may attract more industry investment (see Box 3). The UK has not set targets for vehicle numbers. However the Committee on Climate Change recently recommended aiming for 1.7 million EVs by 2020, as a step towards the UK's long term emissions reduction targets.[3] Given the length of time new vehicle technologies can take to become established, many stakeholders feel this level of uptake by 2020 is unlikely.

Box 3. UK Automotive Industry

The automotive industry is currently worth £10 billion annually to the UK economy (around 1%).

Low-Carbon Vehicle Market

In 2008-2009, the industry-led New Automotive Innovation and Growth Team (NAIGT) conducted a review of the UK automotive industry for government. NAIGT's final report identified the early development of low-carbon vehicles as a major opportunity for the UK.[7] The UK has particular strengths in the integration of different components within new engines[8] and several prototype EVs for major manufacturers have been produced by British design engineering companies. The UK also has a well-developed electric van sector. On NAIGT's recommendation a joint industry/government committee, the Automotive Council, was created to oversee long term development.

Research and Development

Universities, engineers and manufacturers are collaborating in the development of low-carbon vehicles. Via the Technology Strategy Board, the government has provided £80m funding to over 60 of these projects in the last three years. One example is the West Midlands Low Carbon Vehicle Technology Project, which has brought together Coventry and Warwick universities; engineering consultants Zytek, Ricardo and MIRA; and manufacturers Tata/Jaguar Land-Rover.

Future Electricity Grid Requirements of EVs

If EVs became very widespread this would raise a number of issues for the electricity grid. For example, recharging could place strain on local electricity substations, which serve around 1,000 houses. Where they are already close to capacity these substations may need reinforcing. Another issue is that if a future grid allowed variable pricing, this could encourage off-peak recharging of EVs, which would increase grid efficiency. The government plans to establish a 'smart' grid as part of major upgrades to the UK's electricity network required over the coming decades. For a future smart grid to support EVs fully, such requirements would need to be considered at an early stage.[2]

Fuel Cells

Fuel cell vehicles generate electricity on-board using a 'clean' fuel such as hydrogen. This is a low-carbon form of transport if the hydrogen is generated using electricity from low-carbon sources. Hydrogen powered vehicles can be refuelled quickly and have an increased range, compared with battery powered EVs. Fuel cell production is unlikely to be cost competitive in the next decade and little infrastructure exists for transporting hydrogen around the UK. Fuel cells may offer the lowest carbon option for larger vehicles such as HGVs in the long term.

Endnotes

[1] BERR & DfT (Oct 2008) *Investigation into the Scope for the Transport Sector to switch to Electric Vehicles and Plug-in Hybrid Vehicles*
[2] Royal Academy of Engineering (May 2010) *Electric Vehicles: charged with potential*
[3] Committee on Climate Change (Jun 2010) *2nd Progress Report to Parliament*
[4] DfT Horizons Research Programme (Jan 2006) *Visioning and Backcasting for UK Transport Policy*
[5] DfT (Jul 2009) *Low Carbon Transport: A Greener Future*
[6] Centre of Excellence for Low Carbon and Fuel Cell Technologies (Mar 2010) *The Smart Move Trial*
[7] New Automotive Innovation and Growth Team (May 2009) *An Independent Report on the Future of the Automotive Industry in the UK*
[8] Technology Strategy Board (May 2010) *Automotive Technology: the UK's current capabilities*

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