THE CONTINUING PROFESSIONAL DEVELOPMENT PROGRAMME

Fundamentals CPD

For details on how to obtain your **Energy Institute CPD Certificate**, see ENTRY FORM and details on page 20

Moving to Electric Vehicles

Dr Richard Bujko, strategy & business development manager, Manx Electricity Authority

Global decarbonisation will need to focus on new electricity demand growth from the transition of transportation and heating to e-mobility and low and zero carbon heating forms. To accelerate the adoption of the former, digital transformation is a prerequisite in the electrification of transport [1].

The UK has legally committed to achieving a net zero-carbon economy by 2050 and expects to fulfil this ambition by ending sales of new conventional petrol and diesel cars and vans by 2030 with hybrid vehicles only permitted until 2035.

Rechargeable battery

Electric vehicles take a number of forms but are predominantly powered by electricity comprising an electric motor coupled with a rechargeable battery. The main classifications of electric vehicles (EVs) are:

- **battery electric vehicles (BEVs)** which utilise electric motors powered by a rechargeable onboard battery. The latter can also generate energy through the car's own braking system to recharge the battery in a process known as 'regenerative braking';
- **plug-in hybrid electric vehicles** (PHEVs) which can be simultaneously powered by an electric motor and internal combustion engine (ICE) but which require to be charged from an external charge point;
- **hybrid electric vehicles (HEVs)** which employ both an electric motor powered by a battery and ICE where the latter charges the battery and therefore does not require access to an external charge point; and
- **extended-range EVs (EREVs)** comprise the same components as PHEVs but the wheels are always driven by an electric motor with the ICE acting as a generator to recharge the battery when it is depleted.

There are also a smaller number of fuel cell electric vehicles (FCEVs) which source their electricity from fuel cells that use hydrogen and oxygen from the air.

Increased EV sales will inevitably place electricity demand-related pressure on both local and national infrastructure. To mitigate the potential onerous cost impact on future grid network reinforcement, intelligent digital technologies will be required to influence and incentivise EV consumer behaviour by encouraging flexible load control utilising sophisticated EV charging software incorporating Vehicle to Grid (V2G) services. In addition, the rollout of smart meters will facilitate the development from energy suppliers of dynamic price signalling techniques that employ innovative tariff structures that capitalise on renewable energy sources such as solar panels.

Figure 1: Home Charging Wall Box provided by PodPoint

The UK Government's Road to Zero policy[2] anticipates that traditional ICE cars will be phased out by 2040 with an aspiration that at least 50 per cent - and as much as 70 per cent - of new car registrations will become ultra-low emission EVs by 2030 together with 40 per cent of new vans.

There has been a gradual transition to BEVs and both self-charging HEVs and PHEVs globally. Moreover, during the last decade, there has been significant growth in EV ownership with current market share in the UK representing around 1 per cent of all new vehicles on the road and 11 per cent of new vehicle registrations.

According to the website NextGreenCar[3], there were 164,100 BEVs on UK roads at the end of September 2020 and over 373,600 PHEVs. According to the Society of Motor Manufacturers and Traders (SMMT), BEVs accounted for 6.7 per cent of total new car registrations and this figure rises to 10.5 per cent when PHEVs are fully taken into account.

There were also 10,300 plug-in vans and a total of 34,360 charge points (CPs) registered in the UK.

Financial incentives for prospective EV purchasers include the plug-in grant whose value represents 35 per cent of the EV's purchase price with a maximum value of £3,000. However, this has recently been reduced to £2,500. It is primarily aimed at helping finance the relatively higher price of EVs compared to equivalent sized conventional vehicles and is administered by the Office of Low Emission Vehicles (OLEV)[4]. Other qualifying factors included the fact that the eligible low-emission vehicle must have CO_2 emissions of less than 50g/km and be able to travel at least 70 miles without emitting any CO_2. It must also be on the OLEV's approved list.

In addition, the UK Government will provide up to £350 towards the cost of installing a home-charging wall box. However, it must be an officially approved 'smart' charger and will mainly benefit those with off-street parking.

Discontinue petrol car sales

The most common purchased BEVs are Nissan Leafs, Renault Zoes, BMW I3s and Tesla 3/X/S models. However, the range of new models is continually increasing as the leading car manufacturers comply with the UK's Government's 'Ten Point Plan for a Green Industrial Revolution' plan[5] to discontinue the sale of new petrol and diesel cars and vans.

The low- and zero-emission transport market was initially dominated by a comparatively

high percentage of plug-in hybrids such as the Mitsubishi Outlander which featured a relatively small battery enabling a limited driving range of around 30 miles on just 'battery power' but presented the owner with a significantly longer driving range –in excess of 300 miles - on its conventional engine. But as the number of public electric charging stations – particularly those incorporating fast and rapid charging capability – has increased exponentially at easily accessible community centres such as retail and hotel outlets, this has helped to relieve range anxieties commonly felt by prospective EV owners. The added attraction of EVs has been further supplemented by new BEVs incorporating larger battery capacities which provide increased driving ranges that are almost comparable to that of conventional fossil fuelled vehicles with up to 200-300 miles on a single charge.

Other zero emission technologies in transport have included FCEVs such as the Toyota Mirai which is reliant on hydrogen as a fuel and whose waste stream is predominantly water vapour. This latter genre has required substantial financial support from the UK Government and has led to the construction of a number of hydrogen fuelling stations[6].

Larger vehicles such as Electric Refuse Vehicles (eRCV) are also being adopted as in Manchester[7] where the UK's leading sustainable waste management business – Biffa – has launched 27 new Zero Emission (ZEVs) to help reduce air pollution.

Driving range anxiety

There are a number of key anxieties faced by prospective EV purchasers which include the capital cost, driving range and speed of charging.

The average price of the majority of mid range EVs falls in the range of £25,000 - £30,000 even when factoring in the current Plug-in grant of £2,500. Therefore the overall cost of an EV can represent almost double the price of a conventional family saloon. However, as manufacturers make the transition to the production of just pure EVs, the resulting increased economies of scale are expected to result in a gradual fall in the price of the latter. This trend will be accelerated as the manufacture of conventional cars is gradually reduced over the next decade with a combination of Government imposition of higher emission taxes in the form of congestion charges and/or carbon taxes.

For business customers considering purchasing EVs, additional financial benefits include 0 per cent Benefit in Kind Company car tax and a 100 per cent first year allowance on the full cost from your profits before tax on both new EVs and charge points. Given that BEVs have no tailpipe emissions they are exempt from road tax.

On average an EV will have a typical operating cost of just 3p/mile compared to the 9p/mile of conventional petrol or diesel cars. Maintenance costs of EVs can also be around 30 per cent less than ICE vehicles because they have fewer moving parts and can benefit from reduced servicing costs. Additional monetary benefits are anticipated with business EV owners through the implementation of V2G technology which will encourage the development of demand response service offerings (flexibility) from local DNOs[8]. This could take the form of discharging batteries during a DNO's peak demand periods and therefore offsetting or delaying the capital costs necessary for localised grid reinforcement. EV owners could also benefit from reduced electricity costs when recharging during off-peak hours when there is a surplus of generation capacity. Currently only Nissan offer this V2G compatible EVs in the UK with both their Nissan Leaf BEVs and the enV200 van models[9].

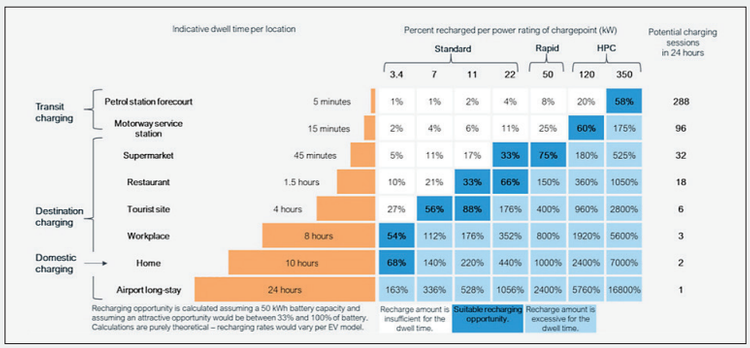
A lack of EV charge points close to home and driving range limitations – commonly referred to as range anxiety – also feature as key barriers by prospective EV purchasers to switching to zero emission transportation. For those without access to off-street parking at home, increased reliance will be placed on workplace charging or 'community hubs' within retail, hospitality, leisure centre car parks, etc.

Initially, the low carbon transportation sector was dominated on the supply side by the large global auto manufacturers developing niche markets in EVs. However, the need for a robust and widespread EV charging infrastructure capability was becoming more competitive and encouraged the entry of new individual service providers such as Chargemaster and PodPoint. Key energy suppliers – both established and new - also entered this marketplace attempting to differentiate themselves with product offerings that covered the various segments such as home, workplace, and destination centre fast charging together with innovative and green tariffs.

EV charging has taken various forms. Home EV charging capability initially comprised a dedicated home '3 pin' (Type 2 socket) 2.3kW charging point which for most EVs could require over eight hours to fully charge an initial 'flat' EV battery providing up to 8 miles of range per hour. Home charging can also be provided at 3.7kW or 7kW as most domestic properties have single phase power facilitating a driving range of around 15-30 miles. However, maximum charging speed may be limited by your EV's onboard charger which can limit the charging rate to 3.6kW. For those households and most commercial properties benefitting from a three phase supply, faster charge points of 22kW are readily available. Home charging is currently regarded as slow charging and best used for overnight charging as a BEV would take between 6-12 hours to fully charge while a PHEV might take 2-4 hours.

Fast charging can take 3-4 hours to fully charge a BEV using an output of 7kW at single phase or 22kW at three phases.

Figure 2: Delta –EE: Identification of suitable charge point power rating per location type.



Electric vehicle tariffs

One of the UK's leading providers of domestic smart EV charging points is PodPoint[10] and one of their standard wall boxes is shown in Figure 1. Installation of a PodPoint application will also allow access to their extensive network of other public charge points across the UK.

Some energy suppliers offer special electric vehicle tariff structures which encourage EV drivers to charge overnight by offering a discounted unit rate for electricity that equates to about 2p/mile. Island utility companies such as Manx Utilities[11] offer a specialised EV tariff which provides a discounted rate of 9.2p/kWh off-peak relative to their standard rate of 16.9p/kWh. Others such as Jersey Electricity have adopted a range of subscription models such as Evolve Public which involves a monthly membership fee of £10 allowing EV owners access to all public chargers. The latter are fitted with dual sockets allowing both 16A and faster 32A charging depending on the type of EV. More expensive monthly membership fees include the capability to also charge at home.

An increasing number of large organisations operating significantly sized vehicle fleets are gradually transitioning to low carbon technologies as the speed and capacity of commercial EV charge points has improved. This has been facilitated with the advent of Rapid Charging which comprises either 43kW AC chargers or 50kW DC chargers with even larger EV capacity becoming available. The larger EV stations are capable of charging the majority of EVs to 70-80 per cent of total capacity within 30 minutes to 1 hour depending on the size of the battery.

Large EV Charge Point Operators (CPOs) have also established collaborative alliances with utility service companies and National Grid to provide fast and ultra-fast EV charging capability ranging from 50kW to 150kW and as large as 350kW. This has encouraged organisations operating large commercial fleets such as delivery vans to switch to all–electric alternatives – zero emission vehicles (ZEVs) as is the case with British Gas / Centrica[12] and which utilise a 'virtual fuel card' for EV charging.

Delta-EE, a major energy consultancy, has summarised in its report 'EV Charging at the Crossroads: The Fast, the Curious & the Race for Sale' the dwell time for EV charging at various locations ranging from home to supermarkets/petrol station forecourts in Figure 2.

Even the major oil and gas companies such as Shell and BP have diversified into renewables and EV charging sectors. BP has acquired the UK's leading EV CPO service provider Chargemaster and is also considering developing a widespread network of ultra-fast EV charging hubs.

Shell has teamed up with COP provider New Motion to accelerate the transition to low carbon transportation in the UK and in Europe. Under the terms of the deal, New Motion will focus on delivering more innovative smart-charging solutions to homes, businesses and public parking spaces.

The majority of EVs have a relatively short driving range of around 150 miles

Figure 3: EV charged by Tidal Power derived Charge Point.

compared to conventional vehicles. However, the next generation of EVs such as the popular Nissan Leaf has a driving range of 180 miles while the latest Tesla Model S has a range of over 310 miles. Increased lithium ion battery capacity and advances in battery storage technologies is already leading to major improvements in the total driving range of modern EVs. Given that the average vehicle journey is 9 miles/day the range of an EV should not be a major concern. Access to home charging and the development by the public and private sector of a wide range of fast and ultra-fast EV charging stations will also contribute to building confidence and allaying prospective EV purchasers' anxiety regarding the perceived short driving range of the average EV model.

EVs are regarded as very energy efficient with 60 per cent of the electrical energy from the national grid is converted to power at the wheels in contrast to the 20 per cent of the energy stored in conventional fuels for ICE vehicles. Other environmental benefits consist of zero emission of CO_2 and other tailpipe discharges.

Advancements in EV technologies and additional incentives are expected to lower the cost of EV batteries and consequently demonstrate the reduced life cycle cost of EVs compared to conventional internal combustion engine cars. EDF – a major energy supplier in the UK- has suggested that across the lifecycle of an EV the latter is around 14 times more carbon efficient than a typical ICE vehicle.

In the short term to reduce the carbon impact of existing ICE vehicles some of the major fuel supplies have installed bio-fuel dispensing units in their forecourts. Advances in bio-fuel production have resulted in short term mitigation of the carbon impact of conventional fuel powered vehicles through increased mixing of ethanol with petrol and methyl fatty acid with diesel. Percentage mixes of up to 10 per cent - known as E10 petrol – will be introduced at petrol stations across the UK in September 2021. This is expected to cut transport related CO_2 emissions by 750,000 tonnes a year.

Ethanol will comprise low-grade grains, sugars and waste wood and will greatly support the UK Government's ambitions to achieve net zero by 2050[13].

Ultra-fast wireless charging

For 2035 zero emission targets to be met rapid transformations are expected in the transport and e-mobility landscape from the universal and ubiquitous adoption of ultra-fast wireless charging of EVs to the design and development of high energy battery systems. Given that current designs of EV batteries are comparatively heavy in order to deliver the required driving range capability translates into more energy being consumed in a single journey. Developments in the 'highly energy dense solid state cells' sector will lead to batteries with better energy storage, a more compact design and the capability of being fast charged. The establishment of high-volume battery manufacturing plants ('gigafactories') in the UK together with incremental investment in EV technology training and the ethical sourcing of the rare materials essential in the composition of batteries[18] will all contribute to expediting the transformation to a smart EV landscape in the UK.

Consequently, a number of alternative forms of low- and zero-emission transportation schemes have been trialled including compressed natural gas, liquid natural gas and liquid petroleum gas.

With rapid EV growth forecast for the coming decade, the National Grid Electricity System Operator's (NG ESO's) Future Energy Scenarios Report [14], 'Community Renewables', considers the impact of this growth on electricity demand. The report projects that unconstrained EV charging demand at peak times could rise to approximately 24GW by 2050 However, NG ESO also highlights that this demand could be significantly mitigated by implementing smart charging techniques and further reduced by exploiting V2G techniques for load control and the provision of flexibility services to the local DNOs.

Other advances in V2G will enable stationary EVs to become an established feature in Grid support and more significantly mitigate battery degradation and extend battery life.

To avoid system peaks a number of alternative and innovative load control measures have been explored including the integration of EV charge point infrastructure with renewable energy sources. This has been explored by the Shetland Island where tidal power is the fuel supply for the Island's EVs[15] as shown in Figure 3.

Green gas HGVs are also an alternative to low carbon transportation and are expected to support the Decarbonising Transport Roadmap[16].

Wireless charging or 'charge on the move' are concepts which require further research to guarantee compatibility and appropriate design installation procedures. Their potential may be more valid for electric taxis as these are constantly on the move as opposed to consumer EVs whose vehicles are predominantly parked either at their workplace or at home.

The UK Government wants to be at the forefront of rolling out autonomous driving technology and the transport ministry predicts that by 2035 around 40 per cent of new UK cars could have self-driving capabilities[17].

To accelerate UK's transition to EVs a combination of various factors have to be given serious consideration including: a robust and expanding manufacturing supply chain geared towards major improvements in battery technology, associated power electronics, machines and drives (PEMD)[18]; additional and sustained financial incentives from the UK Government to 'nudge' and encourage EV purchases; financial support towards the cost of both residential and public sector fast charging EV charging stations strategically positioned across the whole of the UK as well as onerous financial 'carbon reduction/air quality improvement' penalties to discourage the use of existing ICE vehicles on the roads. ■

REFERENCES

1. https://www.energy-uk.org.uk/publication.html?task=file.download&id=7864
2. https://www.gov.uk/government/news/government-launches-road-to-zero-strategy-to-lead-the-world-in-zero-emission-vehicle-technology
3. https://nextgreencar.com/electric-cars/statistics/
4. https://www.gov.uk/plug-in-car-van-grants
5. https://www.gov.uk/government/news/pm-outlines-his-ten-point-plan-for-a-green-industrial-revolution-for-25000-jobs.
6. https://www.driving.co.uk/news/the-future-of-hydrogen-filing-stations-in-britain/
7. https://www.biffa.co.uk/media-centre/news/uks-largest-fleet-of-electric-waste-vehicles-launches-in-manchester
8. https://theenergyst.com/uk-power-networks-awards-123mw-of-flex-contracts-evs-included/
9. https://www.nissan.co.uk/range/electric-cars/v2g.html
10. https://pod-point.com/about
11. https://www.manxutilities.im/your-home/electricity/electric-vehicles/
12. https://www.centrica.com/media-centre/news/2021/centrica-introduces-virtual-fuel-card-for-electric-fleet-charging/
13. https://www.gov.uk/government/news/fuelling-a-greener-future-e10-petrol-set-for-september-2021-launch
14. https://www.nationalgrid.com/uk/stories/journey-to-net-zero-stories/eso-future-energy-scenarios-next-30-years
15. https://www.novainnovation.com/news/news_/i per cent20tidal-powered-cars-driving-scotland-to-net-zero/
16. https://cadentgas.com/news-media/news/march-2021/green-gas-hgvs-are-key-to-net-zero-says-new-report
17. https://www.msn.com/en-ca/autos/news/uk-government-green-lights-self-driving-cars-on-motorways/ar-BB1g7lz0
18. https://committees.parliament.uk/committee/62/environmental-audit-committee/news/154978/supply-chain-for-battery-electric-vehicles-inquiry-launched/

CPD SERIES 19 / Module 01
Electric Vehicles

ENTRY FORM

Please mark your answers below by placing a cross in the box. Don't forget that some questions might have more than one correct answer. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet, return it to the address below. Photocopies are acceptable.

Questions

1) What's the difference between a plug-in hybrid EV(PHEV) and a standard HybridEV (HEV)?
☐ No battery
☐ No electric motor
☐ Requires connection to an external power socket
☐ No difference

2) What does V2G stand for?
☐ Volume-to-Generate
☐ Vehicle-to-Grid
☐ Volume-to-Grid
☐ Variable-to-Gate

3) The UK Government's Road to Zero policy anticipates that traditional ICE cars will be phased out by
☐ 2025
☐ 2030
☐ 2035
☐ 2040

4) What's the current value of the UK's Plug-in grant to encourage purchase of EVs?
☐ £2,5000
☐ £3,000
☐ £4,000
☐ £3,500

5) Which model of car is not a pure battery driven EV (BEV)?
☐ Nissan Leaf
☐ Tesla X
☐ Mitsubishi Outlander
☐ Renault Zoe

6) What are the main anxieties for prospective EV owners?
☐ Capital cost & driving range
☐ Speed of charging and capital cost
☐ Speed of charging and driving range
☐ The capital cost, driving range and speed of charging

7) What is the highest EV charge capability for a domestic home with a three phase supply?
☐ 3kW
☐ 7kW
☐ 22kW
☐ 12kW

8) What is the ethanol content of the bio-fuel known as E10 in petrol?
☐ 10gms
☐ 10cc
☐ 10 per cent
☐ 100 per cent

9) What is a gigafactory?
☐ Electronic chip manufacturer
☐ High-volume battery manufacturer
☐ Solar panel manufacturer
☐ Wind turbine manufacturer

10) What is the source of renewable energy used to charge EVs in the Shetland Islands?
☐ Hydro
☐ Wind
☐ Solar
☐ Tidal

Please complete your details below in block capitals.

Name..... (Mr. Mrs, Ms).....

Business .....

Business Address .....

.....

.....

.....Post Code .....

email address.....

Tel No. .....

Completed answers should be mailed to:
The Education Department, Energy in Buildings & Industry, P.O. Box 825, Guildford, GU4 8WQ.
Or scan and e-mail to: editor@eibi.co.uk.
All modules will then be supplied to the Energy Institute for marking

Produced in Association with
energy institute

"Energy in Buildings and Industry and the Energy Institute are delighted to have teamed up to bring you this Continuing Professional Development initiative"
MARK THROWER Managing Editor

How to obtain a CPD accreditation from the Energy Institute

This is the first module in the nineteenth series and focuses on **Electric Vehicles**. It is accompanied by a set of multiple-choice questions.

To qualify for a CPD certificate readers must submit at least eight of the ten sets of questions from this series of modules to EiBI for the Energy Institute to mark. Anyone achieving at least eight out of ten correct answers on eight separate articles qualifies for an Energy Institute CPD certificate. This can be obtained, on successful completion of the course and notification by the Energy Institute, **FREE OF CHARGE** for both Energy Institute members and non-members.

The articles, written by a qualified member of the Energy Institute, will appeal to those new to energy management and those with more experience of the subject.

Modules from the past 18 series can be obtained free of charge. Send your request to editor@eibi.co.uk. Alternatively, they can be downloaded from the EiBI website: www.eibi.co.uk

SERIES 19 JUNE 2021 - MAY 2022

1. **Electric Vehicles**
2. Refrigeration*
3. Underfloor Heating*
4. Combined Heat & Power*
5. Humidification*
6. Smart Buildings*
7. Photovoltaics & Batteries*
8. Air Handling*
9. Variable Speed Drives*
10. Boilers & Burners*

** Only available to download after publication date*

CPD Fundamentals
THE CONTINUING PROFESSIONAL DEVELOPMENT PROGRAMME

Terms: in submitting your completed answers you are indicating consent to EiBI's holding and processing the personal data you have provided to us, in accordance with legal bases set out under data protection law. Further to this, EiBI will share your details with the Energy Institute (EI) with whom this CPD series is run in contractual partnership. The EI will process your details for the purposes of marking your answers and issuing your CPD certificate. Your details will be kept securely at all times and in a manner complaint with all relevant data protection laws. For full details on the EI's privacy policy please visit www.energyinst.org/privacy.

To hear more from the EI subscribe to our mailing list: visit https://myprofile.energyinst.org/EmailPreferences/Subscribe